Rose & Westra
A Division of GZA

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CONSTRUCTION MANAGEMENT

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December 2, 2022

File No. 16.0062961.81

Ms. Karen Vorce, Project Manager
Grand Rapids District Office
Remediation and Redevelopment Division
Michigan Department of Environment, Great Lakes, and Energy
350 Ottawa Avenue NW, Unit 10
Grand Rapids, MI 49503
vorcek@michigan.gov

Re: Revised Work Plan – Final Remedy
Wolverine World Wide, Inc. – House Street Property
Plainfield Township, Kent County, Michigan

Dear Ms. Vorce:

On behalf of Wolverine World Wide, Inc., Rose & Westra, a Division of GZA GeoEnvironmental, Inc., is submitting this cover letter and attachment in response to the referenced Consent Decree, effective February 19, 2020.

This submittal includes the Approved Work Plan for the Final Remedy cap design identified in Paragraph 7.8 of Consent Decree No. 1:18-cv-00039-JTN-SJB, effective February 19, 2020. This Approved Work Plan and its technical supporting documents provide a guide to the Final Remedy for the HSP. Much of the technical detail is contained in the appendices. If you have any questions, please contact us.

Very truly yours,

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

Loretta J. Powers, CHMM
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ljp/maw/eh/jcf

Attachment: Approved Work Plan – Final Remedy, HSP

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WORK PLAN – FINAL REMEDY
HOUSE STREET PROPERTY

1855 HOUSE STREET NE
Plainfield Township, Kent County, Michigan

April 26, 2022, Revised May 26, 2022, Finalized December 2, 2022
File No. 16.0062961.81

PREPARED FOR:
Wolverine World Wide, Inc.
Rockford, Michigan

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ACRONYMS

AQD	Air Quality Division
AQI	Air Quality Index
bgs	Below Ground Surface
CD	Consent Decree, effective February 19, 2020 (No. 1:18-cv-0039-JTN)
CSM	*Conceptual Site Model Update and Status Report* dated February 9, 2018
CY	Cubic Yards
EGLE	Michigan Department of Environment, Great Lakes and Energy
EPA	U.S. Environmental Protection Agency
FIRM	Flood Insurance Rate Map
FS	*Revised Feasibility Study – Remedial Options, House Street Property, 1855 House Street NE, Plainfield Township, Kent County, Michigan* dated September 13, 2021; Approved Final October 28, 2021.
ft	Feet
GIS	Geographic Information Systems
HSP	House Street Property, also referred to as Site
HAPs	Hazardous Air Pollutants
LandGEM	Landfill Gas Emissions Model
KCRC	Kent County Road Commission
MDARD	Michigan Department of Agriculture and Rural Development
NAAQS	National Ambient Air Quality Standards
NE	Northeast
NOAA	National Oceanic and Atmospheric Administration
NOC	Notice of Coverage
NPDES	National Pollutant Discharge Elimination System
NWS	National Weather Service
PM	Particulate Matter
PTE	Potential To Emit
PTI	Permit to Install
QA/QC	Quality Assurance/Quality Control
R&W/GZA	Rose & Westra, a Division of GZA GeoEnvironmental, Inc.
SESC	Soil Erosion and Sedimentation Control
TPY	Tons per Year
WLSU	EGLE Wetlands, Lakes, and Streams Unit
Wolverine	Wolverine World Wide, Inc.
WP	Work Plan – Final Remedy, HSP
WRD	EGLE Water Resources Division

1.0 INTRODUCTION

On behalf of Wolverine, R&W/GZA prepared this Work Plan (WP) for the Final Remedy for the House Street Property (HSP) that was established in the revised Feasibility Study (FS), dated September 13, 2021, and approved by Michigan Department of Environment, Great Lakes, and Energy (EGLE) on October 28, 2021. The objective of this WP is to provide a scope of work and design to implement the Cap Option, which was selected as the Final Remedy, as required under Paragraph 7.8(c) of the Consent Decree (CD).

This WP is prepared pursuant to the CD and is organized into the following sections (outlined in accordance with the EGLE-Approved Checklist of Applicable Substantive Requirements of Part 115 , the "Checklist"):

SECTION 1.0	INTRODUCTION
SECTION 2.0	BACKGROUND
SECTION 3.0	PROJECT INFORMATION [SECTION A OF CHECKLIST]
SECTION 4.0	ENVIRONMENTAL ASSESSMENT INFORMATION [SECTION B OF CHECKLIST]
SECTION 5.0	HYDROGEOLOGICAL INFORMATION [SECTION C OF CHECKLIST]
SECTION 6.0	MONITORING PLAN [SECTION D OF CHECKLIST]
SECTION 7.0	ENGINEERING DESIGN DRAWINGS [SECTION E OF CHECKLIST]
SECTION 8.0	ENGINEERING PLAN [SECTION F OF CHECKLIST]
SECTION 9.0	OPERATION PLAN [SECTION G OF CHECKLIST]
SECTION 10.0	CONSTRUCTION QUALITY ASSURANCE PLAN [SECTION H OF CHECKLIST]

2.0 BACKGROUND

The HSP, located at 1855 House Street NE, Plainfield Township, Kent County, Michigan, encompasses approximately 76 acres (**Figure 1**). The HSP is currently undeveloped and, according to available information, no buildings were previously present. An electric utility right-of-way and associated high-voltage transmission lines cross the northern portion of the HSP, and a maintenance access road from House Street runs south to north across the HSP. Section 2.0 of the FS summarizes background information for the HSP, including lithology, waste materials, and hydrogeology. For ease of reference, the FS is provided as **Appendix A**.

3.0 PROJECT INFORMATION

Name and Address	House Street Property 1855 House Street NE Plainfield Township, Kent County, Michigan
Name and address of the property owners	Wolverine World Wide, Inc. 9341 Courtland Drive NE Rockford, Michigan 49351
The type of disposal area proposed	Three low-permeability caps consisting of a flexible membrane covered by 2 feet (ft) of soil and 6 inches of vegetated cover, or an EGLE-approved alternative, will be installed over delineated waste material areas. Refer to Section 4.2.1 of the FS for additional information.
A description of the type of waste	Waste consists of material placed at the HSP prior to and when it was a State of Michigan licensed and regulated disposal site until 1970. Refer to Section 2.0 of the FS and Section 6.1 of the 2018 Implementation Summary Report (R&W/GZA, 2019) for additional information. On-Site vegetation removed during construction will also be placed under the cap as described in the FS.
The number of acres	Approximately 27 acres
The design capacity of the landfill	Not applicable
Map	Refer to **Section 7.0**
Legal Description	S 1/2 SE 1/4 NW 1/4 ALSO W 2/3 E 3/4 N 1/2 S 1/2 OF SEC EX COM AT S 1/4 COR TH N 89D 10M 03S W 418.85 FT TH N 42D 16M 46S E 1771.42 FT TH N 89D 16M 44S W 1100 FT TO BEG OF THIS DESC - TH N 0D 43M 16S E 40.0 FT TH N 74D 16M 49S E 278.64 FT TH N 50D 26M 52S E 1527.46 FT TH N 19D 00M 13S E TO E&W 1/4 LINE TH ELY TO NE COR OF NW 1/4 SE 1/4 TH SLY TO SE COR OF NW 1/4 SE 1/4 TH WLY ALONG S 1/8 LINE TO BEG & EX THAT PART OF REMAINDER LYING WITHIN FOL DESC - S 660 FT OF E 660 FT OF W 928.8 FT OF NW 1/4 SE 1/4 * SEC 4 T8N R11W 76.41 A. (Taken from BSA online, Plainfield Charter Township, April 2022)

4.0 ENVIRONMENTAL ASSESSMENT INFORMATION

4.1. <u>REQUIRED PERMITS AND LICENSES</u>

The HSP work will be performed in accordance with applicable laws, and permits will be obtained where required. As part of this WP, R&W/GZA evaluated applicable regulations (i.e., air quality, surface water quality, groundwater quality, waste, and road right-of-way). The following sections describe the evaluation and applicability of relevant permits and licenses and identify applicable exemptions.

4.1.1. <u>Air Quality Regulations</u>

An air permit is not required. The following describes the air quality regulation evaluation process.

Rule 201, R 336.1201 of the Michigan Air Pollution Control Rules requires a person to obtain a Permit to Install (PTI) prior to the installation, construction, reconstruction, relocation, or modification of a process or process equipment that emits air contaminants. *Except as allowed in R 336.1202, R 336.1277 to R 336.1291, or R 336.2823(15) a person shall not install, construct, reconstruct, relocate, or modify any process or process equipment, including control equipment pertaining thereto, which may emit any of the following, unless a permit to install that authorizes such action is issued by the department*.

(a) Any air pollutant regulated by title I of the clean air act and its associated rules, including 40 C.F.R. §51.165 and §51.166, adopted by reference in R 336.1902.

(b) Any air contaminant. "Air contaminant" means a dust, fume, gas, mist, odor, smoke, vapor, or any combination thereof.

Pursuant to R 336.1212(g) *temporary activities related to the construction or dismantlement of …, earthworks, or other structures,* and R 336.1212(k) *Construction, repair, and maintenance of roads or other paved or unpaved areas*, are insignificant activities and do not require a PTI. Also, R 336.1285(aa) exempts *landfills and associated flares and leachate collection and handling equipment* from obtaining a PTI*.* Similarly, Rule 285 (336.1285(gg)) exempts *equipment used for chipping, flaking, or hogging wood or wood residues that are not demolition waste materials.*

Rule 285 does not apply if prohibited by R 336.1278 and unless the requirements of R 336.1278a have been met.

According to 278(1)(a) *Any activity that is subject to prevention of significant deterioration of air quality regulations or new source review for major sources in nonattainment areas regulations.* Based on Landfill Gas Emissions Model (LandGEM), Version 3.03 (provided in **Appendix B**), the total PTE for all landfill gases is approximately 195 tons/year. This is likely conservative, as R&W/GZA assumed all 83,000 CY of estimated waste was organic waste. Based on these estimates, 34,000 CY is a mix of soil and waste. The 195 tons/year total is below the 250 ton/year major source threshold. Therefore, while the source is located in an attainment area for all National Ambient Air Quality Standards (NAAQS), it is not a major source as defined in (1)(b) (i.e., *any activity that results in an increase in actual emissions greater than the significance levels defined in R 336.1119*). For the purpose of this rule, "activity" means the concurrent and related installation, construction, reconstruction, relocation, or modification of any process or process equipment.

According to *278(2) The exemptions specified in R 336.1280 to R 336.1291 do not apply to the construction of a new major source of hazardous air pollutants or reconstruction of a major source of hazardous air pollutants, as defined in 40 C.F.R. §63.2 and subject to §63.5(b)(3), national emission standards for hazardous air pollutants, adopted by reference in R 336.1902.* The estimated Potential To Emit (PTE) of all Hazardous Air Pollutants (HAPs) is 0.2 TPY, less than the major source threshold of 10 Tons per Year (TPY) for a single HAP or 25 TPY for all HAPs. Therefore, the HSP is not a new major source of HAPs.

According to *278(3) The exemptions specified in R 336.1280 to R 336.1291 do not apply to a construction or modification as defined in and subject to 40 C.F.R. Part 61, national emission standards for hazardous air pollutants, adopted by reference in R 336.1902.* The HSP is not an "affected facility" and, therefore, this requirement is satisfied.

The HSP will comply with Rule 278a by maintaining documentation demonstrating the applicability of the exemption. Based on the above information, the HSP is not required to obtain a PTI.

Potential air quality impacts include generation of dust during clearing and earthwork activities, volatilization during earth moving actives, generator usage, and passive venting of subsurface gases. Federal air quality regulations are administered by EGLE's Air Quality Department (AQD). The *Code Of Ordinances Charter Township of Plainfield, Chapter 16 – Environment* also contains applicable noise regulations.

Michigan Part 3 Rules limit emissions of Particulate Matter (PM). The HSP does not perform any of the regulated processes and, therefore, Part 3 Rules are not applicable. In order to prevent nuisance to area residents, a Fugitive Dust Control Plan will be developed implemented on haul roads and a truck tire wash used prior to trucks leaving the Site.

Chapter 16 Article IV of the Plainfield Charter Township Ordinance restricts noise from loud vehicles and construction. *The creation (including excavation therefore), demolition, alteration, or repair of any building and the excavation of streets and highways on Sundays, and other days, except between the hours of 7:00 a.m. and 8:00 p.m., unless a permit, therefore be first obtained from the township manager or superintendent.* Working hours will be restricted to between 7:00 a.m. and 8:00 p.m., Monday through Saturday.

No applicable Kent County regulations were identified.

4.1.2. Surface Water Quality Regulations

A National Pollutant Discharge Elimination System (NPDES) discharge permit is not required. A Soil Erosion and Sedimentation Control (SESC) permit from the County will be required, and a Notice of Coverage (NOC) application will be filed with EGLE. The following describes the surface water quality regulation evaluation process.

No surface water treatment, septic systems, discharges, or withdrawals from the Site to the waters of the State are planned. Therefore, a NPDES discharge permit is not required.

Stormwater will be retained on-Site via the stormwater retention pond or on-Site ground infiltration. Construction will disturb more than five acres. For sites disturbing five or more acres, the applicant/permittee must obtain a Part 91 Permit and submit an application for NOC to EGLE Water Resource Division (WRD). Along with the NOC application, the applicant/permittee must submit a copy of the SESC permit, approved SESC plan, Site location map, and the $400 permit fee. The Kent County Road Commission (KCRC) issues SESC permits in Kent County. An SESC permit will be obtained from KCRC and a WRD NOC will be filed with EGLE WRD.

The SESC permit will specify the erosion and sedimentation control requirements for the Contractor including acreage of unstabilized soil permitted to be exposed, temporary and permanent stabilization measures, and timing for permanent stabilization. In addition to the SESC permit requirements, the Contractor will be required to complete soil disturbance work in phases to minimize the amount of exposed soil at any given time and during Site clearing, the rootballs, topsoil, and organic litter (if present) will remain in place until the area is scheduled for Work. Following completion of Work, each disturbed area will be stabilized in accordance with the SESC permit and the Specifications.

The Plainfield Charter Township, *Chapter 28 Planning and Development, Article VI. Stormwater Management* applies to developments connecting to township stormwater drains. No paved surfaces or buildings are proposed, and stormwater will be retained on-Site.

4.1.3. Groundwater Quality

Groundwater quality regulations are not applicable. The following describes the groundwater quality regulation evaluation process.

No groundwater withdrawals for potable purposes or discharges will occur and, therefore, no applicable federal, state, county, or township regulations apply. Per Section 16.306(2) of the Plainfield Charter Township Ordinances, groundwater monitoring and remediation wells which are part of response activity or corrective action approved by EGLE or U.S. Environmental Protection Agency (EPA) are exempt from §16.303 Groundwater Use ordinances. Post-construction groundwater monitoring in the vicinity of the HSP is described in **Appendix D**.

4.1.4. Waste Regulations

During construction activity, general household rubbish will be generated. Any incidental leaks or spills, if encountered, will be cleaned using absorbent material. Contaminated media, including PPE, will be containerized, and managed according to federal and state regulations. General household rubbish will be containerized and disposed of off-Site at an appropriate facility.

Contractors will be responsible for removing all aerosol cans and universal waste, and managing it according to federal and state regulations.

No liquid waste will be generated and, therefore, Michigan Part 121 Rules do not apply.

No applicable township waste ordinances were identified.

Michigan Part 115 Solid Waste Management rules do not apply as the HSP is a remediation site and not an active landfill. Wastes were placed no later than 1978 and, therefore, it is not a new disposal site. As provided by Section §324.11506(1)(v) of the act, "other wastes regulated by statute" are exempt from Part 115 regulation. However, as determined in the CD, the cap will comply with applicable substantive requirements of Part 115. **Appendix C** contains the EGLE Checklist for Administrative Completeness Solid Waste Landfill Construction Permit Packet, as modified and approved by EGLE to represent the applicable substantive requirements of Part 115. **Section 1.0** contains cross-reference of applicable Checklist information found within this Report.

4.1.5. Kent County Road Commission

Some of the work will involve periodic, temporary lane closures on House Street adjacent to the Site. A KCRC Permit will be obtained for work in or near the House Street right-of-way.

4.2. COMPLIANCE WITH APPLICABLE LOCATION STANDARDS

Table 1 summarizes the final remedy's compliance with applicable location standards.

TABLE 1. APPLICABLE LOCATION STANDARDS

Part 115 Requirement	Supporting Information
Rule 411 Groundwater Isolation	The depth to natural groundwater is greater than 10 feet below ground surface (ft bgs). There will be no liner system. There is no clay surface; therefore, gravity dewatering is not applicable. There will be no soil dike keyed into lower confining layer.
Rule 412 Horizontal Isolation	This rule is not applicable because the final remedy is not for a "new" disposal area. Potential nuisance conditions during construction (e.g., noise, dust, and odor) will be mitigated and managed in accordance with the specifications provided in the FS. Because the final remedy is a remedial activity, the location restrictions specified in 299.4412(4) do not apply.
Rule 413 Sensitive Areas	This rule is not applicable because the Final Remedy is not for a "new" disposal area. The location is not located within a Rule 413 sensitive area.
Rule 414 Airport Safety	The HSP is located approximately 2.75-miles southeast of the Sparta Miller Airport. Sparta Miller Airport services propeller engine planes. The nearest jet engine service is Gerald R. Ford Airport, approximately 15 miles south-southeast of the HSP (**Figure 3**).
Rule 415 Floodplains	According to Flood Insurance Rate Map (FIRM) Panel 260109 0010 B, the site is in a low flood risk area.
Rule 416 Wetlands	Not applicable, Part 303 Permit is not required as there are no mapped Part 303 wetlands on-Site according to the National Wetland Inventory Assessment performed by EGLE WRD EGLE Wetlands, Lakes, and Streams Unit (WLSU).
Rule 417 Fault Areas And Impact Zones	Not applicable, the HSP is not within 200 feet of a recorded / documented fault. Refer to Section 6.3.2 of the Engineering Report (provided as **Appendix D**).
Rule 418 Unstable Areas	Not applicable. Refer to Section 6.3.2 of the Engineering Report (provided as **Appendix D**).
Rule 419 Vertical Expansions	No vertical expansion is planned; therefore, this rule is not applicable.

4.3. COMPLIANCE WITH PERFORMANCE STANDARDS DURING CONSTRUCTION

The following sections summarize compliance with performance standards for the HSP final remedy. Additional details are provided in **Appendix D** (Engineering Report) and Attachment B of **Appendix D** (Construction Quality Assurance/Quality Control [QA/QC] Plan).

4.3.1. Surface Water

A Part 91 SESC Permit will be obtained from Kent County. An SESC Plan will be implemented to prevent runoff from leaving the Site. Long-term surface water management will include a stormwater retention pond and grading to retain all surface water on-Site. The area will be revegetated to prevent erosion in the long term. Erosion and sediment control implementation is further detailed in Section 6.5 of the Engineering Report (**Appendix D**).

4.3.2. Groundwater

Groundwater at the Site has been investigated extensively. Monitoring wells have been installed with the recorded highest water table measurements at a depth of 49.58 ft bgs. Groundwater generally flows from the northwest to the southeast with a gradient that is generally flat, less than or equal to 0.05 ft/ft. Groundwater is not expected to be encountered during construction activities.

Limited areas of perched water have been encountered during investigations at the HSP. However, if perched groundwater is encountered the water will be handled under an approved construction management plan which will require the water be pumped from the excavation into separate holding tanks, sampled and tested, and disposed of properly.

The post-construction groundwater monitoring program is summarized in **Section 6.0** and additional details are provided in **Appendix E**.

4.3.3. Air

As in any similar earthwork project, the Contractor will implement a typical Fugitive Dust Management Plan to control construction dust during Site activities, including mobilization, access road improvements, tree clearing (as appropriate), soil and waste excavation, and demobilization. Standard dust suppression measures (e.g., watering) will be used on roads, parking areas, and excavation areas as needed throughout construction. Dust management and health and safety considerations for excavations is further detailed in Section 4.1 of the Engineering Report (**Appendix D**).

A fence line air monitoring program will also be implemented during construction. The fence line air monitoring program will be performed at upwind and downwind locations around the Site's fence line before and during remedial activities in which soil and waste are excavated. The fence line air monitors will collect organic vapor and particulate matter (PM10) samples at fixed points along the fence line as well as at selected rotating points between the fence and the excavation areas as appropriate.

The fence line air monitoring system is designed to:

- Establish background levels of regulated compounds in ambient air prior to initiation of remedial activities;
- Monitor and document fence line ambient air levels of regulated compounds during remedial activities;
- Provide an early warning system to prevent elevated off-site exposures by responding aggressively to exceedances of short-term action levels, to ensure that longer-term exposures at the fence line are below acceptable risk levels; and,
- Evaluate ongoing effectiveness of, and need for, additional vapor and/or dust suppression controls and/or alteration of work activities, to reduce airborne compounds to below the National Ambient Air Quality Standards (NAAQS) for PM10 (24 hour average of 150 $\mu g/m^3$).

The proposed fugitive dust management measures and the fence line monitoring program are similar to those on other projects of this type, including the approach and equipment used during the prior U.S. Environmental Protection Agency removal actions undertaken at the Former Tannery and HSP (2019).

Both email and telephone points of contact for R&W/GZA and Wolverine will be provided in the Air Monitoring Plan. The Air Monitoring Plan will be completed prior to construction mobilization and made available to residents via the project Blog (www.wearewolverine.com) and the resident email distribution list prior to the start of Work.

4.4. SITE DESCRIPTION

A detailed description of the HSP is included in the FS. The Site will be accessed via House Street NE and Herrington Avenue NE which lead to 10 Mile Road NE. Proposed construction routes will be addressed with contractors during bid solicitation. Refer to the Design Drawings in Attachment C of **Appendix D**.

The aggregate area of the HSP caps is expected to approach approximately 27 acres of disturbed area. The volume of waste materials is estimated to be 49,000 cubic yards (CY), and soil with waste materials is estimated to be approximately 34,000 CY for a total estimated volume of 83,000 CY. The native soil in which the waste materials were disposed included sand, gravel, and clay, and the estimated volume of native or fill material over the top of the waste material is approximately 235,000 CY. Additionally, on-Site vegetation removed during construction will be placed under the caps as described in the FS. The HSP will not receive off-Site waste materials.

4.5. EXISTING ENVIRONMENT

The existing environment has been detailed in the *Conceptual Site Model Update and Status Report* (CSM) and the FS and is summarized below.

4.5.1. Topography, Land Use, and Residences

The Site is located immediately west of US-131 with ground surface elevations ranging from 740 to 800 ft. The terrain is generally hilly in the region. Ground surface elevations for the area east of the Site range from 800 to more than 900 ft; ground surface elevations for the west to southwest of the Site ranges from 800 to 820 ft with lower terrains to the northwest and southeast. The Site is flanked by higher ground to the northeast and southwest, but ground surface generally dips to the northwest toward Clear Bottom Lake and Freska Lake, and to the southeast toward the Rogue River.

The Site is currently undeveloped and, according to available information, no buildings were previously present. The HSP was a State of Michigan licensed and regulated disposal site from the mid-1960s through 1978. Until 1970, the HSP received leather tanning byproducts, including primarily sludges from the wastewater treatment system at the former Wolverine tannery. An electric utility right-of-way and associated high-voltage transmission lines cross the northern portion of the Site, and an access road from House Street runs south to north across the Site. The bordering properties to the HSP consist of residential and undeveloped properties.

Figures 2A and **2B** depict Site topography, land use, and locations of residences near the HSP.

4.5.2. Air Quality

Kent County is in attainment with NAAQS and has an Air Quality Index (AQI) of "good." A copy of the nearest wind rose is provided in Section 2.2 of the Engineering Report (**Appendix D**).

4.5.3. Hydrology

Based on the Michigan's Major Watersheds – Sub-basins Geographic Information Systems (GIS) data (Michigan Department of Environmental Quality, 2011), 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.

From 1989 to 2016, the average annual streamflow rate is approximately 260 cubic feet per second, and the average baseflow rate is approximately 210 cubic feet per second. 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.) Refer to Section 2.2 of the CSM for additional detailed hydrology information.

Table 2 summarizes hydrology information required under Part 115.

TABLE 2. HYDROLOGY INFORMATION REQUIRED UNDER PART 115

Part 115 Requirement	Supporting information
Magnitude of the 24-hour, 25-year storm	4.8 inches (NOAA Atlas 14 Point Precipitation Frequency Estimates)
Average annual rainfall	The average annual rainfall for Kent County is 39.4 inches and 77.6 inches of snowfall. (Climatological Report [Annual] Issued by National Weather Service (NWS) Grand Rapids, Michigan)
Maximum floodplain elevation of surface waters proximate to the HSP	According to FIRM Panel 260109 0010 B, the maximum elevation of the Grand River is approximately 622 ft.

4.5.4. Endangered and Threatened Species

According to the information available on the Michigan Department of Agriculture and Rural Development Endangered Species listings, there or no endangered or threatened species identified within Kent County, Michigan (MDARD, 2022).

4.5.5. Historic or Archaeological Sites

According to information available on file with the Michigan Department of Natural Resources data portal, there are no known historic or archaeological Sites associated with the HSP.

4.5.6. Known Sites of Environmental Contamination

The Site and surrounding area have a groundwater-use restriction. A search of EGLE's online Environmental Mapper identified the following sites of known environmental contamination within one mile of the HSP:

- 8417 Algoma Avenue NE, Rockford
- 8113 Belmont Avenue NE, Belmont
- 8057 Graphic Industrial Drive, Belmont
- 2908 10 Mile Road, Rockford

Figure 4 depicts the Part 201 and Brownfields Sites in the HSP vicinity.

4.5.7. Significant Public Resources

No significant public resources such as public water supplies, parks, or recreation areas were identified within or adjacent to the HSP. **Figure 5** depicts Type I and II public water supplies within ten miles of the Site.

4.5.8. Airports

There are no airports within 10,000 feet of the HSP. Sparta Miller Airport is the nearest airport and is approximately 2.75 miles northwest of the HSP. Sparta Miller Airport services propeller engine planes. The nearest jet engine service is Gerald R. Ford Airport, approximately 15 miles south-southeast. Refer to **Figure 3**.

4.6. ANTICIPATED ENVIRONMENTAL IMPACTS

Environmental impacts of the HSP are discussed in the FS, attached as **Appendix A**.

4.7. PROTECTIVE AND CORRECTIVE MEASURES DURING CONSTRUCTION

Protective and corrective measures during construction are detailed in the Engineering Report (**Appendix D**) and Construction QA/QC Plan (Attachment B of **Appendix D**).

5.0 HYDROGEOLOGICAL INFORMATION

HSP hydrogeological information is detailed in the CSM, R&W/GZA, 2019, and R&W/GZA, 2020. Additional information specific to the scope of this WP can be found in **Appendix D**.

6.0 OPERATIONS, MAINTENANCE, AND MONITORING PLAN

The following summarizes the anticipated components of the interim Operations, Maintenance, and Monitoring (OM&M) for the HSP Final Remedy for the first two years following construction completion.

6.1 INTERIM OPERATIONS, MAINTENANCE, AND MONITORING PLAN

The interim OM&M Plan is detailed in **Appendix** E. Maintenance activities will include:

- Mowing the waste mound caps.
- Observing the retention pond during or following storm events for evidence of erosion on the side slopes and coordinating repairs as necessary.
- Observing the waste mound caps for erosion or surficial damage and coordinating repairs as necessary.

Monitoring activities will include:

- Monitoring for methane gas in the gas vents and perimeter gas probes (refer to **Appendix D**, Attachment C) will be completed quarterly for two years following construction completion;
- Piezometer installation in historical perched water areas;
- Piezometer water level measurements to be completed quarterly for two years following construction completion;
- Baseline groundwater sampling from nine existing monitoring well clusters (installed as part of other investigations related to the HSP) to be completed within six months of construction completion;
- One follow-up groundwater sampling event from the nine existing monitoring well clusters sampled during the baseline event to be completed one year following the baseline event; and,

- Data evaluation and consultation with the EGLE to develop a long-term monitoring plan for landfill gas, historical perched water areas, and groundwater.

These components are detailed **Appendix E**.

6.2 LONG-TERM OPERATIONS, MAINTENANCE, AND MONITORING PLAN

Wolverine will submit a long-term OM&M Plan to EGLE following completion of the 2-year post-construction monitoring period. The post-closure plan will include the following:

- A description of the monitoring and maintenance activities for the HSP and the frequency at which these activities will be performed. Potential activities include:
  - Mowing the waste mound caps.
  - Monitoring landfill gas vents and gas probes.
  - Retention pond monitoring.
  - Perched water measurements.
  - Monitoring the waste mound caps for erosion or surficial damage and coordinating repairs as necessary.
- Name, address, and telephone number of the person or office to contact about the HSP during the post-construction period.
- Confirmation that post-construction use of the House Street Property has not disturbed the integrity of the final cover, or other components of the containment system or the function of the monitoring systems unless necessary to comply with EGLE requirements.

7.0 ENGINEERING DESIGN DRAWINGS

Engineering design drawings for the HSP final remedy are provided in Attachment C of **Appendix D.**

8.0 ENGINEERING PLAN

The Engineering Report is provided as **Appendix D** and contains the following information required under Part 115:

- Settlement Analysis (Section 6.4).
- Slope Stability Study (Section 6.3.1).
- Typical sections showing natural soils underlying waste material as per Rule 904(4); see Design Drawings, provided in Attachment C of **Appendix D.**
- Copies of logs for new borings installed during 2022 (Attachment E of **Appendix D**). Boring logs for prior investigations were provided to EGLE as part of the investigation summary reports (e.g., R&W/GZA 2019, R&W/GZA 2020).
- Stormwater control including run-on and run-off (**Section 6.6**). Note that the retention basin constructed within the south-central portion of the Site will utilize an existing on-site depression that current collects stormwater, which infiltrates into the ground. The constructed retention basin within this general area will, in its post construction condition, be consistent with the depth of the current depression, no closer to House

Street than the current depression, and be constructed with slopes that are generally 4 horizontal to 1 vertical, which are flatter than those existing on the current depression. Additional details regarding stormwater control are included in Section 6.6 of Appendix D.

- Fugitive Dust Control Plan will be implemented during construction (**Section 4.0**). There will be no exposed waste material following construction, and exposed soils (i.e., over the cap or in adjoining areas) will be vegetated or completed as a stabilized structure (e.g., roadway, retention basin).
- Air quality and landfill gas monitoring will be completed during construction (**Section 4.1**).

The Construction QA/QC Plan is provided as Attachment B to **Appendix D** and contains the following information required under Part 115:

- Cap material storage, handling, and installation requirements, including the requirement that LLDPE subgrade and/or material placed as top-of-subgrade will be tested for permeability and the surface will be tracked or rolled, not compacted with vibration (**Section 6.0**).
- Cap material specifications (**Section 6.0**).
- Ability of cap material to maintain its physical properties under varying conditions throughout the post-closure life of the HSP (**Section 6.0**).

Landfill gas monitoring is required under Part 115. Construction monitoring is described in **Section 4.3** and **Appendix D.** Post-construction monitoring for organic vapor and hydrogen sulfide will be completed during on-Site piezometer monitoring activities described in **Section 6.0**. Additional post-construction monitoring requirements will be evaluated, developed, and completed under the long-term monitoring plan (**Section 6.0**).

The following requirements under Part 115 are not applicable as construction activities are proposed to be above the water table:

- Performance analysis under varying groundwater conditions.
- Calculations that show bottom heave or blowout potential.

9.0 OPERATION PLAN

Table 3 summarizes the applicable operational components of Part 115. Other applicable substantive requirements of Part 115 are included in **Appendix C**.

TABLE 3. APPLICABLE OPERATIONAL COMPONENTS OF PART 115

Part 115 Requirement	Proposed Implementation Measure
A fill progression plan over the active life of the landfill including final slopes and elevations and including the location and description of the permanent survey benchmark to be used for elevation control.	Not applicable as fill will not be used in progression. Final elevations are provided in Attachment C of **Appendix D.**
A landscape plan that identifies and locates existing vegetation to be retained and proposed vegetation to be used for cover, screening, and other purposes.	Refer to Attachment C of **Appendix D**. The landscaping plan includes vegetation in the cap areas to protect the caps and stabilize the slopes, and, re-seeding of other disturbed areas to stabilize soil and minimize erosion The cap areas will be seeded with grass and will be mowed in accordance with the maintenance plan. Areas adjoining the caps that were disturbed during construction will be seeded with native conservation seed mix and be maintained as meadow. The retention basin area will be planted with wet meadow mix. In addition to work provided in the landscape plan required for the integrity of the cap under the Consent Decree, landscaping work at the HSP will include selective maintenance or installation of vegetation along portions of the HSP boundary.
All equipment will be used at the landfill for construction and operation.	Typical equipment required for implementation of the final remedy includes excavators, dump trucks, off-road haul trucks (for on-Site use), bulldozers, and compactors. The Contractor's equipment list will be required to be submitted during the bid process. The HSP will not be operated as a disposal facility following remedy implementation. Maintenance equipment such as mowers and trimmers, and road maintenance equipment will be mobilized to the HSP as needed for routine maintenance.
The landfill's personnel requirements, including the duties, training, and authority of the responsible individual who will direct landfill operations.	Planned activities include routine mowing and visual inspection of the Site and pond quarterly, with at least two of the quarterly events completed following a rain event of 2 inches or greater.
Signs.	A sign will be placed on the access gate restricting access to authorized personnel only. Existing signage along the existing fence line will be maintained during construction and replaced as needed following construction.
Natural and artificial barriers.	During and after construction, site security will be maintained by replacing or installing new temporary and permanent fencing, gates, and barriers as appropriate. Refer to Attachment C of **Appendix D**.
Traffic control.	Refer to Attachment C of **Appendix D** for a construction-phase trucking plan.
The methods will be used to control dust and blowing papers from the active fill area.	Not Applicable, no waste will be received. A Dust Control Plan will be implemented during construction as described in **Section 8.0**.

Part 115 Requirement	Proposed Implementation Measure
The on-Site road design and method of controlling fugitive dust.	Refer to Refer to Attachment C of **Appendix D** for access road information. Dust control during construction is described in **Section 8.0**.

10.0 CONSTRUCTION QUALITY ASSURANCE PLAN

Table 4 summarizes the applicable QA components of Part 115. The QA/QC Plan is provided as Attachment B of **Appendix D**.

TABLE 4. APPLICABLE QA COMPONENTS OF PART 115.

Applicable Part 115 Requirement	QA/QC Plan
Flexible membrane liners.	Section 6.0
Final cover systems.	Section 5.0
Structural stability and integrity of the features listed in “H.1.”.	Section 5.0
Proper construction of all components of the liners, primary and secondary collection and removal system(s), and final cover system.	Section 6.0
Conformity of all materials used with design and other material specifications.	Section 6.0

11.0 ESTIMATED PRE-CONSTRUCTION SCHEDULE

The following summarizes the anticipated schedule of pre-construction activities.

- Permit submittals – within 60 days of Work Plan approval
- Bid documents provided to potential bidders – within 90 days of Work Plan approval
- Bid submittals – within 60 days of soliciting bids
- Contract award – within 90 days of bid submittal
- Construction-phase work is anticipated to begin within 90 days of award. Construction schedule to be provided with Bids and revised construction schedule to be provided with Contractor Work Plans.
- Vegetation clearing is anticipated to begin within 30 days of receipt of permits.

The current estimate for construction is approximately 30 months from the start of construction-phase work. The actual construction timeline will be determined upon contractor bid award. Within 60 days following completion of construction of the Final Remedy land and resource use restrictions will be placed on the HSP in accordance with the CD.

12.0 REFERENCES

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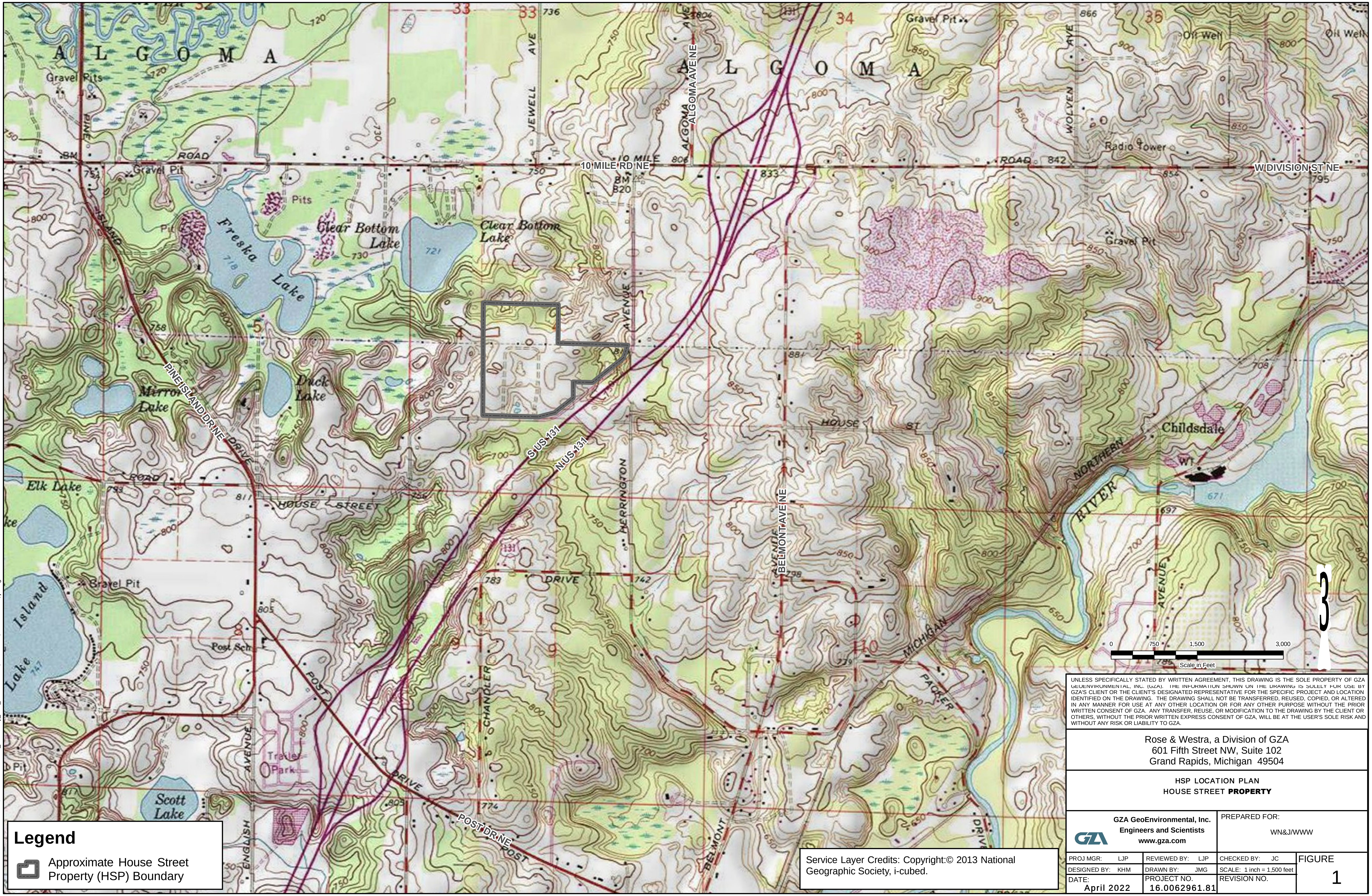
FIGURES



Legend

Approximate House Street Property (HSP) Boundary

Service Layer Credits: Copyright:© 2013 National Geographic Society, i-cubed.

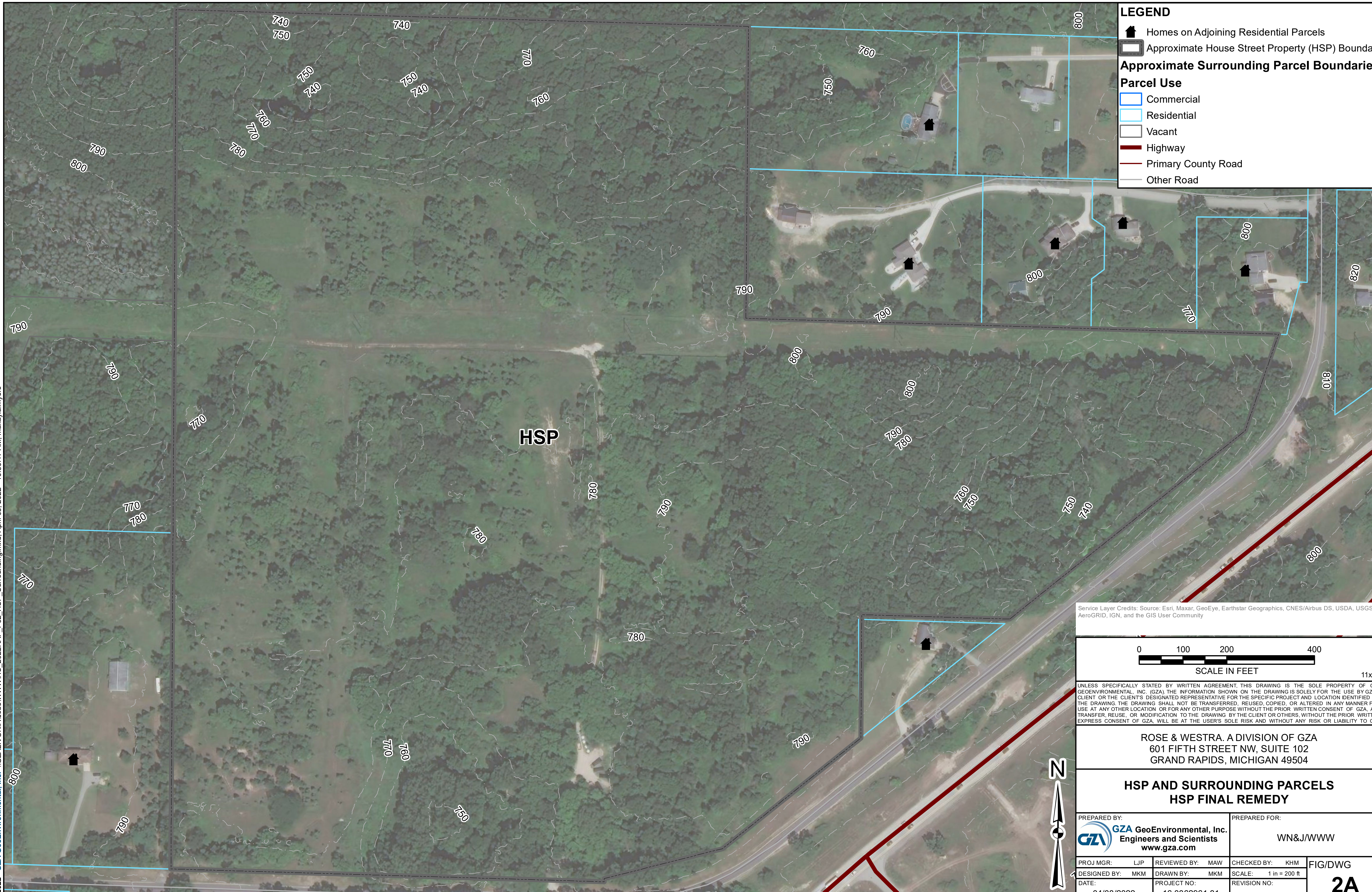
Rose & Westra, a Division of GZA
601 Fifth Street NW, Suite 102
Grand Rapids, Michigan 49504

HSP LOCATION PLAN
HOUSE STREET **PROPERTY**

GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: JMG	SCALE: 1 inch = 1,500 feet	1
DATE: April 2022	PROJECT NO. 16.0062961.81	REVISION NO.	



Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

11x17

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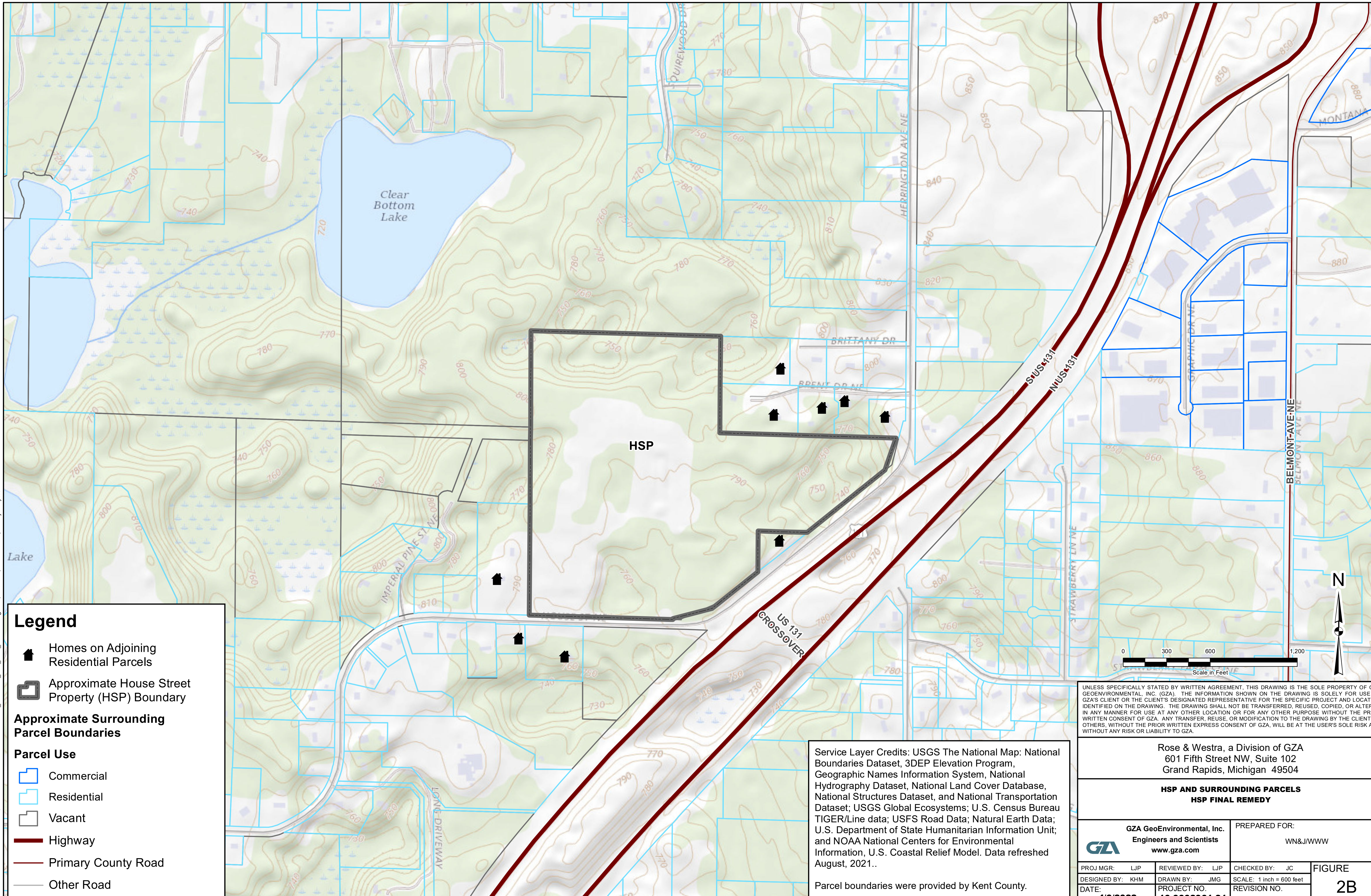
ROSE & WESTRA. A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

HSP AND SURROUNDING PARCELS
HSP FINAL REMEDY

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com		PREPARED FOR: WN&J/WWW	
PROJ MGR: LJP	REVIEWED BY: MAW	CHECKED BY: KHM	FIG/DWG
DESIGNED BY: MKM	DRAWN BY: MKM	SCALE: 1 in = 200 ft	2A
DATE: 04/08/2022	PROJECT NO: 16.0062961.81	REVISION NO:	



Legend

- Homes on Adjoining Residential Parcels
- Approximate House Street Property (HSP) Boundary

Approximate Surrounding Parcel Boundaries

Parcel Use

- Commercial
- Residential
- Vacant
- Highway
- Primary County Road
- Other Road

Service Layer Credits: USGS The National Map: National Boundaries Dataset, 3DEP Elevation Program, Geographic Names Information System, National Hydrography Dataset, National Land Cover Database, National Structures Dataset, and National Transportation Dataset; USGS Global Ecosystems; U.S. Census Bureau TIGER/Line data; USFS Road Data; Natural Earth Data; U.S. Department of State Humanitarian Information Unit; and NOAA National Centers for Environmental Information, U.S. Coastal Relief Model. Data refreshed August, 2021..

Parcel boundaries were provided by Kent County.

Rose & Westra, a Division of GZA
601 Fifth Street NW, Suite 102
Grand Rapids, Michigan 49504

HSP AND SURROUNDING PARCELS
HSP FINAL REMEDY

GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR: WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: JMG	SCALE: 1 inch = 600 feet	2B
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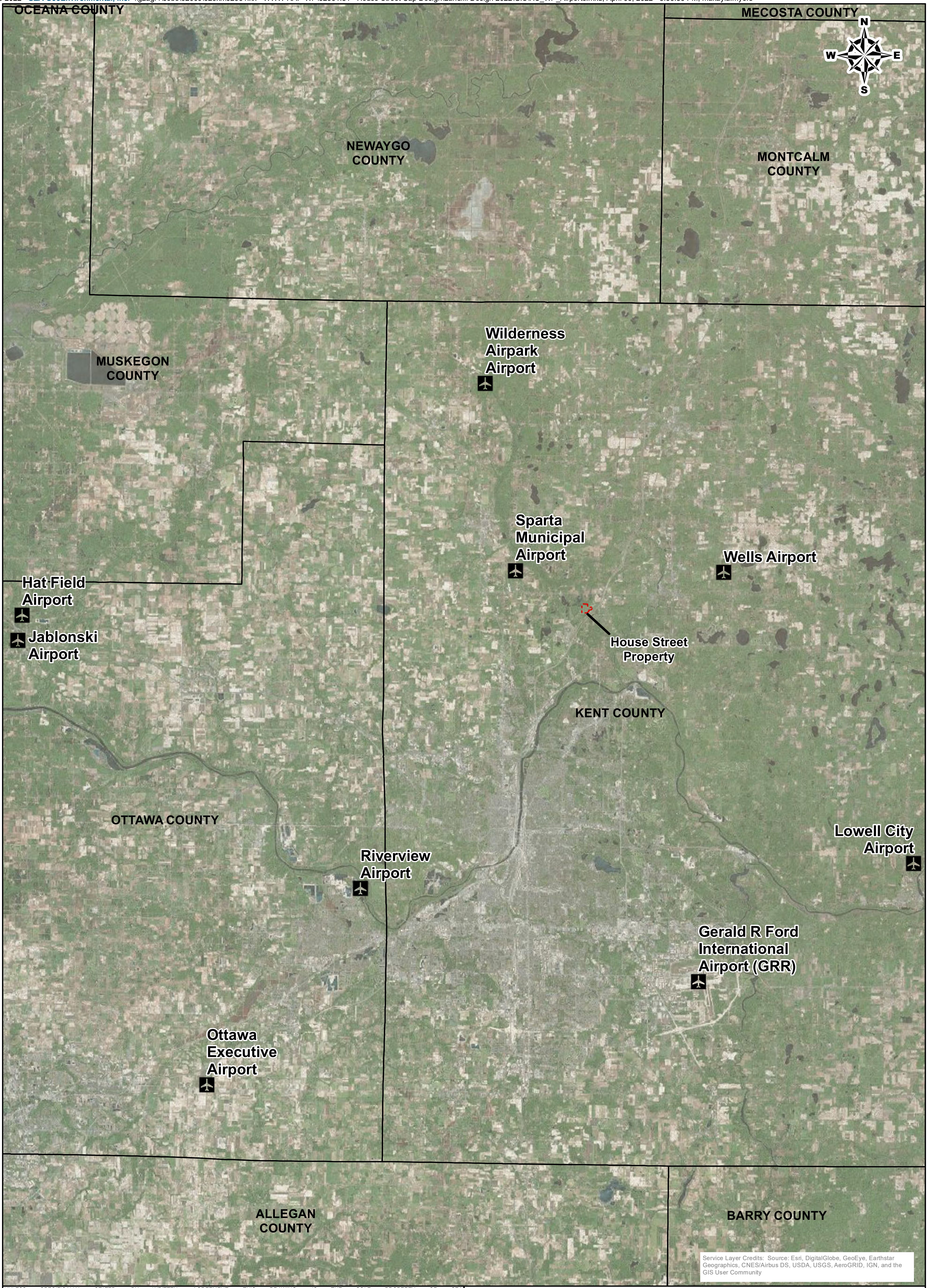


0 10,000 20,000 40,000

SCALE IN FEET

11 X 17

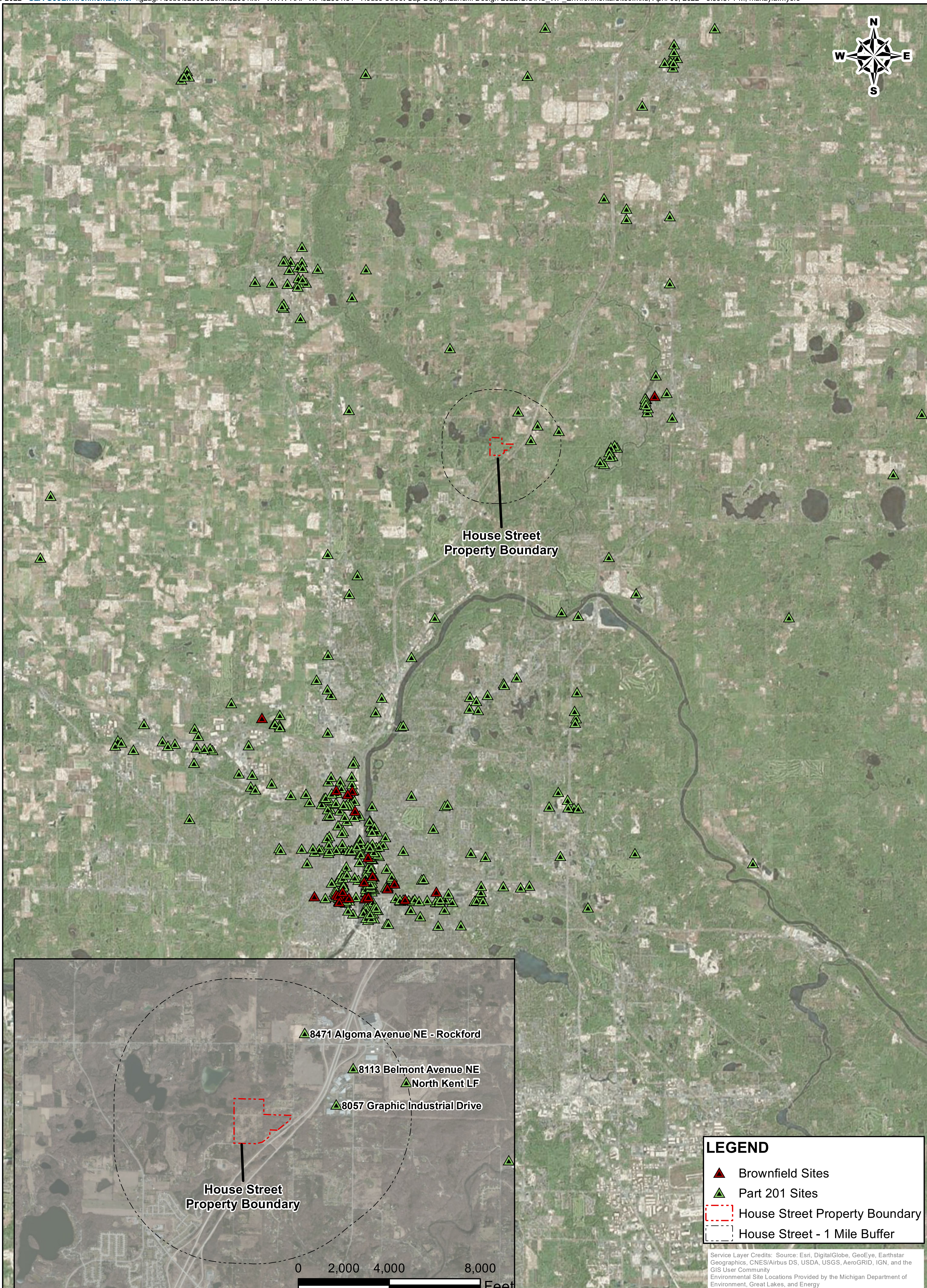
HOUSE STREET FINAL REMEDY
1855 HOUSE ST
BELMONT, MI

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
WN&J/WWW

AIRPORTS
WITHIN 30 MILES OF SITE

PROJ MGR:	LJP	REVIEWED BY:	LJP	CHECKED BY:	TAL	FIG/DWG
DESIGNED BY:	MKM	DRAWN BY:	MKM	SCALE:	1 in = 20,000 ft	3
DATE: 04/06/2022		PROJECT NO: 16.0062961.81		REVISION NO:		SHEET NO:



0 5,000 10,000 20,000

SCALE IN FEET

11 X 17

HOUSE STREET FINAL REMEDY
1855 HOUSE ST
BELMONT, MI

PREPARED BY:

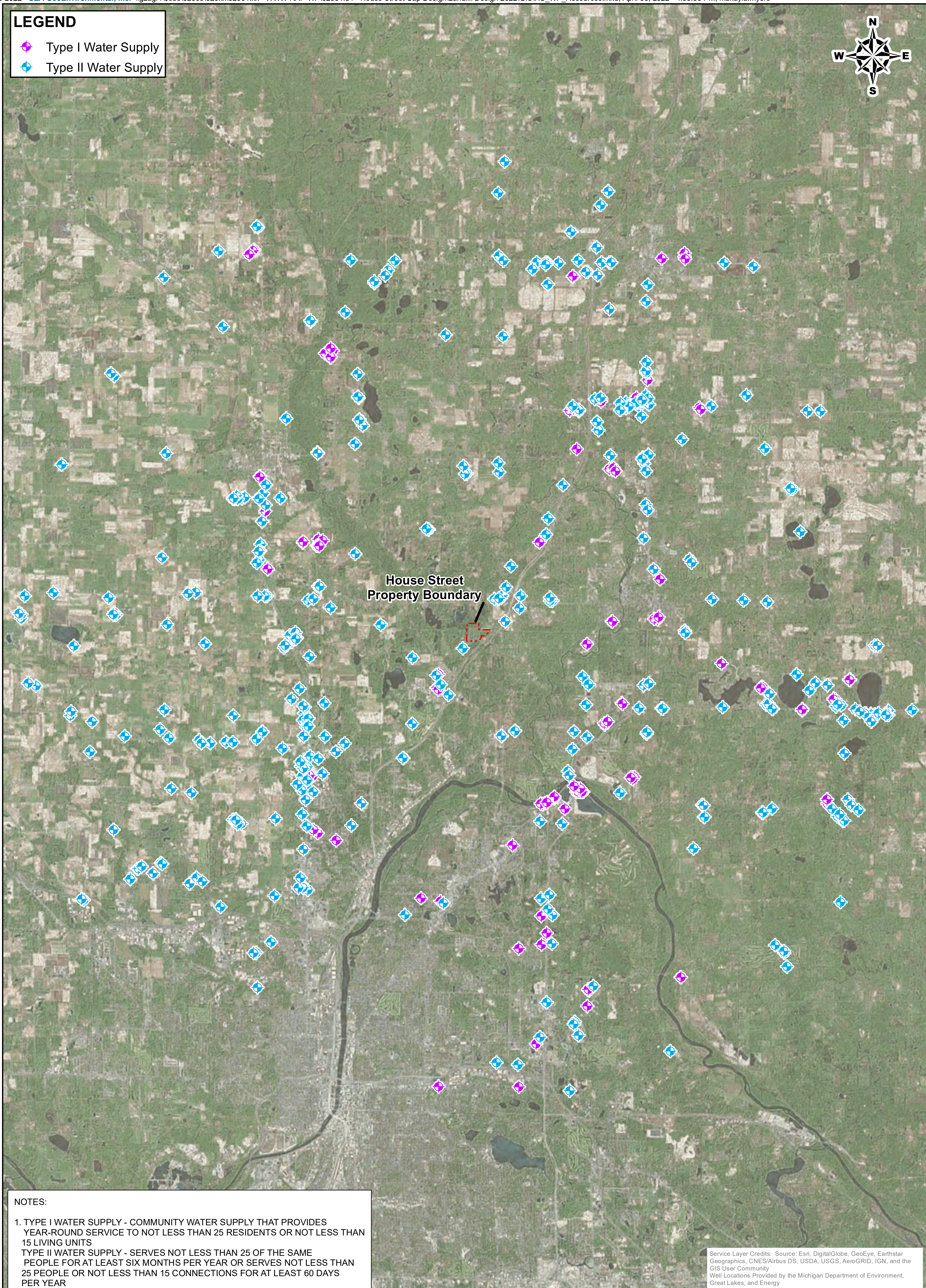
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:

WN&J/WWW

KNOWN SITES OF ENVIRONMENTAL CONTAMINATION WITHIN 10 MILES OF SITE

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: TAL	FIG/DWG
DESIGNED BY: MKM	DRAWN BY: MKM	SCALE: 1 in = 10,000 ft	4
DATE: 04/06/2022	PROJECT NO: 16.0062961.81	REVISION NO:	SHEET NO:



NOTES:

1. TYPE I WATER SUPPLY - COMMUNITY WATER SUPPLY THAT PROVIDES YEAR-ROUND SERVICE TO NOT LESS THAN 25 RESIDENTS OR NOT LESS THAN 15 LIVING UNITS
   TYPE II WATER SUPPLY - SERVES NOT LESS THAN 25 OF THE SAME PEOPLE FOR AT LEAST SIX MONTHS PER YEAR OR SERVES NOT LESS THAN 25 PEOPLE OR NOT LESS THAN 15 CONNECTIONS FOR AT LEAST 60 DAYS PER YEAR

0 5,000 10,000 20,000
SCALE IN FEET

11 X 17

HOUSE STREET FINAL REMEDY
1855 HOUSE ST
BELMONT, MI

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

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WN&J/WWW

SIGNIFICANT PUBLIC RESOURCES WITHIN 10 MILES OF SITE

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: TAL	FIG/DWG
DESIGNED BY: MKM	DRAWN BY: MKM	SCALE: 1 in = 10,000 ft	5
DATE: 04/06/2022	PROJECT NO: 16.0062961.81	REVISION NO:	SHEET NO:

APPENDIX A

HOUSE STREET FEASIBILITY STUDY

Rose & Westra
A Division of GZA

Geotechnical
Environmental
Ecological
Water
Construction Management

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Sent Via Email Only

September 13, 2021; Approved Final October 28, 2021
File No. 16.0062961.80

Ms. Karen Vorce, Project Manager
Grand Rapids District Office
Remediation and Redevelopment Division
Michigan Department of Environment, Great Lakes, and Energy
350 Ottawa Avenue NW, Unit 10
Grand Rapids, Michigan 49503
vorcek@michigan.gov

Re: Revised Feasibility Study – Remedial Options
Wolverine World Wide, Inc. – House Street Property
Plainfield Township, Kent County, Michigan

Dear Ms. Vorce:

On behalf of Wolverine World Wide, Inc. (Wolverine), Rose & Westra, a Division of GZA GeoEnvironmental, Inc. (R&W/GZA), is submitting this cover letter and enclosure in response to the referenced Consent Decree, effective February 19, 2020.

This submittal includes the revised Feasibility Study for remedial options identified in Paragraph 7.8 of the Consent Decree. If you have any questions, please contact us.

Very truly yours,

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

Loretta J. Powers
Senior Project Manager

Ernest Hanna
Senior Principal

Mark A. Westra
Principal

Joseph C. Foglio, CHMM
Senior Principal

ljp/maw/eh/jcf

\\Gzagr1\Jobs\62000\629xx\62961.xx - WWW RAP-WP\62961.80 - HS Feasibility Study\FS Text\Resubmittal\Approved Final Document\62961.80_FS_Rpt_Approved-F.docx

Attachment: House Street Property Feasibility Study

Rose & Westra
A Division of GZA

GEOTECHNICAL
ENVIRONMENTAL
ECOLOGICAL
WATER
CONSTRUCTION MANAGEMENT

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GEOTECHNICAL | ENVIRONMENTAL | ECOLOGICAL | WATER | CONSTRUCTION MANAGEMENT

REVISED FEASIBILITY STUDY – REMEDIAL OPTIONS
HOUSE STREET PROPERTY

1855 HOUSE STREET NE
Plainfield Township, Kent County, Michigan

September 13, 2021; Approved Final October 28, 2021
File No. 16.0062961.80

PREPARED FOR:
Wolverine World Wide, Inc.
Rockford, Michigan

Rose & Westra, a Division of GZA GeoEnvironmental, Inc.
601 Fifth Street NW | Suite 102 | Grand Rapids, MI 49504
616-956-6123

30 Offices Nationwide
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TABLES

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APPENDICIES

ACRONYMS

bgs	Below Ground Surface
CCI	City Cost Index
CD	Consent Decree, effective February 19, 2020 (No. 1:18-cv-0039-JTN-ESC)
CFR	Code of Federal Regulations
CY	Cubic Yards
EGLE	Michigan Department of Environment, Great Lakes and Energy
FML	Flexible Membrane Liner
FS	Feasibility Study
ft	Feet
GCL	Geocomposite Clay Liner
HSP	House Street Property, also referred to as Site
NE	Northeast
OM&M	Operation, Maintenance, and Monitoring
PFAS	Per- and Polyfluoroalkyl Substances
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctane Sulfonate
PPE	Personal Protective Equipment
R&W/GZA	Rose & Westra, a Division of GZA GeoEnvironmental, Inc.
T&D	Treatment and Disposal
USEPA	United States Environmental Protection Agency
Wolverine	Wolverine World Wide, Inc.

1.0 INTRODUCTION

R&W/GZA submits this revised FS on behalf of Wolverine to select the final remedy for the HSP. This revised FS evaluates the two required options under Paragraph 7.8(a)(ii) of the CD: an approximately 30-acre cap (Cap Option) and an approximately 20-acre landfill cell (Landfill Cell Option). For reference, other remedial options that were evaluated in Wolverine's February 19, 2021, Feasibility Study are summarized in **Table 1**.

Under Paragraph 7.8(b) of the CD, "if [EGLE] does not approve of the proposed remedy in the Feasibility Study for the House Street Disposal Site, the final remedy shall be an approximately 30-acre surface cap without a bottom liner." On February 19, 2021, Wolverine submitted a Feasibility Study for the HSP. Wolverine proposed a mixed combination of remediation methods that would have (i) constructed caps to prevent infiltration in the areas of the HSP where waste is the thickest as well as areas where phytoremediation was not preferred or feasible, and (ii) preserved existing vegetation and trees to the extent possible and planted as many as 4,000 new trees to enhance greenspace and create a natural preserve setting at the HSP. EGLE did not approve Wolverine's proposed remedy. Rather than attempting to pursue this remediation proposal over EGLE's non-approval, Wolverine submits this revised FS in accordance with Paragraph 7.8(b) of the CD to implement the Cap Option as the final remedy.

EGLE provided their letter entitled *Disapproval of the House Street Property Feasibility Study Report as Required by the Wolverine World Wide, Inc. Consent Decree Court Case No. 1:18-cv-00039* on June 15, 2021. Since receipt of the disapproval, Wolverine's consultant, R&W/GZA has meet several times with EGLE staff members, including Part 115 staff, to discuss the comments in the letter as well as a path forward. Information agreed upon during those discussions is included throughout this revised FS.

2.0 BACKGROUND

The HSP, located at 1855 House Street NE, Plainfield Township, Kent County, Michigan, encompasses approximately 76 acres (**Figure 1**). The HSP is currently undeveloped and, according to available information, no buildings were previously present. An electric utility right-of-way and associated high-voltage transmission lines cross the northern portion of the HSP, and a maintenance access road from House Street runs south to north across the HSP.

Approximately the northern 12 acres and eastern 16 acres are covered in mature forest. The central portion of the HSP is a mix of grasslands, low lying vegetation, and mature woodland. Driving and walking trails are present throughout the HSP and have been for a number of years. The HSP and surrounding features are shown on **Figure 2.**

The HSP was a State of Michigan licensed and regulated disposal facility from the mid-1960s through 1978. Until 1970, the HSP received leather tanning byproducts, including primarily sludges from the wastewater treatment system at the former tannery. Waste materials were identified and characterized during investigations in 2018 and 2019 and generally consisted of a gray color with black, white, red, and brown waste materials mixed with soil.

The borehole lithology indicated that the soils in the top 20 ft are generally not stratified. Alternating layers of fine-grained and coarse-grained soil are present in individual boreholes without consistent stratification across the Site. Waste materials are also present at varying depths, including intermixed with the soils. This observation is consistent with the site history of waste material placement and filling. Native soil observed at the Site is consistent with the regional overburden geology for areas where no previous Site work had been performed.

The maximum identified depth to the bottom of known waste materials from existing grade is approximately 20 ft bgs. On-site soil borings identify up to 80 ft of primarily well-sorted sand between the bottom of the waste materials and the groundwater table. Because PFAS compounds have been detected in the groundwater, the soil column between the waste materials and groundwater would be considered a secondary source of PFOA+PFOS to groundwater.

The volume of waste materials is estimated to be 49,000 CY, and soil with waste materials is estimated to be approximately 34,000 CY for a total estimated volume of 83,000 CY. The native soil in which the waste materials were disposed included sand, gravel, and clay, and the estimated volume of native or fill material over the top of the waste material is approximately 235,000 CY. The waste materials and waste materials mixed with soil is the primary contaminant source at the HSP.

Some of the waste placed at the HSP contained PFOS and PFOA and their precursors, which are part of a larger group of PFAS. PFAS were in Scotchgard™, a waterproofing material manufactured by 3M Company, that was applied to some leather goods manufactured at the former Wolverine Tannery site in Rockford, Michigan. Some PFAS from the byproducts at the HSP entered the groundwater beneath and are migrating from the HSP.

Additional information regarding the HSP, its historical use, the physical setting (i.e., hydrology, geology, and hydrogeology), and contaminant distribution and concentrations is detailed in R&W/GZA's February 9, 2018, *Conceptual Site Model Update and Status Report* (R&W/GZA, 2018), 2018 Summary Report (R&W/GZA, 2019), 2019 Summary Report (R&W/GZA, 2020), and SOWs included in the CD.

The approximate extent of known waste material and soil with waste material on the HSP is shown on **Figure 3**.

The approximate extent of known groundwater contamination on the HSP is shown on **Figure 4**. The extent of off-site groundwater contamination, including the groundwater-surface water interface, is being further investigated and monitored per separate requirements in the CD. The estimated extent of an off-site groundwater plume is shown on **Figure 4A**.

The depth to top and thickness of the waste materials and soil with waste materials varies across the areas of waste materials on the Site. For example, the waste thickness in the south-central portion of the Site is up to 20 ft while certain areas in the central portion are less than 3 ft of thickness. Cross sections of the estimated extent of the waste materials and waste with soil relative to the water table are included as **Figures 5 and 5A-5D**, respectively. Geological cross sections were provided on Figures 4-1 through 4-3 of the *Implementation of the 2019 Work Plan – Summary Report* dated July 22, 2021 (R&W/GZA, 2021) and submitted to USEPA.

3.0 SCOPE OF ANALYSIS

Paragraph 7.8 of the CD governs the scope and content of this FS:

The Feasibility Study shall set forth and evaluate the remedy options under Part 201. At a minimum, the Feasibility Study shall include the following information:

(A) Definition of remedial objective;

(B) Analysis of each potential remedy options, including an analysis of:

(1) The performance, reliability, ease of implementation, and potential impacts of the potential remedy, including safety impacts, and control of exposure to any residual contamination;

(2) The time required to begin and complete implementation of the remedy;

(3) The cost of remedy implementation;

(4) The institutional requirements that may substantially affect implementation of the remedy; and

(5) The remedy's ability to reduce toxicity and the mobility of PFAS compounds.

(C) A proposed selected remedy based on the analysis.

4.0 ANALYSIS

4.1 DEFINITION OF REMEDIAL OBJECTIVE

Paragraph 7.8 of the CD provides in relevant part as follows:

> *(ii) The Feasibility Study shall evaluate the following remedy options to (1) manage solid wastes at the House Street Disposal Site and (2) reduce and control potential migration of PFAS Compounds from soils and sludges into the groundwater from the House Street disposal Site:*
>
> *(A) an approximately 30-acre surface cap without a bottom liner that complies with Part 201 and meets the applicable substantive requirements of Michigan's Part 115;*
>
> *(B) an approximately 20-acre surface cap over an area in which materials are consolidated and placed above a liner with leachate collection, as required, that comply with Part 201 and meet the applicable substantive requirements of Michigan's Part 115; and*
>
> *(C) other alternatives that may include some combination of a smaller cap and groundwater interceptor, collection, or treatment systems that comply with Part 201 and meet the applicable substantive requirements of Michigan's Part 115.*
>
> * * *
>
> *(b) Subject to Section XVIII (Dispute Resolution for MDEQ and Defendant), if MDEQ does not approve of the proposed remedy in the Feasibility Study for the House Street Disposal Site, the final remedy shall be an approximately 30-acre surface cap without a bottom liner.*

4.2 ANALYSIS OF REMEDY OPTIONS

Under Paragraph 7.8(b) of the CD, "if [EGLE] does not approve of the proposed remedy in the Feasibility Study for the House Street Disposal Site, the final remedy shall be an approximately 30-acre surface cap without a bottom liner." On February 19, 2021, Wolverine proposed a remedy (a combination of phytoremediation and targeted capping) in the draft Feasibility Study for the HSP. EGLE did not approve of that proposed remedy. Accordingly, the final remedy shall be the approximately 30-acre cap (Cap Option).

The two required options under Paragraph 7.8(a)(ii) of the CD, the Cap Option and an approximately 20-acre landfill cell (Landfill Cell Option), are analyzed below.

4.2.1 The Cap Option

Under the Cap Option, three low permeability caps consisting of a flexible membrane covered by 2 ft of soil and 6 inches of vegetated cover, or an approved alternative, will be installed over delineated waste material areas.

As depicted on **Figure 3**, the waste material and soil mixed with waste is generally defined by three areas. The northernmost area is separated from the two southern areas by power lines and an access road. The southern area is comprised of two major lobes separated by a relatively narrow area connecting the two larger areas.

The Cap Option involves constructing three individual caps as illustrated on **Figure 6**. The aggregate area of the three caps is expected to approach 27 acres. The narrow band of impacted material separating the two larger areas on the southern portion of the HSP, along with the two isolated areas and localized areas of near-surface waste materials on the boundary of the Site, will be excavated and relocated below the southern caps. Constructing three individual caps will significantly limit excavation and material handling that would be associated with construction of a single cap, thereby reducing the construction schedule and impact to adjacent property owners. Because the caps will overlap with the five areas previously capped during USEPA response actions, those five areas will be incorporated within the new capped areas.

The Cap Option will comply with Part 201, and the caps will meet all applicable substantive requirements of Part 115, including Rule 304. For example, the Cap Option will include, among other things: a system to address decomposition gasses from chipped trees, stumps, and vegetation; a final slope greater than 2% to prevent ponding and less than 25% to allow vegetative growth and limit erosional runoff; a cover comprised of a flexible geomembrane component covered by at least 2 ft of soil and 6 inches of organic soil that can support native plant growth. Sources for cover material atop the flexible geomembrane or the organic layer will be primarily obtained from areas on the HSP that have not been impacted by prior disposal operations. Should this source be insufficient, off-site cover material and organic soil will be imported.

Because stormwater conveyances are not currently present on the House Street right-of-way or on either direction of US-131 other than a drainage swale, run-off from the southern caps will be directed to a retention basin located and constructed on the southeast portion of the Site and then possibly pumped or directed to the eastern wooded portion of HSP and allowed to naturally infiltrate in an area not previously used for waste disposal. Runoff from the northern cap will naturally infiltrate with proper erosion control around the cap on the surrounding HSP. Stormwater control including the potential impact of infiltration may influence the direction of groundwater flow and will be modeled during the design. The final design will be sufficient to meet Part 115 requirements and applicable Plainfield Township requirements, if any. This runoff design may require a significant area of the HSP as well as engineering and approval of a high-water contingency.

Areas disturbed outside the capped footprints (access roads, laydown areas, areas of excavation for near surface waste materials) will be re-graded to facilitate drainage, covered with topsoil, and hydroseeded. A portion of the HSP will contain access roads to allow crews to mow and maintain the cap. Portions of the HSP will also remain fenced and secure to ensure the integrity of the caps is not compromised. This will include the capped and immediately surrounding areas.

The construction and design details of the Cap Option will be included in a work plan as specified under Paragraph 7.8(c) of the CD.

Figure 6 is a conceptual site plan for the Cap Option showing the approximate cap outlines (red outline) and limits of the work area (black outline). Areas within the black outline that are not capped would be regraded and filled after excavation and construction is complete. The stormwater retention area is shown in the southeastern portion of the HSP.

4.2.1.1 Performance

The Cap Option will limit infiltration through the waste and soil with waste material.

4.2.1.2 Reliability

The Cap Option is considered a reliable environmental remedy. Typically, geosynthetic components like those that will be used in the Cap Option have shown long-term resiliency past a 30-year post-closure period. Research at the Geosynthetic Institute infers geomembranes are capable of a lifespan of 100-years or greater (Geosynthetic Institute, GRI White Paper #6, 2011). Items that could shorten its lifespan include animal burrowing, heavy recreation, tree roots, and exposure to the weather.

Well-established means and methods for construction as well as quality control procedures will be employed to document integrity of the caps. Consolidation of the organic material through decomposition will result in settling over the long-term; however, the cap slope will be designed to accommodate some settlement. In addition, areas of the cap that reveal excess settling (i.e., collection of ponded water, topsoil discontinuity, or erosion) will be evaluated and repaired as required to maintain the integrity of the cap. More generally, maintenance activities will include establishing routine procedures to sustain vegetative growth of the organic cover layer, periodic mowing, watering in areas that have been repaired, addressing areas that may be prone to erosion during or after significant storm events, eliminating animal burrows, removing trees, and occasionally accessing and repairing or removing portions of the caps that may have been damaged.

4.2.1.3 Ease of Implementation

The Cap Option is more easily implemented than the Landfill Cell Option. Installation of the caps will require installing erosion controls prior to clearing and grubbing vegetation overlying the work areas, as well as, the temporary access roads, decontamination and laydown areas needed to construct the caps, and the additional areas need to re-contour the ground around the caps to direct runoff and drainage to control areas that will be identified in the final design. Access roads and areas under the caps will be stabilized during construction to allow heavy equipment and vehicles to operate safely. Stormwater runoff and sediment/erosion controls needed to handle water from exposed areas of impacted soil and/or waste will be installed, as well as localized areas to collect and temporarily store impacted runoff. Impacted soil on the perimeter of the capped areas will be excavated and relocated so it can ultimately be consolidated below the cap(s).

Typical earthwork equipment associated with site development and landfill construction in addition to the specialized heavy equipment necessary to backfill and compact the existing material to limit differential settlement and reduce strain on the cap will be employed throughout the construction effort.

Typical remedial construction techniques and controls will be implemented to limit exposure during handling (i.e., considerations of odor and worker exposure) by on-site workers including a construction health and safety plan, daily toolbox talks that identify the work to be completed and potential hazards. An on-site water truck will be available to minimize visible dust.

Additional information needed before final design and construction include evaluating the engineering properties of the waste and soils impacted by the waste, refining the limits of near-surface waste, refining the geotechnical characteristics of the near surface soil to determine its suitability for placement below the FML, identifying a source of on-site backfill and/or topsoil and confirming stormwater infiltration location(s) for the cap areas.

4.2.1.4 Potential Impacts

Potential impacts of the Cap Option are similar in kind to those of the Landfill Cell Option. The Cap Option will include clear cutting and grubbing at least 30 acres, likely up to 40 acres of vegetated and wooded land to accommodate approximately 27 acres of cap and re-contouring the surrounding land to facilitate drainage after construction. Construction and implementation impacts will involve typical construction safety and worker exposure, which will be mitigated by training and PPE. There will be a short-term increase in runoff and infiltration during construction when vegetation is removed. Temporary covers and water spray will be used to control dust during clearing, grubbing and waste material relocation during dry, windy weather conditions. If conditions persist, the presence of dust will be mitigated with other control measures, such as limiting a work area and/or work activity.

Measures to control noise, smell, dust, and traffic will be implemented during construction to limit impact on the surrounding property owners.

4.2.1.5 Control of Exposure to Residual Contamination

Waste (primary source) and the majority of the soil beneath the waste (secondary source) will be under a cap. Some deeper secondary source soil whose footprint may extend beyond the cap boundary will remain in areas not capped. At least portions of the HSP will remain fenced and access restricted.

4.2.1.6 Time to Implement

The Cap Option will be implemented more quickly than the Landfill Cell Option. Design and permitting work can begin immediately upon acceptance of the work plan, and the expected time to completion, inclusive of design and permitting, is approximately 30 months. This implementation time is longer than typical cap construction schedules due to significant clearing, grubbing, and grading that will be required to prepare the Site and waste areas for capping. Following acceptance of the work plan, this timeframe allows for the following: completion of final design work; regulatory review and approval of the final design; solicitation and procurement of qualified contractors; additional geotechnical testing to verify material suitability for re-use; establish soil and erosion controls, clearing, grubbing and chipping; consolidation of some soils and wastes; preparation of the subgrade, access roads and staging areas; installing the caps and landfill gas venting system as needed; and Site restoration. Long term Operation, Maintenance and Monitoring (OM&M) are not included in this estimate.

4.2.1.7 Institutional Requirements

Deed restrictions will be imposed to limit groundwater use and prevent cap damage. Additional exposure and access controls such as fencing will also be used. Cap inspection and maintenance will be required long-term.

4.2.1.8 Ability to Reduce Toxicity and Mobility of PFAS Compounds

The Cap Option will reduce mobility by reducing infiltration through on-site waste material and the soil beneath it.

4.2.1.9 Estimated Cost

Design					
Sitework & Geotech Investigation	$	65,000.00	-	$	121,000.00
Prepare Plans, Specifications & Permit Applications	$	135,000.00	-	$	250,000.00
Subtotal	**$**	**200,000.00**		**$**	**371,000.00**
Construction					
Contractor Prequalification & Procurement	$	35,000.00	-	$	40,000.00
Construction Management	$	1,200,000.00	-	$	1,440,000.00
Construction	$	13,750,000.00	-	$	16,500,000.00
Subtotal	**$**	**14,985,000.00**		**$**	**17,980,000.00**
Operation Maintenance & Monitoring (Annual)					
Cap & Grounds Maintenance	$	8,000.00	-	$	9,000.00
Groundwater Monitoring & Reporting	$	60,000.00	-	$	66,000.00
Allocation for Major Repairs (Design & Construct) *	$	35,000.00	-	$	42,000.00
Subtotal	**$**	**103,000.00**		**$**	**117,000.00**

* Presented as 1/7th cost per annum

As agreed during EGLE and R&W/GZA working calls, the estimated costs are presented at a high level, and are based on estimated quantities and assumptions regarding construction procedures. More detailed costs cannot be provided until design of the Cap Option is completed and bid out to subcontractors. These cost estimates were developed from several sources that include the on-line version of RS Means using cost data generated for either "Heavy Construction" or "Commercial New Construction," Union Labor with the CCI for Grand Rapids, Michigan, quotes from similar projects, and R&W/GZA's experience designing and executing similar remediation and/or landfill construction projects. The estimate assumes the general contractor and subcontractors who comply with Occupational Health and Safety Administration (OSHA) Hazardous Waste Operations and Emergency Response Requirements contained in CFR Part 1910.120 and the Safety and Health Regulations for Construction contained in CFR Part 1926 will be allowed to work on the HSP.

Act 451 the Natural Resources and Environmental Protection Act, Part 201 Environmental Remediation, Section 20120 requires remedial action selection factors, among other considerations to include: long-term uncertainties; cost of long-term maintenance; and the potential for future response if the alternative fails. Recognizing that the cost for these items may be undefinable based on current information and potential regulatory changes, the contingency varied for each of the cost elements. The "*Allocation for Major Repairs*" line item is based on an estimated cost to design a major repair and remove sediment from the retention basin over an average period of 7 years.

4.2.2 The Landfill Cell Option

The Landfill Cell Option will consolidate waste on-site within a containment cell that consists of a base with a double layer of FML and leachate collection, and a GCL cap / cover. Because the bottom of the cell will be constructed above soil that has likely been impacted by leaching through the waste and impacted groundwater it is defined as an "unmonitorable" unit and the double lined system will be designed to operate as both a leak detection and a leachate collection system. Based on the estimated volume of known waste and soil impacted by waste (soil between layers of waste), the current estimate is that the cell would be designed to accommodate approximately 160,000 CY of material with a footprint of approximately 5 acres. This estimate differs from the previously reported waste and impacted soil volume of 83,000 CY, which was based on the volume of impacted soil estimated between identified pockets of waste material. The 83,000 CY estimate did not include presumably non-impacted overburden, nor did it include a definitive clean-boring point below the waste. Borings that were completed through the waste were terminated once natural soil was encountered. To conservatively estimate the volume of impacted material that would be placed inside the containment cell, we assumed approximately 2 ft of soil below the known depth of waste would be excavated and placed in the cell. This additional 2-ft excavation depth allows for the removal of additional impacted soil, installation of the primary and secondary containment, and grading the bottom of the excavation to meet the design requirements for leachate collection in a Type II landfill. To account for chipped vegetation and additional impacted material that may be encountered during excavation, the cell could readily accommodate as much as 170,000 CY of material without expanding the 5-acre footprint.

Paragraph 7.8(ii)(B) of the CD summarizes the Landfill Cell Option as:

> *(B) an approximately 20-acre surface cap over an area in which materials are consolidated and placed above a liner with leachate collection, as required, that comply with Part 201 and meet the applicable substantive requirements of Michigan's Part 115;*

At the time the CD was entered into full delineation of the Site was not complete and, as a result, the approximately 20-acre cell size assumed for the Landfill Cell Option was based on rudimentary estimates. After execution of the CD, evaluation and characterization of the Site and waste delineation continued. This additional data shows that a cell size of approximately 5 acres[1] is necessary for the estimated waste volume in order to comply with substantiative requirements of Part 115, including appropriate maximum and minimum slopes, as well as good engineering practices. A cell larger than approximately 5 acres would require significantly more construction materials, more long-term operation and maintenance, and may result in additional potential failure points in the liner and capping materials.

To construct the containment cell, at least 30 acres, likely up to 40 acres of the Site would be clear cut and grubbed; the vegetation and trees would be chipped to allow the material to be placed within the containment cell. While the containment cell is expected to be 5 acres in size, overburden soil must be removed to allow access to the waste and soil impacted by the waste. Chipped organic material would be stockpiled and maintained on Site and then placed in a localized area of the containment cell that will be designed for decaying material and gas venting. Topsoil and wood chips from areas that had not previously been used for waste disposal or did not indicate concentrations of chemical constituents greater than regulatory clean-up goals may be separately staged, stockpiled and covered so that it could be re-used on Site. Overburden soil removed to access impacted soil and waste would be similarly handled.

Considering the volume of overburden, and presumably non-impacted soil that would require temporary storage until the containment cell was constructed, additional chemical analysis for the constituents of concern would be performed to verify its justification for reuse on the Site as cover on the GCL cap. In addition to the space required to accommodate and maintain the various stockpiles of non-impacted material, additional space is required to stockpile and maintain the volume of known impacted soil while allowing room for material that may be determined to be impacted based on laboratory analysis. Sequencing the construction to limit cross contamination and double- or triple-handling of material will be time consuming.

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[1] The February 2021 draft FS submittal included a 15-acre landfill cell which was developed based on an inadvertent, erroneous waste volume calculation. The error in the volume calculations was identified by EGLE during their review.

The location of the containment cell, covering the lowest area of the HSP, was selected because the majority of impacted material is present in this part of the HSP, and the natural topography will facilitate runoff control and collection to the proposed drainage basin located north of House Street. Runoff that contacts impacted material or accumulates during cell excavation and backfilling will be collected and transferred off-site for treatment and/or disposal. Final grades of the liners (primary, secondary and cap) will be designed and installed to comply with the minimum grades required in Part 115.

Upon excavation of the cell footprint, the soil will be graded to the design elevations, inspected, and made free of rocks or debris that could damage the bottommost liner. The leak detection system with appropriate collection locations will be installed between the primary and secondary liner. The primary liner drainage layer (or primary leachate collection system) will be designed to transfer leachate through a series of pipes to recovery locations so that the head on the liner will be limited to 1 foot. Sumps will be designed and located to comply with applicable Michigan Part 115 Type II Solid Waste Landfill regulations. Stockpiled impacted material will be placed into the cell, compacted, and graded to facilitate drainage. Chipped trees and vegetation, that are not suitable for reuse, would be located in a designated area of the containment which would be designed and outfit with the equipment required to adequately vent the area. Cover material placed on top of the primary liner FML will consist of either a 1-foot or 2-foot-thick drainage layer. Cover material placed on top of the GCL within the landfill cap will consist of a 2-foot-thick drainage layer and 6 inches of soil that will facilitate growth.

A retention basin located adjacent and to the east of the containment cell will be designed to accommodate a 25- year, 24-hour rainfall storm event. It is intended to allow runoff to infiltrate over time. Leachate will be periodically collected from the primary drainage layer and the leak detection/secondary leachate collection system and transported off-site for treatment and/or disposal.

Areas disturbed outside the capped footprints (access roads, laydown areas, areas of excavation for near surface waste materials) that will not continue to be used for maintenance access will be re-graded to facilitate drainage, covered with topsoil, and hydroseeded. At a minimum the containment cell area of the HSP will remain fenced.

Figures 7 and 8 are conceptual site plans for the Landfill Cell Option.

Figure 7 illustrates the location and expected configuration of the containment cell bottom with the limits of work (limits of clearing) required to store excavated soil and waste on site during cell construction.

Figure 8 presents a conceptual site plan for the Containment with Leachate Collection Option showing the likely locations of the Cell (black contours) and limits of the work area (blue outline). Should the cell contain the projected volume of approximately 166,000 CY, the finish elevation of the cell peak will be at elevation 818 which is approximately 38 feet above House Street to the South. Areas outside of the containment cell that are within the limits of work would be regraded and recontoured to direct drainage to the stormwater retention area in the southeastern portion of the HSP.

The Landfill Cell Option will comply with Part 201, and the surface cap, liner, and leachate collection system will comply with all applicable substantive requirements of Part 115, including Rules 304, 308, and 423.

Because stormwater conveyances are not currently present on the House Street right-of-way or on either direction of US-131 other than a drainage swale, run-off from the containment cell will be directed to a retention basin located on the southeast portion of the Site and then possibly pumped or directed to the eastern wooded portion of HSP and allowed to naturally infiltrate in an area not previously used for waste disposal. Stormwater control, including the potential impact infiltration may influence on the direction of groundwater flow, will be modeled during the design. The final design will be sufficient to meet Part 115 requirements and applicable

Plainfield Township requirements, if any. This runoff design will consider those portions of the HSP that formerly contained waste and soil impacted by waste and may require a larger area for retention than conceptually shown. In addition, and if needed, engineering and approval of a high-water contingency outlet for the retention basin will be conducted.

Areas disturbed outside the containment cell's capped footprint, that will not continue to be used for site access, (access roads, laydown areas, areas of excavation for near surface waste materials) will be re-graded to facilitate drainage, covered with topsoil, and hydroseeded. A portion of the HSP will contain access roads to allow crews to mow and maintain the cap maintenance. The HSP will also remain fenced and secure to ensure the integrity of the caps is not compromised. This will include the capped and immediately surrounding areas.

4.2.2.1 Performance

The Landfill Cell Option will limit infiltration through waste and impacted soil.

4.2.2.2 Reliability

Like the Cap Option, the Landfill Cell Option is considered a reliable environmental remedy, however, USEPA 2020 describes multiple uncertainties specifically regarding landfilling PFAS-containing material, including their behavior in the landfill itself and effect on the liner systems. Laboratory studies have published results that project the longevity of the geomembranes that will be used under the conditions expected at the HSP are hundred years or greater (these studies did not include PFAS-specific evaluation). The potential for (localized) leakage of precipitation into the cell is limited to design and/or construction errors. Subsurface consolidation in areas where chipped trees and other cleared vegetation will be stored may require additional maintenance over time to remove or close gas vents once decomposition has ended and they are no longer required. Well-established means and methods exist for construction as well as Quality Control procedures to verify integrity of the FML and GCL.

4.2.2.3 Ease of Implementation

The Landfill Cell Option is significantly more difficult to implement than the Cap Option. The Landfill Cell Option will require more construction traffic and a longer construction period than required to complete the Cap Option. Suitability of subgrade below the containment cell is currently unknown and may require imported material before placing the synthetic liner, or expansion of the containment system if additional impacted material is discovered below the design depth. Removal of impacted material from the deep ravine at the southern end of the Site is likely to require use of specialty construction equipment or installation of temporary support system to limit over excavation. Simultaneous construction and storage/maintenance of waste and impacted material may require additional laydown area east of the currently delineated waste footprint. Backfilling and compacting a deep excavation to limit differential settlement and reduce strain on the FML also require specialized heavy equipment. Water collected (from precipitation) during construction and backfilling the containment cell will require a collection system and storage system along with temporary on-site storage with periodic removal and off-site disposal. Dust control during dry, windy periods to limit air borne particulates will require specialized material handling and dust control techniques which could periodically exacerbate runoff control. Stormwater control will need to be sufficient to meet Part 115 and Plainfield Township requirements, if applicable. The runoff design will consider and may require a significant area of the HSP, as well as engineering and approval of a high-water contingency as noted earlier.

Additional information that would be needed before final design and construction include confirming engineering properties of the waste material, refining the limits of waste, and confirming stormwater infiltration location.

4.2.2.4 Potential Impacts

The potential impacts of the Landfill Cell Option are similar in kind but slightly greater than the Cap Option. The Landfill Cell Option will include clear cutting and grubbing at least 30 acres, likely up to 40 acres of vegetated and wooded land with the potential to increase the clearing if additional impacted material is encountered that would require temporary storage until the containment cell construction is completed. Construction and implementation impacts will involve typical construction safety and worker exposure over a longer duration that the cap alone alternative, which will be mitigated by training and PPE. There will be a short-term increase in runoff and infiltration during construction when vegetation is removed. Temporary covers and other control measures (e.g., water) will be used to control the wind-borne spread of dust during clearing, grubbing and waste material relocation during dry, windy weather conditions.

Measures to control noise, smell, dust, and traffic will be implemented during construction to limit impact on the surrounding property owners.

4.2.2.5 Control of Exposure to Residual Contamination

Waste (primary source) will be located in a landfill cell. The soil beneath the waste (secondary source) will remain in place but generally will be at least 5 ft below grade. Portions of the HSP will remain fenced and access restricted.

4.2.2.6 Time to Implement

Design and permitting can begin immediately upon acceptance of a work plan, with construction and implementation likely up to 36 months. This does not include design and permitting process or long-term OM&M.

4.2.2.7 Institutional Requirements

Deed restrictions will be imposed to limit soil and groundwater use, and additional exposure controls such as the cell capping and fencing will be used. Cap and cell inspection and maintenance will be required long-term.

4.2.2.8 Ability to Reduce Toxicity and Mobility of PFAS Compounds

The Landfill Cell Option would contain the on-site waste and limit mobility from the primary source.

4.2.2.9 Estimated Cost

Design					
Sitework & Geotech Investigation	$	95,000.00	-	$	167,000.00
Prepare Plans, Specifications & Permit Applications	$	175,000.00	-	$	263,000.00
Subtotal	**$**	**270,000.00**		**$**	**430,000.00**
Construction					
Contractor Prequalification & Procurement	$	35,000.00	-	$	39,000.00
Construction Management	$	1,950,000.00	-	$	2,800,000.00
Construction	$	17,500,000.00	-	$	24,500,000.00
Subtotal	**$**	**19,485,000.00**		**$**	**27,339,000.00**

Operation Maintenance & Monitoring					
Cap & Grounds Maintenance	$	8,000.00	-	$	9,000.00
Groundwater Monitoring & Reporting	$	60,000.00	-	$	66,000.00
Leachate Collection & Off-Site T&D*	$	250,000.00	-	$	300,000.00
Allocation for Major Repairs (Design & Construct)**	$	45,000.00	-	$	54,000.00
Subtotal	**$**	**363,000.00**		**$**	**429,000.00**

* Leachate collection avg for 3 years - decline with time

** Major repairs every 7 years

As agreed during EGLE and R&W/GZA working calls, the estimated costs are presented at a high level, and are based on estimated quantities and assumptions regarding construction procedures. More detailed costs cannot be provided until design of the Landfill Cell Option was completed and bid out to subcontractors. The cost estimate was developed from several sources that include the on-line version of RS Means using cost data generated for either "Heavy Construction" or "Commercial New Construction", Union Labor with the CCI for Grand Rapids, Michigan, quotes from similar projects, and R&W/GZA's experience designing and executing similar remediation and/or landfill construction projects. The estimate assumes the general contractor and subcontractors who comply with OSHA Hazardous Waste Operations and Emergency Response Requirements contained in CFR Part 1910.120 and the Safety and Health Regulations for Construction contained in CFR Part 1926 will be allowed to work on the HSP.

Act 451 the Natural Resources and Environmental Protection Act, Part 201 Environmental Remediation, Section 20120 requires remedial action selection factors, among other considerations to include: long-term uncertainties; cost of long-term maintenance; and the potential for future response if the alternative fails. Recognizing that the cost for these items may be undefinable based on current information and potential regulatory changes, the contingency varied for each of the cost elements presented below. The "Allocation for Major Repairs" line item is based on an estimated cost to design a major repair and remove sediment from the retention basin over an average period of 7 years.

5.0 SELECTION OF FINAL REMEDY

Wolverine intends to implement the Cap Option going forward because it is feasible, reliable, and meets the performance objectives outlined in the CD.

In any event, under Paragraph 7.8(b) of the CD, "if [EGLE] does not approve of the proposed remedy in the Feasibility Study for the House Street Disposal Site, the final remedy shall be an approximately 30-acre surface cap without a bottom liner." On February 19, 2021, Wolverine proposed a remedy (a combination of phytoremediation and targeted capping) in the Feasibility Study for the HSP. EGLE did not approve of that proposed remedy. Accordingly, the final remedy shall be the approximately 30-acre cap.

6.0 REFERENCES

Geosynthetic Institute, GRI White Paper #6, Geomembrane Lifetime Prediction: Unexposed and Exposed Conditions; Koerner, Robert M., Hsuan, Y. Grace, and Koerner, George R.; February 8, 2011; https://geosynthetic-institute.org/papers/paper6.pdf

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TABLES

Table 1 – Summary of Initial Screening of Options

1855 House Street Site

Technology Type	Process Option	Description	Effectiveness	Implementability	Screening Comment
No Further Action					
None	None	No further action.	The no action alternative does not result in reduction of waste volume, toxicity, or mobility.	Good	Not evaluated further as it does not meet CD objectives.
Institutional Controls					
Access and Use Restrictions	Deed restrictions	Implement deed restrictions on soil and groundwater use as well as property zoning and use. May be used in conjunction with other remedial options.	Provides additional limitation to direct contact human exposure. Effectiveness relies on ability to implement and enforce. Deed restrictions do not reduce the mobility or toxicity of the PFAS compounds.	Good	Retained for likely inclusion with other actions to improve their reliability.
Containment					
On-site capping		Consolidating some waste material and then constructing an impermeable cap over affected areas. Runoff allowed to infiltrate side-gradient of waste.	Limits direct contact human exposure, reduces infiltration through the waste material on the HSP. Likely to decrease the mobility of the PFAS compounds contained with the waste materials by limiting infiltration. This alternative does not reduce the toxicity of the PFAS compounds or waste volume.	Readily implementable using standard landfill capping techniques. Challenge associated with removing vegetation and re-shaping finish grade to accommodate run-off collection.	Retained for further evaluation, as required by the CD.
On-Site containment cell		Excavation of waste materials and soil with waste material and consolidation into a containment cell constructed on-site.	Limits direct contact human exposure, reduces infiltration through the waste material on the HSP. Ceases mobility of the PFAS compounds contained with the waste materials and soil with waste material. This alternative does not reduce volume or the toxicity of the PFAS compounds but does contain them within the cell.	Moderately implementable due to the extensive handling required to excavate, stockpile and maintain waste material on-site and handle runoff during cell construction. Challenge associated with removing vegetation and re-shaping finish grade to accommodate run-off collection.	Retained for further evaluation, as required by the CD.
Collection					
Active Filtration	Groundwater pump and treat	Installation of extraction wells to pump PFAS contaminated water through filtration and activated carbon system or other suitable media. Discharge would ideally be located significantly outside of the House Street parcel itself (i.e. down- or side-gradient).	Reduces contaminant migration in groundwater. Does not address primary or secondary sources. Does not reduce the toxicity or mobility of the PFAS compounds from the source material.	Moderately implementable to construct; however, the volume of groundwater pumped and treated would be significant without a logistically possible discharge location for the treated water that is outside of the groundwater plume. On-site discharge would increase leaching PFAS from waste, waste soil mixture or PFAS-saturated vadose zone soil. Fouling of the activated carbon with co-contaminants and naturally occurring metals will shorten operational life and may in significant long-term OMM logistics and disposal of spent GAC considerations.	Not retained for further evaluation due to lack of implementable discharge area for treated water.

Table 1 – Summary of Initial Screening of Options

1855 House Street Site

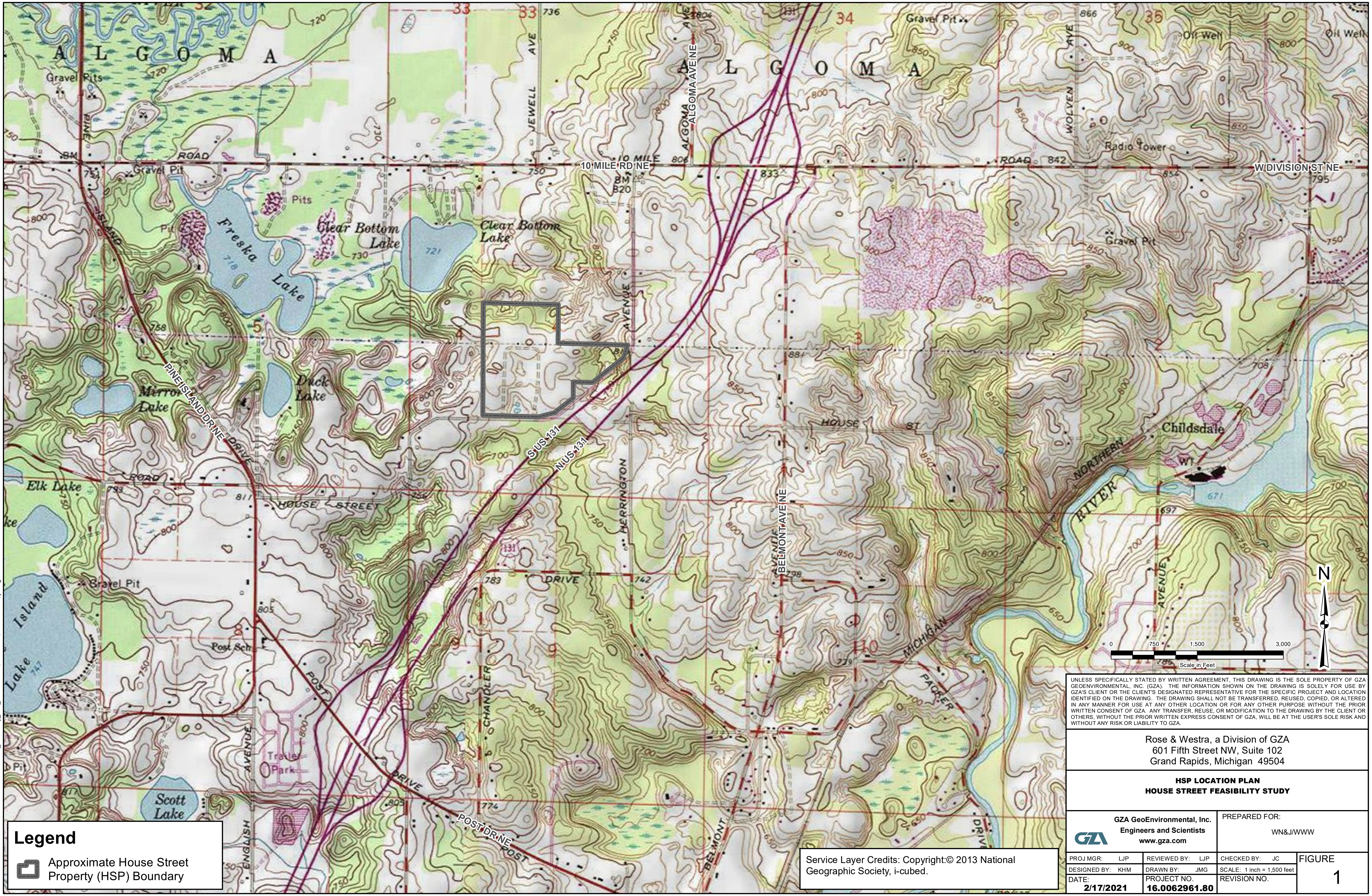
Technology Type	Process Option	Description	Effectiveness	Implementability	Screening Comment
Passive Filtration	Funnel and gate system	Construction of cutoff walls subgrade to modify groundwater flow (i.e., funnel) into a specific pattern. The groundwater is directed to a passive treatment zone (i.e., funnel). For PFAS this may be granular activated carbon.	Reduces the contaminant load in deep groundwater. Does not address primary or secondary sources. Does not reduce the toxicity or mobility of the PFAS compounds in the source area.	Exceptionally difficult to implement and maintain during operation. Saturated thickness approaching 120 vertical feet over length of capture zone for funnel system presents exceptional technical challenges as does installation of the cutoff wall on either side of the gate.	Dismissed from further evaluation due to depth to groundwater, groundwater thickness, and predominately high permeability saturated zone soil.
Deep Well Injection	Ultra-filtration. Stand alone or coupled with Reverse Osmosis (RO)	Installation of extraction wells to pump PFAS contaminated water, discharge to Class I injection wells.	Reduces contaminant migration in groundwater. Does not address primary or secondary sources. Causes significant water withdrawal from the aquifer. Does not reduce the toxicity or mobility of the PFAS compounds from the source material. If coupled with RO, discharge volume limited to a mixture of residue (with a higher PFAS concentration) and filtrate (to allow proper discharge).	Moderately implementable depending upon location of well(s) and permit compliance. Must be coupled with groundwater extraction, filtration to remove sediment, and high-pressure pumping.	Not retained for further evaluation as it would only be practicable and usable as part of the possible groundwater pump and treatment option, which is dismissed from further evaluation as discussed above.
Treatment					
In-Situ	Waste stabilization	Consolidation of near surface waste with deeper impacted areas (ravine adjacent to House Street), mixing of surrounding soil and impacted material (i.e., primary source) using laboratory verified mix to create a stabilized mass. Covering the stabilized mass with ISS swell (excess material generated during mixing) and at least 4-feet of natural material to prevent freeze/thaw cracking.	Provides limitation to direct contact human exposure, eliminates infiltration through the waste material on the HSP. Ceases mobility of the PFAS compounds contained with the waste materials and soil with waste material. This alternative does not reduce the toxicity of the PFAS compounds but does bind them in the treatment material. Limited documented use and effectiveness for PFAS compounds. Not universally accepted by regulatory agencies.	Moderately to implement in certain areas of the site, difficult in other areas. Significant logistical challenges handing and relocating swell.	Dismissed from further evaluation based on the significant time and resources necessary to conduct bench and pilot scale testing necessary to evaluate the applicability of the technology to solidify/stabilize PFAS compounds.
In-Situ	Thermal desorption treatment	In place heat treatment of waste material and soil to temperatures known to desorb or destroy PFAS compounds	Still experimental treatment for PFAS compounds. Not proven technology. Concerns of off-gassing.	Exceptionally difficult to implement and considered to be technically impractical.	Dismissed from further evaluation. Temperatures need to thermally treat 80 to 100-foot-thick column of waste and soil are technical impractical

Table 1 – Summary of Initial Screening of Options

1855 House Street Site

Technology Type	Process Option	Description	Effectiveness	Implementability	Screening Comment
In-Situ	Chemical oxidation	Injection of oxidants to neutralize or reduce toxicity of contaminants	Still experimental treatment for PFAS compounds. Not proven technology.	Poor	Dismissed from further evaluation because it has not been demonstrated for PFAS treatment, difficulty to apply and mix reagents, and cost relative to likely benefit.
Disposal					
Excavation, Transport, and Disposal	Excavation and removal of waste materials and waste material mixed with soil for transport for off-site disposal at a permitted landfill.	Excavate waste materials and waste materials mixed with soil as well as overburden and marginal soil using typical earthwork equipment. Permanently dispose of soil in a permitted landfill.	Highly effective as primary PFAS compound source is removed, eliminating mobility and toxicity. Secondary PFAS compound source remains on-site. Permitted landfills are designed and operated to contain disposed wastes. Based on the calculated volume of PFAS-impacted waste and soil, disposal will likely require more than one facility.	Readily implementable - Excavation is routine, well proven, and can commence almost at any time Subtitle D landfills are locally present if willing to accept PFAS-containing waste. However, there are TCLP exceeding soil and waste on-site. Waste/soil meeting the definition of a hazardous waste would require greater transportation distances.	Dismissed from further evaluation based on the cost, significant disturbances to the community, and lack of reasonable off-site disposal location options.
Mixed Remediation					
	Phytoremediation and Strategic Capping	Continued maintenance of existing capped areas. Additional strategic capping in select areas (i.e. potentially where the thickest waste is present). Planting of trees for phytoremediation in areas of waste not capped. Potential remains for future limited access and use.	Capping and phytoremediation will reduce stormwater infiltration and mobility of PFAS compounds from some of the waste materials (primary source).	Readily implementable. Capping exposed waste on the ravine sidewall is most disruptive and complex construction component of the work. Maintenance of the vegetation used for phytoremediation would require specialized handling and disposal.	Dismissed from further evaluation based on EGLE's rejection of this concept in the February 19, 2021, original draft FS submittal.

FIGURES



Legend

Approximate House Street Property (HSP) Boundary

Service Layer Credits: Copyright:© 2013 National Geographic Society, i-cubed.

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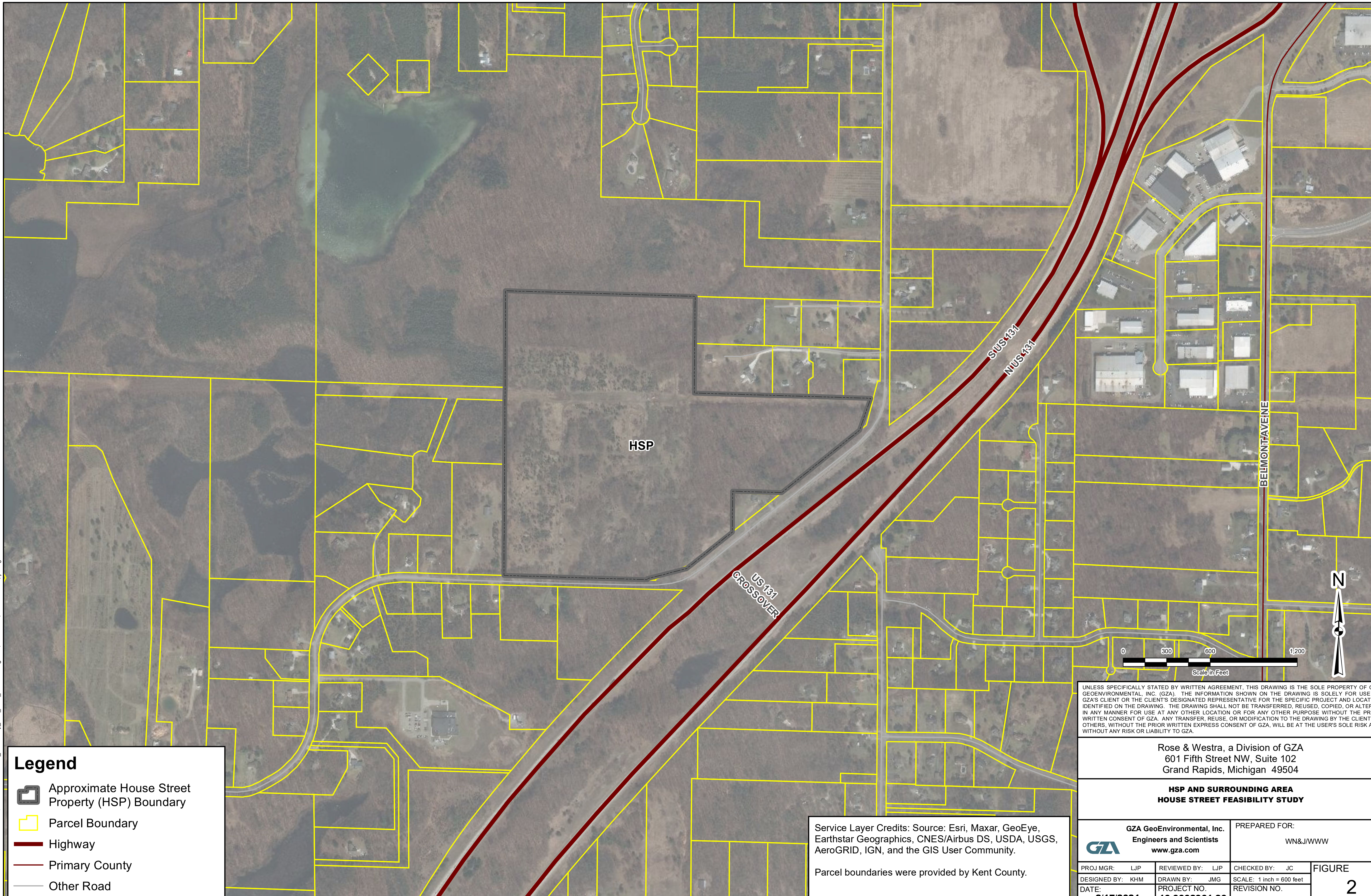
HSP LOCATION PLAN
HOUSE STREET FEASIBILITY STUDY

GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: JMG	SCALE: 1 inch = 1,500 feet	1
DATE: 2/17/2021	PROJECT NO. 16.0062961.80	REVISION NO.	



Legend

- Approximate House Street Property (HSP) Boundary
- Parcel Boundary
- Highway
- Primary County
- Other Road

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

Parcel boundaries were provided by Kent County.

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HSP AND SURROUNDING AREA
HOUSE STREET FEASIBILITY STUDY

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Engineers and Scientists
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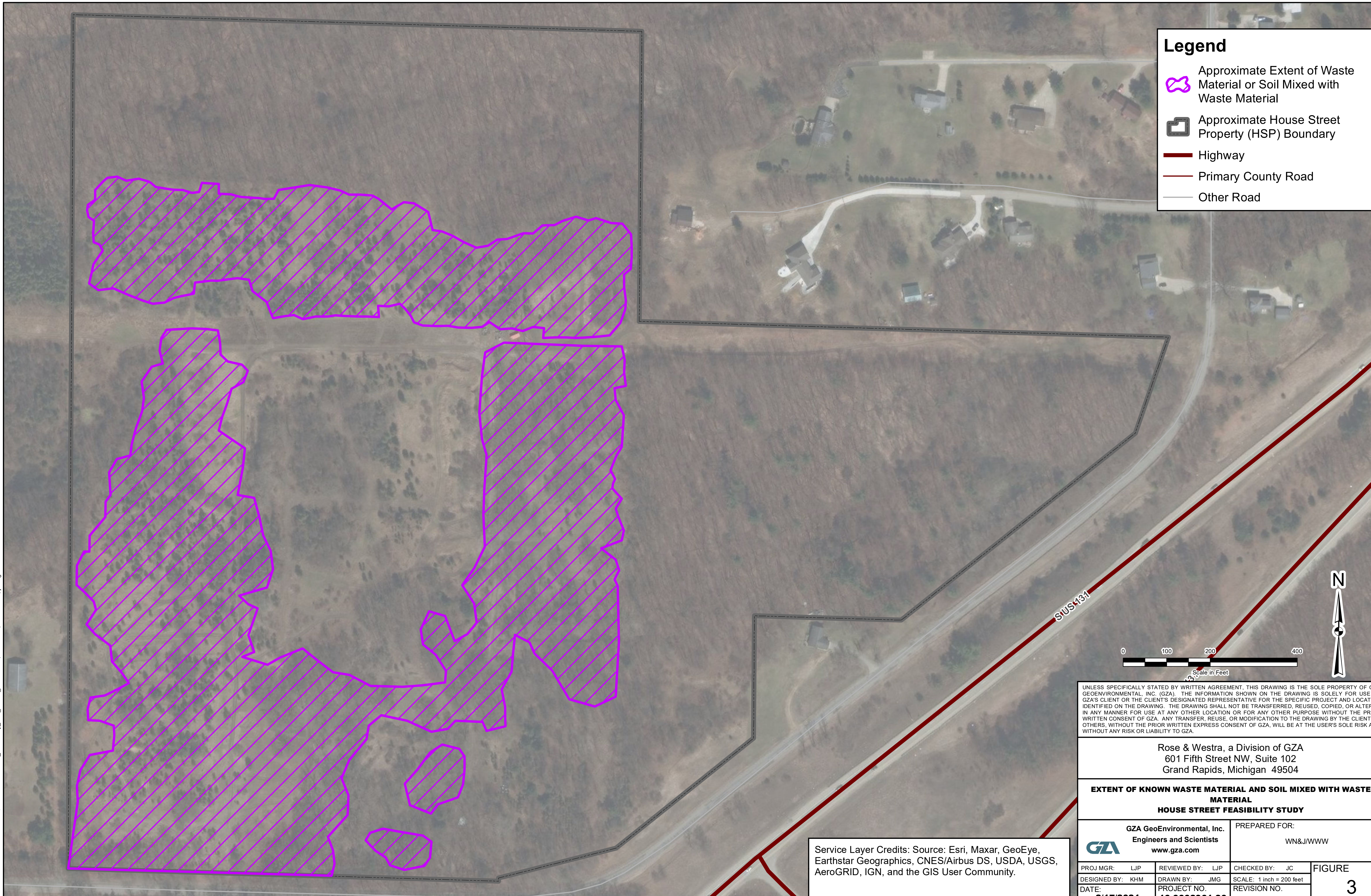
PREPARED FOR:
WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: JMG	SCALE: 1 inch = 600 feet	2
DATE: **2/17/2021**	PROJECT NO. **16.0062961.80**	REVISION NO.	



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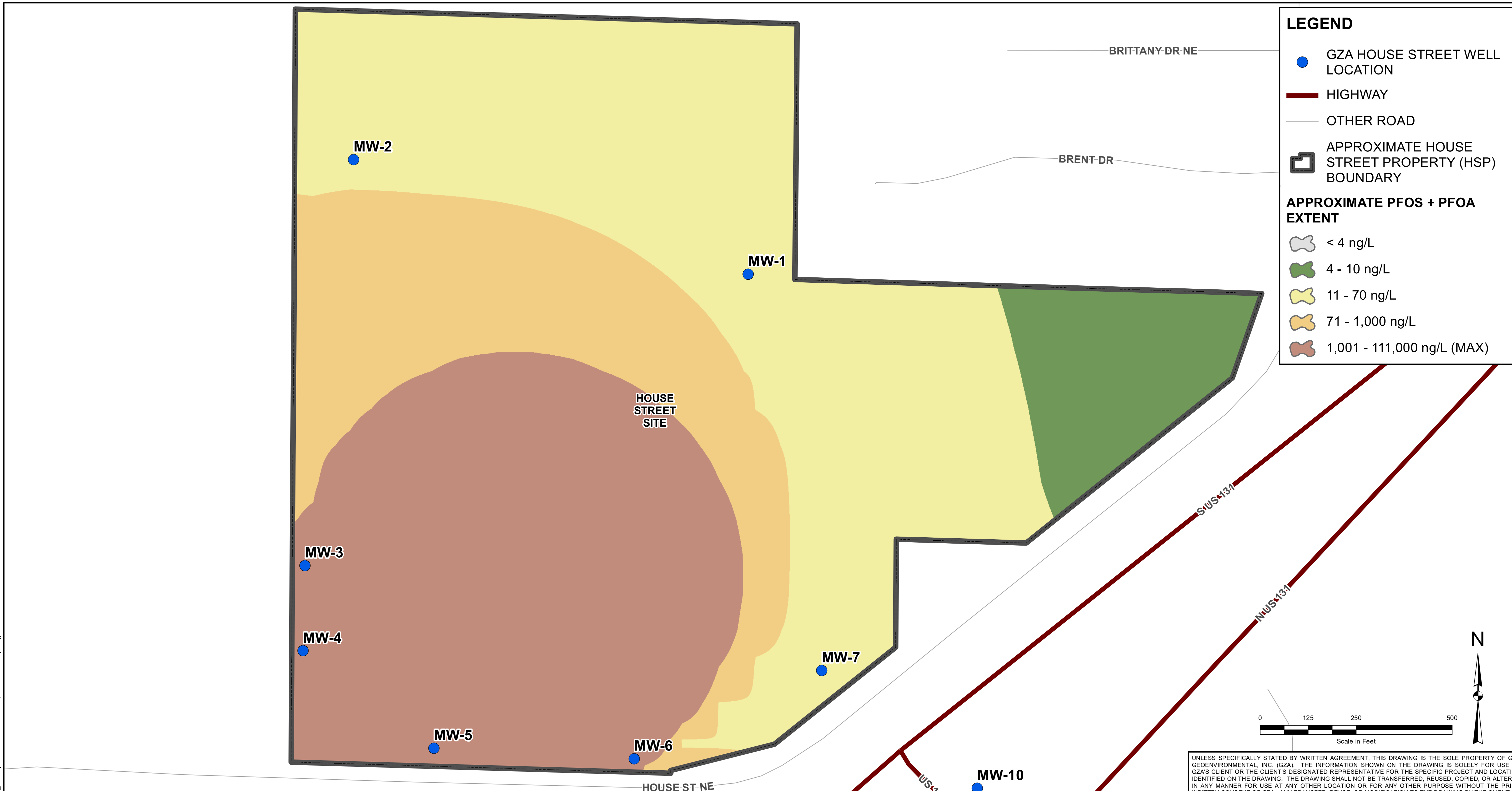
Grand Rapids, Michigan 49504

EXTENT OF KNOWN WASTE MATERIAL AND SOIL MIXED WITH WASTE MATERIAL
HOUSE STREET FEASIBILITY STUDY

GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE 3
DESIGNED BY: KHM	DRAWN BY: JMG	SCALE: 1 inch = 200 feet	
DATE: **2/17/2021**	PROJECT NO. **16.0062961.80**	REVISION NO.	



NOTES:
1. LOCATIONS AND SITE FEATURES ARE APPROXIMATE.

2. ACRONYMS
- (MAX) = MAXIMUM DETECTED CONCENTRATION IN THE SAMPLES.
- ng/L = NANOGRAM PER LITER
- PFOA = PERFLUORONOCTANOIC ACID
- PFOS = PERFLUOROOCTANE SULFONATE

3. MAXIMUM CONCENTRATION FROM MONITORING AND RESIDENTIAL WELL SAMPLE RESULTS (INCLUDING THE NORTH KENT LANDFILL STUDY AREA) WERE USED TO DEVELOP CONCENTRATION ISOPLETHS.

4. CONCENTRATION ISOPLETHS WERE DEVELOPED USING NATURAL NEIGHBOR INTERPOLATION IN ARCGIS. CONCENTRATIONS WERE NOT EXTRAPOLATED OUTSIDE OF THE AREA OF KNOWN CONCENTRATIONS.

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EXTENT OF KNOWN ON-SITE GROUNDWATER PLUME - PFOS + PFOA
HOUSE STREET FEASIBILITY STUDY

GZA GeoEnvironmental, Inc.
Engineers and Scientists
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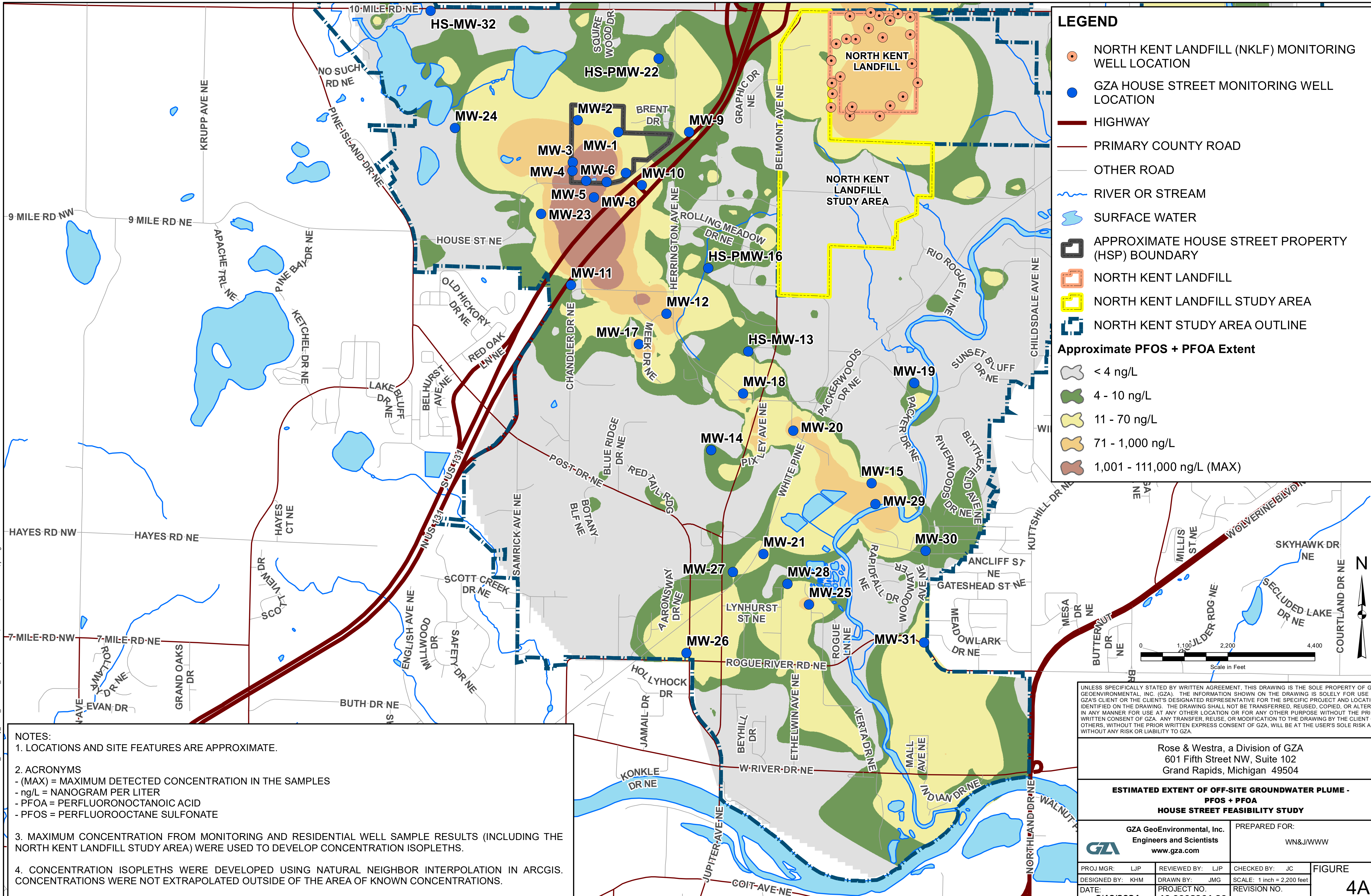
PREPARED FOR:
WN&J/WWW

PROJ MGR: LIP	REVIEWED BY: LIP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: ADM	SCALE: 1 inch = 250 feet	
DATE: **2/19/2021**	PROJECT NO. **16.0062961.80**	REVISION NO.	4



NOTES:

1. LOCATIONS AND SITE FEATURES ARE APPROXIMATE.

2. ACRONYMS
- (MAX) = MAXIMUM DETECTED CONCENTRATION IN THE SAMPLES
- ng/L = NANOGRAM PER LITER
- PFOA = PERFLUORONOCTANOIC ACID
- PFOS = PERFLUOROOCTANE SULFONATE

3. MAXIMUM CONCENTRATION FROM MONITORING AND RESIDENTIAL WELL SAMPLE RESULTS (INCLUDING THE NORTH KENT LANDFILL STUDY AREA) WERE USED TO DEVELOP CONCENTRATION ISOPLETHS.

4. CONCENTRATION ISOPLETHS WERE DEVELOPED USING NATURAL NEIGHBOR INTERPOLATION IN ARCGIS. CONCENTRATIONS WERE NOT EXTRAPOLATED OUTSIDE OF THE AREA OF KNOWN CONCENTRATIONS.

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ESTIMATED EXTENT OF OFF-SITE GROUNDWATER PLUME - PFOS + PFOA
HOUSE STREET FEASIBILITY STUDY

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Engineers and Scientists
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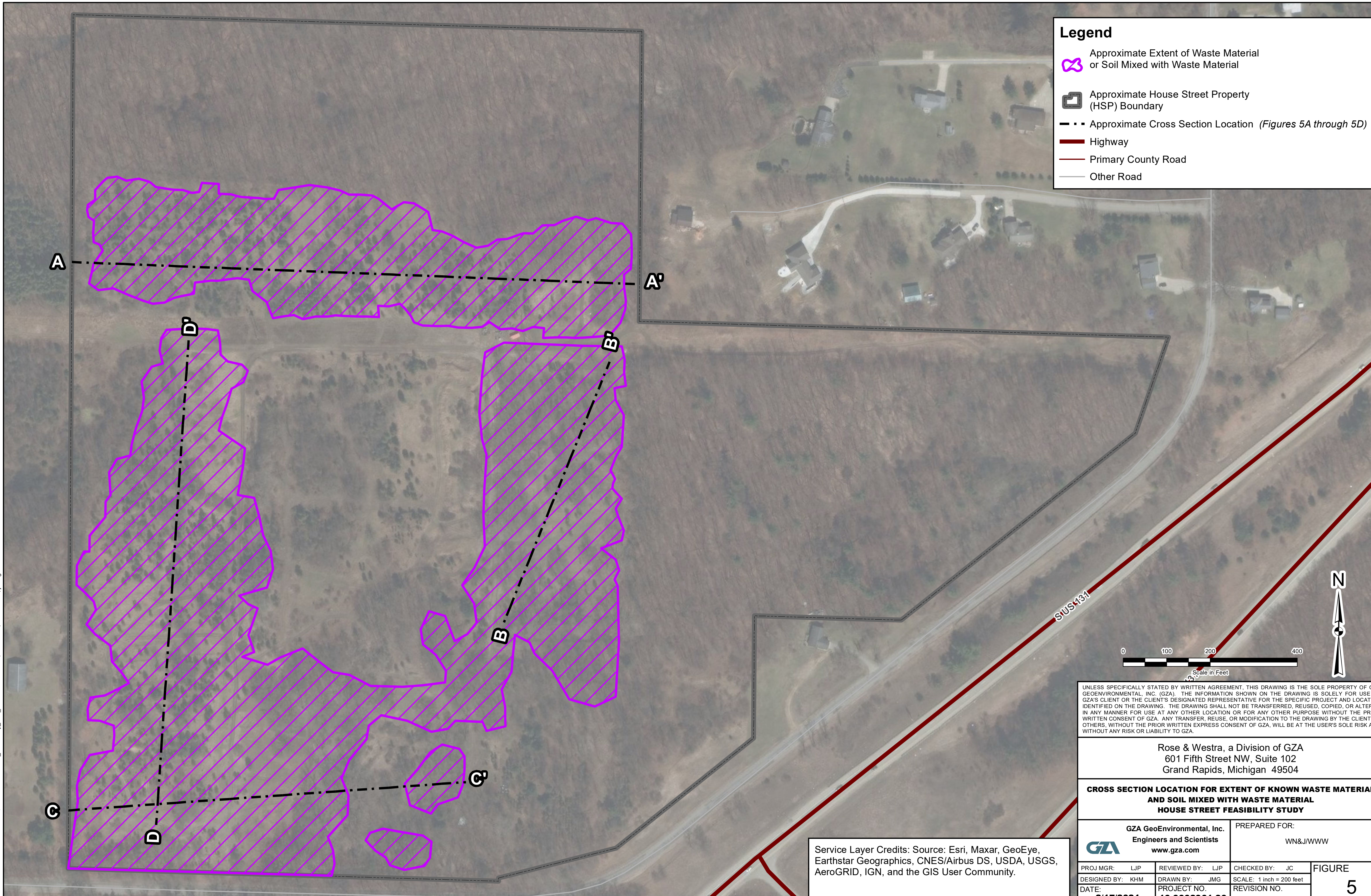
PREPARED FOR:
WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: JMG	SCALE: 1 inch = 2,200 feet	4A
DATE: 2/19/2021	PROJECT NO. 16.0062961.80	REVISION NO.	



Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

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CROSS SECTION LOCATION FOR EXTENT OF KNOWN WASTE MATERIAL AND SOIL MIXED WITH WASTE MATERIAL
HOUSE STREET FEASIBILITY STUDY

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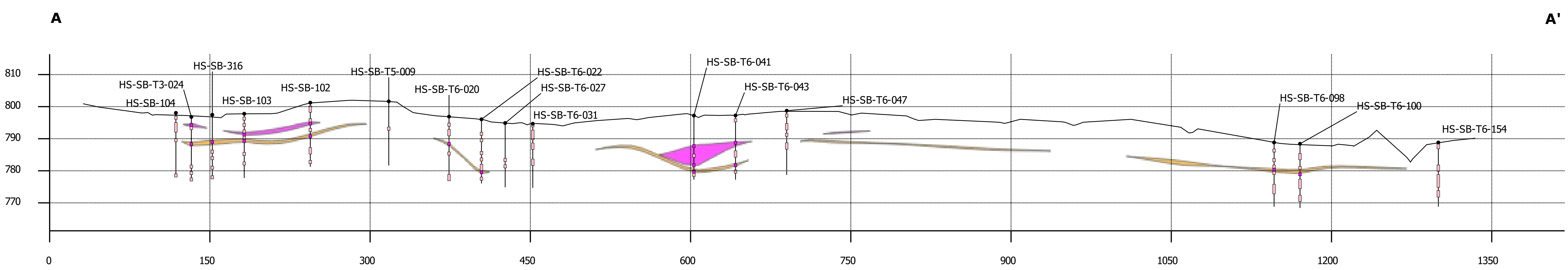
PREPARED FOR:
WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: JMG	SCALE: 1 inch = 200 feet	5
DATE: 2/17/2021	PROJECT NO. 16.0062961.80	REVISION NO.	

Figure 5A

Cross Section A - A'

View North



Legend

Observed Soil Conditions

No Waste

Waste

Modeled Waste Material

Estimated Waste Bottom

Waste

Topography

Note:

Based on measurements at permanent monitoring wells, the groundwater table at the site ranges in elevation from approximately 722 to 730 feet above mean sea level.

Location

A: 12787541, 588746

A': 12788958, 588694

Scale: 1:1,100

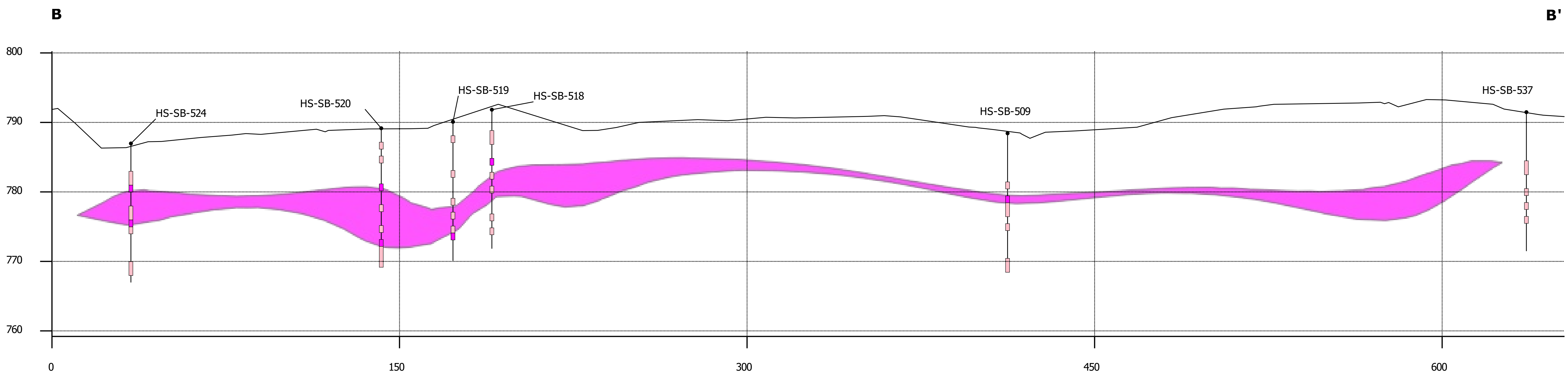
Vertical exaggeration: 3x

0ft 300ft

Figure 5B

Cross Section B - B'

View West



Legend

Observed Soil Conditions

No Waste   Waste

Modeled Waste Material

Waste

Topography

Note:

Based on measurements at permanent monitoring wells, the groundwater table at the site ranges in elevation from approximately 722 to 730 feet above mean sea level.

Location

B: 12788604, 587917

B': 12788801, 588539

Scale: 1:520

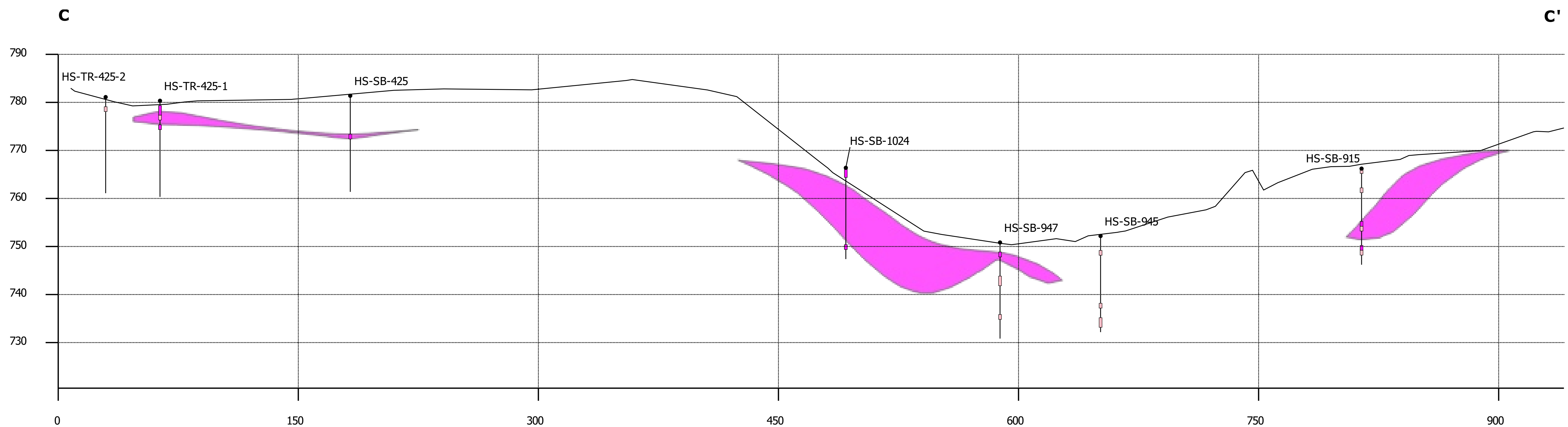
Vertical exaggeration: 3x

0ft 75ft

Figure 5C

Cross Section C - C'

View North



Legend

Observed Soil Conditions

No Waste — Waste

Modeled Waste Material

Waste

Topography

Note:

Based on measurements at permanent monitoring wells, the groundwater table at the site ranges in elevation from approximately 722 to 730 feet above mean sea level.

Location

C: 12787556, 587496

C': 12788495, 587563

Scale: 1:800

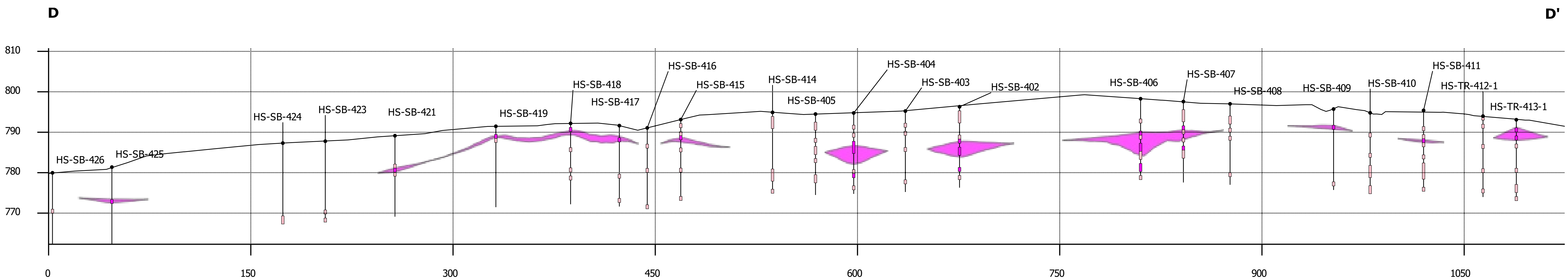
Vertical exaggeration: 3x

0ft 150ft

Figure 5D

Cross Section D - D'

View West



Legend

Observed Soil Conditions

No Waste

Waste

Modeled Waste Material

Waste

Topography

Note:

Based on measurements at permanent monitoring wells, the groundwater table at the site ranges in elevation from approximately 722 to 730 feet above mean sea level.

Location

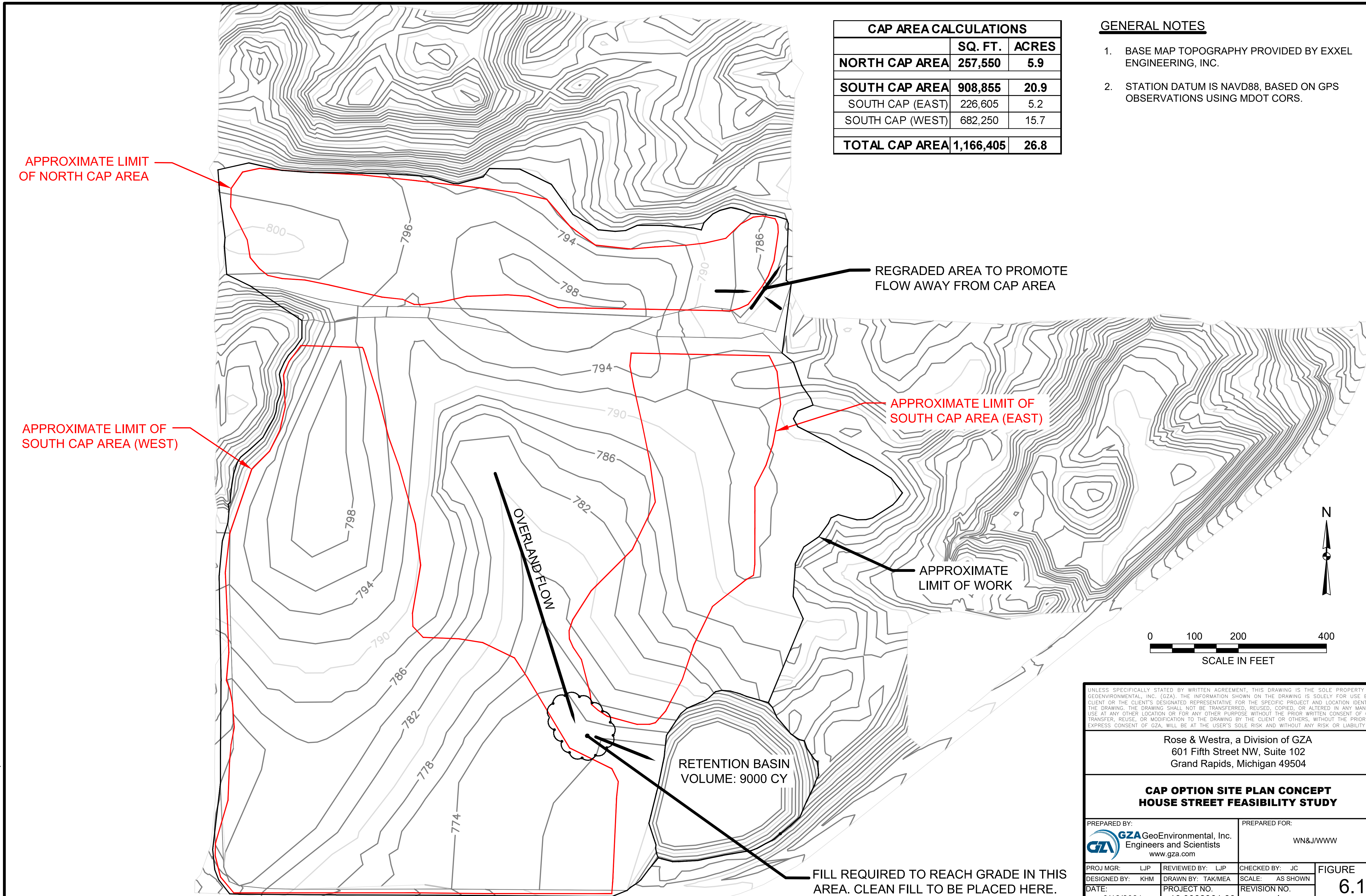
D: 12787727, 587459

D': 12787803, 588581

Scale: 1:850

Vertical exaggeration: 3x

0ft 150ft



CAP AREA CALCULATIONS

	SQ. FT.	ACRES
NORTH CAP AREA	**257,550**	**5.9**
SOUTH CAP AREA	**908,855**	**20.9**
SOUTH CAP (EAST)	226,605	5.2
SOUTH CAP (WEST)	682,250	15.7
TOTAL CAP AREA	**1,166,405**	**26.8**

GENERAL NOTES

1. BASE MAP TOPOGRAPHY PROVIDED BY EXXEL ENGINEERING, INC.
2. STATION DATUM IS NAVD88, BASED ON GPS OBSERVATIONS USING MDOT CORS.

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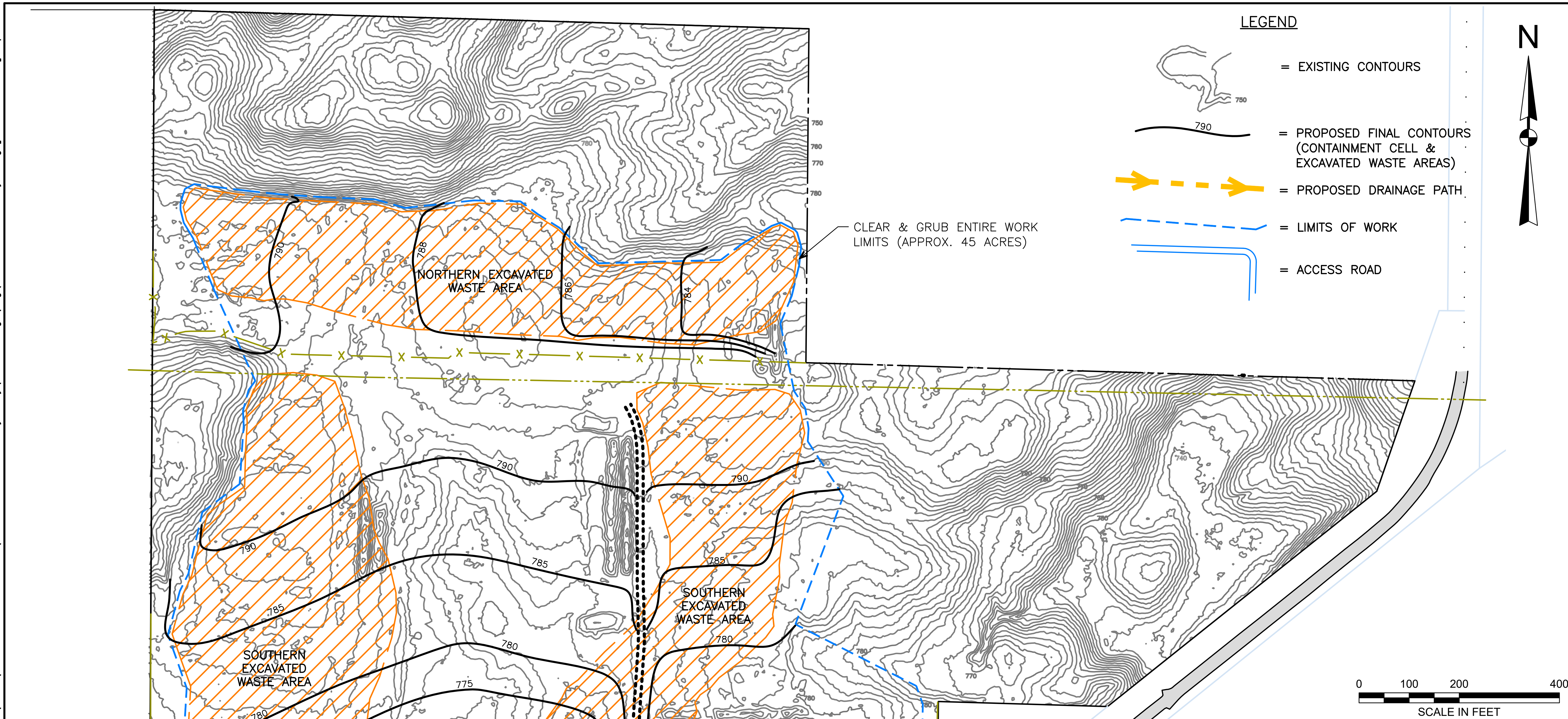
CAP OPTION SITE PLAN CONCEPT
HOUSE STREET FEASIBILITY STUDY

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com		PREPARED FOR: WN&J/WWW	
PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: TAK/MEA	SCALE: AS SHOWN	6.1
DATE: 8/12/2021	PROJECT NO. 16.0062961.80	REVISION NO. 1	



NO.	ISSUE/DESCRIPTION	BY	DATE

Rose & Westra, a Division of GZA
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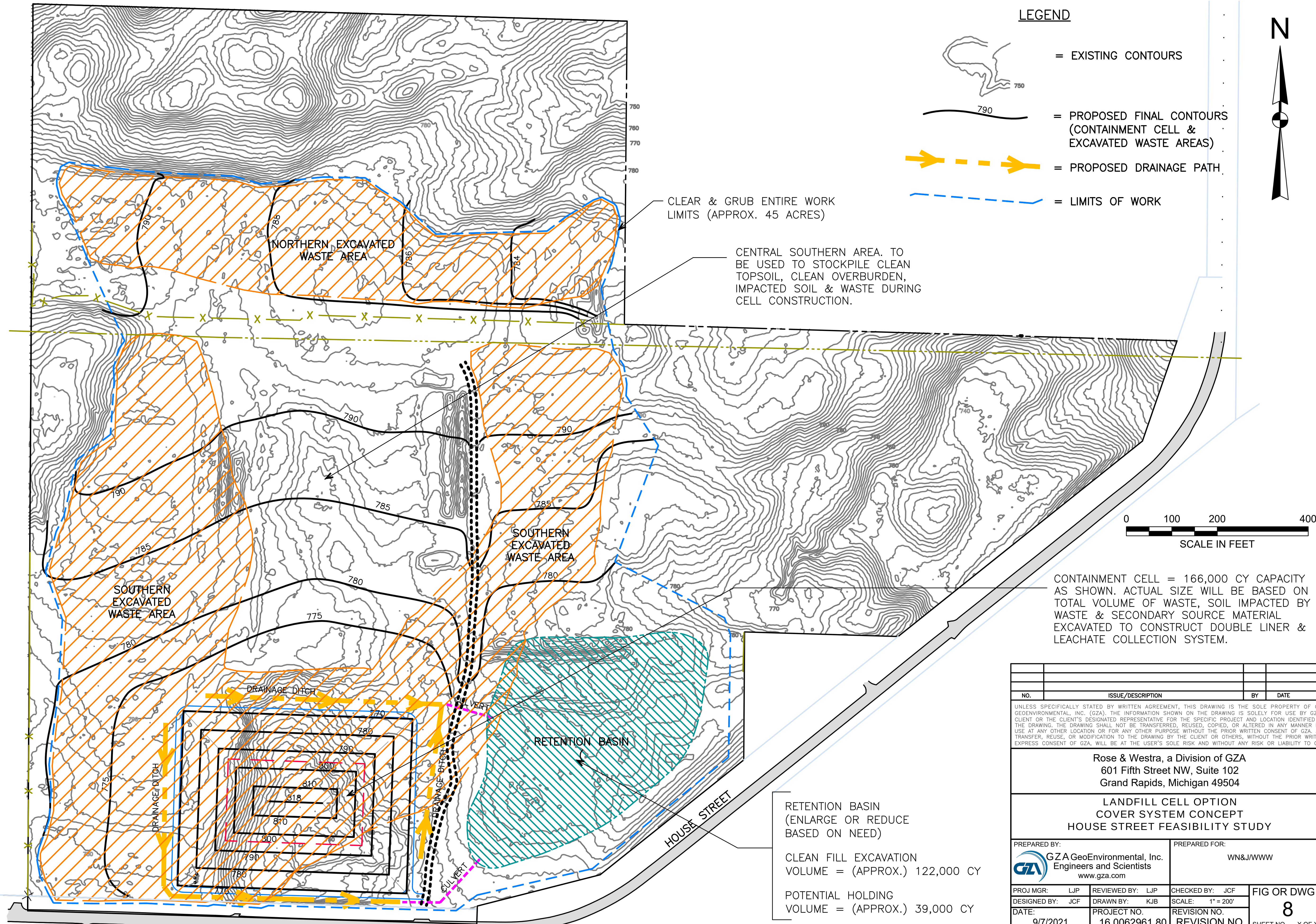
Grand Rapids, Michigan 49504

LANDFILL CELL OPTION
COVER SYSTEM CONCEPT
HOUSE STREET FEASIBILITY STUDY

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com	PREPARED FOR: WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JCF	FIG OR DWG 7
DESIGNED BY: JCF	DRAWN BY: KJB	SCALE: 1" = 200'	
DATE: 9/7/2021	PROJECT NO. 16.0062961.80	REVISION NO. REVISION NO.	SHEET NO. X OF XX



NO.	ISSUE/DESCRIPTION	BY	DATE

Rose & Westra, a Division of GZA
601 Fifth Street NW, Suite 102
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LANDFILL CELL OPTION
COVER SYSTEM CONCEPT
HOUSE STREET FEASIBILITY STUDY

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com		PREPARED FOR: WN&J/WWW	
PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JCF	FIG OR DWG 8
DESIGNED BY: JCF	DRAWN BY: KJB	SCALE: 1" = 200'	
DATE: 9/7/2021	PROJECT NO. 16.0062961.80	REVISION NO. REVISION NO.	SHEET NO. X OF XX

APPENDIX A – R&W/GZA QUALIFICATION DOCUMENTATION

Proactive by Design

GZA SOLID WASTE DESIGN SERVICES
STATEMENT OF QUALIFICATIONS
December 31, 2019

GZA Solid Waste Design Services Qualifications

GZA Experience Overview

GZA has provided environmental investigation, engineering and design services on more than 500 solid waste management facilities nationwide and in several foreign countries. Solid waste management services are provided mainly by our Buffalo, New York and Providence, Rhode Island offices, with technical and field support provided by other offices in the Midwest and Northeast.

We have provided design and construction oversight services for ash containment cell liners and final cover systems at 2 coal-fired electric generating plants in western New York. In addition to our landfill-related work, we have also performed regulatory compliance work (SPCC, SWPPP, BMPs, etc.) and are currently guiding a major energy client through the New York State Brownfield Cleanup Program – showing our breadth of experience for the energy industry.

Our landfill experience covers from the investigation/evaluation phase of a project through to permitting, design, CQA and direct survey data upload for providing construction level layout and final survey certification.

Our landfill work in Rhode Island includes a number of firsts; including the first Brownfields Landfill Redevelopment (Manton Avenue Landfill/Stop & Shop Site in Providence where we used Deep Dynamic Compaction to lower grades and prepare building pads for construction); the largest actively operating landfill and Superfund site (the 330 acre Central Landfill in Johnston, RI), the first voluntary landfill assessment and closure under RIDEM's program (the Jamestown Landfill & Transfer Station in Jamestown) and geotechnical and landfill gas assessment for Rhode Island's first on-landfill solar development (Forbes Street Landfill, E. Providence, RI).

Technical expertise, innovation, and responsiveness are GZA trademarks that have earned us a national reputation as a high-quality firm. Our awareness of, and attention to, the commercial aspects of our clients' business also sets us apart from other environmental engineering firms. Specific to your needs, we have practical and proven landfill cell and closure design, ecological risk and restoration and extensive Superfund experience, and our organization makes that experience readily available. Our success on these projects is, in no small part, due to the strong relationship we have developed with EPA Region 1 and state regulators. GZA has the proven ability to overcome regulatory hurdles having demonstrated hybrid cap equivalency, negotiated two ESD's and one ROD modification at Rhode Island Superfund landfills. We note that the strength of these relations arise from respect for our technical expertise and our understanding of the regulations. We have invested significant time volunteering on numerous RIDEM task forces and our clients have benefited directly from these activities.

Detailed Project Descriptions are attached. A summary of the solid waste/remedial facilities are as follows:

"The GZA team understands National Grid's challenges and objectives, and consistently looks for ways to assist in meeting those objectives in accordance with regulatory requirements."

Elizabeth Greene, National Grid

Project Experience Relevant to Vectren Energy

1. Somerset Operating Company, LLC (fka AES Somerset, LLC), Barker, NY – Provided design and CQA services over the past 12 years for six sub-cell liners, final cover systems and sedimentation basin re-linings. Successfully obtained a Beneficial Use Determination (BUD), through the New York State DEC, to allow using coal ash for cell subgrade construction. Updated site wide SPCC, SWPPP, Spill Prevention Report and BMP. Currently providing design for: developing a final grading plan for balancing cut/fill volumes to provided proper grading to close out 35 acres of open cell area; final cover system including sizing drainage structures; quantifying available soil borrow for low permeability soil barrier.

2. NRG Dunkirk Power, Dunkirk, NY – Design and CQA services for construction of a 5.5-acre ash containment cell. Services also included a borrow source evaluation to determine the existing volume and adequacy of the borrow for use as a low permeability soil barrier.

3. NRG Energy, Huntley Station, Tonawanda, NY – Conducted an embankment stability assessment for a berm separating their settlement pond from the Niagara River. Our findings determined that the existing embankment had a low hazard classification and that no remedial construction was required. Currently providing environmental engineering services for their entry into the NYS Brownfield Cleanup Program.

4. Central Landfill, RI – Large Superfund/NPL landfill with multiple operable units; demonstrated RCRA C cap equivalency with a hybrid cap design; obtained No Action determination for OU2 thru focused human health and ecological risk evaluation.

5. Fresh Kills Landfill, Staten Island, NY – Large CERCLIS landfill closure (Phase 6/7 is 290 acres); challenges included overfilling and waste consolidation, mitigating wetland impacts, limited storm water management options; the landfill being transformed into a park.

6. McKenna Landfill, Orleans County, NY - Superfund landfill, located on the NY Barge Canal system. GZA's scope included capping alternatives evaluation; successful negotiation with numerous agencies including NYSDEC, NYS Canal Corporation and US Army Corps of Engineers.

7. Grant Gear Manufacturing facility, Norwood, MA – Superfund site, waste/soil excavation, consolidation, and capping; effective PRP advocacy in negotiations with US EPA Region 1 and Department of Justice; remedial strategy developed to result in cost-effective closure and to promote site redevelopment.

8. Allied Waste, Niagara Falls Landfill - RCRA Subtitle D Landfill 80-acre expansion involving reclamation of adjacent fill area and waste consolidation; design plans, specifications and procurement assistance; and complex construction phasing and management. Conducted a comprehensive hydrology/hydraulic study of this 370-acre site and provided design for a major re-direction of stormwater flows, incorporating 3 box culverts, and riprap drainage channels. We have provided permitting, design and CQA oversight continuously for over 30 years at this site.

9. Wyman Gordon Facility, N. Grafton, MA – PCB Risk-Based Clean-up (RBC) under EPA Region 1 TSCA. GZA consolidated PCB containing waste soils on-site and created a disposal cell with modified RCRA D cap. Clean-up goal for soil approved by EPA was an average concentration of ≤0.9 mg/kg with a maximum residual (point-by-point) concentration of 18 mg/kg.

10. Coventry Landfill, RI - CERCLIS landfill/State Superfund Site, work with large responsible party group, complex multi-media investigation, negotiated soil-only cap with State regulators, creative closure design allowing offset of closure cost thru a BUD soil program.

GZA Personnel

GZA personnel offers the talent, skills, desire, experience, and resources to provide a wide range of solid waste design and construction support services.

Senior members of GZA's Team bring over 80 years of solid waste design experience to benefit Vectren. Specifically, our personnel bring the following benefits:

- Proven successes designing and constructing complex landfill projects, including successfully demonstrating RCRA C cap equivalency using a hybrid cap design;
- In-depth regulatory experience and understanding, and a track record in developing successful working relationships with regulators;
- Pragmatic and cost-effective technical approaches that are flexible enough to address unanticipated changes and issues raised by stakeholders.
- Our proven ability to incorporate sophisticated geotechnical engineering principles into creative and cost saving designs.

Senior members of GZA's Team bring over 80 years of solid waste design experience to benefit Vectren.

Effective management on any project requires committing the right people to meet the technical, schedule, and cost challenges of the project. Effective management also requires clear and concise communication between project personnel, the Client and appropriate regulatory agencies and stakeholders. We believe GZA has the breadth of experience to provide Vectren with the highest level of quality and service to achieve the overall project goals.

Qualifications of key GZA Personnel are summarized below, with their resumes attached.

Bart A. Klettke, P.E. (NY) – Technical Design Lead. Mr. Klettke is a Principal with the firm and has over 35 years of professional experience. Klettke attained his Bachelor of Science Degree in Civil Engineering from Valparaiso University. He serves as the Solid Waste Technical Practice Lead for the entire company. He has permitted, designed, managed the construction of landfill liners and closures for many solid waste management facilities. He is experienced in performing and supervising landfill liner and closure designs, site civil designs, geotechnical investigations/designs, and CQA monitoring programs. His project experiences, highlighted on his resume, demonstrates the depth of his successes associated with solid waste facility liner design and closure engineering. His experience is illustrated in the Project Descriptions for the AES Somerset, NRG Energy, McKenna, Allied Waste and western New York landfill projects. As a Principal in the firm, he has the authority to implement the resources needed and oversee project execution to meet those needs and goals in a responsive and cost-efficient manner.

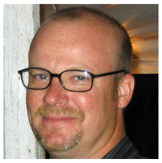
Edward Summerly, PG (RI). Edward Summerly, is a Principal with the firm and a registered Professional Geologist. He holds a Bachelor of Science Degree in Geology from the University of Rhode Island and a certification in Geological Field Studies from the University of Texas. Mr. Summerly has over 30 years of experience in the environmental engineering field. He has served as technical lead on numerous large multidisciplinary projects within the solid waste industry including the Central Landfill, Fresh Kills Landfill and Coventry Landfill projects. Ed's experience includes EPA Superfund studies and remediation, landfill permitting, and geohydrologic studies, site investigations, regulatory compliance, and environmental testing at more than 30 solid waste facilities in New England, New York and the Midwest. Ed has a broad environmental background, extensive landfill engineering experience, and landfill gas design experience along with his proven management capabilities. As a Principal and Sr. Vice President in the firm, he has the authority to implement the resources need by the GZA Project Team and oversee project execution to meet those needs and goals in a responsive and cost-efficient manner.

Todd Greene, PE (RI) - Project Manager - Design Services. Mr. Greene is a Sr. Technical Consultant with GZA and has 23 years of design experience on civil, landfill and environmental engineering projects. Specific project experience includes hydrology, storm water management, site grading, landfill baseliner design and landfill construction oversight, landfill capping design and cap construction oversight, and landfill gas collection system design. Notably and as presented on the Project Descriptions, Todd served as Project Manager and lead designer on the Fresh Kills Landfill, Central Landfill and Coventry Landfill closure projects.

Ted Klettke – Project Engineer/Designer. Ted Klettke has extensive landfill design and construction oversight experience. His designs incorporate 3-dimensional surface models for direct data upload for machine-control grading and survey certification. He is proficient in Sketchup Pro 3-Dimensional Modeling to portray easily understandable visual models of site and design features such as groundwater contours, buildings, subsurface features, and aerial topography for landfill-related designs. He has produced 3-Dimensional Virtual Walkthrough Videos of several work sites for presentations to clients, contractors and regulators.

"GZA has always been a pleasure to work with. Their knowledge, expertise and attitude are second to none and GZA delivers a quality product."

Ed Hughes, Massachusetts Department of Conservation and Recreation



Michael Kress – Assistant Project Manager. Mr. Kress has over 12 years of professional experience including geotechnical engineering, construction management, contracting, project budgeting and scheduling, oversight of MGP and brownfield remediation, development of storm water management plans and construction specifications. Michael has extensive field experience in geotechnical subsurface investigations, solid waste management facility design, construction, management, and construction quality assurance monitoring. His responsibilities have included management of subsurface exploration programs, monitoring well design and observation and logging of soil and rock samples. His AutoCAD skills have been utilized in the design and layout of landfill systems, details and Site plans.

References

Edward Segali Superintendent *Fresh Kills Landfill Project*	Tully Construction Co. 127-50 Northern Boulevard Flushing, NY 11368	718.446.7000
Claude Cote, Esq. Director of Regulatory Compliance and Safety *(Kahuku Wind Energy Clean-up Project)*	Sun Edison 179 Lincoln Street/Suite 500 Boston, MA 02111	207-480-0499
Michael Gray Public Works Director *(Jamestown Landfill Closure Project)*	Town of Jamestown 93 Narragansett Ave Jamestown, RI 02835	401.423.7225
Mark Zimmerman Operations Manager *(AES Somerset Ash Containment Facility)*	Somerset Operating Co. 7725 Lake Road Barker, NY 14012	716.696.2463

Ralph Larimore Environmental Manager *Allied Waste Niagara Falls Landfill*	Republic Services 5600 Niagara Falls Blvd. Niagara Falls, NY 14304	716.371.4222
George Streit Operations Manager *(NRG Huntley and Dunkirk Facilities)*	NRG Energy, Inc. 106 Point Drive North Dunkirk, NY 14150	716.200.2797
Brian Card Director of Engineering and Operations *(Central Landfill Project)*	RIRRC 65 Shun Pike Johnston, RI 02835	401.942.1430

Proactive by Design

PROJECT DESCRIPTIONS

GZA Solid Waste Statement of Qualifications:
December 30, 2019

Project Highlights

- **Design/Contractor Bid Solicitation**
- **Relined Active Retention Basins**
- **Construction Quality Assurance**
- **Engineering Budget: $240K; Construction Budget: $5.1 Million**

AES Somerset LLC Solid Waste Disposal Area II, Phases C & D Landfill Liner & Relining of Retention Basins

BARKER, NY

GZA provided engineering design and construction quality assurance (CQA) monitoring services for construction of a 14-acre landfill cell and relining of two active retention basins for this 675 megawatt, coal-fired electric generating station on the south shore of Lake Ontario in upstate New York.

GZA modified the existing engineering reports, drawings, technical specifications and QA/QC Plan to replace the original design geosynthetic clay liner (GCL) with an HDPE geomembrane in accordance with newly imposed regulatory requirements. We performed a slope stability analysis to demonstrate that the revised design was stable.

The design for relining the 2 retention basins required removal of existing pond sediments and relining the base and side slopes with 12 inches of low permeability soil and an HDPE geomembrane. The pond configurations were altered to maximize capacity and modifications were made to the pond inlet channels and outlet structures. We developed a dewatering plan to allow bypass of stormwater inflow during basin relining.

GZA developed construction-level drawings, technical specifications and a construction QA/QC plan to sufficiently define the proposed work in soliciting contractor proposals. Drawing development included establishing a 3-D computer model of the landfill layers for direct data transfer to the contractor and certifying surveyor. The 3 lowest contractor bids were within 3% of GZA's engineer's estimate for this $5.1 million project.

GZA provided CQA monitoring during the landfill subgrade and liner construction. The CQA program included density test monitoring and collecting undisturbed tube samples of the compacted clay liner. Monitoring of the geomembrane installation required detailed construction documentation including assigning destructive sample tests, observation of non-destructive tests and placement of overlying materials.

GZA coordinated between the Owner, earthwork and geosynthetics contractors, project surveyor and the regulator on a tight project schedule to complete the project within budget. GZA reviewed contractor submittals and prepared a construction certification report documenting the landfill cell construction.

GZA was retained in 2008 by AES Somerset to provide design and CQA monitoring services for construction of SWDA II, Phases E & F East (10 acres) in 2008 and 2010. GZA prepared construction-level drawings, technical specifications and a construction QA/QC plan to solicit contractor proposals.

Project Highlights

- Design/Contractor Bid Solicitation
- Construction Quality Assurance
- Prepared Beneficial Use Determination (BUD) Application for waste materials

AES Somerset LLC Solid Waste Disposal Area II, Phases E & E East Landfill Liner

BARKER, NEW YORK

GZA provided engineering design and construction quality assurance (CQA) monitoring services for construction of a 10-acre landfill cell for this 675 megawatt, coal-fired electric generating station on the south shore of Lake Ontario in upstate New York.

GZA developed construction-level drawings, technical specifications and a construction QA/QC plan to sufficiently define the proposed work in soliciting contractor proposals. Drawing development included establishing a 3-D computer model of the landfill layers for direct data transfer to the contractor and certifying surveyor.

GZA provided CQA monitoring during the landfill subgrade and liner construction over a two year period. The CQA program included performing density testing of the subgrade and clay liner materials. Bulk samples of these materials were collected and tested for physical parameters and compared to established specifications. Undisturbed Shelby tube samples were collected from the compacted clay liner to asses permeability properties. Monitoring of the geomembrane installation required detailed construction documentation including assigning destructive sample tests, observation of non-destructive tests and placement of overlying materials.

GZA coordinated between the Owner, earthwork and geosynthetics contractors, project surveyor and the regulator on a tight project schedule to complete the project within budget. GZA reviewed contractor submittals and prepared a construction certification report documenting the landfill cell construction.

GZA prepared an application for Beneficial Use Determination (BUD) to use a coal by-product (bottom ash) to be used as subgrade material to build the foundation of the landfill. The application was submitted to and subsequently approved by the NYSDEC. The use of this waste material in future cell construction will benefit the client by reducing the cost of fill soils purchased and imported from off-site sources.

Project Highlights

- Borrow Source Evaluation
- 3-D Landfill Cell Design with Leachate Forcemain
- Construction QA Monitoring

NRG Dunkirk Power, LLC
Solid Waste Management Facility, Cell B2
POMFRET, NEW YORK

GZA provided engineering design and construction quality assurance (CQA) monitoring services for construction of a 5.5-acre landfill cell for ash waste generated from the Dunkirk coal-fired electric generating station on the southern shore of Lake Erie in upstate New York.

GZA generated engineering reports, drawings, technical specifications and QA/QC Plan for construction of a landfill liner consisting of low permeability soil and HDPE geomembrane liner in accordance with newly imposed regulatory requirements. We also performed a slope stability analysis to demonstrate that the proposed design was stable.

The general design included preparation of subgrade soil and placement of required thickness of subbase soils within the Cell B2 foot print. A minimum two feet of secondary low permeability soil followed by one foot of primary low permeability soil and HDPE geomembrane liner and associated geocomposite and granular drainage layers. Soils used for Subbase and low permeability soils were mined from a NRG borrow pit located north of Van Buren Road, north of the Site. These borrow soils were determined to be suitable for their respected usage in the proposed landfill cell B2 as part of a borrow source evaluation completed by GZA. This evaluation included completion of over 20 test pits and several soil tests for sieve, moisture/density and low permability analysis. Our evaluation identified the borrow area had a sufficient volume of soil for use as Subbase and low permeability soils needed to be processed prior to placement and included increasing moisture and screened soil to less than 1-inch.

GZA also designed a double contained HDPE leachate forcemain to replace the existing system for the soil waste management facility. This new larger volume forcemain consists of an approximate 1,800 linear feet of piping to the connected between two existing manholes at the Site for eventual discharge into the facilities sedimentation ponds.

GZA developed construction-level drawings, technical specifications and a construction QA/QC plan to sufficiently define the proposed work in soliciting contractor proposals. Drawing development included establishing a 3-D computer model of the landfill layers for direct data transfer to the contractor and certifying surveyor.

GZA provided CQA monitoring during the landfill cell and leachate forcemain construction. The CQA program included density test monitoring and collecting undisturbed tube samples of the compacted clay liner. Monitoring of the geomembrane installation required detailed construction documentation including assigning destructive sample tests, observation of non-destructive tests and placement of overlying materials. GZA also observed and documented the construction and testing of leachate collection pipies and associated manholes and the construction of the leachate forcemain pipe.

GZA coordinated between the Owner, earthwork and geosynthetics contractors, project surveyor and the regulator on a tight project schedule to complete the project within budget. GZA reviewed contractor submittals and prepared a construction certification report documenting the landfill cell construction.

Project Highlights

- Subsurface Soil Borings
- Embankment Evaluation
- Utilization of PCSTABL (version 6) Slope Stability Program

NRG- Huntley Power, LLC
Embankment Stability Assessment
TONAWANDA, NEW YORK

GZA was engaged by NRG to drill three (3) test borings to observe subsurface conditions and provide an embankment stability assessment of the facilities embankment which is situated between an on-Site ash settlement pond and the Niagara River and is located in the southern portion of the NRG Huntley Power Plant. An existing discharge pipe is present within this embankment that allows surface water to drain from the settling pond to the Niagara River. GZA completed the following scope of services for this project:

- Retained the services of our drilling subcontractor to complete three test borings at the Site for collection and classification of soil samples. Two borings were done in the embankment area on each side of the existing discharge pipe and one test boring was done in an area of presumed undisturbed soils located south of the settlement pond and discharge pipe. Ground water measurements were also made from within the drilling augers at the completion of each test boring.

- Selected overburden soil samples were tested by GZA's geotechnical laboratory for moisture content and grain size analysis (i.e., sieve and hydrometer tests). Additionally, one Shelby tube sample was collected from a layer of fine grained soils (located below the embankment and associated settlement pond) and was submitted to our soils laboratory for consolidated undrained triaxial testing and unit weight determination.

- Ground surface elevations in the area of the embankment area were measured by our subcontracted land surveyor. The ground surface elevations and locations of the three test borings were recorded, as well as, existing embankment features including rip-rap location, the shoreline of the Niagara River the settlement pond water level, and discharge pipe inverts, among others. These locations were tied into an existing Site benchmark that was provided by NRG for our use with plan and cross-section figures.

- The evaluation included an assessment of the embankment stability via the slope stability analysis program PCSTABL (Version 6) assuming circular and block failures and calculations for infinite slope analysis. The program and calculations were completed with internal friction angles and cohesion values obtained from lab test results and published values for similar materials to provide an assessment of the existing conditions at the Site.

- GZA prepared an evaluation report that summarized the findings of the completed subsurface explorations, laboratory testing program, and embankment evaluation. Our findings determined that the existing embankment would have a hazard classification of low to remote and that a more detailed stability analysis was not warranted at this time.

Central Landfill- Rhode Island Resource Recovery Corporation

Johnston, Rhode Island

GZA's success on RIRRC projects at the Central Landfill is the result of a highly motivated GZA Team, technically challenging objectives and high client expectations. GZA has enjoyed a 30-year history with the Rhode Island Resource Recovery Corporation (RIRRC) as their environmental and engineering consultant. During this contract, we have undertaken more than 300 tasks, many of which are ongoing. Our services have included: general regulatory compliance consulting, monitoring and reporting of surface water (RIPDES program), groundwater (RIDEM Solid Waste Program and EPA Superfund Program), soil gas/landfill gas, radon and waste water (IWDP/DMR Program); Phase I/II Environmental Site Assessment and property acquisition support; public relations assistance; solid waste facility permitting; wetlands permitting and reconstruction; SWPPP, SPCC and BMP plan development and training; air emission permitting, monitoring, and GHG reporting; geohydrologic studies; UST/AST management and closure; ecological/habitat studies; construction support and certification to name a few.

While too numerous to list, the highlights of several are presented below.

Superfund Remedial Investigations (OU1 and OU2)

GZA has completed two remedial investigations at the facility for RIRRC under State and Federal guidelines for Superfund studies. The first, Operable Unit 1, evaluated the nature and extend of solid and hazardous waste within the source area – a 121-acre unlined landfill that operated from 1955 to 1993. The second study, Operable Unit 2, evaluated the extent of offsite contaminant migration via surface water and groundwater flow, landfill gas migration and air-borne contamination.

Project Highlights

- Provided full range of environmental engineering and regulatory compliance support services for 2,000-4,000 ton/day facility
- Landfill planning, design, permitting and expansion construction support
- Oversaw closure of 121-acre RCRA C Superfund Landfill and 33-acre RCRA D Landfill
- Designed, installed and operate two groundwater pump & treatment systems for contaminants in bedrock
- Sampling and analysis of surface water, groundwater, soil, soil gas, landfill gas and waste and evaluation of regulatory compliance
- GZA has enjoyed a 30 year history with the Rhode Island Resources Recovery Corporation as their environmental consultant
- In implementing studies and developing appropriate solutions, GZA worked actively and successfully with RIRRC, Town officials, EPA, RIDEM and local Citizens group.
- To date, GZA has logged more than two million records of chemical testing data into our database system on behalf of the RIRRC.

Central Landfill- Rhode Island Resource Recovery Corporation

Johnston, Rhode Island

Our work included:

- Surficial and borehole geophysical analysis;
- Shallow and Deep monitoring well installations;
- Groundwater, surface water, soil, sediment, air, landfill gas and waste sampling and analysis;
- Aquatic toxicity testing;
- Human health and ecological risk assessment following State and Federal guidance;
- Data evaluation, management and reporting;
- Participation in public workshops, public meetings and hearings.

Our work products, technical opinion and recommendations have consistently been accepted by the USEPA, RIDEM and the Army Corp of Engineers (ACOE).

Environmental Compliance and Monitoring

This category includes a wide variety of related and unrelated environmental tasks. Most tasks are required by RIDEM regulations, EPA Superfund or Clean Air Act mandates, or local requirements (e.g., Cranston Sewer Authority, Town of Johnston) Our services have included:

- Sampling, Testing and Reporting for the Storm Water Discharge (RIPDES)
- Sampling, Testing and Reporting of Groundwater conditions as required by RIDEM Solid Waste Regulations and EPA Superfund Requirements
- Sampling, Monitoring and Reporting of Surface Landfill Gas Emissions
- Air Emissions Permitting and Annual Inventory Reporting
- Alternative Cover Materials Testing and Evaluation
- Waste Water Monitoring and Reporting (IWDP/DMRs)
- Wetland Delineation and Permitting
- Emergency Response Actions
- Regulatory Meetings and Presentations
- Property Transaction Site Assessments

We use the Equis System by EarthSoft, a sophisticated chemical and geological information database with GIS capabilities through ArcView, to manage, analyze and report on compliance monitoring programs. To date, GZA has logged more than two million records of chemical testing data into our database system on behalf of the RIRRC.

Landfill Closures

As part of our Superfund work for RIRRC, GZA conducted feasibility studies to evaluate innovative waste capping and groundwater migration control methods. Our work formed the basis for the closure of the 121 acre unlined Phase I Landfill. GZA also acted as RIRRC's technical representative on the Phase I RCRA C cap design and installation project overseeing this multi-year/multi-million dollar project which was competed in 2006.

GZA designed the RCRA D caps for both the Phase II and III Landfill (33-acres in all). The capping systems used for these projects are suitable for active solid waste landfills (i.e., RCRA D) or hazardous waste landfill (i.e., RCRA C). They incorporate a synthetic membrane liner, low permeability soils, and sophisticated geotextile drainage systems to promote stability and prevent erosion.

Groundwater Containment System

GZA conducted state of the art bedrock fracture flow modeling using Fracman/MAFIC code to assess containment migration in waste, overburden and bedrock. This model was accepted by both EPA and RIDEM and then used by GZA to design an efficient groundwater containment pump and treatment system as part of the Superfund remedial actions. The system consists of an air operated groundwater extraction pump, an equilization tank and defoaming system, a shallow tray air stripper and 2,100 feet long double-wall conveyance piping system. GZA installed and operates the system, on behalf of RIRRC, which has removed and treated more than 6,000,000 gallons of highly contaminated groundwater.

Permitting, Design, and Construction Management of the Relocation of Cedar Swamp Brook and Associated Wetlands for Landfill Expansion

Cedar Swamp Brook was an existing waterway and associated wetland corridor located along the southerly toe of the existing 200 acre landfill. In order to expand the landfill, the relocation of approximately 7,500-feet of the existing brook channel was undertaken by the RIRRC, in two phases, to make way for a new 44-acre lined landfill (Phase

Central Landfill- Rhode Island Resource Recovery Corporation

Johnston, RI

IV) and a new 33-acre landfill (Phase V). The stage 1 permitting process had taken a serious time setback and was into its sixth year when GZA was brought on-board. Approval for the stage 1 brook relocation was obtained within three months of GZA's project involvement. GZA was then retained for the entire design and permitting process for the second stage of relocation which was completed in only 2.5 years. GZA also provided procurement services, construction oversight and management for both stages of relocation. This project involved significant habitat assessment and hydrologic modeling; stream channel relocation via bedrock blasting and removal; and installation of compensatory riparian wetlands.

Contracting Agency (Client)
Rhode Island Resource Recovery Corporation
65 Shun Pike, Johnston, RI
Mr. Michael O'Connell
Executive Director
(401) 942-1430

Date of Project:
1984 – on-going

Consulting Fees:
$5+ million

Project Team Members:
GZA GeoEnvironmental, Inc.

Principals-in-Charge:
Edward A. Summerly, P.G.

Project Managers:
Igor Runge, PhD, P.H.
Todd R. Greene, P.E.
Richard A. Carlone, P.E.
Anthony Urbano, P.E.

PROJECT PROFILE

Freshkills Landfill, Sections 6 and 7 Design/ Build Services

Staten Island, NY

Project Highlights

- Provided complete design including construction drawings for 285-acre Landfill Cap and Landfill Gas Collection and Central Alarm
- Provided value engineering services with project savings of approximately $5,000,000
- Overall Closure design and Phase 1 constructon drawings completed in 3 months
- Value engineering and re-design of proposed landfill gas collection system resulted in superior gas collection and significantly reduced emissions

GZA was retained by Tully Construction Co. to complete all engineering design task associated with the a 285-acre landfill in closure at the New York City Department of Sanitation's (DSNY's) Fresh Kills Landfill, Section 6/7 located on Staten Island, New York.

The Fresh Kills Landfill facility is owned and operated by DSNY. The Section 6/7 landfill closure project was contracted by DSNY as a construction design/build project. The closure permit documents were prepared by Malcolm Pirnie, Inc for the DSNY. The permit documents were utilized for the design/build contract documents. GZA's responsibilities were to review the permit documents and develop construction plans and details, which met the intent of the permit and complied with the New York State Department of Environmental Conservation's (NYSDEC's) landfill closure regulations, Part 360. The final construction documents were reviewed and approved by both the DSNY and NYSDEC prior to commencing with construction activities. GZA worked directly with DSNY on all closure design components and addressed NYDOS design comments as required to expedite the approval process to start construction activities.

Subsequent to the overall closure design, GZA provided value engineering services for Tully and prepared engineering calculations and design modifications to DSNY for review and approval. GZA's value engineering services included alternate geocomposite drainage layer design, develop construction sequencing plans to manage stormwater runoff during construction, landfill gas conveyance modifications to reduce head loss, promote condensate drainage, minimize system maintenance requirements, and grading modifications to reduce general fill and embankment fill quantities. These modifications streamlined the construction process and schedule, saved DSNY millions of dollars on geocomposite drainage net cost, soil material cost, increase landfill gas recovery rates and provided a better end product for our client and DSNY.

Freshkills Landfill, Sections 6 and 7
Design/ Build Services
Staten Island, NY

GZA prepared intial working drawings for the overall landfill closure design and prepared subsequent temporary working drawings, final working drawings and construction as-builts for each phase of the construction. The landfill closure was divided into five (5) phases with intial working drawings and Phase 1 temporary working drawings prepared in the winter and spring of 2006. Phase 1 construction was intiated in the spring of 2007 and Phase 5 construction was completed in Fall of 2011. GZA submitted the final construction as-built plan package to Tully and DSNY in the Spring of 2012. The overall landfill cap design incorporated future end use components as provided by DSNY, for a recreational park and future roadway expansions associated with Yukon Avenue.

GZA provided full time project Quality Control (QC) and landfill gas system construction support during Phase 1 of construction. GZA's QC engineer monitored construction and reviewed constructed portions of the landfill cap for compliance with the construction drawings and project specifications. GZA's QC engineer reviewed all material testing data associated with the project, which included analysis (both structural characteristics and environmental), geomembrane testing and pipe pressure testing. The QC engineer review construction as-builts as it pertained to the design intent and compliance with Part 360 and provided all QC data to DSNY for construction certification.

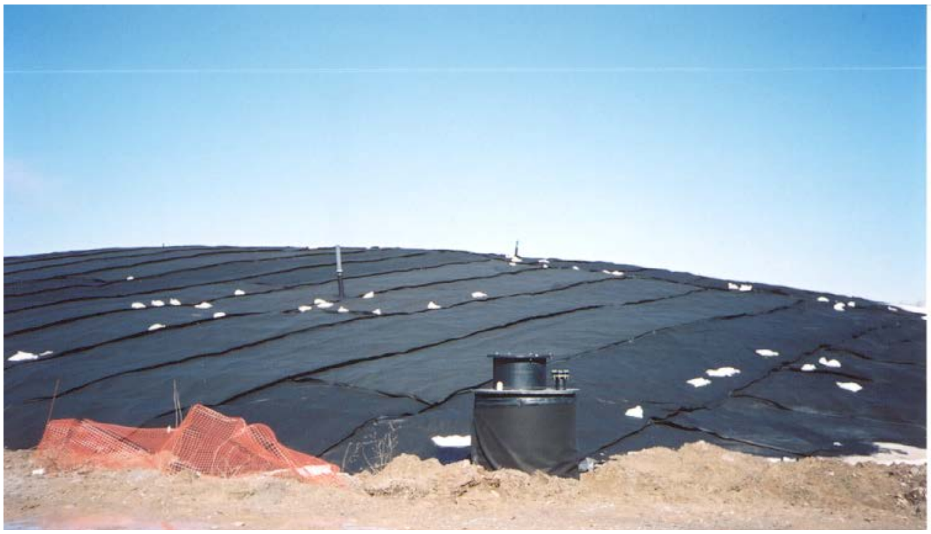
Throughout the construction process GZA attended DSNY's weekly construction meetings as requested by Tully and or DSNY to interact with DSNY and ensure the landfill cap construction is completed per GZA's construction drawings and details, address any field modifications to the design to ensure the construction process progressed efficiently and in a timely manner without interruptions.

GZA's engineering design tasks included all aspects of landfill closure design including the following:

- Geotechnical and slope stability analysis;
- Geosynthetic and geomembrane design:
- Developing subgrade and finish grading plans;
- Stormwater management and conveyance (hydrologic and hydraulic design);
- Swale and downchute layout and design;
- Landfill gas collection and control systems; including custom wellhead and vault designs;
- Material quantity estimates;
- Construction drawings;
- Approval of Contractor Shop Drawings;
- Provide recommendations for construction sequencing;
- Field Construction Oversight and Construction Certification;
- On-site QC testing including pneumatic pressure testing; confirmation of pipe pitches via as-built survey;
- Provided construction recommendations for piping and vault installations and critical connections to existing header pipes and flaring systems;
- Provided construction sequencing recommendations for landfill gas header switch overs and temporary header placement to maintain active gas collection during construction activities;
- Direction of remedial measure needed to meet the design intent; and
- Project documentation.
- Worked closely with the gas system operator and developed detailed system switchover procedures to allow the continued operation of the existing systems during construction and a seamless transfer to the new systems components upon their completion.

McKenna Landfill Closure

Orleans County, NY



Project Highlights

- Successful coordination and negotiation with numerous agencies including NYSDEC, NYS Canal Corporation and US Army Corps of Engineers
- Pre-design investigations allowed better determination of material quantities for remedial design
- Use of geosynthetic components reduces quantities of soil materials needed, shortened construction schedule and lessened remedial construction costs

The McKenna Landfill was listed on the New York State Registry of Inactive Hazardous Waste Sites as a Class 2 site. It is approximately 1800 feet long by 500 feet wide and consists of about 20-acres. The New York State (NYS) Barge Canal adjoins one side of the landfill. A proposed remedial action plan and "Record of Decision" were issued by the New York State Department of Environmental Conservation (NYSDEC). GZA GeoEnvironmental was retained to provide remedial design and observe, test and document remedial construction. Prior to remedial design, GZA collected additional site data through a site reconnaissance, land surveying, test pit and test boring explorations, installation of groundwater monitoring wells, landfill gas survey, wetland delineation and leachate collection/analysis.

Perimeter Clay Cutoff Wall

Our remedial design incorporated a plan to recover existing cover and fill soils for reuse. The closure design included a perimeter barrier wall system consisting of both a compacted clay wall and an 1800 lf soil-bentonite slurry wall, a geosynthetic landfill gas/leachate collection blanket, a perimeter leachate collection system, a gas venting system and a soil/geosynthetic composite final cover system. Additional analysis was done to evaluate the impacts of seasonal draining of the adjacent NYS Barge Canal on the soil-bentonite barrier wall and leachate collection system. We also made an evaluation of various final cover systems with comparative costs. In addition to remedial design, a surface water management plan, a post-closure maintenance and monitoring plan, and an environmental monitoring plan were prepared.

Following remedial design and its approval by the various agencies, GZA prepared construction contract drawings for competitive bidding. We remained involved during the bidding process through participation in the pre-bid meeting, prepared meeting minutes and contract addendum, and analyzed the bids received.

McKenna Landfill Closure

Orleans County, NY

During remedial construction, GZA provided construction administration, engineering and construction quality assurance/quality control observation and testing. This work involved soil laboratory testing (including permeability and direct shear), field testing for compaction and geomembrane seam strength, and observation of the work done for comparison to project specifications. A construction certification report was prepared and submitted to NYSDEC. Our report was approved and the Site is currently in post-closure monitoring.

PROJECT PROFILE

Grant Gear PCB Superfund Site

Norwood, MA

Project Highlights

- Excavation, consolidation, and capping
- Effective PRP advocacy in negotiations with US EPA Region 1 and Department of Justice
- Remedial strategy developed to result in cost-effective closure and to promote site redevelopment
- Brownfields Redevelopment
- Building demolition, stream diversion, sediment and soil consolidation and capping

In two distinct efforts, GZA has assisted the Potentially Responsible Parties (PRPs) with evaluation of site conditions and remedial response actions at the Norwood PCB Superfund site in Norwood, Massachusetts. In 1984, GZA assisted Grant Gear Realty Trust, a PRP that had previously operated a capacitor manufacturing business on the property, with an assessment of site conditions to evaluate the potential for off-site migration of PCBs by air and surface water transport. Using a combination of low-cost, PCB-screening techniques developed by GZA for this project and EPA-approved analytical methods, PCBs were measured in soils and sediment. Based on GZA's exposure assessment, the State of Massachusetts implemented immediate remedial measures at the site, which included installation of a temporary cap of geotextile and crushed stone over selected contaminated areas. Later, a U.S. EPA contractor prepared the RI/FS, which formed the basis of the Record of Decision (ROD).

In 1995, GZA's multi-disciplinary team of engineers and scientists was retained by three of the Potentially Responsible Parties for this Superfund Site to re-evaluate the costly, over-designed 1989 ROD. GZA developed equally protective, yet much more economical and conducive to redevelopment, remedial alternatives for the site cleanup that led to EPA's reconsideration of the ROD for the site and the amendment of the remedial plans for contaminated groundwater, soil, sediments and the on-site facility.

This work, which focused on both evaluation of site-related risks and selection of feasible remedial alternatives, was performed in response to the technical and financial impracticability of U.S. EPA's remedy specified in the 1989 ROD. U.S. EPA's initial remedy included groundwater extraction and treatment; on-site solvent extraction of PCB-contaminated soils and sediments from the adjacent Meadow Brook; and, the decontamination of machinery and surfaces in the on-site building to

Grant Gear PCB Superfund Site
Norwood, MA

remove PCBs. However, due to the high cost and difficulties with implementing the ROD as well as the initially selected remedial strategy's interference with site redevelopment, EPA considered changing the remedial strategy for site soils. GZA's work in this phase of the project included:

- Participation in negotiations with EPA and DEP regarding the remediation of this Site.
- The development of human health and ecological risk-based cleanup levels.
- The development of a defensible Maximum Acceptable Sediment Concentration (MASC) for PCBs in the sediments of a stream adjacent to this CERCLA site. The MASC was based on bioconcentration/ bioaccumulation modeling of PCBs through the food chain using raccoons as receptor organisms.
- The delineation of soil and sediment cleanup areas using risk-based target levels.
- An assessment of the need to maintain the already installed EPA groundwater extraction and treatment system.
- The development of cost-effective remedial options that would promote site reuse, including soil consolidation and capping, source removal, building demolition and long-term groundwater monitoring.
- An evaluation of feasible remedial options using CERCLA alternative evaluation criteria.
- The preparation of a detailed analysis comparing the benefits of our strategy to those of EPA's strategy.
- The development of cost estimates for the remedial strategies evaluated during the analysis.

The site remedy proposed by GZA included: extensive consolidation of contaminated soils and sediment followed by installation and maintenance of a multilayer asphalt and geotextile soil cap; removal of sludge from the building's drainage system and in-place closure; demolition of the building (containing asbestos, lead paint and PCB contamination) and capping of the building slab; and, source control coupled with long-term monitoring of contaminated site groundwater. GZA's proposed remedial strategy, which was accepted by EPA in an amended ROD, was a protective, highly implementable option, which cost-effectively promoted redevelopment of the property. This re-evaluation of the proposed CERCLA cleanup, coupled with a proactive legal strategy, resulted in substantial cost savings to the PRPs, as well as quicker attainment of site closure.

Throughout the negotiations with EPA, the PRP's utilized GZA's cost estimates for the remedial alternatives in their decision making process. They also used these estimates to seek cost recoveries under their insurance policies. GZA's willingness to perform the remediation on a fixed price basis for our cost estimate facilitated resolution of the dispute with EPA and convinced the PRP's to take the lead in performing the remediation.

GZA was subsequently contracted by the PRP's to implement the remedy to regulatory sign off on a negotiated fixed price basis. GZA prepared plans, specifications, and work plans for building demolition within one month of issuance of the Consent Agreement. We completed the building demolition by the end of 1996 within four months of Contract award, meeting one of EPA's goals. GZA developed innovative methods for managing demolition debris onsite by incorporating it into the overall cap design, which substantially lowered the project costs.

GZA then prepared the plans, specifications and work plans for the remaining work, which was conducted during 1997 and 1998. This work included:

- Diversion of the stream, utilizing pumps with a combined capacity of 18 mgd;
- Removal of the stream sediments in the "dry" using standard earthwork equipment;
- Consolidation of material onsite;
- Assessment of excavation limits utilizing field screening immunoassay techniques; and
- Capping of the contaminated material including sediments with a geotextile and 6 inches of asphalt.

In addition to the remediation, the Site has been redeveloped

Grant Gear PCB Superfund Site
Norwood, MA

as a retail facility. GZA was contracted to perform certain aspects of the redevelopment including installation of subsurface utilities and of the storm water management system to limit potential future exposure to site contaminants and development of site-grading and building plans that meet both remedial and redevelopment objectives. In addition we designed a vapor barrier to protect building occupants from potential vapor intrusion.

Following redevelopment as a retail center in 2008, the Site was delisted from the NPL in 2011.

PROJECT PROFILE

Allied Waste Niagara Falls Landfill, LLC
Sanitary Landfill VIII- Subareas A through F

Niagara Falls, NY

GZA performed a State Environmental Quality Review Act (SEQRA) permit application for an 84-acre landfill expansion. The proposed expansion involved remediation/removal of long-existing industrial fill to allow landfilling operations to continue for another 15 to 20 years. Excavation of a former on-site hazardous waste treatment facility with disposal off-site at a permitted hazardous waste facility is one of the benefits of the project. The landfill expansion effectively transformed this industrial "Brownfield" into an aesthetically pleasing "Green Space". These positive aspects of the project allowed Allied to procure the expansion permit with little to no public opposition.

Our design required removal of about 2.2 million cubic yards of waste lime from the landfill expansion footprint and disposal of the waste back into the constructed cells. About 1 million cubic yards of lime was left in-place with the landfill cells partially constructed over the lime. The design called for the surface of the lime to be graded at a steep slope (about 6 to 10 percent) to account for consolidation upon filling.

The landfill design met 6 NYCRR Part 360 regulations having a double-composite liner system consisting of primary and secondary (drainage geocomposite) leachate collection systems and two low permeability barriers covered with HDPE geomembranes.

GZA prepared contract bid documents to solicit and evaluate contractor proposals for construction of the first two Subareas A & B, in 2006. The bid documents quantified different on-site fill types for excavation and removal or use as subgrade construction material. Disposal of excavated waste into Allied's active cell occurred concurrent with regular landfill disposal activities. Costs for constructing Subarea A and the west part of Subarea B, completed in 2006-2009, came under budgeted costs and the project was completed on schedule.

Project Highlights

- Active facility, receives approximately 2,500 tons of waste per year
- SEQRA Permit Application – 84 Acre Landfill
- Large Volume Management of Existing Industrial Fill
- Design/Contractor Bid Solicitation
- Construction Quality Assurance Oversight

Contracting Agency (Client)-Allied Waste Niagara Falls Landfill Division of Republic Services

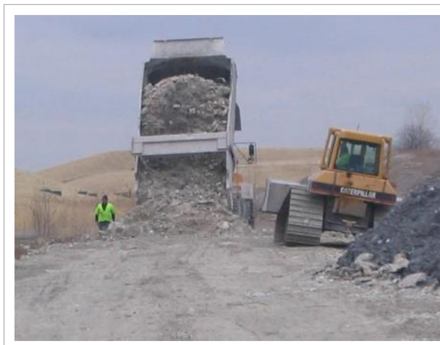
Mr. David Grenier, Division Manager,-(716) 285-3344

Date of Project: 2005 – on-going

Consulting Fee: $5,000,000

Project Team Firms:-GZA GeoEnvironmental, Inc.

Project Personnel-Bart A. Klettke (PIC), P.E., John Beninati, Ted Klettke, Dan Wulf



Allied Waste Niagara Falls Landfill, LLC
Sanitary Landfill VIII, Subareas A through F
Niagara Falls, NY

GZA performed construction quality assurance (CQA) monitoring and soils and geosynthetics laboratory testing in our Buffalo and Hopkinton, Massachusetts labs. GZA directed investigations and assigned analytical lab testing of suspected contaminated soils, including known areas having polychlorinated biphenyl (PCB) contamination. Based on these investigations, GZA directed remedial excavation and off-site disposal of the contaminated soils into a permitted hazardous waste facility. GZA prepared a final construction certification report for approval by NYSDEC.

Subsequent development of the east portion of Subarea B (7 acres) and Subarea C (18 acres) occurred on an accelerated schedule in the years 2010, 2011 and will continue thru 2012 to facilitate managing the large amounts of waste required to be excavated and placed in the newly built landfill cells. To date (Jan. 2012), over 1 million tons of waste have been relocated to facilitate new cell construction.

Wyman-Gordon – West PCB Area

North Grafton, MA

The Wyman-Gordon facility is a large aerospace forging facility with multiple OHM sources and releases that occurred from the 1940s through the 1970s. Investigation and remediation of historic contaminant releases are being managed under the Massachusetts Contingency Plan (MCP) and the federal Resource Conservation and Recovery Act (RCRA) Corrective Action Program. The West PCB Area is a historic dumping area for industrial and laboratory refuse, forge operation by-products, and building refuse and asphalt rubble from various construction projects. The historic dump was located partially on Wyman-Gordon property and partially on an electrical power transmission corridor owned by the regional power distribution company. During the site investigation field work several empty and crushed barrels, other refuse, and black fill material were observed deposited on the edge of a wetland area. Subsequent analytical results for this area reported concentrations of PCB Aroclor 1254 as high as 1,832 mg/kg in wetland soil, and as high as 32,500 mg/kg in the upland soil/fill material. The West PCB Area also contains historic disposal pits for industrial by-products including acid waste neutralization sludge, descaling salt cake/salt sludge, and aluminum dross.

The West PCB Area remediation is being implemented under the MCP, RCRA, and as a Risk-Based Clean-up (RBC) under the federal Toxic Substances Control Act (TSCA; 40 CFR 761.61(c)). GZA secured final approvals from the US Environmental Protection Agency (USEPA) for the RBC under TSCA in October, 2014. Based on GZA's human health and environmental risk assessments for the site EPA approved clean-up goals of:

- A total PCB concentration ≤ 3.4 mg/kg for wetland soil, on a point-by-point basis.
- And average total PCB concentration of ≤0.9 mg/kg within the top three feet of upland soil within the excavation area.
- A maximum residual total PCB concentration of ≤18 mg/kg in upland soil on a point-by-point basis.

Project Highlights

- PCB Risk-Based Clean-up under TSCA
- USEPA approved risk-based goals range from:
- Average of 0.9 mg/kg in surficial soil
- 18 mg/kg not to exceed
- 3+ acres of upland remediated
- 0.9 acres wetland remediated
- 7,795 tons of >100 mg/kg PCB soil shipped to hazardous waste landfill via on-site rail siding
- 5,143 yds3 of ≤100 mg/kg PCB soil consolidated beneath on-site low permeability cap
- Non-friable asbestos management and disposal effectively integrated with PCB remediation

Wyman Gordon – West PCB Area

North Grafton, MA

By agreement with the property owner of the electrical power transmission corridor, the clean-up goal for upland and wetland soil on the transmission corridor was <1 mg/kg on a point-by-point basis.

GZA also secured several other permits and authorizations related to wetland protection, dewatering and water treatment and discharge, and erosion control.

The remediation program consisted of excavation of PCB contaminated soil to reach the clean-up goals, and restoration of the disturbed upland and wetland areas. PCB contaminated soil with concentrations >100 mg/kg PCBs were trucked to a rail-road siding located on a different area of the 200 acre Site, and transport by rail to the Wayne Disposal Inc. (WDI) facility in Belleville, Michigan which is licensed to accept RCRA and TSCA wastes. Excavated soil with ≤100 mg/kg PCBs were consolidated on-site and covered with an engineered low permeability cap.

The approved plan included confirmatory sampling of the excavated sub-grade and sidewalls on a 25-foot grid. The ultimate depth and extent of the excavation was based on the results of iterative confirmatory sampling rounds to show that the clean-up goals had been met.

Other aspects of the project included:

- Excavation took place under 345kV transmission lines and distribution poles. The utility approved a geotechnical pole stability analyses prepared by GZA to define a "stability cone" around each pole to define how close and deep to each pole the excavation could advance without temporary shoring of the pole structures.
- Construction of an asphalt decontamination pad and water collection sump where heavy equipment and trucks could be de-contaminated using Metal X/Pipe X detergent when moving from higher to lower contaminated portions of the site, or when moving off-site.
- Dewatering wetland excavation areas, and on-site treatment and discharge of approximately 3 million gallons of dewatering and decontamination water under a NPDES Remedial General Permit.
- Establishment of a clean-travel way and loading area to avoid decontamination of earth moving/rock trucks being used to transport PCB contaminated soil approximately 1-mile to a rail siding located on the east side of the WG facility.
- Establishment of a containment and loading area at the on-site rail siding where PCB contaminated soils could be dumped without contaminating tires of the off-loading truck, and to facilitate containment and daily clean-up of the loading area to avoid release of contaminated particulates to the surrounding area.
- Broken pieces of corrugated, cementitious, asbestos-containing building materials ("transite") were observed in the PCB contaminated fill early in the remediation project. GZA developed and gained approval for an asbestos management and monitoring plan that allowed the project to move forward with minimal disruption and added expense.
- The regulatory agencies approved the use of a low permeability cap for consolidated PCB contaminated soils which was also designed to cover the historic sub-surface disposal pits to minimize contact between hazardous materials in the pits and infiltrating storm water.

GZA performed construction over sight, and acted as the general contractor for the remediation work. The following work accomplished:

- Approximately 7,795 tons of PCB-contaminated soils with concentrations >100 mg/kg PCBs were excavated and transported by rail to the WDI facility.
- Approximately 5,143 cubic yards of soils with concentrations ≤100 mg/kg PCBs were excavated and consolidated on-Site beneath the low permeability cap.
- The one acre low permeability cap has been completed and stabilized.
- Approximately 2.1 acres of upland (not including the cap area) have been restored and stabilized.
- Approximately one acre of vegetated wetland has been restored and stabilized.

As of the end of the 2015 construction season the West PCB remediation field work was largely completed. A small area with PCBs >100 mg/kg was discovered in an unexpected location based on confirmatory sampling results. In addition, soill with PCB concentrations above the ≤1 mg/kg clean-up goal was left within the "stability cone" adjacent to the some of the powerline poles. WG and the land owner are in discussions regarding the disposition of those soils. We expect the remediation to be completed in 2016.

Former Coventry Landfill
Site Investigation, Remedial Action Work Plan and Landfill Closure

Coventry, Rhode Island

GZA was selected through a quality-based competitive process by the Coventry Landfill Performing Parties Group (CLPPG) for environmental engineering services needed to evaluate and close the town landfill. The inactive landfill is included on the RI Department of Environmental Management's (RIDEM's) State Solid Waste Facilities/Landfill list and "State Sites" inventory. It is also inventoried on the USEPA's CERCLIS list (list of potential Superfund sites). As such, the Coventry Landfill is subject to numerous regulatory programs, most notably RIDEM's Solid Waste and Site Remediation Programs.

The approximately 27-acre Site is owned by the Town of Coventry, Rhode Island. The Town operated landfill accepted municipal waste and lesser amounts of commercial/industrial waste, including drum cleaning and reclamation liquids, for land-disposal between approximately 1945 and 1975.

GZA's investigation was conducted in accordance with a ***Site Investigation Work Plan***. The investigation involved the collection, screening and laboratory testing of soil, groundwater, landfill gas and soil vapor samples. In addition, GZA performed a soil vapor survey of the down-gradient neighborhood, a soil vapor extraction pilot study and a groundwater remediation pilot study. The studies found:

- The lateral The lateral extent of buried waste exceeded the previously defined waste disposal area by several acres;
- Although the existing landfill cover materials met the required minimum thickness of 2-feet, the existing site grading and storm water management systems were inadequate to prevent ponding and soil erosion;
- Groundwater quality was impacted both on-Site and off-Site in the downgradient area;
- A contaminant hot spots was identified within the waste cell;
- The SVE pilot study and landfill gas survey show the need to control methane within the waste cell to prevent off-Site migration.

Project Highlights

- Investigations and cleanup under RIDEM's Closure Policy for Inactive and Abandoned Solid Waste Landfills
- CERCLIS/State listed property
- Closure requirements address both Site Remediation & Solid Waste regulatory programs
- Off-Site contaminant migration driving groundwater remediation and vapor intrusion evaluation
- In developing our work scope, evaluating our findings and developing remedial alternatives, GZA worked actively and successfully with the CLPPG members
- A portable landfill gas flare will be installed beneficially reuse landfill methane to destroy VOCs extracted by the SVE system
- Closure will use 300,000 cubic yards of impacted soil for shaping and grading, significantly reducing landfill closure costs

Former Coventry Landfill
Site Investigation, Remedial Action Work Plan and Landfill Closure

At the conclusion of the investigative phase, GZA completed a Remedial Action Work Plan (RAWP). The RAWP was prepared to address the applicable requirements of RIDEM's Remediation Regulations, as well as their Solid Waste Regulations and Closure Policy for Inactive or Abandoned Solid Waste Landfills. The recommended and approved alternative for closure of the landfill consists of the following actions which incorporated a combination of remedial measures to address the requirements of applicable regulatory programs:

- Increase the thickness of the soil cap so that all areas of the Site that received municipal solid wastes are provided with the equivalent of a soil cap thickness of not less than two feet.
- Use approximately 300,000 cubic yards of lightly impacted controlled fill materials under a beneficial use determination (BUD) to shape the subgrade in order to establish proper design grades prior to installation of a new final clean soil cap.
- Re-graded the Site, as necessary, to meet a minimum drainage slope of 3% and maxim stable slope (i.e., 3:1) to control erosion, reduce infiltration and manage stormwater drainage.
- Installation of a soil vapor extraction system (SVE) as part of the landfill closure to address aromatic and chlorinated VOCs within the Hot Spot waste and reduce methane levels within and around the waste cell.
- Develop a revised post-closure groundwater and soil gas monitoring program.
- Modify the Site's groundwater classification to GB to be consistent with RIDEM's Rules and Regulations for Groundwater Quality.
- Protect the long-term effectiveness of the remedy by establishing an Environmental Land Use Restriction for the property.
- Assist the Town of Coventry in drafting and enacting a Groundwater Ordinance, which prohibits the use of groundwater down-gradient of the landfill as a potable water supply.

The RAWP was accepted by RIDEM and GZA developed detailed construction plans and specification for the remediation and closure. In addition to the regulatory requirement of the landfill closure scope, the Town wanted to evaluate the Site for future solar energy development. GZA is actively involved in a number of renewable energy projects involving solar power installed on landfills and our diverse technical expertise allows us to support our client's endeavors from concept through completion.

In the spring of 2014, GZA was selected by the CLPPG as the Construction Oversight/Consulting Engineer, which included construction supervision/oversight and consulting services from pre-Construction planning through completion of the Construction and post-Construction operation, maintenance, and monitoring of the SVE system. The objective of this phase of the project was to provide the Group with construction administration, contractor/construction oversight, project documentation and regulatory reporting to ensure the project is constructed in accordance with the RIDEM approved RAWP, Order of Approval and the corresponding construction specifications prepared by GZA. Our construction oversight services will provide sufficient field documentation, and construction quality assurance (CQA) to allow GZA to certify, as Engineer-of-Record, that the as-built cap and SVE systems comply with the contract documents, thus allowing the Group to obtain a Letter of Compliance and Certificate of Landfill Closure from RIDEM and removal of the Site from EPA's CERCLIS list.

Construction of the SVE system began in October of 2014 and was completed in January 2015. The landfill grading and shaping with BUD material and landfill closure began in November of 2014 and is anticipated to be completed in 2018. GZA provides ongoing BUD program oversight, engineering services and environmental compliance monitoring on the project.

Contracting Agency (Client)
Coventry Landfill Preforming Parties Group, 4801 Courthouse Street, Suite 300Williamsburg, VA

Mr. David Graham, Esq. Landfill Group Representative- (757) 259-3855

Date of Project: April 2008 – on-going
Consulting Fee: $975,500

Project Team Firms: GZA GeoEnvironmental, Inc.
Project Personnel: Edward A. Summerly, P.G. (PIC), Todd R. Greene, P.E., Mark Dalpe, Rick Carlone, P.E., Erik Beloff, Nichole Murawski

Proactive by Design

RESUMES OF KEY STAFF

GZA Solid Waste Statement of Qualifications for:
Vectren Energy

RESUME

Bart A. Klettke, P.E.

Principal/District Office Manager

Summary of Experience

Mr. Klettke has over 30 years of professional experience. He has permitted, designed and managed the construction of solid waste management facilities including coal ash containment cells, and site civil projects. He is experienced in performing and supervising CQA monitoring programs, civil site plans, and geotechnical investigations. As the Principal in Charge and Operations Manager of the Buffalo, New York office, Mr. Klettke is responsible for contracting, project budgeting, scheduling of office and field staff activities, and conducting a profitable operation.

Education

B.S., 1984, Civil Engineering, Valparaiso University, Indiana

Registrations & Certificates

Professional Engineer – 1992
New York, #069423

Affiliations

- Member - American Society of Civil Engineers
- Member – Engineering Society of Buffalo
- Member - New York State Association for Solid Waste Management
- Member – New York State Society of Professional Engineers

Areas of Specialization

- Solid Waste Design
- Civil Site Design
- Geotechnical Engineering
- Construction Administration

Relevant Project Experience

Principal, Sanitary Landfill Area VIII, Allied Waste Niagara Falls Landfill, Niagara Falls, New York. Designed a 90-acre solid waste management facility including developing permit drawings and writing a design rationale report. Design required management of on-site miscellaneous fill soils to minimize relocation of soils and maximize available air space. Currently administering QA/QC monitoring program for on-going construction of landfill cells.

Principal, Sanitary Landfills V & VIII Final Closure Design, Allied Waste Niagara Falls Landfill, Niagara Falls, New York. Designed a final cover system for a 125-acre sanitary landfill having a combination soil cover and geosynthetics system. The soil cover system is required in areas having limited truck and heavy equipment traffic access at the bottom of the landfill cell, which greatly restricted placing cover soils over an alternative geosynthetic cover system. Additional design features included incorporating passive gas vent risers tied into the gas vent layer, rip-rap downchutes in interior swale areas, rip-rap drainage swales and extension of leachate clean-out access pipes.

Principal, Solid Waste Disposal Area II, Phases C - H, AES Somerset, LLC, Barker, New York. Designed a 34-acre ash monofill waste management facility and re-lining of 2 retention basins. Procured a Beneficial Use Determination (BUD) from NYSDEC to allow use of coal bottom ash for cell liner subgrade. Prepared contract documents and developed ACAD 3-dimensional surface models for construction layout of multiple layered landfill liner. Administered QA/QC programs, overseeing a field engineer and 1 to 2 technicians.

Associate Principal, NRG Dunkirk Power, Ash Landfill Cell B-2 Expansion, Pomfret, New York. Provided Principal review of the design of a 5.5-acre solid waste management cell expansion at an existing ash landfill. Prepared permit and contract documents and developed ACAD 3-dimensional surface models for construction layout of multiple layered landfill liner. Interfaced with contractor's construction manager and certifying land surveyor for construction layout including proper tie-in to existing containment cells. Quantified available variable borrow soils based upon test pit explorations and topography of borrow area.

Bart A. Klettke, P.E.

Principal/District Officer Manager

Project Manager, Landfill Remediation Project, Town of Hamburg, New York. Overall design responsibility for remedial closure of this solid waste management facility. Developed work plan to consolidate waste and re-grade existing landfill, and provide surface water drainage.

Project Manager, Chaffee Landfill, Waste Management of North America, Sardinia, New York. Performed design modifications for the containment berms, site access roads and surface drainage structures for this solid waste management facility. Design modifications saved client 70,000 cubic yards of earth fill. Calculated survey control for construction layout. Calculated earthwork and air-space volumes, using computer surface modeling program.

Project Manager, McKenna Landfill Remedial Closure, Waste Management of North America, Albion, New York. Developed construction drawings for remedial closure of this solid waste management facility. Calculated earthwork and construction material volumes using computer surface modeling program. Provided design interpretation, reviewed contractor submittals, reviewed payment quantities, and addressed concerns and questions by contractor. Monitored geosynthetic installations.

Project Manager, Sanitary Landfill Area V, Subarea B, BFI Waste Systems of North America, Niagara Falls, New York. Designed a 13-acre solid waste management facility including developing construction drawings, and writing technical specifications and QA/QC plan. Construction drawings were developed as 3-dimensional ACAD files to allow direct data extraction for survey layout. Calculated earthwork and material volumes, using computer surface modeling program. Coordinated with client and project surveyor in obtaining pre-construction survey data for design of this project in highly sensitive environment.

Senior Project Manager, Alltift Landfill & Ramco Steel Site, Buffalo, New York. Developed an extensive Quality Assurance/Quality Control Plan and Health & Safety Plan for the project Contractor for landfill remediation work done at this site. Managed the project budget, assigned soils and geosynthetics laboratory testing, and supervised engineering technicians in administering these plans.

Project Engineer, Sanitary Landfill Area V, Subarea A, BFI Waste Systems of North America, Niagara Falls, New York. Designed a 22-acre solid waste management facility. Developed permit drawings and QA/QC plan for approval by NYSDEC. Developed construction drawings and technical specifications. Calculated cut and fill volumes, using computer surface modeling program. Estimated construction costs to assist client in determining viability of project. During construction, managed the field activities and coordinated the contractor's earthwork efforts. Made recommendations for acceptance of subgrade and fill placement in sensitive existing fill soils. Supervised four technicians in implementing QA/QC plan. Provided design interpretation, reviewed contractor submittals, reviewed payment quantities, and addressed concerns and questions by client and NYSDEC. Wrote formal construction observation report for NYSDEC approval.

Project Engineer, Sanitary Landfill Area VI, Subareas A through D, Closure Construction, BFI Waste Systems of North America, Niagara Falls, New York. Designed closure plans, including surface water management structures, for this 45-acre solid waste management facility. Developed construction drawings, technical specifications and QA/QC plan. Managed the contractor's earthwork activity and acted as the Owner's construction manager. Supervised two to three technicians in implementing QA/QC plan. Provided contract administration, design interpretation, reviewed contractor submittals and addressed concerns and questions by client and NYSDEC.

Project Engineer, Mohawk Valley Sanitary Landfill Expansion, Waste Management of New York, Frankfort, New York. Coordinated subsurface exploration in evaluating hydrogeological conditions of a proposed landfill expansion. Work included monitoring of test boring activities, installation of multi-level groundwater monitoring wells, groundwater screening and sampling, and field permeability testing. Evaluated permeability test data and coordinated soils laboratory testing. Assisted in preparation of technical reports. All work done in accordance with New York State Department of Environmental Conservation 6 NYCRR Part 360 regulations.

Project Engineer, Ellery Sanitary Landfill, Jamestown, New York. Designed a final cover system for a 12-acre landfill cell. Design included multiple double containment leachate transfer systems, access road and surface drainage structures. Wrote technical specifications, QA/QC plan, contract documents for competitive bids; and calculated material quantities and construction costs.

RESUME

Edward A. Summerly, P.G.

Principal

Education

B.S., 1985, Geology,
University of Rhode Island
Geological Field Methods, 1984, University of Texas at El Paso

Registrations & Certificates

Professional Geologist – 1994, Kentucky, # 1871

Affiliations

- Environmental Business Council, RI Chapter Board Member
- Solid Waste Association of North America, Landfill Gas Technical Division Member
- Association of Ground Water Scientists and Engineers
- Rhode Island Society of Environmental Professionals

Areas of Specialization

- CERCLA/RCRA/State
- Site Investigations
- Feasibility Studies
- Site Remediation
- Solid Waste & Landfill Gas

Specialized Training

- 2001, Queens University, Hydrogeology of Fractured Rock
- 1999, PSMJ Resources, Advanced Project Management Training Course
- 1997, ASTM, Risk Based Corrective Action (RBCA) Decision Making Training Course
- 1996, OSHA, Confined Space Entry Training Certification
- 1995, GSC, Contaminant Fate and Groundwater Transport Modeling Course
- 1995, EPA, Human Health Risk Assessment Guidance for Superfund Course

Summary of Experience

Mr. Summerly is a Principal and Registered Professional Geologist. He serves as manager and technical lead on multi-disciplinary studies and design projects focusing on Solid Waste Management Facilities, landfill gas control and reuse, and contaminated sites requiring assessment of environmental contamination (soil, groundwater, surface water, air), human health and ecological risk management and hazardous waste remediation. His responsibilities include: technical direction, contract management, project planning, budget control, and quality assurance. Mr. Summerly has been involved with site investigations (soil, groundwater, surface water, air), environmental compliance issues, permitting, and testing at more than 30 solid waste management facilities in the northeast. He has managed several Superfund, RCRA Corrective Action and State lead studies involving remedial investigation (waste identification, groundwater, surface water and geologic characterization) groundwater contaminant migration evaluation, human health and ecological risk assessment/risk management, and public relations. Mr. Summerly has supervised and participated in the preparation and implementation of Superfund, RCRA, and State Remedial Investigation/Feasibility Studies, QAPPs, and subsequent site clean-up and Remedial Actions.

Mr. Summerly's more than 30 years of experience includes participation in RIDEM's regulatory Task Force for the redevelopment of Rhode Island's Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases and he is GZA's Technical Practice Leader for Solid Waste Services.

Solid Waste Management Facility Experience Includes :

Central Landfill, Johnston, RI
Fresh Kills Landfill, Staton Is, NY
Jamestown Landfill, Jamestown, RI
Richmond Landfill, Richmond, RI
Manton Avenue Landfill, Providence, RI
Rose Hill Landfill, South Kingstown, RI
Macera Landfill, Johnston, RI
Home Town Properties Landfill, Exeter, RI
Global Waste Recycling, Coventry, RI
Materials Recycling Facility, Johnston, RI
Plainfield Pike Recycling Facility, Johnston, RI
Tuckers Industrial Dump, Johnston, RI
Coventry Landfill, Coventry, RI
Cumberland Landfill, Cumberland, RI
Canton Landfill Solar Facility, Canton, MA
A Street Landfill Solar Facility, Johnston, RI
Kingston Landfill, Kingston, MA
Rocky Hill Landfill, East Greenwich, RI
Plainfield Landfill, Plainfield, MA
Oak Bluff Landfill, Martha's Vineyard, MA
Edgartown Landfill, Martha's Vineyard, MA
Vineyard Haven Landfill, Martha's Vineyard, MA
Tisburry Landfill, Martha's Vineyard, MA
Gay Head Landfill, Martha's Vineyard, MA
SeMass/American Ref-Fuel, West Wareham, MA
Rocky Point Landfill, Warwick, RI
Barrington Landfills 1 and 2, Barrington, RI
MOA Landfill, Atlanta, MI
Violia ES Landfill, Zion, IL
Charlestown Landfill, Charlestown, RI
Ravenbrook Landfill Solar Facility, Carver, MA
Forbes St. Landfill Solar Facility, E. Prov,, RI

Relevant Project Experience

Principal, Central Landfill Superfund Site RI/FS and RD/RA, Johnston, Rhode Island. This EPA mandated study involved evaluation of environmental conditions (air, soil, bedrock, groundwater, surface water, and sediment) at New England's largest solid waste management facility, which is also an EPA Superfund Site. Project elements included development and implementation of work plans for subsurface explorations,

Edward A. Summerly, P.G.

Principal

multi-media environmental sampling and analysis, geophysical studies and groundwater transport evaluation. The project culminated in the closure of the 121 acre Operable Unit 1 Landfill with a modified RCRA Subtitle C Cap, installation of a groundwater pump and treatment system in an identified Hot Spot and a finding of No Action Required for the Operable Unit 2 off-site area.

Principal, Fresh Kills Landfill Closure, Staten Island, NY. Mr. Summerly serves as technical lead for landfill gas collection and control on this multi-year design-build landfill closure project. This project involves closing and capping a 300 acre cell of the former Fresh Kills Landfill working as the design engineer for the construction contractor. Key elements of GZA's services are design of all closure elements including: the RCRA D synthetic membrane cap, stormwater control structures, landfill gas collection and conveyance systems, and roadways. Mr. Summerly's responsibilities also include coordination of operation of the new landfill gas collection and control systems, and integration of the new and existing gas systems with the DSNY's gas system operator who produces pipeline quality natural gas from the recovered methane for resale.

Principal, Coventry Landfill Assessment, Closure Design and Construction QA/QC, Coventry, RI. Mr. Summerly directed GZA's work on this CIRCLIS and State List landfill site which, to date, has consisted of extensive environmental investigations both on and off-site, landfill cap and closure design, remedial action planning, groundwater and landfill gas migration assessment, and meetings with State regulators. The closure design incorporates the use of 300,000 cubic yards of impacted soil from off-site sources under a Beneficial Use Determination (BUD) regulatory approval, the revenue from which will significantly reduce Site closure costs. The proposed future use of the facility is as a utility-scale solar energy farm. Final landfill closure grading and cap design integrates the needs of the solar farm to put this otherwise fallow land back into productive use.

Principal, Central Landfill Phase VI Landfill Design and Permitting, Johnston, Rhode Island. Mr. Summerly serves as contract manager and technical specialist on this 153 acre landfill expansion design and permitting project. Work to date has involved: conducting a pre-design geohydrologic investigation of the site, design of a double-composite synthetic baseliner system using HDPE, as well as a geocomposite clay liner and dual composite drainage nets to gain additional air space, leachate collection system design, operational and post-closure landfill gas collection and control system designs for regulatory compliance, gas mining for beneficial reuse, and preparation of landfill license application documents for regulatory approval.

Principal, Central Landfill Environmental Engineering General Services Contract, Johnston, Rhode Island. Mr. Summerly serves as contract manager and technical specialist on this multi-year task order contract. Work to date has involved the completion of more than 65 individual jobs/tasks with budgets ranging from $400 to $750,000 including portions of two broad based remedial investigations and feasibility studies. Other work performed under this contract has drawn upon more than 20 distinct environmental services areas such as: landfill permitting, air quality evaluation and permitting, landfill gas control, BUD soil/waste evaluation, emergency response, hazardous waste disposal, regulatory compliance auditing and monitoring, environmental monitoring, dredging, geotechnical soils testing and blast monitoring, technical support for public meetings and presentations, and environmental data interpretation and reporting.

Associate Principal, Rose Hill Landfill Superfund Site. Mr. Summerly directed GZA's work on this project which consisted of evaluating the results of a Remedial Investigation and Feasibility Study that was conducted by the EPA, for the Potentially Responsible Parties (PRP Group). The purpose of our work was to ensure that the regulatory agencies had selected the most cost-effective remedy (capping and landfill gas control) that was protective of human health and the environment. Our recommendations lead to additional field studies (completed by GZA), to better assess groundwater migration, landfill mining options, and landfill gas control. As a result of our work, the EPA and RIDEM changed the selected remedy to a more protective and cost-effective approach.

Principal, Jamestown Landfill Assessment and Closure. Mr. Summerly directed GZA's work which consisted of the completion of a site investigation work plan, site investigation, underground injection control closure, remedial action work plan preparation, landfill capping and closure design, landfill gas migration assessment, landfill capping and closure engineering oversight, site redevelopment as a Department of Public Works facility and quarterly environmental compliance monitoring of groundwater and soil gas. GZA assisted the Town in obtaining and/or evaluating off-site soils from a variety of sources which resulted in a significant reduction in landfill closure costs. This project has also included public relations work including public meetings, presentations, and participation in a citizen's advisory committee.

Principal, Barrington Landfills 1 and 2 Assessment and Closure. Mr. Summerly directed GZA's work which consisted of the completion of a multi-media site investigation, landfill gas migration assessment, survey and boundary determination, landfill capping and closure design and construction oversight. Our closure design incorporated the redevelopment of the Site as a recreational facility including two soccer fields, walking paths and paved parking.

Principal, A. Macera Landfill Assessment and Closure, Johnston, Rhode Island. Mr. Summerly directed GZA's work which consisted of the completion of a site investigation work plan, site investigation, landfill gas migration assessment, remedial action work plan preparation, landfill capping and closure design, and site redevelopment as an industrial park. As part of this closure design GZA worked with the Client and RIDEM to reduce the closed landfill footprint by 40%, and reuse excavated waste and soils in the capping project under a BUD approval. The Site reuse plan incorporates on-landfill bus parking for the Town of Johnston and passive recreation, and the recovered land has been developed into an industrial park.

Principal, Tucker's Industrial Dump Assessment and Closure Design, Johnston, Rhode Island. Mr. Summerly directed GZA's work which consisted of the completion of a site investigation work plan, site investigation, landfill gas migration assessment and control design, remedial action work plan preparation, landfill capping and closure design, and site reuse as a residential development. A significant component of this work included delineating a chlorinated solvent groundwater contaminant plume and associated vapor plume migrating from the dump below a proposed residential development.

Principal, Richmond Landfill. Mr. Summerly directs a team of environmental professionals conducting ongoing quarterly compliance monitoring of groundwater at this closed landfill and CERCLIS site. Work consists of Low Flow groundwater sampling, chemical analysis, statistical data evaluation, perimeter landfill gas monitoring for migration control, and reporting to the RIDEM's Office of Waste Management.

RESUME

Todd R. Greene, P.E.

Senior Project Manager/Senior Engineer

Education

B.S., 1996, Civil Engineering, Norwich University

Registrations & Certificates

Professional Engineer – 2008, Rhode Island, 8567

Areas of Specialization

- Civil Engineering
- Landfill Engineering and Construction
- Construction Management & Oversight
- Stormwater Management & Design
- Hydrologic and Hydraulic Analysis
- Environmental Engineering
- Soil and Groundwater Remediation
- Groundwater Hydrology
- Solid and Hazardous Waste Disposal
- Wastewater Treatment – OWTS Design
- Topographic Survey

Summary of Experience

Mr. Greene's has 15 years of experience primarily on civil, landfill and environmental engineering projects. Specific project experience includes hydrology, stormwater management, site grading, structural steel design and analysis, landfill baseliner design and landfill construction oversight, landfill capping design and cap construction oversight, landfill gas collection system design, trouble shooting small industrial wastewater pretreatment facilities, construction layout and surveying utilizing GPS, geohydrological studies, industrial wastewater permitting, site remediation (pump and treat, bioremediation and soil vapor extraction with air sparging) and various air, water and soil sampling techniques.

Relevant Project Experience

Landfill Engineering Projects

Project Manager / Project Engineer, Fresh Kills Landfill Closure, Staten Island, New York. Mr. Greene serves as project manager and lead designer to develop construction drawings and details for Section 6/7 of the Fresh Kills Landfill located in Staten Island New York. The landfill closure design included, grading, geosynthetic design, storm water conveyance and management, maintenance road layout and design, erosion control design and specification, gas collection and conveyance design. This project involves closing 285 acre cell of the former Fresh Kills Landfill under a five phase construction sequence and schedule, working as the design engineer for the construction contractor, Tully Construction. Key elements of GZA's services are design of all closure elements and preparing construction drawing submittals as follows: Initial Working Drawings and details for the 285 acre closure and Temporary and Final Working Construction drawings for each specific construction phase. Mr. Greene work directly for Tully Construction and interact and communicated with the New York Department of Sanitation (DSNY) and DSNY's engineering consult to address and incorporate site and design considerations into the project. As part of the Temporary Working Drawing submittals value engineering was conducted for the geosynthetic layering, geosynthetic drainage details, gas system and earthwork activities.

Project Manager, Central Landfill, Johnston, Rhode Island. Providing multiple general and daily engineering services for the Rhode Island Resource Recovery Corp. at the Central Landfill Facility in Johnston, RI; services include environmental, site civil, solid waste and landfill engineering services for the following tasks:

- Review and oversight of the implementation of the erosion control and sediment monitoring;
- Trash and construction material volume estimates;
- Develop grading plans;
- Property acquisition evaluations;
- Landfill planning;
- Landfill settlement and filling monitoring;
- Review, evaluate and prepare RFP / RFQ packages;
- Waste Compaction evaluation;

Todd R. Greene, P.E.

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- Construction layout;
- Construction oversight of horizontal methane extraction lines;
- Construction as-built surveys;
- Utility installation construction oversight;
- Haul road design and layout;
- Perform Topographic surveys;
- Drafting / design utilizing Autodesk Civil design series;
- GPS trouble shooting; and
- Facility design modifications and trouble shooting.

Project Manager / Project Engineer, Central Landfill, Johnston, Rhode Island. Performed multiple design and layout modifications to the tipping facility; projects included construction as-built and layout for the relocation of the tarping racks and bollards located on the northern and eastern side of the facility, performed a structural analysis to determine if the existing trash shoot areas could support the operation of knuckle booms, designed an alternative trash shoot curtain to minimize air-born litter, designed alternative trash pit covers and push wall protection plates and performed several field evaluations on the facility.

Project Manager / Project Engineer, Central Landfill, Johnston, Rhode Island. Phase V 110 Acre landfill design modification and construction drawing preparation. Project include incorporating alternative geo composites to increase landfill air space and reduce construction cost and time to the base cell area and utilizing the existing OU-1 cap construction materials for the secondary containment system to minimize construction cost of the Phase V piggy back area.

Project Manager / Project Engineer, Central Landfill, Johnston, Rhode Island. Phase II / III RCRA 30 acre capping project. Project included construction oversight of the cap subgrade and overall cap construction. In addition the project required grading and bench design modifications to minimize slope cuts and constructability issues. The project also required GPS file modification to create grid and triangulation files compatible to the corporations Gradestar GPS software and the implementation of leachate controls to dewater the caps anchor trench to expose the existing baseliner system.

Project Manager / Project Engineer, Central Landfill Phase VI Landfill Design and Permitting, Johnston, Rhode Island. Phase VI landfill expansion permit application submittal and performed associated calculations and designs corresponding with the landfill gas collection system, leachate collection and conveyance systems, base cell subgrade design and developed permitting drawings and prepared the overall landfill cell permitting submittal for RIDEM review and comment.

Project Manager, Town of Barrington Landfills 1 & 2 Site Investigation (SIR), Barrington, Rhode Island. Mr. Greene provided the Town with engineering services to conduct a site investigation at the former Barrington landfill. The site investigation included, waste delineation and characterization, characterization of cover materials, groundwater sampling and monitoring, evaluate groundwater flow direction, soil gas monitoring and proposed site redevelopment alternatives and preparation of the SIR for submittal with to RIDEM. Once the SIR was approved, GZA prepared a Remedial Action Work Plan, which has subsequently been approved by the Department. GZA services included construction drawings and specifications and full time construction oversight.

Project Manager, Town of Barrington Landfill 1 & 2 Closure Design & Construction Oversight, Barrington, Rhode Island. Mr. Greene was the project manager and certifying engineer for the closure and landfill capping of Barrington's landfills 1 & 2. The landfills were approximately 9 acres divided by a town roadway. The closure required the preparation of a Remedial Action Work Plan for review and approval by the Rhode Island Department of Environmental Managements (RIDEM). In addition Mr. Greene prepared construction drawings, details and specifications and contractor bid packages and assisted the town in contractor selection. Mr. Greene was responsible for all construction administration & management of the project through construction on behalf of the Town of Barrington. Full time construction oversight and landfill closure certification was also conducted and prepared, respectively. Value engineering was performed to obtain regulatory approval of reducing the minimum cap slope requirement from 3 to 5 percent to 1 percent, which will with beneficial re- use of the properties as recreational sports fields.

Project Manager, Town of Jamestown Landfill Closure, Jamestown, Rhode Island. Mr. Greene provided engineering services to close and cap the former town landfill. As part of the landfill closure, design plans were developed to site the Town's Department of Public Works Facility (DPW) on the landfill. Design and permitting services included the landfill closure, site grading, stormwater management, waste management plan, ELUR, water supply and sewer / ISDS design, wetlands permitting and development of a remedial action work plan. The project included providing the Town with engineering cost estimates and closure and site redevelopment

Todd R. Greene, P.E.

Senior Project Manager/Senior Engineer

alternatives. This project required a close working relationship with RIDEM's Department of Waste Management.

Project Manager, Hartford Landfill, Connecticut Resource Recovery Corporation (CRRA), Hartford, Connecticut. Mr. Green performed an operational and site audit on the Hartford landfill. The landfill operates in two separate areas: The Bulky Waste Cell and The Ash Landfill, which receives ash from CRRA's Mid Connecticut Project trash to energy plant. Engineering services include an overall evaluation of the landfill including site staff and management, filling sequencing, filling procedures, available equipment, stormwater management, daily cover practices, site erosion and sediment controls, leachate breakouts, methane extraction, overall site maintenance and long term planning. The results of the evaluation was summarized and presented to CRRA for their use to modify the landfill operation to function more efficiently and potentially extend the overall life of the landfill.

Project Manager, Hi-Lo Landfill Redevelopment, Johnston, Rhode Island. GZA's provided third party engineering review of proposed environmental remediation and closure activities associated with the Hi-Lo landfill property. In addition, we reviewed the Pocasset River flood plain maps and information as delineated by FEMA and identified potential re-development issues for the property as they pertain to the current flood plain delineation. GZA prepared an M-1 Form to request for Letter of Map Revisions based on Fill (LOMR-F) to submit to FEMA and prepared a wetland edge verification request to RIDEM.

Project Reviewer / Technical Specialist, Former Coventry Landfill, Coventry, Rhode Island. Project involved the design remedial actions and a final closure system for the former Coventry Landfill located on Arnold Road in Coventry, Rhode Island. The landfill was subject to two RIDEM regulatory programs; the Solid Waste Program (due to the former use of the properties as solid waste disposal facility) and the Site Remediation Program, and the RIDEM policy memorandum entitled "Closure Policy for Inactive or Abandoned Solid Waste Landfills". GZA develop a Remedial Action Work Plan (RAWP) and Landfill Closure Design consisting of a soil vapor extraction system, 24-inch thick soil cap and associated stormwater management system, designed in accordance with the *Rhode Island Stormwater Design and Installation Standards Manual Dated: December 2010.* The landfill closure and associated remedial activities include a Beneficial Use Determination to import slightly contaminated soils to the site to prepare the landfill cap subgrade and a Construction Stormwater Pollution Prevention Plan (SWPPP).

Project Manager, Providence & Worcester Railroad (P&W) / JM Mills Landfill / Peterson & Puritan Super Fund Site, Mendon Road to Martin Street Rail Siding. GZA provided engineering and environmental consulting services to assist P&W in obtaining RIDEM and EPA approvals to construct a new 8000 foot long railroad siding within the OU-2 area associated with the Peterson & Puritan Super Fund Site and associated JM Mills Landfill. The proposed rail side is located adjacent to the eastern edge of the JM Mills Landfill Site. GZA prepared a Field Investigation Work Plan (FIWP) for submittal to EPA and RIDEM to perform a series of test pits along the eastern perimeter of the JM Mills Landfill to delineate the extent of the buried waste within P&W's ROW and or adjacent to, the area of the proposed rail siding. Following EPA and RIDEMs approval of the FIWP, GZA conducted the test pitting program and obtained field data to delineate the extent of buried waste adjacent to the proposed rail siding. The result of the test pitting program was utilized to assess if construction of the proposed rail siding may be completed without requiring the removal of significant amounts of buried waste material and to identify construction techniques and details that would be compatible with available alternatives for a RCRA C landfill closure. Based on GZA's evaluation, EPA accepted the proposed rail siding concept and the rail siding is currently under construction.

Project Manager, Former Rocky Hill Fair Grounds Landfill Closure, East Greenwich, Rhode Island. GZA designed and prepared a corresponding remedial action work plan, which received RIDEM approval to construct a landfill cap and implementation of an Environmental Land Use Restriction (ELUR). The approved remedial action complied with the RIDEM policy memorandum entitled "Closure Policy for Inactive or Abandoned Solid Waste Landfills". The landfill closure consists of consolidating the landfill to a 0.4 acre area within the interior limits of the existing utility easement constructing a 24-inch thick engineered soil cap consisting of 6-inches of loam, 18-inches of gravel borrow (vegetative support) and an underlying high visibility permeable geotextile warning barrier. GZA prepared construction drawings, specifications and construction bid documents to solicit contractor bids to construct the proposed landfill cap. In addition GZA provided construction administration, management and field oversight services during construction. Following the completion of construction activities, a Remedial Action Closure Report was prepared in accordance with RIDEMs Remediation Regulations and Solid Waste Resubmitted to RIDEM for review and approval.

RESUME

Theodore A. Klettke

Project Engineer

Summary of Experience

Mr. Klettke's experience includes both environmental and geotechnical engineering projects. He utilizes AutoCad skills to develop 3-dimensional design and layout of landfill liner and final cover systems. Other responsibilities include: Supervising landfill CQA programs and providing survey design interpretation for construction contractors and certifying surveyors, surveying, soil and groundwater site investigations, geotechnical investigations, observation and logging of subsurface explorations, and sampling of soil, groundwater, surface water, sediment, and air.

Education

B.S., 2011, Mechanical Engineering, Valparaiso University

Areas of Specialization

- CQA/CQC Monitoring and Testing
- 3-Dimensional AutoCad Landfill Design
- 3-Dimensional Sketchup Modeling
- Surface Volume Calculation
- Geosynthetics QA/QC
- Photo Documentation
- Surveying
- Geotechnical Investigations

Relevant Project Experience

Sanitary Landfill VIII, Subarea E, Allied/BFI Waste Systems of North America, Inc., Design, Niagara Falls, New York. Designed a 13-acre solid waste management facility including development of construction drawings developed as 3-dimensional ACAD files for construction layout and survey certification. Calculated earthwork and material volumes for developing accurate bid quantities. Developed 3-dimensional Sketchup Pro model and virtual tour video of a complex multi-faceted leachate cleanout and drainage pipe system, storm-water improvements, excavation cut surface, and fill grade surfaces.

Hydrogeologic and Geomembrane System Assessment of the State Licensed Disposal Area (SDA) of the Western New York Nuclear Services Center (WNYNSC), West Valley, New York. Developed 3-dimensional Sketchup Pro model and virtual tour video of groundwater in comparison to site features. Created groundwater database within excel to populate graphs and 3-dimensional model as current groundwater levels are added. Converted data to Geographic and State Planar North American Datum of 1983 (NAD83) & North American Vertical Datum of 1988 (NAVD).

NRG Dunkirk Power LLC Landfill Closure Assessment, Dunkirk, New York. Designed multiple final grading options for closure of an operational 11-acre landfill cell. Calculated earthwork and material volumes within a computer surface modeling program.

Sanitary Landfill VIII, Subarea B East, Allied/BFI Waste Systems of North America, Inc., Subgrade and Primary and Secondary Liner Construction, Niagara Falls, New York. Observed/documented daily field activities and implemented construction quality assurance (CQA) testing and documentation. Recorded observations/measurements during installation of subgrade soils, low permeability soils, high density polyethylene geomembrane (HDPE) and geocomposite material including: In-place nuclear density measurements, thin wall Shelby tube permeability sampling, placement and seam orientation for conformance with permit requirements; destructive testing of HDPE liner materials; non-destructive testing of HDPE liner materials in accordance with applicable operation/construction permits. Coordinated with contractors the job progress/schedule, tracking of quantities as well as any quality control issues. Recorded geosynthetic panel placement, seam locations, destructive sample locations and patch locations. Observed and recorded non-destructive geosynthetics liner testing.

Theodore A. Klettke

Project Engineer

Sanitary Landfill VIII, Subarea C, Allied/BFI Waste Systems of North America, Inc., Subgrade and Liner Construction CQA, Niagara Falls, New York. Performed air monitoring during the excavation of industrial fill from the landfill footprint. The work included screening the excavated fill with a photo-ionization detector (PID), 4-gas meter, and sampling the upwind and downwind air for dust particulates. Observed/documented daily field activities and implemented construction quality assurance (CQA) testing and documentation. Recorded observations/measurements during installation of subgrade soils, low permeability soils including: In-place nuclear density measurements, thin wall Shelby tube permeability sampling. Monitored, tested, sampled and documented the construction of a test pad to qualify proposed soil borrow for use as low permeability soil.

Sanitary Landfill VIII, Subarea D Permit Design, Allied Waste Niagara Falls Landfill, Niagara Falls, New York. Designed a 17-acre landfill liner system using 3-D ACAD for permit-level drawings. Developed excavation grades in area of extensive existing industrial fill, top of subgrade and landfill liner grades, and containment berm cross-sections. Determined optimal design grades to minimize relocation of existing fill and maximize airspace, and calculated excavation volumes from design work.

312 Maple Street, Village of Endicott, New York. Monitored installation of a groundwater monitoring well system. The work included the decommissioning and installation of monitoring wells to assess groundwater in top-of-clay, top-of-rock and bedrock zones. Sampled and logged overburden fill, natural soils and bedrock. Documented well installation and well development. Surveying was performed to find the elevation and location of the newly installed monitoring wells. Ground water sampling was performed at several wells around the site.

Solid Waste Disposal Area II, Cells C & D, AES Somerset. LLC Subgrade and Liner Construction, Somerset, New York. Observed/documented daily field activities and implemented construction quality assurance (CQA) during completion of two sub-areas totaling 14.5 acres. Recorded observations/measurements during installation of subgrade soils, low permeability soils, high density polyethylene (HDPE) geomembrane and geocomposite material including: In-place nuclear density measurements, thin wall Shelby tube permeability sampling, placement and seam orientation for conformance with permit requirements; destructive testing of HDPE liner materials; non-destructive testing of HDPE liner materials in accordance with applicable operation/construction permits. Coordinated with contractors regarding job progress/schedule, tracking of quantities as well as quality control issues. Recorded geosynthetic panel placement, seam locations, destructive sample locations and patch locations. Observed and recorded non-destructive geosynthetics liner testing and completed daily field progress reports.

Solid Waste Disposal Area II Cells G & H East, AES Somerset. LLC Design, Somerset, New York. Designed a 10-acre solid waste management facility including developing construction drawings developed as 3-dimensional ACAD files for construction layout. Calculated earthwork and material volumes, using a computer surface modeling program.

Enbridge Pipeline, Erosion Control Monitoring, Buffalo New York. Created AutoCad maps for each excavation site along the pipeline where the pipeline integrity was evaluated. Wrote weekly & monthly reports for active or completed dig evaluation sites & developed and updated on a daily basis, a project status sheet for past, current and future dig evaluation sites.

Buffalo State College Underground Utilities Improvement Project, Buffalo, New York. Performed pre-construction documentation of existing conditions for underground utility installations being done on the Buffalo State College campus. Work consisted of photographing & recording video of nearby buildings, sidewalks, and other structures to show their condition before work was done by the contractor. Photographs were logged in a photo page Microsoft Word document and the videos were compiled and edited within Windows Movie Maker. The photograph and video locations were plotted on a map of the campus area.

Signore Brownfield Clean-up Program Supplemental Remedial Investigation, Ellicottville, New York. Soil vapor intrusion samples were taken of the air space beneath basements of houses surrounding the Signore site. Work consisted of drilling a hole through the concrete floor of the basement and sampling the vapors below the sub-slab of the house. Air samples were also taken from the basement ambient air and the outdoor ambient air. Air samples were then sent to a lab for analysis.

Army Reserve Underground Storage Tanks & Fire Main Investigation. Surveyed temporary and permanent groundwater wells to find the elevation of each well based on a known benchmark.

Theodore A. Klettke

Project Engineer

AUTOCAD

Mr. Klettke has experience in AutoCAD design. His work consists of developing 3-dimensional surface models for developing grading plans, providing survey layout data, and calculating earthwork and landfill airspace volumes. He has been involved in the design of several solid waste management facilities in western New York.

SKETCHUP PRO 3-D DIMENSIONAL MODELING

Mr. Klettke is proficient in Sketchup Pro 3-Dimensional Modeling. His work consists of developing 3-dimensional models of site features such as groundwater contours, buildings, subsurface features, and aerial photography layered atop TIN surfaces. He has produced 3-Dimensional Virtual Walkthrough Videos of several work sites.

SURVEYING

Mr. Klettke has surveying experience working at Klettke Land Surveyors P.C. during his high school and college years. His work consisted of operating a survey total station, data collector, & level instruments. He determined if residences were within the Federal Emergency Management Administration (FEMA) flood elevation boundaries by noting and recording elevation measurements. He also drafted and prepared maps based on data collected from field notes.

Professional Experience

OSHA 40-Hour HAZWOPER Training

Certified Operator of Nuclear moisture/Density Gauge (Troxler Electronics, Inc.)

Contractor Safety Orientation at GM – Lockport Complex

NSC CPR Course

NSC First Aid Course

RESUME

Michael Kress

Assistant Project Manager

Education

B.S., 2004, Civil Engineering, State University of New York at Buffalo
A.A.S., 1990, Civil Engineering Technology, Erie Community College, North Campus

Professional Development

- Passed Fundamental of Engineering Exam (EIT), October 2004
- OSHA 40 Hour Health & Safety Training Course – 29 CFR 1910.120
- NYSDEC Stormwater Management Training
- HAZWOPER Certification
- Troxler Nuclear Density Trained

Areas of Specialization

- Geotechnical Investigation
- Construction Management and CQA
- Stormwater Analysis and Design
- AutoCAD, MathCAD
- Landfill Design
- Soil and Rock Classification
- Geosynthetic QA/QC
- Stormwater Management Plans

Summary of Experience

Mr. Kress has over 12 years of professional experience including geotechnical engineering, construction management, contracting, project budgeting and scheduling, oversight of MGP and brownfield remediation, development of storm water management plans and construction specifications. Michael has extensive field experience in geotechnical subsurface investigations, solid waste management facility design, construction, management, construction quality assurance monitoring and in-place nuclear density testing. His responsibilities have included management of subsurface exploration programs, monitoring well design and observation and logging of soil and rock samples. His AutoCad skills have been utilized in the design and layout of landfill systems, details and Site plans.

Relevant Project Experience

Former Gloucester Gas Light Company MGP Facility, Gloucester, Massachusetts. Lead Field Engineer for remediation implementation involving timber pier and granite seawall demolition, mechanical and suction dredging, by divers, of 30,000 cubic yards of impacted sediment, excavation and disposal of upland impacted soils, capping in-situ materials, DNAPL collection systems, marine armor mattress installation, mechanically stabilized earth walls, re-construction of seawalls and pier systems and Site restoration.

Former Supertane Coal Tar Site, Charles Town, West Virginia. Design of soil management and impermeable cap containment structures above consolidated coal tar wastes. Design of Stormwater conveyance and containment structures, block retaining walls with associated stability analysis and site restoration. Development of Plans, Specifications and Bid Documents.

22 Cooper Street Former Coal Tar Site, Waltham, Massachusetts. Performed on-site construction oversight of field work involving, impacted material excavation and disposal and in-situ stabilization via mixing.

Former Manufactured Gas Plant (MGP) Remedial Action, Vineland, New Jersey. Assisted in development of Remedial Action Work Plans and specifications for work associated with remedial efforts at a former manufactured gas plant. Performed on-site construction oversight throughout the duration of the field work involving, sheetpile earth support, vibration and optical survey monitoring, utility relocation, impacted material excavation, groundwater management and site restoration.

Solid Waste Disposal Area II, Cells C through H, AES Somerset. L.L.C. Subgrade and Liner Construction, Somerset, New York. Developed a Beneficial Use Determination (BUD) application submitted to the NYSDEC to use a waste coal by-product as fill material in landfill subgrade construction. Observed/documented daily field activities and implemented construction quality assurance (CQA) during completion of six sub-areas totaling 40 acres. Recorded observations/measurements during installation of subgrade soils, low permeability soils, high density polyethylene geomembrane (HDPE) and geocomposite materials including: In-place nuclear density measurements, thin wall Shelby tube permeability sampling, placement and seam orientation for

Michael Kress

Assistant Project Manager

conformance with permit requirements; destructive and non-destructive testing of HDPE liner materials in accordance with applicable operation/construction permits.

Sanitary Landfill VIII, Subarea A, Allied/BFI Waste Systems of North America, Inc., Subgrade, Liner and Cap Construction, Niagara Falls, New York. Oversight and documentation of daily field activities and implemented construction quality assurance (CQA) during the installation of HDPE and linear low density polyethylene geomembrane (LLDPE), geocomposite and geosynthetic clay liner (GCL) materials including: placement and seam orientation for conformance with permit requirements; destructive and non-destructive testing of liner materials in accordance with applicable permits; recorded observations/measurements; coordinated daily installation activities with surveyor to: record location of each panel, seam location, destructive sample locations, patch locations, and tracking of quantities. Completed daily field progress reports and addressed project issues and concerns with the regulatory agency (NYSDEC) and the client.

Fresh Kills Landfill, Section 6/7 Sanitary Landfill Final Cover, New York City Department of Transportation, Staten Island, New York. Performed stormwater analysis, design of Swales, Culverts, Gabion Downchutes, Piping and Detention Basins for final closure and capping. Utilized AutoCad, FlowMaster, Win TR55, and other design programs to check/size capacity of the structures mentioned above. Performed slope stability analysis for liner components as well as overall stability. Supplied the Survey team with control points for layout of above mentioned features.

McWilliams Forge, Sanitary Sewer Re-alignment, Rockaway, New Jersey. Project oversight and quality control manager for sanitary and process wastewater system modifications with oversight and documentation of sub-contractor construction/demolition activities, scheduling progress and tracking changed conditions. When required, construction alternatives were evaluated and presented to the Site owner and sub-contractor when unforeseen conditions were identified or encountered.

First Winds Wind Farm, Buffalo, New York. Field engineer for investigation of an 8-tower wind farm expansion. Field staff responsible for oversight of the subsurface explorations, electroresistivity testing and laboratory testing; assisted in foundation and road analysis; and preparation of the geotechnical report.

Solid Waste Disposal Projects Summary

Project Name/Location	*Client*	*Remedial Investigations/ Feasibility Studies*	*Hydrogeological Investigation/ Environmental Monitoring*	*Permitting Services*	*Design Services*	*Landfill Closure/Remediation*	*Construction Administration/ Support and/or CQA*
Massachusetts							
Foxboro State Hospital Landfill Foxboro, Massachusetts	DCAMM	■			■	■	■
Lakeville State Hospital Lakeville, Massachusetts	New England Development	■	■	■	■		
E. Bridgewater Landfill East Bridgewater, Massachusetts	Browning-Ferris Industries	■		■			
Fall River Landfill Fall River, Massachusetts	Republic Services/BFI			■	■		■
Chicopee Landfill Chicopee, Massachusetts	Browning-Ferris Industries		■	■	■		■
Haverhill Ash Landfill Haverhill, Massachusetts	Ogden Industries				■		■
Hunt Road Landfill Amesbury, Massachusetts	Waste Management of North America				■		■
Millbury Ash Landfill Millbury, Massachusetts	Wheelabrator, Inc.				■		■
Plainville Landfill Plainville, Massachusetts	Laidlaw Waste Systems	■					
Canton Landfill Canton, Massachusetts	Gemma Renewable Power, LLC			■	■		■
Ravenbrook Landfill Carver, Massachusetts	Ravenbrook, Inc.		■	■	■		■
Shrewsbury Ash Landfill Shrewsbury, Massachusetts	Wheelabrator, Inc.				■		■
North Meadow Road Landfill Medfield, Massachusetts	Town of Medfield		■	■	■	■	■
Battis Road Landfill Merrimac, Massachusetts	Town of Merrimac	■	■	■	■	■	■
Martone Landfill Barre, Massachusetts	United Waste Systems	■	■	■	■	■	■
Hudson-Stow Landfill Hudson, Massachusetts	United Waste Systems	■	■	■	■	■	■
Kmito Landfill Randolph, Massachusetts	Browning-Ferris Industries	■	■	■	■	■	■
Fitchburg Landfill Fitchburg, MA	United Waste/ USA Waste/ Waste Management	■	■	■	■	■	■
Ashby Landfill Ashby, MA	Town of Ashby, MA	■		■		■	■

Project Name/Location	*Client*	*Remedial Investigations/ Feasibility Studies*	*Hydrogeological Investigation/ Environmental Monitoring*	*Permitting Services*	*Design Services*	*Landfill Closure/Remediation*	*Construction Administration/ Support and/or CQA*
Granby Landfill Granby, MA	United Waste/ USA Waste/ Waste Management						
Indian Road Landfill Dudley, MA	Town of Dudley, MA						
Certainteed Shingle Landfill Walpole, MA	Certainteed Corporation Walpole, MA						
Rhode Island							
Central Landfill Johnston, Rhode Island	Rhode Island Resource Recovery Corporation						
Jamestown Landfill Jamestown, Rhode Island	Town of JamestownJamestown, Rhode Island						
Manton Avenue Landfill Providence, Rhode Island	Stop & Shop Company						
A. Macera Landfill Johnston, Rhode Island	Rhode Island Resource Recovery Corporation						
Richmond Landfill Richmond, Rhode Island	Town of RichmondRichmond, Rhode Island						
Rose Hill Landfill South Kingston, Rhode Island	Town of South Kingston and Narragansett, Rhode Island						
Woonsocket Landfill Woonsocket, Rhode Island	RI Department of TransportationProvidence, Rhode Island						
Former Forbes Street Landfill East Providence, Rhode Island	City of East Providence, RIEast Providence, RI						
Middletown Town Landfill Middletown, Rhode Island	Town of MiddletownMiddletown, Rhode Island						
Cranston Sanitary Landfill Cranston, Rhode Island	Messina Upright Company, LLPCranston, Rhode Island						
Barrington Landfills 1 & 2 Barrington, Rhode Island	Town of BarringtonBarrington, Rhode Island						
Tuckers Industrial Dump Johnston, Rhode Island	DAC Corporation						
Rock Point Landfill Narragansett, Rhode Island	Toll Brothers Corporation/RIDEM						
Coventry Landfill Coventry, Rhode Island	Town of Coventry/PRP Group Coventry, Rhode Island						

Project Name/Location	*Client*	*Remedial Investigations/ Feasibility Studies*	*Hydrogeological Investigation/ Environmental Monitoring*	*Permitting Services*	*Design Services*	*Landfill Closure/Remediation*	*Construction Administration/ Support and/or CQA*
Rocky Hill Fair Grounds Landfill East Greenwich, Rhode Island	New England Institute of Technology Warwick, Rhode Island						
Charlestown Landfill Charlestown, Rhode Island	Town of Charlestown Charlestown, Rhode Island						
Connecticut							
Bristol Landfill Bristol, Connecticut	Town of Bristol						
DePaulo Drive RCRA Closure Southington, Connecticut	Town of Southington						
Yaworski Lagoon Superfund Canterbury, Connecticut	Pervel Industries						
Vermont							
Waste USA Landfill Coventry, Vermont	Resicon, Inc.						
New Hampshire							
Auburn Road Landfill Londonderry, New Hampshire	Town of Londonderry						
Brookline Municipal Landfill Brookline, New Hampshire	Town of Brookline						
Charlestown Landfill Charlestown, New Hampshire	Hoyle, Tanner & Associates						
Consumat Sanco Landfill Bethlehem, New Hampshire	Consumat Sanco, Inc.						
Demolition Debris Landfill Nashua, New Hampshire	RDG, Inc.						
Dover Municipal Landfill Superfund Site Dover, New Hampshire	Wehran Engineer						
Exeter Landfill Exeter, New Hampshire	Town of Exeter						
Franklin Ashfill Franklin, New Hampshire	Craig Musselman Associates						
Franklin Sanitary Landfill Franklin, New Hampshire	City of FranklinHoyle, Tanner & Associates						
Fremont Landfill Fremont, New Hampshire	Town of Fremont						

Project Name/Location	*Client*	*Remedial Investigations/ Feasibility Studies*	*Hydrogeological Investigation/ Environmental Monitoring*	*Permitting Services*	*Design Services*	*Landfill Closure/Remediation*	*Construction Administration/ Support and/or CQA*
Gilson Road Superfund Site Nashua, New Hampshire	State of New Hampshire						
Hudson Municipal Landfill Hudson, New Hampshire	Town of Hudson						
Industrial Casting Sand Landfill Mt. Vernon, New Hampshire	Hitchner Manufacturing, Inc.						
Laconia Disposal Gardens Laconia, New Hampshire	City of Laconia						
Merrimack Landfill Merrimack, New Hampshire	Kimball-Chase, Inc.						
New Boston Municipal Landfill New Boston, New Hampshire	Town of New Boston						
PSNH Ashfill Bow, New Hampshire	Public Service Co. of New Hampshire						
Roketenetz Landfill Pelham, New Hampshire	Stanley Roketenetz						
Somersworth Landfill Somerworth, New Hampshire	Wehran Engineering						
Souhegan Regional Landfill Amherst, New Hampshire	Souhegan Regional Landfill DistrictAmherst, New Hampshire						
Turnkey Landfill I, II and III Rochester, New Hampshire	Waste Management of New Hampshire						
Turnkey Landfill of Danbury Danbury, New Hampshire	Turnkey Landfill of Danbury, Inc.						
Unity Landfill Unity, New Hampshire	Town of Unity						
Washington Landfill Washington, New Hampshire	Town of Washington						
Windham Landfill Windham, New Hampshire	Town of Windham						
Four Hills Landfill Nashua, New Hampshire	City of Nashua						
Lebanon Landfill Lebanon, New Hampshire	Town of Lebanon						
Maine							
Candidate Site, Special Waste Landfill Buxton, Maine	Town of Buxton						

Project Name/Location	*Client*	*Remedial Investigations/ Feasibility Studies*	*Hydrogeological Investigation/ Environmental Monitoring*	*Permitting Services*	*Design Services*	*Landfill Closure/Remediation*	*Construction Administration/ Support and/or CQA*
City of Lewiston Landfill, Phase II Landfill Expansion Lewiston, Maine	City of Lewiston		■	■	■		■
Crossroads Landfill, Asbestos Landfill Closure Norridgewock, Maine	Waste Management Disposal Services of Maine, Inc.			■		■	■
Crossroads Landfill, Phase 3C Expansion Norridgewock, Maine	Waste Management Disposal Services of Maine, Inc.			■	■	■	■
Crossroads Landfill, Phase 10 Expansion Norridgewock, Maine	Waste Management Disposal Services of Maine, Inc.			■	■	■	■
Crossroads Landfill, Phase 1-6 Closure Plan Norridgewock, Maine	Waste Management Disposal Services of Maine, Inc.			■		■	
Crossroads Landfill, Phase 9, 11 & 12 Expansion Norridgewock, Maine	Waste Management Disposal Services of Maine, Inc.	■		■	■		
Crossroads Landfill, Phase 5 Construction Norridgewock, Maine	Waste Management Disposal Services of Maine, Inc.						■
Crossroads Landfill, Phase 7 Expansion/Closure Norridgewock, Maine	Waste Management Disposal Services of Maine, Inc.			■	■	■	■
Defense Fuel Supply Point Landfill Casco Bay Facility	U.S. Department of Defense Defense Logistics Agency		■		■	■	
Demolition Debris Landfill Scarborough, Maine	Attorneys for Present Property Owner		■				
Kiln Dust and Clinker Landfills Thomaston, Maine	Dragon Products Company		■				
Old Buxton Landfill Buxton, Maine	Maine Department of Environmental Protection		■				
Paris Utility District Sludge Landfill (AC Lawrence Disposal Site) Paris, Maine	Paris Utility District, Maine Department of Environmental Protection		■	■		■	■
Portsmouth Naval Shipyard, Solid Waste Planning/Transfer Station Permitting	U.S. Navy			■			
Rushton St. (Municipal) Landfill Sanford, Maine	Maine Department of Environmental Protection		■				

Project Name/Location	*Client*	*Remedial Investigations/ Feasibility Studies*	*Hydrogeological Investigation/ Environmental Monitoring*	*Permitting Services*	*Design Services*	*Landfill Closure/Remediation*	*Construction Administration/ Support and/or CQA*
Town of Fairfield Landfill Fairfield, Maine	Maine Department of Environmental Protection						
Town of Gorham Landfill Gorham, Maine	Maine Department of Environmental Protection						
Town of Hollis Landfill Hollis, Maine	Town of Hollis						
Town of Lebanon Landfill Lebanon, Maine	Town of Lebanon						
Town of Norway Landfill Norway, Maine	Maine Department of Environmental Protection						
Town of Pittsfield Landfill Pittsfield, Maine	Town of Pittsfield						
Town of Vinalhaven Landfill Vinalhaven, Maine	Town of Vinalhaven						
U.S. Navy Landfill Redington Township, Maine	U.S. Navy						
Wood Waste and Ash Landfills E. Wilton, Strong & Mattawamkeag, Maine	Confidential Client						
Midwestern States							
Evergreen Landfill Toledo, Ohio	Waste Management of North America						
Pine Tree Acres, Inc. Lenox Township, Michigan	Town of Lenox Township						
Seymour Road Landfill Montrose Township, Michigan	Pollard Disposal						
South Macomb Sites 9 and 9A Macomb Township, Michigan	South Macomb Disposal Authority						
MOA Landfill Atlanta, Michigan	MOA Solid Waste Management Authority						
New York							
Freshkills Landfill Section 6/7 Staten Island, New York	Tully Construction Co., Inc.						
Love Canal ICF Niagara Falls, New York	NYSDEC						
Mohawk Valley Sanitary Landfill Frankfort, New York	Waste Management of North America						

Project Name/Location	*Client*	*Remedial Investigations/ Feasibility Studies*	*Hydrogeological Investigation/ Environmental Monitoring*	*Permitting Services*	*Design Services*	*Landfill Closure/Remediation*	*Construction Administration/ Support and/or CQA*
Monroe-Livingston Landfill Scottsville, New York	Waste Management of North America						
Niagara County Refuse Disposal Landfill Lockport, New York	Niagara County Refuse Disposal District						
Niagara Landfill Niagara, New York	Browning-Ferris Industries						
Sanitary Landfill VI Niagara, New York	Browning-Ferris Industries						
Sanitary Landfill VII Niagara, New York	CECOS International						
Sanitary Landfills I, II, III and IV Niagara, New York	Browning-Ferris Industries						
Secure Chemical Management Facility No. 4 Niagara Falls, New York	CECOS International						
Secure Chemical Management Facility No. 5 Niagara Falls, New York	CECOS International						
New York Department Sanitation Fresh Kills Landfill Staten Island, New York	Tully Construction						
Fountain Avenue Landfill Brooklyn, New York	FGG/Cashman						
Sanitary Landfill V, Subareas A-C Niagara Fall, New York	Allied Niagara Fall Landfill						
Sanitary Landfill VIII, Subareas A-D Niagara Fall, New York	Allied Niagara Fall Landfill						
Pennsylvania							
Pelegrene Landfill Coral, Pennsylvania	USA Waste Services, Inc.						
Washington, DC							
Uline Arena Transfer Station Washington, DC	USA Waste Services, Inc.						
New Jersey							
Keegan Landfill Kearney, New Jersey	Creamer Sanzari—Joint Venture						

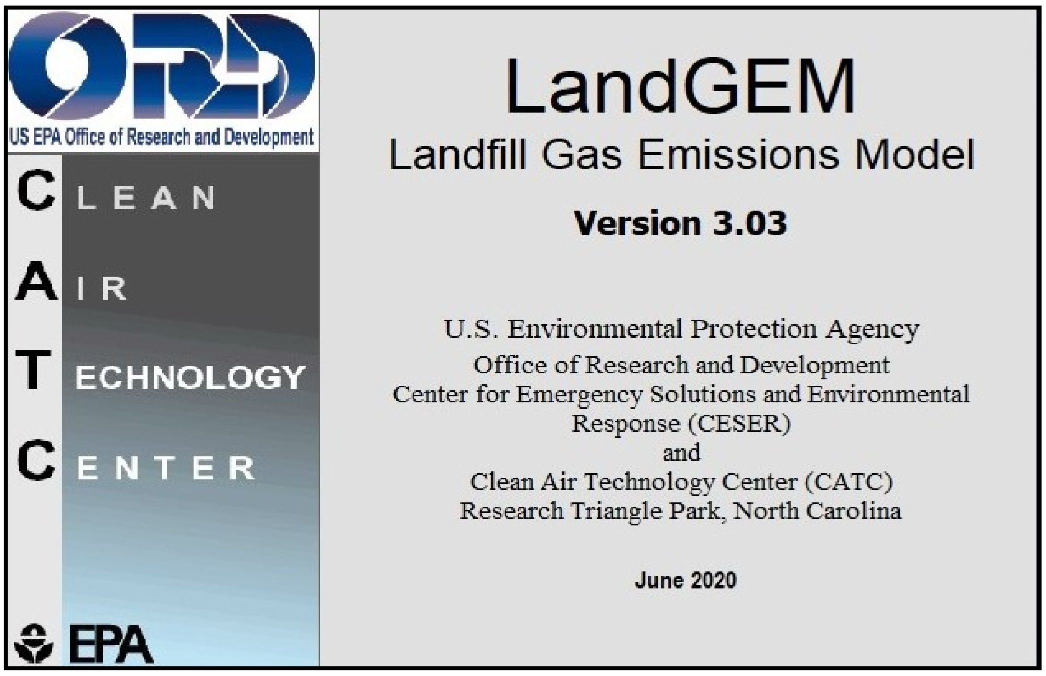
Project Name/Location	*Client*	*Remedial Investigations/ Feasibility Studies*	*Hydrogeological Investigation/ Environmental Monitoring*	*Permitting Services*	*Design Services*	*Landfill Closure/Remediation*	*Construction Administration/ Support and/or CQA*
Bergen County Residual Ash Landfill North Arlington, New Jersey	Bergen County Utilities Authority						
Koppers Ash Landfill Kearney, New Jersey	Koppers Industries						
Salem County Utilities Authority	Salem County Utilities Authority						
Mississippi							
Clearview Landfill Lake, Mississippi	Chambers Waste Systems of Mississippi, Inc., Scott County, Mississippi						
Jackson Transfer Station Jackson, Mississippi	USA Waste Services, Inc.						
Central Landfill Pearl River, Mississippi	TransAmerica						
MidSouth Landfill Hinds County, Mississippi	USA Waste Services, Inc.						
Florida							
C&D Landfill Central Florida	Sanifill, Inc.Norcross, Georgia						
Berman Road Landfill Okeechobee, Florida	Chambers Waste Systems of Florida, Inc., Okeechobee, Florida						
Transfer Station Miami, Florida	Confidential Client						
Tennessee							
Quail Hollow Landfill Tullahoma, Tennessee	USA Waste Services, Inc.						
Nashville Transfer Station Nashville, Tennessee	Sanifill of Tennessee, Inc.						
Cedar Ridge Landfill Lewisburg, Tennessee	Sanifill of Tennessee, Inc.						
Georgia							
Athens Clark County Clark County, Georgia	M.R. Chasman & Associates						
Lawrenceville Transfer Station Lawrenceville, Georgia	USA Waste Services, Inc.						
Pine Bluff Landfill Ballground, Georgia	USA Waste Services						

Project Name/Location	Client	Remedial Investigations/ Feasibility Studies	Hydrogeological Investigation/ Environmental Monitoring	Permitting Services	Design Services	Landfill Closure/Remediation	Construction Administration/ Support and/or CQA
Oakdale Road Landfill Smyrna, Georgia	USA Waste Services, Inc.						
R&B Landfill Banks County, Georgia	USA Waste Services, Inc.						
Paulding County Transfer Station Hiram, Georgia	USA Waste Services, Inc.						
RTS Landfill Hall County, Georgia	USA Waste Services, Inc.						
Speedway Landfill Winder, Georgia	USA Waste Services, Inc.						
Forrest Park Transfer Station Georgia	USA Waste Services, Inc.						
South Carolina							
Solid Waste Transfer Station Fairfield County, South Carolina	USA Waste Services, Inc.						
Oak Ridge Landfill Dorchester, South Carolina	USA Waste Services, Inc.						
Screaming Eagle Landfill Elgin, South Carolina	USA Waste Services, Inc.						
Twin Oaks Transfer Station York County, South Carolina	USA Waste Services, Inc.						
North Carolina							
Anson County Landfill Anson County, North Carolina	Chambers Development						
Solid Waste Transfer Station Charlotte, North Carolina	Chambers Waste Systems of North Carolina						
Virginia							
Maplewood Recycling and Disposal Facility Amelia County, Virginia	Chambers of Virginia						
Big Bethel Landfill Disposal Facility Hampton, Virginia	USA Waste of Virginia						
Maryland							
King George Landfill King George County, Maryland	USA Waste Services, Inc.						
Calvert County Transfer Station Calvert County, Maryland	USA Waste Services, Inc.						

Project Name/Location	*Client*	*Remedial Investigations/ Feasibility Studies*	*Hydrogeological Investigation/ Environmental Monitoring*	*Permitting Services*	*Design Services*	*Landfill Closure/Remediation*	*Construction Administration/ Support and/or CQA*
Calvert County Landfill Calvert County, Maryland	USA Waste Services, Inc.						
Honeygo Landfill Jessup, Maryland	USA Waste Services, Inc.						
Puerto Rico							
CDS Frog Landfill Humacao, Puerto Rico	USA Waste Services, Inc. Casquas, Puerto Rico						

APPENDIX B

LANDGEM OUTPUT



Summary Report

Landfill Name or Identifier: HSP

Date: Thursday, October 20, 2022

Description/Comments:

About LandGEM:

First-Order Decomposition Rate Equation:

$$Q_{CH_4} = \sum_{i=1}^{n} \sum_{j=0.1}^{1} kL_o \left(\frac{M_i}{10} \right) e^{-kt_{ij}}$$

Where,

Q_{CH4} = annual methane generation in the year of the calculation *(m^3/year)*

i = 1-year time increment

n = (year of the calculation) - (initial year of waste acceptance)

j = 0.1-year time increment

k = methane generation rate (*$year^{-1}$*)

L_0 = potential methane generation capacity (*m^3/Mg*)

M_i = mass of waste accepted in the i^{th} year (*Mg*)

t_{ij} = age of the j^{th} section of waste mass M_i accepted in the i^{th} year (*decimal years*, e.g., 3.2 years)

LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in municipal solid waste (MSW) landfills. The software provides a relatively simple approach to estimating landfill gas emissions. Model defaults are based on empirical data from U.S. landfills. Field test data can also be used in place of model defaults when available. Further guidance on EPA test methods, Clean Air Act (CAA) regulations, and other guidance regarding landfill gas emissions and control technology requirements can be found at http://www.epa.gov/ttnatw01/landfill/landflpg.html.

LandGEM is considered a screening tool — the better the input data, the better the estimates. Often, there are limitations with the available data regarding waste quantity and composition, variation in design and operating practices over time, and changes occurring over time that impact the emissions potential. Changes to landfill operation, such as operating under wet conditions through leachate recirculation or other liquid additions, will result in generating more gas at a faster rate. Defaults for estimating emissions for this type of operation are being developed to include in LandGEM along with defaults for convential landfills (no leachate or liquid additions) for developing emission inventories and determining CAA applicability. Refer to the Web site identified above for future updates.

Input Review

LANDFILL CHARACTERISTICS

Landfill Open Year	**1965**	
Landfill Closure Year (with 80-year limit)	**2022**	
Actual Closure Year (without limit)	***2022***	
Have Model Calculate Closure Year?	**No**	
Waste Design Capacity	**170,000**	*short tons*

MODEL PARAMETERS

Methane Generation Rate, k	**0.050**	*year^{-1}*
Potential Methane Generation Capacity, L_0	**170**	*m^3/Mg*
NMOC Concentration	**4,000**	*ppmv as hexane*
Methane Content	**50**	*% by volume*

GASES / POLLUTANTS SELECTED

Gas / Pollutant #1:	**Total landfill gas**
Gas / Pollutant #2:	**Methane**
Gas / Pollutant #3:	**Carbon dioxide**
Gas / Pollutant #4:	**NMOC**

WASTE ACCEPTANCE RATES

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
1965	7,836	8,619	0	0
1966	7,836	8,619	7,836	8,619
1967	7,836	8,619	15,671	17,238
1968	7,836	8,619	23,507	25,858
1969	7,836	8,619	31,343	34,477
1970	7,836	8,619	39,178	43,096
1971	7,836	8,619	47,014	51,715
1972	7,836	8,619	54,850	60,335
1973	7,836	8,619	62,685	68,954
1974	7,836	8,619	70,521	77,573
1975	7,836	8,619	78,357	86,192
1976	7,836	8,619	86,192	94,812
1977	7,836	8,619	94,028	103,431
1978	0	0	101,864	112,050
1979	0	0	101,864	112,050
1980	0	0	101,864	112,050
1981	0	0	101,864	112,050
1982	0	0	101,864	112,050
1983	0	0	101,864	112,050
1984	0	0	101,864	112,050
1985	0	0	101,864	112,050
1986	0	0	101,864	112,050
1987	0	0	101,864	112,050
1988	0	0	101,864	112,050
1989	0	0	101,864	112,050
1990	0	0	101,864	112,050
1991	0	0	101,864	112,050
1992	0	0	101,864	112,050
1993	0	0	101,864	112,050
1994	0	0	101,864	112,050
1995	0	0	101,864	112,050
1996	0	0	101,864	112,050
1997	0	0	101,864	112,050
1998	0	0	101,864	112,050
1999	0	0	101,864	112,050
2000	0	0	101,864	112,050
2001	0	0	101,864	112,050
2002	0	0	101,864	112,050
2003	0	0	101,864	112,050
2004	0	0	101,864	112,050

WASTE ACCEPTANCE RATES (Continued)

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	(short tons/year)	(Mg)	(short tons)
2005	0	0	101,864	112,050
2006	0	0	101,864	112,050
2007	0	0	101,864	112,050
2008	0	0	101,864	112,050
2009	0	0	101,864	112,050
2010	0	0	101,864	112,050
2011	0	0	101,864	112,050
2012	0	0	101,864	112,050
2013	0	0	101,864	112,050
2014	0	0	101,864	112,050
2015	0	0	101,864	112,050
2016	0	0	101,864	112,050
2017	0	0	101,864	112,050
2018	0	0	101,864	112,050
2019	0	0	101,864	112,050
2020	0	0	101,864	112,050
2021	0	0	101,864	112,050
2022	66,436	73,080	101,864	112,050
2023	0	0	168,300	185,130
2024	0	0	168,300	185,130
2025	0	0	168,300	185,130
2026	0	0	168,300	185,130
2027	0	0	168,300	185,130
2028	0	0	168,300	185,130
2029	0	0	168,300	185,130
2030	0	0	168,300	185,130
2031	0	0	168,300	185,130
2032	0	0	168,300	185,130
2033	0	0	168,300	185,130
2034	0	0	168,300	185,130
2035	0	0	168,300	185,130
2036	0	0	168,300	185,130
2037	0	0	168,300	185,130
2038	0	0	168,300	185,130
2039	0	0	168,300	185,130
2040	0	0	168,300	185,130
2041	0	0	168,300	185,130
2042	0	0	168,300	185,130
2043	0	0	168,300	185,130
2044	0	0	168,300	185,130

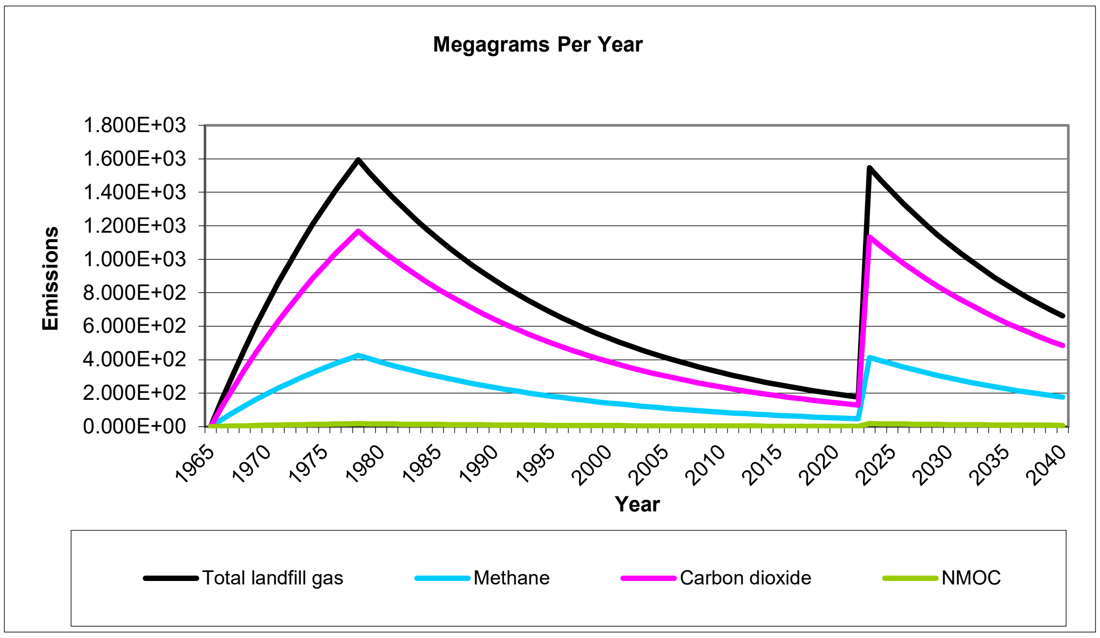
Pollutant Parameters

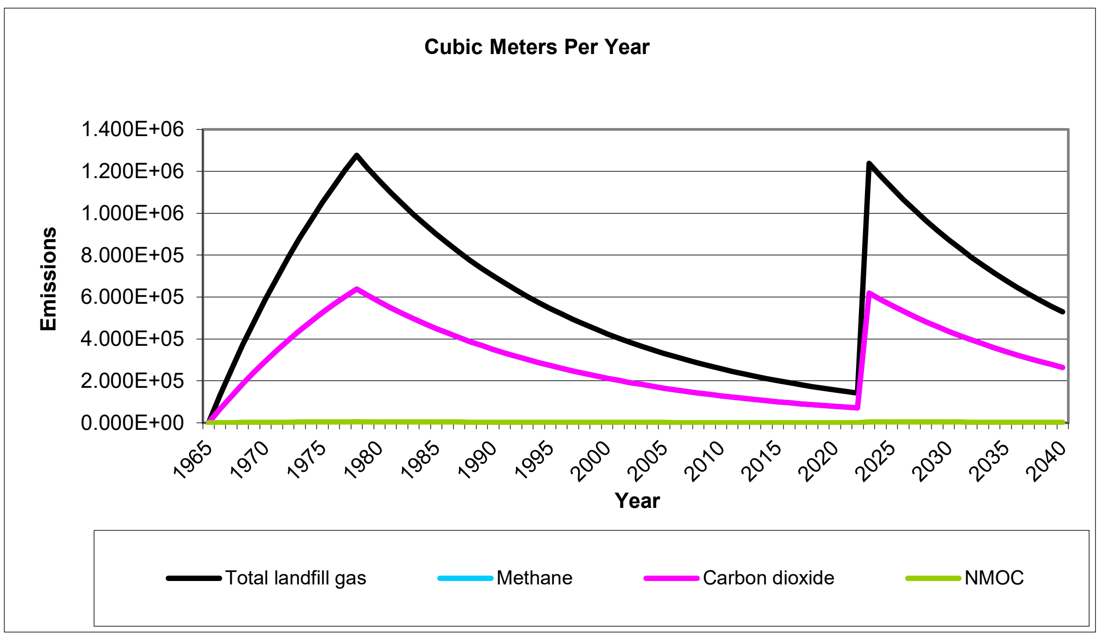
		Gas / Pollutant Default Parameters:		User-specified Pollutant Parameters:	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Gases	Total landfill gas		0.00		
	Methane		16.04		
	Carbon dioxide		44.01		
	NMOC	4,000	86.18		
Pollutants	1,1,1-Trichloroethane (methyl chloroform) - HAP	0.48	133.41		
	1,1,2,2-Tetrachloroethane - HAP/VOC	1.1	167.85		
	1,1-Dichloroethane (ethylidene dichloride) - HAP/VOC	2.4	98.97		
	1,1-Dichloroethene (vinylidene chloride) - HAP/VOC	0.20	96.94		
	1,2-Dichloroethane (ethylene dichloride) - HAP/VOC	0.41	98.96		
	1,2-Dichloropropane (propylene dichloride) - HAP/VOC	0.18	112.99		
	2-Propanol (isopropyl alcohol) - VOC	50	60.11		
	Acetone	7.0	58.08		
	Acrylonitrile - HAP/VOC	6.3	53.06		
	Benzene - No or Unknown Co-disposal - HAP/VOC	1.9	78.11		
	Benzene - Co-disposal - HAP/VOC	11	78.11		
	Bromodichloromethane - VOC	3.1	163.83		
	Butane - VOC	5.0	58.12		
	Carbon disulfide - HAP/VOC	0.58	76.13		
	Carbon monoxide	140	28.01		
	Carbon tetrachloride - HAP/VOC	4.0E-03	153.84		
	Carbonyl sulfide - HAP/VOC	0.49	60.07		
	Chlorobenzene - HAP/VOC	0.25	112.56		
	Chlorodifluoromethane	1.3	86.47		
	Chloroethane (ethyl chloride) - HAP/VOC	1.3	64.52		
	Chloroform - HAP/VOC	0.03	119.39		
	Chloromethane - VOC	1.2	50.49		
	Dichlorobenzene - (HAP for para isomer/VOC)	0.21	147		
	Dichlorodifluoromethane	16	120.91		
	Dichlorofluoromethane - VOC	2.6	102.92		
	Dichloromethane (methylene chloride) - HAP	14	84.94		
	Dimethyl sulfide (methyl sulfide) - VOC	7.8	62.13		
	Ethane	890	30.07		
	Ethanol - VOC	27	46.08		

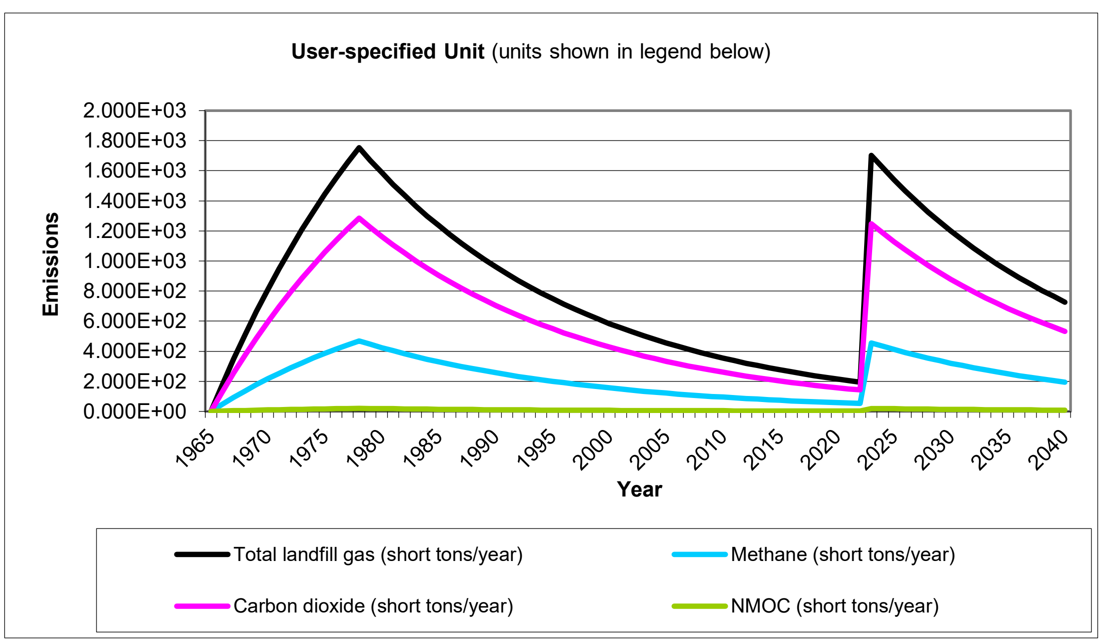
Pollutant Parameters (Continued)

	Gas / Pollutant Default Parameters:			User-specified Pollutant Parameters:	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Pollutants	Ethyl mercaptan (ethanethiol) - VOC	2.3	62.13		
	Ethylbenzene - HAP/VOC	4.6	106.16		
	Ethylene dibromide - HAP/VOC	1.0E-03	187.88		
	Fluorotrichloromethane - VOC	0.76	137.38		
	Hexane - HAP/VOC	6.6	86.18		
	Hydrogen sulfide	36	34.08		
	Mercury (total) - HAP	2.9E-04	200.61		
	Methyl ethyl ketone - HAP/VOC	7.1	72.11		
	Methyl isobutyl ketone - HAP/VOC	1.9	100.16		
	Methyl mercaptan - VOC	2.5	48.11		
	Pentane - VOC	3.3	72.15		
	Perchloroethylene (tetrachloroethylene) - HAP	3.7	165.83		
	Propane - VOC	11	44.09		
	t-1,2-Dichloroethene - VOC	2.8	96.94		
	Toluene - No or Unknown Co-disposal - HAP/VOC	39	92.13		
	Toluene - Co-disposal - HAP/VOC	170	92.13		
	Trichloroethylene (trichloroethene) - HAP/VOC	2.8	131.40		
	Vinyl chloride - HAP/VOC	7.3	62.50		
	Xylenes - HAP/VOC	12	106.16		

Graphs


Megagrams Per Year
Emissions
1.800E+03
1.600E+03
1.400E+03
1.200E+03
1.000E+03
8.000E+02
6.000E+02
4.000E+02
2.000E+02
0.000E+00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


Cubic Meters Per Year
Emissions
1.400E+06
1.200E+06
1.000E+06
8.000E+05
6.000E+05
4.000E+05
2.000E+05
0.000E+00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


User-specified Unit (units shown in legend below)
Emissions
2.000E+03
1.800E+03
1.600E+03
1.400E+03
1.200E+03
1.000E+03
8.000E+02
6.000E+02
4.000E+02
2.000E+02
0.000E+00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040
Year
Total landfill gas (short tons/year)
Methane (short tons/year)
Carbon dioxide (short tons/year)
NMOC (short tons/year)

Results

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(short tons/year)*	*(Mg/year)*	*(m^3/year)*	*(short tons/year)*
1965	0	0	0	0	0	0
1966	1.627E+02	1.303E+05	1.789E+02	4.345E+01	6.513E+04	4.780E+01
1967	3.174E+02	2.542E+05	3.491E+02	8.478E+01	1.271E+05	9.326E+01
1968	4.646E+02	3.720E+05	5.110E+02	1.241E+02	1.860E+05	1.365E+02
1969	6.046E+02	4.841E+05	6.651E+02	1.615E+02	2.421E+05	1.776E+02
1970	7.378E+02	5.908E+05	8.116E+02	1.971E+02	2.954E+05	2.168E+02
1971	8.645E+02	6.922E+05	9.509E+02	2.309E+02	3.461E+05	2.540E+02
1972	9.850E+02	7.887E+05	1.083E+03	2.631E+02	3.944E+05	2.894E+02
1973	1.100E+03	8.805E+05	1.210E+03	2.937E+02	4.403E+05	3.231E+02
1974	1.209E+03	9.678E+05	1.329E+03	3.228E+02	4.839E+05	3.551E+02
1975	1.312E+03	1.051E+06	1.444E+03	3.505E+02	5.254E+05	3.856E+02
1976	1.411E+03	1.130E+06	1.552E+03	3.769E+02	5.649E+05	4.146E+02
1977	1.505E+03	1.205E+06	1.655E+03	4.020E+02	6.025E+05	4.422E+02
1978	1.594E+03	1.277E+06	1.754E+03	4.258E+02	6.383E+05	4.684E+02
1979	1.516E+03	1.214E+06	1.668E+03	4.050E+02	6.071E+05	4.456E+02
1980	1.442E+03	1.155E+06	1.587E+03	3.853E+02	5.775E+05	4.238E+02
1981	1.372E+03	1.099E+06	1.509E+03	3.665E+02	5.494E+05	4.032E+02
1982	1.305E+03	1.045E+06	1.436E+03	3.486E+02	5.226E+05	3.835E+02
1983	1.242E+03	9.942E+05	1.366E+03	3.316E+02	4.971E+05	3.648E+02
1984	1.181E+03	9.457E+05	1.299E+03	3.154E+02	4.728E+05	3.470E+02
1985	1.123E+03	8.995E+05	1.236E+03	3.001E+02	4.498E+05	3.301E+02
1986	1.069E+03	8.557E+05	1.175E+03	2.854E+02	4.278E+05	3.140E+02
1987	1.016E+03	8.139E+05	1.118E+03	2.715E+02	4.070E+05	2.987E+02
1988	9.669E+02	7.742E+05	1.064E+03	2.583E+02	3.871E+05	2.841E+02
1989	9.197E+02	7.365E+05	1.012E+03	2.457E+02	3.682E+05	2.702E+02
1990	8.749E+02	7.006E+05	9.624E+02	2.337E+02	3.503E+05	2.571E+02
1991	8.322E+02	6.664E+05	9.154E+02	2.223E+02	3.332E+05	2.445E+02
1992	7.916E+02	6.339E+05	8.708E+02	2.115E+02	3.169E+05	2.326E+02
1993	7.530E+02	6.030E+05	8.283E+02	2.011E+02	3.015E+05	2.213E+02
1994	7.163E+02	5.736E+05	7.879E+02	1.913E+02	2.868E+05	2.105E+02
1995	6.814E+02	5.456E+05	7.495E+02	1.820E+02	2.728E+05	2.002E+02
1996	6.481E+02	5.190E+05	7.129E+02	1.731E+02	2.595E+05	1.904E+02
1997	6.165E+02	4.937E+05	6.782E+02	1.647E+02	2.468E+05	1.811E+02
1998	5.865E+02	4.696E+05	6.451E+02	1.566E+02	2.348E+05	1.723E+02
1999	5.579E+02	4.467E+05	6.136E+02	1.490E+02	2.234E+05	1.639E+02
2000	5.306E+02	4.249E+05	5.837E+02	1.417E+02	2.125E+05	1.559E+02
2001	5.048E+02	4.042E+05	5.552E+02	1.348E+02	2.021E+05	1.483E+02
2002	4.801E+02	3.845E+05	5.282E+02	1.283E+02	1.922E+05	1.411E+02
2003	4.567E+02	3.657E+05	5.024E+02	1.220E+02	1.829E+05	1.342E+02
2004	4.345E+02	3.479E+05	4.779E+02	1.160E+02	1.739E+05	1.277E+02
2005	4.133E+02	3.309E+05	4.546E+02	1.104E+02	1.655E+05	1.214E+02
2006	3.931E+02	3.148E+05	4.324E+02	1.050E+02	1.574E+05	1.155E+02
2007	3.739E+02	2.994E+05	4.113E+02	9.988E+01	1.497E+05	1.099E+02
2008	3.557E+02	2.848E+05	3.913E+02	9.501E+01	1.424E+05	1.045E+02
2009	3.384E+02	2.709E+05	3.722E+02	9.038E+01	1.355E+05	9.942E+01
2010	3.219E+02	2.577E+05	3.540E+02	8.597E+01	1.289E+05	9.457E+01
2011	3.062E+02	2.452E+05	3.368E+02	8.178E+01	1.226E+05	8.996E+01
2012	2.912E+02	2.332E+05	3.203E+02	7.779E+01	1.166E+05	8.557E+01
2013	2.770E+02	2.218E+05	3.047E+02	7.400E+01	1.109E+05	8.139E+01
2014	2.635E+02	2.110E+05	2.899E+02	7.039E+01	1.055E+05	7.743E+01

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(short tons/year)*	*(Mg/year)*	*(m^3/year)*	*(short tons/year)*
2015	2.507E+02	2.007E+05	2.757E+02	6.695E+01	1.004E+05	7.365E+01
2016	2.384E+02	1.909E+05	2.623E+02	6.369E+01	9.546E+04	7.006E+01
2017	2.268E+02	1.816E+05	2.495E+02	6.058E+01	9.081E+04	6.664E+01
2018	2.157E+02	1.728E+05	2.373E+02	5.763E+01	8.638E+04	6.339E+01
2019	2.052E+02	1.643E+05	2.257E+02	5.482E+01	8.217E+04	6.030E+01
2020	1.952E+02	1.563E+05	2.147E+02	5.214E+01	7.816E+04	5.736E+01
2021	1.857E+02	1.487E+05	2.043E+02	4.960E+01	7.435E+04	5.456E+01
2022	1.766E+02	1.414E+05	1.943E+02	4.718E+01	7.072E+04	5.190E+01
2023	1.547E+03	1.239E+06	1.702E+03	4.133E+02	6.195E+05	4.546E+02
2024	1.472E+03	1.179E+06	1.619E+03	3.931E+02	5.893E+05	4.324E+02
2025	1.400E+03	1.121E+06	1.540E+03	3.740E+02	5.605E+05	4.113E+02
2026	1.332E+03	1.066E+06	1.465E+03	3.557E+02	5.332E+05	3.913E+02
2027	1.267E+03	1.014E+06	1.393E+03	3.384E+02	5.072E+05	3.722E+02
2028	1.205E+03	9.649E+05	1.325E+03	3.219E+02	4.824E+05	3.540E+02
2029	1.146E+03	9.178E+05	1.261E+03	3.062E+02	4.589E+05	3.368E+02
2030	1.090E+03	8.731E+05	1.199E+03	2.912E+02	4.365E+05	3.204E+02
2031	1.037E+03	8.305E+05	1.141E+03	2.770E+02	4.152E+05	3.047E+02
2032	9.866E+02	7.900E+05	1.085E+03	2.635E+02	3.950E+05	2.899E+02
2033	9.384E+02	7.515E+05	1.032E+03	2.507E+02	3.757E+05	2.757E+02
2034	8.927E+02	7.148E+05	9.819E+02	2.384E+02	3.574E+05	2.623E+02
2035	8.491E+02	6.799E+05	9.340E+02	2.268E+02	3.400E+05	2.495E+02
2036	8.077E+02	6.468E+05	8.885E+02	2.158E+02	3.234E+05	2.373E+02
2037	7.683E+02	6.152E+05	8.452E+02	2.052E+02	3.076E+05	2.258E+02
2038	7.309E+02	5.852E+05	8.039E+02	1.952E+02	2.926E+05	2.147E+02
2039	6.952E+02	5.567E+05	7.647E+02	1.857E+02	2.783E+05	2.043E+02
2040	6.613E+02	5.295E+05	7.274E+02	1.766E+02	2.648E+05	1.943E+02
2041	6.291E+02	5.037E+05	6.920E+02	1.680E+02	2.519E+05	1.848E+02
2042	5.984E+02	4.792E+05	6.582E+02	1.598E+02	2.396E+05	1.758E+02
2043	5.692E+02	4.558E+05	6.261E+02	1.520E+02	2.279E+05	1.672E+02
2044	5.414E+02	4.336E+05	5.956E+02	1.446E+02	2.168E+05	1.591E+02
2045	5.150E+02	4.124E+05	5.665E+02	1.376E+02	2.062E+05	1.513E+02
2046	4.899E+02	3.923E+05	5.389E+02	1.309E+02	1.961E+05	1.439E+02
2047	4.660E+02	3.732E+05	5.126E+02	1.245E+02	1.866E+05	1.369E+02
2048	4.433E+02	3.550E+05	4.876E+02	1.184E+02	1.775E+05	1.302E+02
2049	4.217E+02	3.377E+05	4.638E+02	1.126E+02	1.688E+05	1.239E+02
2050	4.011E+02	3.212E+05	4.412E+02	1.071E+02	1.606E+05	1.179E+02
2051	3.815E+02	3.055E+05	4.197E+02	1.019E+02	1.528E+05	1.121E+02
2052	3.629E+02	2.906E+05	3.992E+02	9.694E+01	1.453E+05	1.066E+02
2053	3.452E+02	2.764E+05	3.798E+02	9.222E+01	1.382E+05	1.014E+02
2054	3.284E+02	2.630E+05	3.612E+02	8.772E+01	1.315E+05	9.649E+01
2055	3.124E+02	2.501E+05	3.436E+02	8.344E+01	1.251E+05	9.178E+01
2056	2.971E+02	2.379E+05	3.269E+02	7.937E+01	1.190E+05	8.731E+01
2057	2.827E+02	2.263E+05	3.109E+02	7.550E+01	1.132E+05	8.305E+01
2058	2.689E+02	2.153E+05	2.958E+02	7.182E+01	1.076E+05	7.900E+01
2059	2.558E+02	2.048E+05	2.813E+02	6.831E+01	1.024E+05	7.515E+01
2060	2.433E+02	1.948E+05	2.676E+02	6.498E+01	9.740E+04	7.148E+01
2061	2.314E+02	1.853E+05	2.546E+02	6.181E+01	9.265E+04	6.800E+01
2062	2.201E+02	1.763E+05	2.421E+02	5.880E+01	8.814E+04	6.468E+01
2063	2.094E+02	1.677E+05	2.303E+02	5.593E+01	8.384E+04	6.152E+01
2064	1.992E+02	1.595E+05	2.191E+02	5.320E+01	7.975E+04	5.852E+01
2065	1.895E+02	1.517E+05	2.084E+02	5.061E+01	7.586E+04	5.567E+01

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	(m^3/year)	(short tons/year)	(Mg/year)	(m^3/year)	(short tons/year)
2066	1.802E+02	1.443E+05	1.983E+02	4.814E+01	7.216E+04	5.295E+01
2067	1.714E+02	1.373E+05	1.886E+02	4.579E+01	6.864E+04	5.037E+01
2068	1.631E+02	1.306E+05	1.794E+02	4.356E+01	6.529E+04	4.792E+01
2069	1.551E+02	1.242E+05	1.706E+02	4.144E+01	6.211E+04	4.558E+01
2070	1.476E+02	1.182E+05	1.623E+02	3.941E+01	5.908E+04	4.336E+01
2071	1.404E+02	1.124E+05	1.544E+02	3.749E+01	5.620E+04	4.124E+01
2072	1.335E+02	1.069E+05	1.469E+02	3.566E+01	5.346E+04	3.923E+01
2073	1.270E+02	1.017E+05	1.397E+02	3.392E+01	5.085E+04	3.732E+01
2074	1.208E+02	9.674E+04	1.329E+02	3.227E+01	4.837E+04	3.550E+01
2075	1.149E+02	9.202E+04	1.264E+02	3.070E+01	4.601E+04	3.377E+01
2076	1.093E+02	8.753E+04	1.202E+02	2.920E+01	4.377E+04	3.212E+01
2077	1.040E+02	8.326E+04	1.144E+02	2.777E+01	4.163E+04	3.055E+01
2078	9.891E+01	7.920E+04	1.088E+02	2.642E+01	3.960E+04	2.906E+01
2079	9.409E+01	7.534E+04	1.035E+02	2.513E+01	3.767E+04	2.764E+01
2080	8.950E+01	7.167E+04	9.845E+01	2.391E+01	3.583E+04	2.630E+01
2081	8.513E+01	6.817E+04	9.365E+01	2.274E+01	3.409E+04	2.501E+01
2082	8.098E+01	6.485E+04	8.908E+01	2.163E+01	3.242E+04	2.379E+01
2083	7.703E+01	6.168E+04	8.474E+01	2.058E+01	3.084E+04	2.263E+01
2084	7.328E+01	5.868E+04	8.060E+01	1.957E+01	2.934E+04	2.153E+01
2085	6.970E+01	5.581E+04	7.667E+01	1.862E+01	2.791E+04	2.048E+01
2086	6.630E+01	5.309E+04	7.293E+01	1.771E+01	2.655E+04	1.948E+01
2087	6.307E+01	5.050E+04	6.938E+01	1.685E+01	2.525E+04	1.853E+01
2088	5.999E+01	4.804E+04	6.599E+01	1.602E+01	2.402E+04	1.763E+01
2089	5.707E+01	4.570E+04	6.277E+01	1.524E+01	2.285E+04	1.677E+01
2090	5.428E+01	4.347E+04	5.971E+01	1.450E+01	2.173E+04	1.595E+01
2091	5.164E+01	4.135E+04	5.680E+01	1.379E+01	2.067E+04	1.517E+01
2092	4.912E+01	3.933E+04	5.403E+01	1.312E+01	1.967E+04	1.443E+01
2093	4.672E+01	3.741E+04	5.139E+01	1.248E+01	1.871E+04	1.373E+01
2094	4.444E+01	3.559E+04	4.889E+01	1.187E+01	1.779E+04	1.306E+01
2095	4.228E+01	3.385E+04	4.650E+01	1.129E+01	1.693E+04	1.242E+01
2096	4.021E+01	3.220E+04	4.424E+01	1.074E+01	1.610E+04	1.182E+01
2097	3.825E+01	3.063E+04	4.208E+01	1.022E+01	1.532E+04	1.124E+01
2098	3.639E+01	2.914E+04	4.003E+01	9.719E+00	1.457E+04	1.069E+01
2099	3.461E+01	2.772E+04	3.807E+01	9.245E+00	1.386E+04	1.017E+01
2100	3.292E+01	2.636E+04	3.622E+01	8.795E+00	1.318E+04	9.674E+00
2101	3.132E+01	2.508E+04	3.445E+01	8.366E+00	1.254E+04	9.202E+00
2102	2.979E+01	2.386E+04	3.277E+01	7.958E+00	1.193E+04	8.753E+00
2103	2.834E+01	2.269E+04	3.117E+01	7.570E+00	1.135E+04	8.326E+00
2104	2.696E+01	2.159E+04	2.965E+01	7.200E+00	1.079E+04	7.920E+00
2105	2.564E+01	2.053E+04	2.821E+01	6.849E+00	1.027E+04	7.534E+00

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(short tons/year)*	*(Mg/year)*	*(m^3/year)*	*(short tons/year)*
1965	0	0	0	0	0	0
1966	1.192E+02	6.513E+04	1.311E+02	1.868E+00	5.210E+02	2.054E+00
1967	2.326E+02	1.271E+05	2.559E+02	3.644E+00	1.017E+03	4.009E+00
1968	3.405E+02	1.860E+05	3.745E+02	5.334E+00	1.488E+03	5.867E+00
1969	4.431E+02	2.421E+05	4.874E+02	6.941E+00	1.937E+03	7.636E+00
1970	5.407E+02	2.954E+05	5.948E+02	8.470E+00	2.363E+03	9.318E+00
1971	6.336E+02	3.461E+05	6.969E+02	9.925E+00	2.769E+03	1.092E+01
1972	7.219E+02	3.944E+05	7.941E+02	1.131E+01	3.155E+03	1.244E+01
1973	8.059E+02	4.403E+05	8.865E+02	1.262E+01	3.522E+03	1.389E+01
1974	8.858E+02	4.839E+05	9.744E+02	1.388E+01	3.871E+03	1.526E+01
1975	9.618E+02	5.254E+05	1.058E+03	1.507E+01	4.203E+03	1.657E+01
1976	1.034E+03	5.649E+05	1.138E+03	1.620E+01	4.520E+03	1.782E+01
1977	1.103E+03	6.025E+05	1.213E+03	1.728E+01	4.820E+03	1.901E+01
1978	1.168E+03	6.383E+05	1.285E+03	1.830E+01	5.106E+03	2.013E+01
1979	1.111E+03	6.071E+05	1.222E+03	1.741E+01	4.857E+03	1.915E+01
1980	1.057E+03	5.775E+05	1.163E+03	1.656E+01	4.620E+03	1.822E+01
1981	1.006E+03	5.494E+05	1.106E+03	1.575E+01	4.395E+03	1.733E+01
1982	9.565E+02	5.226E+05	1.052E+03	1.498E+01	4.180E+03	1.648E+01
1983	9.099E+02	4.971E+05	1.001E+03	1.425E+01	3.977E+03	1.568E+01
1984	8.655E+02	4.728E+05	9.521E+02	1.356E+01	3.783E+03	1.491E+01
1985	8.233E+02	4.498E+05	9.056E+02	1.290E+01	3.598E+03	1.419E+01
1986	7.832E+02	4.278E+05	8.615E+02	1.227E+01	3.423E+03	1.350E+01
1987	7.450E+02	4.070E+05	8.195E+02	1.167E+01	3.256E+03	1.284E+01
1988	7.086E+02	3.871E+05	7.795E+02	1.110E+01	3.097E+03	1.221E+01
1989	6.741E+02	3.682E+05	7.415E+02	1.056E+01	2.946E+03	1.162E+01
1990	6.412E+02	3.503E+05	7.053E+02	1.004E+01	2.802E+03	1.105E+01
1991	6.099E+02	3.332E+05	6.709E+02	9.555E+00	2.666E+03	1.051E+01
1992	5.802E+02	3.169E+05	6.382E+02	9.089E+00	2.536E+03	9.998E+00
1993	5.519E+02	3.015E+05	6.071E+02	8.645E+00	2.412E+03	9.510E+00
1994	5.250E+02	2.868E+05	5.775E+02	8.224E+00	2.294E+03	9.046E+00
1995	4.994E+02	2.728E+05	5.493E+02	7.823E+00	2.182E+03	8.605E+00
1996	4.750E+02	2.595E+05	5.225E+02	7.441E+00	2.076E+03	8.185E+00
1997	4.518E+02	2.468E+05	4.970E+02	7.078E+00	1.975E+03	7.786E+00
1998	4.298E+02	2.348E+05	4.728E+02	6.733E+00	1.878E+03	7.406E+00
1999	4.088E+02	2.234E+05	4.497E+02	6.405E+00	1.787E+03	7.045E+00
2000	3.889E+02	2.125E+05	4.278E+02	6.092E+00	1.700E+03	6.702E+00
2001	3.699E+02	2.021E+05	4.069E+02	5.795E+00	1.617E+03	6.375E+00
2002	3.519E+02	1.922E+05	3.871E+02	5.513E+00	1.538E+03	6.064E+00
2003	3.347E+02	1.829E+05	3.682E+02	5.244E+00	1.463E+03	5.768E+00
2004	3.184E+02	1.739E+05	3.502E+02	4.988E+00	1.392E+03	5.487E+00
2005	3.029E+02	1.655E+05	3.332E+02	4.745E+00	1.324E+03	5.219E+00
2006	2.881E+02	1.574E+05	3.169E+02	4.513E+00	1.259E+03	4.965E+00
2007	2.741E+02	1.497E+05	3.015E+02	4.293E+00	1.198E+03	4.723E+00
2008	2.607E+02	1.424E+05	2.868E+02	4.084E+00	1.139E+03	4.492E+00
2009	2.480E+02	1.355E+05	2.728E+02	3.885E+00	1.084E+03	4.273E+00
2010	2.359E+02	1.289E+05	2.595E+02	3.695E+00	1.031E+03	4.065E+00
2011	2.244E+02	1.226E+05	2.468E+02	3.515E+00	9.806E+02	3.866E+00
2012	2.134E+02	1.166E+05	2.348E+02	3.344E+00	9.328E+02	3.678E+00
2013	2.030E+02	1.109E+05	2.233E+02	3.181E+00	8.873E+02	3.499E+00
2014	1.931E+02	1.055E+05	2.124E+02	3.025E+00	8.440E+02	3.328E+00

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	(m^3/year)	(short tons/year)	(Mg/year)	(m^3/year)	(short tons/year)
2015	1.837E+02	1.004E+05	2.021E+02	2.878E+00	8.029E+02	3.166E+00
2016	1.747E+02	9.546E+04	1.922E+02	2.737E+00	7.637E+02	3.011E+00
2017	1.662E+02	9.081E+04	1.828E+02	2.604E+00	7.265E+02	2.864E+00
2018	1.581E+02	8.638E+04	1.739E+02	2.477E+00	6.910E+02	2.725E+00
2019	1.504E+02	8.217E+04	1.654E+02	2.356E+00	6.573E+02	2.592E+00
2020	1.431E+02	7.816E+04	1.574E+02	2.241E+00	6.253E+02	2.465E+00
2021	1.361E+02	7.435E+04	1.497E+02	2.132E+00	5.948E+02	2.345E+00
2022	1.295E+02	7.072E+04	1.424E+02	2.028E+00	5.658E+02	2.231E+00
2023	1.134E+03	6.195E+05	1.247E+03	1.776E+01	4.956E+03	1.954E+01
2024	1.079E+03	5.893E+05	1.187E+03	1.690E+01	4.714E+03	1.859E+01
2025	1.026E+03	5.605E+05	1.129E+03	1.607E+01	4.484E+03	1.768E+01
2026	9.760E+02	5.332E+05	1.074E+03	1.529E+01	4.265E+03	1.682E+01
2027	9.284E+02	5.072E+05	1.021E+03	1.454E+01	4.057E+03	1.600E+01
2028	8.831E+02	4.824E+05	9.714E+02	1.383E+01	3.860E+03	1.522E+01
2029	8.400E+02	4.589E+05	9.241E+02	1.316E+01	3.671E+03	1.448E+01
2030	7.991E+02	4.365E+05	8.790E+02	1.252E+01	3.492E+03	1.377E+01
2031	7.601E+02	4.152E+05	8.361E+02	1.191E+01	3.322E+03	1.310E+01
2032	7.230E+02	3.950E+05	7.953E+02	1.133E+01	3.160E+03	1.246E+01
2033	6.878E+02	3.757E+05	7.566E+02	1.077E+01	3.006E+03	1.185E+01
2034	6.542E+02	3.574E+05	7.197E+02	1.025E+01	2.859E+03	1.127E+01
2035	6.223E+02	3.400E+05	6.846E+02	9.749E+00	2.720E+03	1.072E+01
2036	5.920E+02	3.234E+05	6.512E+02	9.274E+00	2.587E+03	1.020E+01
2037	5.631E+02	3.076E+05	6.194E+02	8.821E+00	2.461E+03	9.703E+00
2038	5.356E+02	2.926E+05	5.892E+02	8.391E+00	2.341E+03	9.230E+00
2039	5.095E+02	2.783E+05	5.605E+02	7.982E+00	2.227E+03	8.780E+00
2040	4.847E+02	2.648E+05	5.331E+02	7.593E+00	2.118E+03	8.352E+00
2041	4.610E+02	2.519E+05	5.071E+02	7.222E+00	2.015E+03	7.944E+00
2042	4.385E+02	2.396E+05	4.824E+02	6.870E+00	1.917E+03	7.557E+00
2043	4.172E+02	2.279E+05	4.589E+02	6.535E+00	1.823E+03	7.188E+00
2044	3.968E+02	2.168E+05	4.365E+02	6.216E+00	1.734E+03	6.838E+00
2045	3.775E+02	2.062E+05	4.152E+02	5.913E+00	1.650E+03	6.504E+00
2046	3.590E+02	1.961E+05	3.950E+02	5.625E+00	1.569E+03	6.187E+00
2047	3.415E+02	1.866E+05	3.757E+02	5.350E+00	1.493E+03	5.885E+00
2048	3.249E+02	1.775E+05	3.574E+02	5.089E+00	1.420E+03	5.598E+00
2049	3.090E+02	1.688E+05	3.399E+02	4.841E+00	1.351E+03	5.325E+00
2050	2.940E+02	1.606E+05	3.234E+02	4.605E+00	1.285E+03	5.066E+00
2051	2.796E+02	1.528E+05	3.076E+02	4.381E+00	1.222E+03	4.819E+00
2052	2.660E+02	1.453E+05	2.926E+02	4.167E+00	1.162E+03	4.584E+00
2053	2.530E+02	1.382E+05	2.783E+02	3.964E+00	1.106E+03	4.360E+00
2054	2.407E+02	1.315E+05	2.647E+02	3.770E+00	1.052E+03	4.147E+00
2055	2.289E+02	1.251E+05	2.518E+02	3.586E+00	1.001E+03	3.945E+00
2056	2.178E+02	1.190E+05	2.396E+02	3.412E+00	9.518E+02	3.753E+00
2057	2.072E+02	1.132E+05	2.279E+02	3.245E+00	9.053E+02	3.570E+00
2058	1.971E+02	1.076E+05	2.168E+02	3.087E+00	8.612E+02	3.396E+00
2059	1.874E+02	1.024E+05	2.062E+02	2.936E+00	8.192E+02	3.230E+00
2060	1.783E+02	9.740E+04	1.961E+02	2.793E+00	7.792E+02	3.072E+00
2061	1.696E+02	9.265E+04	1.866E+02	2.657E+00	7.412E+02	2.923E+00
2062	1.613E+02	8.814E+04	1.775E+02	2.527E+00	7.051E+02	2.780E+00
2063	1.535E+02	8.384E+04	1.688E+02	2.404E+00	6.707E+02	2.644E+00
2064	1.460E+02	7.975E+04	1.606E+02	2.287E+00	6.380E+02	2.516E+00
2065	1.389E+02	7.586E+04	1.527E+02	2.175E+00	6.069E+02	2.393E+00

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(short tons/year)*	*(Mg/year)*	*(m^3/year)*	*(short tons/year)*
2066	1.321E+02	7.216E+04	1.453E+02	2.069E+00	5.773E+02	2.276E+00
2067	1.256E+02	6.864E+04	1.382E+02	1.968E+00	5.491E+02	2.165E+00
2068	1.195E+02	6.529E+04	1.315E+02	1.872E+00	5.223E+02	2.060E+00
2069	1.137E+02	6.211E+04	1.251E+02	1.781E+00	4.969E+02	1.959E+00
2070	1.081E+02	5.908E+04	1.190E+02	1.694E+00	4.726E+02	1.864E+00
2071	1.029E+02	5.620E+04	1.132E+02	1.612E+00	4.496E+02	1.773E+00
2072	9.785E+01	5.346E+04	1.076E+02	1.533E+00	4.277E+02	1.686E+00
2073	9.308E+01	5.085E+04	1.024E+02	1.458E+00	4.068E+02	1.604E+00
2074	8.854E+01	4.837E+04	9.739E+01	1.387E+00	3.870E+02	1.526E+00
2075	8.422E+01	4.601E+04	9.264E+01	1.319E+00	3.681E+02	1.451E+00
2076	8.011E+01	4.377E+04	8.813E+01	1.255E+00	3.501E+02	1.381E+00
2077	7.621E+01	4.163E+04	8.383E+01	1.194E+00	3.331E+02	1.313E+00
2078	7.249E+01	3.960E+04	7.974E+01	1.136E+00	3.168E+02	1.249E+00
2079	6.896E+01	3.767E+04	7.585E+01	1.080E+00	3.014E+02	1.188E+00
2080	6.559E+01	3.583E+04	7.215E+01	1.028E+00	2.867E+02	1.130E+00
2081	6.239E+01	3.409E+04	6.863E+01	9.774E-01	2.727E+02	1.075E+00
2082	5.935E+01	3.242E+04	6.529E+01	9.298E-01	2.594E+02	1.023E+00
2083	5.646E+01	3.084E+04	6.210E+01	8.844E-01	2.467E+02	9.729E-01
2084	5.370E+01	2.934E+04	5.907E+01	8.413E-01	2.347E+02	9.254E-01
2085	5.108E+01	2.791E+04	5.619E+01	8.002E-01	2.233E+02	8.803E-01
2086	4.859E+01	2.655E+04	5.345E+01	7.612E-01	2.124E+02	8.373E-01
2087	4.622E+01	2.525E+04	5.084E+01	7.241E-01	2.020E+02	7.965E-01
2088	4.397E+01	2.402E+04	4.836E+01	6.888E-01	1.922E+02	7.577E-01
2089	4.182E+01	2.285E+04	4.601E+01	6.552E-01	1.828E+02	7.207E-01
2090	3.978E+01	2.173E+04	4.376E+01	6.232E-01	1.739E+02	6.856E-01
2091	3.784E+01	2.067E+04	4.163E+01	5.928E-01	1.654E+02	6.521E-01
2092	3.600E+01	1.967E+04	3.960E+01	5.639E-01	1.573E+02	6.203E-01
2093	3.424E+01	1.871E+04	3.767E+01	5.364E-01	1.497E+02	5.901E-01
2094	3.257E+01	1.779E+04	3.583E+01	5.103E-01	1.424E+02	5.613E-01
2095	3.098E+01	1.693E+04	3.408E+01	4.854E-01	1.354E+02	5.339E-01
2096	2.947E+01	1.610E+04	3.242E+01	4.617E-01	1.288E+02	5.079E-01
2097	2.804E+01	1.532E+04	3.084E+01	4.392E-01	1.225E+02	4.831E-01
2098	2.667E+01	1.457E+04	2.933E+01	4.178E-01	1.165E+02	4.595E-01
2099	2.537E+01	1.386E+04	2.790E+01	3.974E-01	1.109E+02	4.371E-01
2100	2.413E+01	1.318E+04	2.654E+01	3.780E-01	1.055E+02	4.158E-01
2101	2.295E+01	1.254E+04	2.525E+01	3.596E-01	1.003E+02	3.955E-01
2102	2.183E+01	1.193E+04	2.402E+01	3.420E-01	9.542E+01	3.762E-01
2103	2.077E+01	1.135E+04	2.285E+01	3.254E-01	9.077E+01	3.579E-01
2104	1.976E+01	1.079E+04	2.173E+01	3.095E-01	8.634E+01	3.404E-01
2105	1.879E+01	1.027E+04	2.067E+01	2.944E-01	8.213E+01	3.238E-01

APPENDIX C

EGLE-APPROVED CHECKLIST OF APPLICABLE SUBSTANTIVE REQUIREMENTS OF PART 115

APPENDIX C
CROSSWALK TABLE
HSP WORK PLAN TO PART 115 REQUIREMENTS

Description of Item	Location of Documents
A. General information required to be submitted on the construction permit application provided. Rule 902(1)(a).	
1. Name and location of the facility.	Refer to Section 3.0
2. Name and address of the operation.	Refer to Section 3.0
3. Name and address of the property owner(s).	Refer to Section 3.0
4. Name and address of any mineral rights owner(s).	Not Applicable
5. The type of disposal area proposed.	Refer to Section 3.0
6. The type of application being submitted.	Not Applicable
7. A description of the type of waste proposed for disposal attached to application form.	Refer to Section 3.0
8. The number of acres applied for.	Refer to Section 3.0
9. The design capacity of the landfill.	Not Applicable
10. The signature of the owner and proposed operator.	Not Applicable
11. Facility map included with application form.	Refer to Section 7.0
12. Facility's legal description attached to application form.	Refer to Section 3.0
13. Indicate the amount of the application fee **Rule 902(1)(b)**	Not Applicable
14. Verification of receipt of application fee from Cashier's Office.	Not Applicable
B. An environmental assessment must contain the following information. Rule 902(1)(c)	
1. Documentation of consistency with the county solid waste management plan through either of the methods allowed. **Rule 902(2)** and **Rule 903(1)(a)**	
a. Letter, resolution, or other document from designated planning agency that the proposed disposal area is consistent.	Not Applicable
b. Statement from applicant saying why they believe the proposed disposal area is consistent based on the requirements of the plan, if the designating planning agency refuses to provide the original documentation.	Not Applicable
2. A list of required governmental permits/licenses required for the disposal area. **Rule 903(1)(b)** and **903(2)(c)**	Refer to Section 4.1
3. Documentation of compliance with location standards specified in Rules 411-419 (for Type II) or Rules 305 and 310 (for Type III). **Rule 903(1)(c)**	Refer to Section 4.2
a. Rule 411 Groundwater Isolation	
b. Rule 412 Horizontal isolation	
c. Rule 413 Sensitive areas	
d. Rule 414 Airport safety	
e. Rule 415 Floodplains	
f. Rule 416 Wetlands	
g. Rule 417 Fault areas and impact zones	
h. Rule 418 Unstable areas	
i. Rule 419 Vertical expansions	
4. Demonstration of compliance with performance standards for surface water, groundwater, and air; specified in Rule 306 (for Type III) and Rule 436 (for Type II). **Rule 903(1)(d)**	Refer to Section 4.3
a. Surface water,	
b. Groundwater, and	
c. Air	

Description of Item	Location of Documents
5. A description of the proposed facility which includes “a. - e.” as follows: **Rule 903(2)(a)**	
a. Type and size of the disposal area.	Refer to Section 4.4
b. Public roads to be used to access the facility.	
c. Anticipated volume waste to be received per day.	Not Applicable
d. Anticipated counties to be served.	Not Applicable
e. Anticipated useful life of the facility.	Not Applicable
6. A description of the existing environment including: **Rule 903(2)(b)**	
a. Maps showing the existing topography, land use, and residences surrounding the facility.	Refer to Section 4.5
b. Existing air quality including a wind rose from the closest available station.	
c. Hydrology including the following from the nearest available station:	
(1) Magnitude of the 24-hour, 25-year	
(2) Average annual rainfall.	
d. Maximum floodplain elevation of surface waters proximate to the facility.	
e. List of all endangered or threatened species whose range falls within the property boundaries of the facility.	
f. List of historic or archaeological sites proximate to the property boundary.	
g. List of any known sites of environmental contamination.	
h. Identification of any significant public resources within or adjacent to the proposed facility.	
i. Identification of any airport within 10,000 feet of the facility.	
7. Statement of the anticipated environmental impacts in relation to each component of the existing environment (as described in B.6). **Rule 903(2)(d)**	Refer to Section 4.6
8. A listing of alternative actions for waste disposal in the country or region, including alternatives considered positive and negative, economic, and environmental impacts of the alternatives, and the alternative of no action. **Rule 903(2)(e)**	Not Applicable
9. A summary statement of the unavoidable adverse impacts. **Rule 903(2)(f)**	Not Applicable
10. A statement of the protective and corrective measures that will be taken to reduce and mitigate adverse impacts to acceptable levels. **Rule 903(2)(g)**	Refer to Section 4.6
11. Graphic displays and references as follow: **Rule 903(3)**	
a. Maps that show the location of the proposed action, if applicable, with respect to communities or features that readily identifiable as locations in the state.	Refer to Figures 1 through 5
b. Maps, diagrams, or photographs that illustrate the relationships of the disposal area to the environmental element being impacted.	
c. References to the literature or other sources of information from which data in the environmental impact statement is taken and upon which conclusions are based.	
C. A hydrogeological report that includes the following: Rule 902(1)(d)	
1. A determination of existing groundwater quality, including the area and vertical extent of any groundwater contamination. **Rule 904(1)(a)**	Refer to Section 5
2. Definition of the following aquifer: **Rule 904(1)(e)(i)-(iii)**	
a. The uppermost aquifer and aquifers that are hydraulically inter-connected to the uppermost aquifer beneath the facility property.	Refer to Section 5
b. Any aquifer that is utilized by Type I and Type II and public water supplies, as defined in R 325.10502, within 1,000 feet of the proposed active work area.	
c. Any aquifer that is utilized by Type IIb and Type III public water supplies, as define in R 325.10502, within 1,000 feet of the proposed active work area.	
3. A determination of the background groundwater quality. **Rule 904(1)(b)** and **Rule 904(4)(a)**	Refer to Section 5

Description of Item		Location of Documents
4.	A map of the site and surrounding area, drawn to scale and showing "a. - g.": **Rule 904(4)(b)**	
	a. Distance to existing wells and properties with the potential for groundwater supplies showing all soil borings within one-half mile, including all domestic municipal, industrial, oil, and gas wells for which copies of logs area available.	Refer to Section 5
	b. Existing lakes or ponds.	
	c. Streams, springs, or wetlands.	
	d. Direction of surface drainage and groundwater movement in the area.	
	e. Locations of borings, observation wells, and other well data used in the report.	
	f. Topography, including predominant topographic features.	
	g. Location of any known or potential sources of groundwater contaminants.	
5.	Observation well records or soil borings to locate and identify aquifers beneath the property identifying: **Rule 904(4)(c)**	
	a. Depth to groundwater.	Refer to Section 5
	b. Aquifer thickness.	
	c. Vertical and horizontal groundwater flow directions.	
	d. Vertical and horizontal flow rates.	
6.	A groundwater elevation map, based on stabilized water level readings, contoured at not more than one foot, referenced to U.S. Geological Survey datum and including: **Rule 904(4)(d)**	
	a. Groundwater flow directions and possible variations in groundwater flow directions.	Refer to Section 5
	b. Depth of groundwater.	
7.	An evaluation of site earth materials, including bedrock characteristics, if bedrock exists within 50 feet of the proposed base of fill, based on boring logs including: **Rule 904(4)(e)**	
	a. Soil and rock descriptions.	Refer to Section 5
	b. Methods of sampling.	
	c. Sample depths.	
	d. Data of boring.	
	e. Water level measurements at the time of the boring.	
	f. Soil tests data.	
	g. Boring locations.	
8.	A series of geologic cross sections or fence diagrams that pass through representative borings, referenced to a site map that shows all wells and borings, and illustrating the following: **Rule 904(4)(f)**.	
	a. Existing topography.	Refer to Section 5
	b. Soil borings.	
	c. Soil classification.	
	d. Stratigraphy.	
	e. Bedrock.	
	f. Wells.	
	g. Stabilized water level readings.	
	h. Proposed site grades.	
9.	The nature, extent and consequence of any mounding that results from diversion of infiltration and surface runoff during operation and post-closure. **Rule 904(4)(g)**	
10.	A description of any proposed engineering modifications intended to modify groundwater level. **Rule 904(4)(h)**	Not Applicable
11.	A determination of the horizontal and vertical flow system, and diagrams that illustrate horizontal and vertical flow directions of groundwater. **Rule 904(4)(i)**	Refer to Section 5

Description of Item	Location of Documents
12. A compilation and interpretation of data, maps, and charts based on site conditions to support the conclusions and recommendations of the hydrogeological report. **Rule 904(4)(k)**	
D. The hydrogeological plan as required by R 299.4905. Rule 902(1)(e)	
1. A plan that includes monitoring of the following: **Rule 905(1)**	
a. The monitoring well system which is in compliance with R 299.4906.	Not Applicable. Refer to Section 6 for Monitoring Plan
b. The leachate and secondary collection system of the landfill, as specified in R 299.4432.	Not Applicable
c. Any surface water that may receive runoff from the active work area.	
2. The following specific information: **Rule 905(2)**	
a. The location to be sampled.	Not Applicable
b. A list of constituents to be sampled and the frequency of sampling.	
c. Identification of the sampling and analysis procedures to be used for each constituent or parameter proposed including:	
(1) Sample collection.	Refer to Section 6
(2) Sample preservation and shipment.	
(3) Analytical procedures including the method detection limit for the procedure specified.	
(4) Chain of custody control.	
(5) Laboratory and field Quality Assurance/Quality Control.	
(6) Procedures for preventing cross-contamination during well installation, purging, and sampling.	
d. Statistical procedures for evaluating data in compliance with R299.4908.	Not Applicable
E. Topographic maps that meet the following requirements: Rule 902(1)(f)	
1. Maps referenced to U.S. Geological Survey. datum at a scale of not more than 200 feet to the inch with contour intervals that clearly show the character of the land and land uses within 1,500 feet of the solid waste disposal unit(s). **Rule 909(1)**	Refer to Figure 2
2. The following specific information: **Rule 909(2)**	
a. A legal description of the property included in the application.	Refer to Section 3
b. Proposed solid waste disposal units.	Refer to Appendix D
c. Structures on the site.	There are no structures on the Site
d. Existing and proposed utilities.	Refer to Appendix D
e. Borrow areas.	Refer to Appendix D
f. Surface waters, wetland, or floodplains.	
g. Special drainage devices, if necessary.	
h. On-site roads.	
i. Public access roads.	
j. Fencing and other means of controlling access.	
k. The location of all residences.	Refer to Figure 2
F. Engineering plans and engineering reports for a landfill that meet the following requirements: Rule 902(1)(g) and Rule 910	
1. Details of the following: **Rule 910(1)(a)**	
a. Soils underlying each liner system including information on: **Rule 910(1)(a)** and **Rule 910(2)**	
(1) A settlement analysis estimating total and differential settlement including immediate settlement, primary consolidation, and secondary consolidation based on maximum loading. **Rule 910(2)(a)**	Refer to Appendix D
(2) A slope stability study. **Rule 910(2)(b)**	
(3) A performance analysis under varying groundwater conditions. **Rule 910(2)(c)**	Not applicable

Description of Item	Location of Documents
(4) Calculations that show the potential for bottom heave or blowout. **Rule 910(2)(d)**	Not applicable
b. Compacted soil liners or natural soil that is used in place of a compacted liner including information on: **Rule 910(1)(b)** and **Rule 910(3)**	
(1) The location and thickness of soils to be used for the compacted or natural soil liner.	Not Applicable
(2) Copies of well boring logs documenting soil deposits.	Refer to Section 8
(3) Data documenting soil source classification, and permeability's including the locations of the tests performed (horizontal and vertical).	Not Applicable
(4) For compacted liners, calculations which show the volume of the source.	Not Applicable
c. Bentonite geocomposites or flexible membrane liners that includes the following information: **Rule 910(1)(c)** and **Rule 910(4)**	Refer to Appendix D
(1) The methods of storage, handling, and installation including any written instructions from the manufacturer, and quality control procedures.	
(2) The physical specifications of the liner material.	
(3) The ability of the liner material and scrim material, where application, to maintain physical properties under varying conditions of temperature, pH, ultraviolet radiation, biological attack, and prolong leachate throughout the operating and post-closure life of the landfill.	
d. Primary leachate collection and removal systems that includes the following information: **Rule 910(1)(d)** and **Rule 910(5)**	
(1) Specifications for the material to be used for the leachate collection system. **Rule 910(5)(a)**	Not Applicable
(2) The design of the collection pipe including the following: **Rule 910(5)(a)**	
a. Diameter.	Not Applicable
b. Perforations.	
c. Slope.	
d. Spacing.	
e. Leachate compatibility.	
f. Structural integrity under static and dynamic loading.	
(3) Design features that allow cleaning of drainage pipes. **Rule 910(5)(c)**	
(4) Procedures to prevent clogging during construction and operation. **Rule 910(5)(d)**	
(5) Calculations to show that the leachate head will be one foot or less above the liner at any point in the system except the sump. **Rule 910(5)(e)**	Not Applicable
(6) Provisions to remove obstructions from the system. **Rule 910(5)(f)**	
(7) Calculations to determine the anticipated volume of the leachate collected. **Rule 910(5)(g)**	
(8) Information on the proposed methods of disposal for the leachate collected. **Rule 910(5)(h)**	
e. Secondary leachate collection or leak detection systems that includes the following information: **Rule 910(1)(e)** and **Rule 910(6)**	Not Applicable
(1) The design of the secondary collection system shall include the information required under **Rule 910(5):**	
a. Specifications for the material to be used for the leachate collection system. **Rule 910(6)(a)** and **Rule 910(5)(a)**	Not Applicable
b. The design of the collection pipe including the following: **Rule 910(5)(a)**	
1. Diameter.	Not Applicable
2. Perforations.	
3. Slope.	
4. Spacing.	
5. Leachate compatibility.	
6. Structural integrity under static and dynamic loading.	

Description of Item	Location of Documents
c. Design features that allow cleaning of drainage pipes. **Rule 910(5)(c)**	
d. Procedures to prevent clogging during construction and operation. **Rule 910(5)(d)**	
e. Calculations to show that the leachate head will be one foot or less above the liner at any point in the system except the sump. **Rule 910(5)(e)**	
f. Provisions to remove obstructions from the system. **Rule 910(5)(f)**	
g. Calculations to determine the anticipated volume of the leachate collected. **Rule 910(5)(g)**	Not Applicable
h. Information on the proposed methods of disposal for the leachate collected. **Rule 910(5)(h)**	
(2) The method of detecting, removing, and analyzing leaks that are detected in the system. **Rule 910(6)(a)**	
f. Dewatering systems that include the following information: **Rule 910(1)(f)** and **Rule 910(7)**	Not Applicable
(1) Design calculations for the drain pipe diameter.	
(2) Design features that allow cleaning.	
(3) Procedures to prevent clogging during construction and operation.	
(4) An evaluation of the structural suitability of underdrain pipe under both static and dynamic loadings.	
g. Information on the control of the following: **Rule 910(1)(g)** and **Rule 910(8)**	
(1) Run-on.	
(2) Run-off.	
(3) Wind dispersal of particulate matter.	
(4) Gas that is generated within the landfill	
a. A description of a landfill gas monitoring plan that complies with R 299.4433.	Refer to Section 6.0 and Appendix E
h. The final cover as specified in a closure plan that is in compliance with the provisions of **R 299.4446** and includes the following: **Rule 910(1)(h)**	
(1) An overall description of the methods, procedures, and processes that will be used to close each unit of the landfill in accordance with R 299.4446.	Not applicable
(2) An estimate of the maximum extent of operation that will be open at any time during the active life of the landfill.	
(3) An estimate of the maximum inventory of waste ever on-site over the active life of the landfill.	
(4) A description of the final cover, including engineering plans and specifications.	
(5) A schedule for completing all activities that are necessary to satisfy the final cover requirements of these rules.	
i. Post-closure maintenance and monitoring, as specified in a plan that is in compliance with provisions of R 299.4447 and including the following: **Rule 910(1)(i)**	
(1) A description of the monitoring and maintenance activities that are required for each unit, and the frequency at which these activities will be performed.	Refer to Section 6.0 and Appendix E
(2) Name, address, and telephone number of the person or office to contact about the facility during the post-closure period.	
(3) A description of the planned uses of the property during the post-closure period.	
2. Engineering plans prepared and sealed by a professional engineer. **Rule 910(9)**	
G. Operation plans which meet the requirements of R 299.4911 by including the following: Rule 902(1)(h)	
1. The following plans that describe how the facility will be operated: **Rule 911(1)**	
a. A fill progression plan over the active life of the landfill including final slopes and elevations and including the location and description of the permanent survey benchmark to be used for elevation control.	Not Applicable. Survey Control Points provided on Figure PE-005B

Description of Item	Location of Documents
b. A landscape plan that identifies and locates existing vegetation to be retained and proposed vegetation to be used for cover, screening, and other purposes.	(Appendix D)
c. Engineering plans that detail leachate collection and removal facilities and, if applicable, that show any systems to be used for leachate recirculation.	Refer to Appendix D
d. An engineering plan that shows gas management systems, if applicable. (If not applicable, indicate "NA").	
2. Engineering reports that describe: **Rule 911(2)**	
a. All equipment to be used at the landfill for construction and operation.	Refer to Section 8
b. The landfill's personnel requirements, including the duties, training, and authority of the responsible individual who is to direct landfill operations.	Not applicable
c. Access controls to be used including:	
(1) Signs.	Refer to Section 9
(2) Hours of operation.	Not Applicable
(3) Usage rules.	
(4) Natural and artificial barriers.	Refer to Section 8
(5) Traffic control.	
d. The methods to be used to control dust and blowing papers from the active fill area.	Not Applicable
e. The methods for disposal of large or bulky items.	
f. The on-site road design and method of controlling fugitive dust.	Refer to Section 9
g. The methods to control salvaging, if allowed.	
h. The storage locations of, and the design for, white goods and other recyclable materials.	
i. The procedures for separating recyclable materials from general refuse, if applicable.	
j. The type of daily cover to be used and the source, quantity, and method of placement of the cover.	
k. The process for receiving and unloading solid waste including the procedures for inspecting loads for hazardous waste.	Not Applicable
(1) A description of a program for detecting and preventing the disposal of wastes that are prohibited by R 299.4430.	
(2) The program meets all the requirements of R299.4430(3)	
l. The procedures for the receipt and disposal of asbestos waste.	
H. Construction Quality Assurance Plans that meet the requirements of R 299.4916 by including the following: Rule 902(1)(i)	
1. Method for addressing the following physical components where applicable: **Rule 916(2)**	
a. Foundations.	Not Applicable
b. Dikes.	
c. Low-permeability soil liners.	
d. Flexible membrane liners.	Refer to Appendix D
e. Leachate collection and removal systems and secondary collection systems.	Not Applicable
f. Final cover systems.	Refer to Appendix D
2. Observations, inspections, tests, and measurements that will be used to ensure: **Rule 916(4)**	
a. Structural stability and integrity of the features listed in "H.1."	
b. Proper construction of all components of the liners, primary and secondary collection and removal system(s), and final cover system.	Refer to Appendix D
c. Conformity of all materials used with design and other material specifications.	
I. Include Remedial Action Plan in compliance with Part 201 and Part 115 Rules if landfill facility has been determined to be a source of probable source of groundwater contamination. Rule 902(3)	Not Applicable

APPENDIX D

ENGINEERING REPORT

Rose & Westra
A Division of GZA

GEOTECHNICAL
ENVIRONMENTAL
ECOLOGICAL
WATER
CONSTRUCTION MANAGEMENT

HOUSE STREET FINAL REMEDY ENGINEERING REPORT

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December 2, 2022
File No. 16.0062961.81

PREPARED FOR:
Wolverine World Wide, Inc.
Rockford, Michigan

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ACRONYMS

4(H):1(V)	4-foot horizontal to 1-foot vertical
bgs	Below Ground Surface
CD	Consent Decree, effective February 19, 2020 (No. 1:18-cv-0039-JTN-ESC)
CH4	Methane
CQAP	Construction Quality Assurance And Quality Control Plan
cy	Cubic Yards
EGLE	Michigan Department of Environment, Great Lakes and Energy
ft	Feet
g	Gravity
HAZWOPR	Hazardous Waste Operations
HSP	House Street Property, also referred to as Site
H_2S	Hydrogen Sulfide
LEL	Combustible Gas
LLDPE	Linear Low-Density Polyethylene
MHA	maximum horizontal acceleration
NOAA	National Oceanic and Atmospheric Administration
OVM-PID	Organic Vapor Meter-Photoionization Detector
O_2	Oxygen
psf	per square foot
R&W/GZA	Rose & Westra, a Division of GZA GeoEnvironmental, Inc.
SOWs	Scopes of Work
USDA	U.S. Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	U.S Geological Survey
Wolverine	Wolverine World Wide, Inc.
WP	Work Plan

1.0 INTRODUCTION

1.1 GENERAL

GZA GeoEnvironmental, Inc. (GZA) has prepared permit drawings and this design rationale report for the Work Plan (WP) associated with the House Street Property (HSP) cap. A Site location plan is included as **Figure 1**. Engineering calculations related to this WP are included as **Attachment A**. A Construction Quality Assurance And Quality Control (CQAP) Plan is presented as **Attachment B**. The following is a list of the preliminary engineering drawings that accompany this design rationale report for the HSP Final Remedy. These drawings are included as **Attachment C**. Typical draft specifications for materials considered for use during the remedial action are included as **Attachment D**. Boring logs for borings completed in 2022 are included as **Attachment E**.

Drawing Number (62961.81)	Title
-PE-001	Cover Sheet and Drawing Index
-PE-002	Site Plan
-PE-003-A	Soil Erosion & Sediment Control Plan
-PE-003-B	Soil Erosion & Sediment Control – Typical Details
-PE-004	Boring Location Plan
-PE-005-A	Excavation / Waste Relocation Plan
-PE-005-B	Control Points and Site Access
-PE-005-C	Control Point Coordinates
-PE-006-A	Top of Prepared Subgrade / Bottom of Capping Materials (Northwest Mound)
-PE-006-B	Top of Prepared Subgrade / Bottom of Capping Materials (Northeast Mound)
-PE-006-C	Top of Prepared Subgrade / Bottom of Capping Materials (Southwest Mound)
-PE-006-D	Top of Prepared Subgrade / Bottom of Capping Materials (Southeast Mound)
-PE-007	Approximate Cut and Fill Areas
-PE-008	Top of Prepared Subgrade / Bottom of Capping Materials with Gas Vent & Piezometer Locations
-PE-009	Limits of 40-mil LLDPE Geomembrane
-PE-010	Landfill Gas Monitoring Probe Locations
-PE-011	Top of Finish Grade (Capping Topsoil and Drainage Swale)
-PE-012	Final Cover System Typical Profiles A-A’, B-B’, C-C’, D-D’, & E-E’
-PE-013	Final Cover System Typical Profiles F-F’, G-G’, H-H’, & I-I;
-PE-014	Typical Final Capping System Sections & Details
-PE-015-A	Retention Basin & Southwest Drainage Channel Plan
-PE-015-B	Retention Basin & Southwest Drainage Channel Profiles
-PE-016	Typical Waste Excavation Details
-PE-017	Landscaping Plan
-PE-018	Perimeter View Plan
-PE-019	Perimeter View Profiles

1.2 BACKGROUND

The HSP (Site), located at 1855 House Street NE, Plainfield Township, Kent County, Michigan, encompasses approximately 76 acres. The HSP is currently undeveloped and, according to available information, no buildings were previously present. The HSP and surrounding features are shown on **Figure 2.** Numerous soil borings have been conducted on the Site (**Figure 3, Boring Location Plan**).

Additional information regarding the HSP, its historical use, the physical setting (i.e., hydrology, geology, and hydrogeology), waste and contaminant distribution and concentrations is detailed in Rose and Westra, A Division of GZA (R&W/GZA)'s February 9, 2018, *Conceptual Site Model Update and Status Report* (R&W/GZA, 2018), 2018 Summary Report (R&W/GZA, 2019), 2019 Summary Report (R&W/GZA, 2020), *Implementation of the 2019 Work Plan – Summary Report* dated July 22, 2021 (R&W/GZA, 2021), and Scopes of Work (SOWs) included in the Consent Decree No. 1:18-cv-00039-JTN-SJB, effective February 19, 2020 (CD).

2.0 DATA COLLECTION AND REVIEW

2.1 DOCUMENTS EVALUATED

The reports and associated plans or drawings that were evaluated or utilized are referenced are presented in **Section 7.0**.

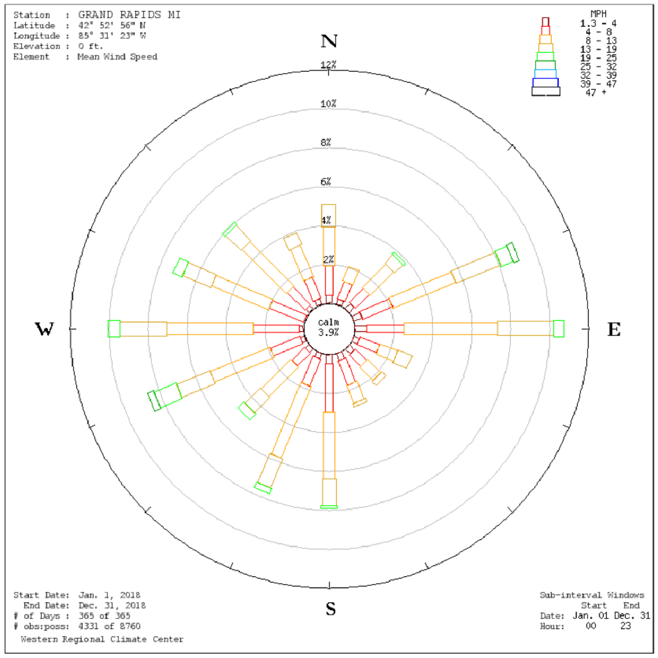
2.2 WEATHER INFORMATION

Average monthly values of temperature and precipitation were collected from data provided by the National Oceanic and Atmospheric Administration (NOAA). This weather data was obtained from a weather station (located approximately 24 miles south of the HSP) operated by the NOAA and located at the Gerald R. Ford International Airport in Grand Rapids, MI. The information reviewed indicated:

1. Temperature averages in Kent County, MI are 46.7°F based on collected data from 1901 through 2021; and

2. Precipitation in December 2021 was about 2 inches, which is near its monthly average (measurements from 1985 through 2021), and yearly precipitation averages about 33.8 inches based on measurements from 1901 through 2021.

Prevailing wind information was also obtained from the airport weather station; a wind rose from this station for 2018 (latest current data available) is inserted below.



2.3 SUBSURFACE EXPLORATIONS

The HSP has been explored by completion of numerous soil borings, constructing groundwater monitoring wells, and observing historical aerial photographs and available records. The locations of the subsurface explorations are shown on **Drawing No. 62961.81-PE-004** (**Attachment C**). Copies of boring logs for the on-Site test borings have been provided to the Michigan Department of Environmental, Great Lakes, and Energy (EGLE) in reports referenced in **Section 7**. A summary of the subsurface exploration data and historical aerial photographs are provided below.

The borehole lithology indicated that the soils in the top 20 feet are generally not stratified. Alternating layers of fine-grained and coarse-grained soil are present in individual boreholes without consistent stratification across the Site. Waste materials are also present at varying depths, including intermixed with the soils. This observation is consistent with the Site history of waste material placement and filling. Native soil observed at the Site is consistent with the regional overburden geology for areas where no previous Site work had been performed.

The depth to top and thickness of the waste materials and soil with waste materials varies across the areas of waste materials on the Site. For example, the waste material thickness in the south-central portion of the Site is up to 20 feet while certain areas in the central portion are less than 3 feet of thickness. The approximate extent of known waste material and soil with waste material on the HSP is shown on **Figure 4**. Cross sections of the estimated extent of the waste materials and soil with waste material are included as **Figures 5** through **9**, respectively. Geological cross sections were provided on Figures 4-1 through 4-3 of R&W/GZA, 2021, submitted to USEPA.

The maximum identified depth to the bottom of known waste materials from existing grade is approximately 20 feet bgs. On-Site soil borings identify up to 80 feet of primarily well-sorted sand between the bottom of the waste materials and the groundwater table.

2.4 LABORATORY MEASUREMENTS

2.4.1 Site Soils

GZA collected representative samples for laboratory tested of indigenous and fill soils collected from explorations at the HSP. Samples were tested for natural moisture content (ASTM D2216), liquid and plastic limits (ASTM D4318), and particle size distribution (ASTM D422); and permeability of granular soils estimated based on particle size distribution. Soils laboratory test data is included in **Attachment A.7**.

2.4.2 Possible Borrow Soils

Site soils that are not impacted and outside or above the extent of waste materials are proposed for subgrade, perimeter berm and cap construction. Based on the design limits of cap, cap grades and final site grades about 68,000 cubic yards (cy) of non-impacted soils are needed as cover soil. An additional roughly 17,000 cy of topsoil is required. If needed, imported suitable subgrade fill, geomembrane cover soil, and topsoil may be required; these materials are anticipated to have similar characteristics to on-Site indigenous soils. However, the intent of the remedial action is to limit the need for imported soils. The on-Site soils will be initially obtained from the southeastern portion of the Site, where grading is anticipated for use during construction for construction offices and lay-down area. The excavation plan provided as Drawing No. **62961.81-PE-005-A** shows the approximate location and proposed regrading of this area. It is estimated that approximately 30,000 cubic yards (cy) of site soil may be available from this regrading effort. In addition, and depending on the finished size of the retention basin and final site grades leading into the retention basin, 30,000 cy may be available from the additional site grading. Finally, as much as practical, existing topsoil on site will be stockpiled and re-used if not impacted.

The remedial action plan includes the construction of an access road and drainage swale along the west and south side of the Southwest Mound. In addition, a drainage swale will be constructed on the southerly east slope of the Southwest Mound, where surface water flow is expected to concentrate; plus, rip rap will be placed at the toe of the planned retention basin. Crushed stone for the access road and rip rap stone for the drainage channels / retention basin toe will be imported and trucked to the site.

2.5 GROUNDWATER MEASUREMENTS

Historical water level measurements made by GZA are summarized in R&W/GZA, 2019.

3.0 SUBSURFACE CONDITIONS

3.1. GENERAL DESCRIPTION

Subsurface soil conditions were interpreted from soil borings conducted during past Site investigations within and around the area of proposed construction and our understanding of the local geology. Soil boring locations are shown on **Figure 3** and Drawing No. **62961.81-PE-004**. An additional six (6) test borings were completed during the cap design process and representative soils selected for geotechnical index testing.

In general, unconsolidated site soils and/or miscellaneous fill materials overlie the natural soils layer within the Site boundaries. The materials encountered during explorations generally consisted of the following:

- Stratified fine-grained silts and clay soils with intermixed waste

- Granular sands, silts and intermixed clayey soils
- Granular silty sand natural soil layer

The unconsolidated miscellaneous fill material ranges in thickness from under 1 foot to up to 20 feet. The underlying natural soil layer consist of silty sands, with a thickness greater than 80 feet.

3.2. GEOTECHNICAL TESTING

Test Designation	Number of Samples	Low Test Value	High Test Value
Moisture Content	16	2%	25%
Granular Soils	8	2%	19%
Cohesive Soils	8	12%	25%
Gradation Test	20		
% Gravel		0	41
% Sand		29	99
% passing #200 Sieve		1	66
% Silt		1	21
% Clay		0	46
Atterberg Limits	9		
Plastic Limit		12%	17%
Liquid Limit		27&	52%
Plasticity Index		15%	35%
Granular Soil Permeability	2	9.8×10^{-3} cm/sec	2.6×10^{-2} cm/sec

4.0 SOIL HANDLING

4.1. HEALTH AND SAFETY CONSIDERATIONS FOR EXCAVATIONS

Prior to excavation activities, the contractor will clearly lay out and identify work areas in the field and limit equipment, operations, and personnel in the areas as defined below. These areas are:

1. Exclusion Zone(s): Includes areas where known or potentially contaminated soils and waste materials are being, or may be contacted, disturbed, or handled and, areas where equipment or personnel that have come into contact with potentially contaminated materials travel. Personnel working in this area will be limited to only those individuals who have current Hazardous Waste Operations (HAZWOPR) training certifications.

2. Contaminant Reduction Zone(s): Occurs at the interface of the Exclusion Zone and the Clean Zone and provides for the transfer of construction materials from clean to site-dedicated equipment, the cleaning of equipment and vehicles prior to entering the Clean Zone from the Exclusion Zone, the cleaning of personnel and clothing prior to entering the Clean Zone from the Exclusion Zone, and for the physical segregation of the Clean and the Exclusion Zones.

3. Clean Zone: Defined as a clearly delineated predominantly upwind area outside the Exclusion Zone(s) and the Contaminant Reduction Zone(s), which functions include:

   a) An entry area for personnel, material, and equipment to the Contaminant Reduction Zone.

   b) An exit area for personnel, material, and equipment from the Contaminant Reduction Zone.

   c) A storage area for clean safety and work equipment.

Excavation of the waste material and/or associated soil designated for placement into one of the cells shall be conducted in accordance with the following safety recommendations.

Worker Designation	Recommended PPE
Backhoe operator(s) and truck drivers situated within closed cabs.	• Level D personnel protection to include long sleeve shirt, pants, steel toe boots, dust mask (if needed), hard hat when outside of vehicle, gloves, and safety vest. • Locate equipment upwind to maximum extent possible.
Laborer working in direct contact with soil.	• Latex inner gloves. • Outer gloves. • Dust mask. • Safety goggles. • Work boots with steel toe and shank. • Hard hat. • Full-length pants and long-sleeve shirt.
Laborer working more than 50 feet from excavation area	• Level D, provided sustained particulate levels are less than 2 mg/m^3 • If particulate levels exceed 2 mg/m^3, mitigation activities will be employed per the Specifications.

Dust suppression (watering) will be done at the excavation face, when moving overburden soils into the waste mound area, and when constructing the perimeter berms and/or earthwork layers of the mound cap to reduce sustained particulate levels to below 2 mg/m^3. Additional dust suppression may be used as needed on roads and parking areas during Site activities including mobilization, road improvements, tree clearing (as appropriate), and demobilization. Air monitoring for the following parameters will be monitored and documented during soil moving and excavation at the HSP;

- Organic vapor using a photoionization meter,
- Oxygen (O_2), hydrogen sulfide (H_2S), methane (CH4), and combustible gas (LEL) using a 4-gas meter,
- Air-born particulates using a particulate monitor, and
- Wind direction using a pennant, windsock, or anemometer.

If sustained organic vapor readings within the worker breathing zone are:

- Greater than 5 ppm, or
- Hydrogen sulfide readings are greater than 10%, or
- LEL is greater than 10%, or
- Oxygen level is less than 19.5%;

Then work in the excavation area will cease, data from the monitoring will be evaluated and, based on the specific criteria that exceeded pre-set health & safety parameters, additional engineering controls will be implemented. The air monitoring plan and equipment will be similar to that employed previously at House Street during the interim cap work completed in 2021. Boundary air monitors will collect dust samples to confirm compliance with PM10 NAAQS requirements (PM10 < 150 µg/m^3 in a 24-hour period). Moveable air monitors will be used to monitor the air quality at excavation locations. The moveable monitors will be in a down-wind location between the excavation and nearest House Street property boundary.

Soils excavated from outside known areas of concern will be assessed using visual and olfactory senses, and field screened with an organic vapor meter-photoionization detector (OVM-PID). Soils that do not exhibit signs of contamination (as described above) will be temporarily stockpiled and reused on-Site. Depending upon its geotechnical characteristics, this material will be used for either subgrade backfill, berm construction, or the initial layer of cover on the geomembrane. Soils that exhibit signs of contamination will be staged at an on-Site stockpile and placed below the cap. The intent of this design plan is to keep contaminated soil on Site and under a geomembrane / soil cap.

Subgrade preparation is expected to occur at the perimeter of each of the individual waste mounds, the access roads, trailer, staging area(s), and runoff diversion/control areas. GZA personnel (hereafter referred to as the Engineer) will observe, evaluate, and document the following steps during the subgrade preparation and construction at the HSP.

1. Following removal of the existing organic cover and temporary relocation of contaminated material, the existing subgrade will be proof rolled. If the soil is geotechnically suitable, it will remain in place and additional subgrade fill will be placed to meet existing grades or planned design grades. If the soil is not geotechnically suitable, it will be excavated and temporarily stockpiled in a designated area. The final subgrade elevation / surface will consist of geotechnically suitable material.

2. Fill will be placed in 9- to 12-inch lifts and compacted to a stable matrix. Depending upon the location and elevation, fill within the waste mound areas will be either waste, waste mixed with soil, or non-contaminated soil (primarily to maintain the final design grades). Fill placed above the geomembrane and/or outside of the waste mound areas will be non-contaminated soil.

3. Final bottom of cap grade will be established once all fill material has been placed and compacted, and the area proof rolled.

4. Protrusions, rocks, sticks or other deleterious material that could puncture the geomembrane will be removed from the area filled and then re-compacted.

4.2. GROUNDWATER

Groundwater flow patterns at the HSP have been measured predominantly in an upper soil aquifer at depths of 80 feet or greater. Monitoring wells have been installed with the recorded highest water table measurements at a depth of 49.6 feet bgs. Groundwater generally flows from the northwest to the southeast with a gradient that is generally flat, less than or equal to 0.05 feet/foot. A potentiometric map was prepared based on these high measurements (R&W/GZA, 2019). Groundwater elevations vary seasonally by approximately 5 feet (on average) throughout the year at the Site. High groundwater levels were generally measured in March or April.

Perched groundwater, temporarily restricted from infiltrating deeper by fine-grained soils, has been encountered on-Site. It is not anticipated that perched groundwater will be encountered during waste relocation excavations. However, if perched groundwater is encountered during construction activities on-Site, it will be handled under an approved construction water management plan. This plan will require that the perched groundwater either be allowed to infiltrate to deeper depths or it be pumped from the excavation, stored in separate holding tanks, sampled and tested, and then disposed of properly.

5.0 DESIGN PLAN

5.1. CAP PLAN FOR WASTE MOUNDS

The WP has been developed to: (1) limit maintenance of the cells; (2) provide controls to limit the potential for the post-Remedy escape of waste materials; and (3) limit surface water infiltration through waste materials. Final grade elevations are designed to not exceed elevation 805, which is within 10 to 12 feet +/- of existing site grades. However, for most of the mound area, the height change will be under 4 to 5-feet. The 10- to 12-foot grade change is only located within the existing depression at the south-central area of the site where fill is needed to flatten the slope. The waste material outside of the capped area that is proposed to be consolidated under each mound are provided on **Figure 10** and shown on Drawing No. **62961.81-PE-005-A**. The proposed final grading plan is shown on Drawing No. **62961.81-PE-011**. Typical cross-sections and details are included on Drawings Nos. **62961.81-PE-012** through **- 14.**

5.2. FINAL CAP COVER

The final cover system consists of a layered system including, from top down, a topsoil layer, a barrier protection layer, and a 40-mil thick, linear low-density polyethylene (LLDPE) geomembrane. The final cover system is described in more detail below.

Landfill Top (i.e., area with slopes generally no flatter than 5% and no steeper than 25%)

- 6 inches of a topsoil layer, over
- 24 inches of a barrier protection layer, over
- A 40 mil LLDPE geomembrane.

The top 6 inches of the final cover system consists of topsoil suitable to maintain vegetative growth (i.e., grass or similar groundcover). Following placement, the topsoil layer will be seeded to promote the growth of vegetation, to limit erosion and create a more aesthetic appearance. The vegetated topsoil also has the ability to hold moisture near the surface of the facility so that moisture can be evapotranspired directly back to the atmosphere without infiltrating into the cap.

A 24-inch barrier protection layer will be installed over the 40-mil LLDPE geomembrane. It provides a base on which the topsoil can be placed and vegetation developed. It also provides protection of the 40-mil LLDPE geomembrane. The lower six inches of this layer will be reasonably free of particles greater than 3-inches.

The majority of the top and side slopes of each mound has a design slope of about 5%. The slope of the southwestern mound, where it is adjacent to the retention basin has a side slope of less than 25%. The 40-mil LLDPE geomembrane material used in the final cover system complies with product manufacturing standards for chemical and physical resistance to the compounds that it may be in contact, and can accommodate the expected differential settlement of waste materials and fill beneath the cap, which is expected to be minimal. The 40-mil LLDPE geomembrane will have a double rough surface at locations where the mound slope is greater than 5%.

Gas vents will be installed at each mound to discharge decomposition gases if it develops. A preliminary plan showing the location of passive gas vents is presented on Drawing No. **62961.81-PE-010**. It shows 20 vent locations or approximately one vent per acre of mound cap. A detail of the gas vent is presented on Drawing No. **62961.81-PE-014**. Final gas vent locations will be determined further as construction continues based on placement of organic materials. In addition, perimeter gas monitoring probes will be installed at 12 locations between the capped mounds and property boundary. The 12 planned locations are shown on Drawing No. **62961.81-PE-010**, a typical detail of the perimeter gas monitoring probe is provided on Drawing No. **62961.81-PE-014**.The grading plans presented provide for positive drainage for the entire length of slope from the top of the completed landfill to the base of the slope. Drainage channels, constructed at the base of the final graded slopes, routes the runoff as the Site currently drains; however, a Retention Basin is planned for the south-middle section of the Site. The design incorporates a slope from the high point at the top of the cap to its toe. This approach will accommodate settlements and still maintain positive drainage. The drainage channels are constructed at the toe of the fill on compacted soils, where settlements are expected to be small and channel grades will be more easily maintained. Rip-rap lined drainage swales are also planned along portions of the west and south property line (on the west and south side of the southwestern mound), and on the southerly eastern slope of the Southwest Mound where surface water run-off will concentrate. The drainage swale on the southerly eastern slope of the Southwest Mound will mirror the cap grade, at a slope of about 5 percent (%).The drainage swale along the west and south property line is designed to provide a minimum 1 percent (%) slope for proper drainage. Other drainage swales constructed adjacent to the capped mounds vary in slope; but are generally greater than 0.5%.

The area impacted by construction will be regraded and landscaped in general conformance with Drawing Nos. **62961.81-PE-011** and **62961.81-PE-014.** As noted on Drawing No. **62961.81-PE-014**, the landscape components will consist of grass seeding of the Capped Mounds, a plant, wet meadow mix within the retention basin area, and native conservation seeding of the remaining disturbed areas. It is anticipated that the capped mounds will be mowed at least once per year; while the remaining areas will be allowed to grow undisturbed. Access roads and drainage channels will be maintained as needed to allow proper functionality. In addition to work provided in the landscape plan required for the integrity of the cap under the Consent Decree, landscaping work at the HSP will include selective maintenance or installation of vegetation along portions of the HSP boundary.

A post-construction operation and maintenance (O&M) plan will be provided to EGLE following the remedial action construction and stabilization of disturbed areas. In general, the post-construction O&M plan will provide a description of the monitoring and maintenance activities planned including:

1. Frequency of site visits to observe and document that the site access road, drainage swales, retention basin and cap areas are in stable and operational condition;
2. Erosion or surficial damage that requires repair;
3. Location and frequency of mowing activities specific to the capped mounds;
4. Groundwater monitoring well and perched monitoring well sampling and analysis (frequency, compounds for analysis, and documentation);
5. Gas vent and perimeter gas probe monitoring (initially conducted on a quarterly basis using a 4-gas meter to document the concentration of methane, hydrogen sulfide, carbon dioxide, and oxygen, plus that the lower explosive limit of methane gas is not exceeded), and documentation of screening measurements;
6. Gas screening at property boundaries near residential structures to document the absence of nuisance odors; and
7. Mitigation steps and remedial measures to follow should site observations and/or measurements indicate an exceedance in the agreed upon O&M specified limits.

The O&M plan will include a contact name, address, and telephone number responsible for O&M items. Following the agreed upon site visits, on a minimum frequency of once per year, a certification report shall be provided that documents the site visits within the reporting period, provides summary description of observations and measurements, notes observations or measurements that require follow-up action and status, and certifies that the post-construction use of the House Street property has not disturbed the integrity of the final cover, or other components of the containment system, or the function of the monitoring systems unless necessary to comply with EGLE requirements.

6.0 ENGINEERING ANALYSES

6.1. GENERAL

Analyses were made to estimate the cap's structural integrity, slope stability, settlement, efficiency, and surface water runoff upon implementation of the Final Remedy. The following sections describe the procedures used in our evaluation and summarize the results. Engineering calculations are provided as attachments to this Report.

6.2. STRUCTURAL INTEGRITY

The subgrade construction consists of the excavation and placement of soil fill in a controlled manner over existing stable grades. The proposed design with properly controlled construction quality assurance program (CQAP) will result in a stable condition based on our evaluation discussed herein. In addition, test borings at the House Street site did not identify very loose granular soils or very soft to soft cohesive soils.

The subgrade construction is expected to consist of re-grading soils present within the mound berm area and/or excavating natural soils or miscellaneous fill material, as appropriate, followed by visual observations, compaction with smooth drum compactor, and/or proof rolling over each of the designated mounds, followed by controlled placement of compacted subgrade fill soil to design subgrade elevations. Each mound, and its perimeter containment berm is to be constructed on a prepared stable subgrade. Any loose, wet, and/or deleterious soils encountered will be removed and backfilled with suitable on-Site subgrade soils placed in a controlled manner. The subgrade backfill is to be placed in lifts generally about 9 to 12 inches thick and compacted with smooth drum compactors. The constructed subgrade is considered stable with a low probability of liquefaction. In addition, the mounds are designed to balance the cut and fill required. So, limited fill will be placed over existing grades, generally limited to 4 to 5-feet, except in the existing depression at the south-central portion of the site, where additional fill, 12 feet or less, is required to flatten the existing slope. Therefore, the additional loading imparted on subsurface soils due to additional fill placement is anticipated to be less than 1,500 pounds per square foot (psf), resulting in less than 1 inch of settlement.

Excavations are anticipated and planned where fill is present outside the limits of the capped areas. The excavated waste material will be relocated and will be over-excavated to depths that encounter soils free of waste material, as identified by observation. Depending on location, these excavations will be backfilled with suitable subgrade soils obtained from either on-Site borrow or an approved off-Site source, or regraded to meet site design grades. Backfill will be completed in lifts generally about 9 to 12 inches thick and compacted with smooth drum compactors to the planned finish grade elevation.

The structural integrity of the proposed landfill is dependent on it having a suitable factor of safety for slope stability and having total and differential settlement that will not be detrimental to the facility's performance. GZA evaluated the slope stability and potential settlement as discussed in the following sections. These analyses considered the proposed bearing pressures on the cap components and subgrade soils due to placement of waste materials or on-Site soils to the final design elevation and subsequent cap construction.

The final site grades within the limits of construction will not exceed a slope of 25 percent (%) or 4-foot horizontal to 1-foot vertical (4(H):1(V)). Based on these slopes a conservative soil friction angle of 26^{o} to 33^{o}, a conservative soil to textured LLDPE friction angle of 28^{o}, the slope factor-of-safety is greater than 1.5. Our analyses indicate that the proposed construction will have a suitable factor of safety for slope stability and the estimated total and differential settlement will not be detrimental to its structural integrity. It is estimated that the proposed bearing pressures (i.e., up to 1,500 pounds per square foot [psf] depending on location) of the completed facility will not exceed the bearing capacity of the subgrade soils. Loading on the 40-mil LLDPE liner will generally be under 600 psf (2.5 to 4 feet of cover), which is minimal. The facility is expected to maintain its structural integrity provided it is properly constructed and maintained in accordance with the project specifications and CQAP plan.

6.3. SLOPE STABILITY OF THE LANDFILL

Stability analyses were done using infinite slope analysis due to the flat slopes of the containment mounds.

6.3.1 Static Slope Stability

Analyses made for typical containment berms and shallow cap conditions are provided in the calculations in **Attachment A.3**. These analyses considered infinite slope conditions which are independent of end of construction and/or long-term conditions. The calculated minimum factor of safety for the conditions considered is equal to or greater than 1.5.

GZA considered site conditions and analyzed the stability of the perimeter berm slopes during construction and the cap slopes and cap components for long term conditions (Remedy implementation phase and post-Remedy implementation phase). Potential infinite slope failure surfaces on the perimeter containment berm, at the top of the waste material fill, and at the various cap material interphases were analyzed. The soil types listed below are shown on a typical mound cross-section (see Drawing Nos. **62961.81-PE-012** through **014**).

- Soil Type 1 – Waste Material or Impacted Fill
- Material Type 2 – LLDPE Smooth Geomembrane
- Material Type 3 – LLDPE Textured or Rough Geomembrane
- Soil Type 4 – On-Site clayey or cohesive soils
- Soil Type 5 – Indigenous sandy or granular soils

Our analyses were made utilizing the infinite slope method to represent the failure surfaces. The infinite slope failure mechanism was analyzed because the presence of the 40-mil LLDPE potentially represents a weaker zone through which failure could occur and due to the limited depth of the cap section (2.5-ft thick).

The presumed values for soil and material properties are summarized below.

PRESUMED VALUES

Soil Type	Total Unit Weight (pcf)	Saturated Unit Weight (pcf)	Unconsolidated Undrained Condition[1]		Consolidated Drained Condition[2]	
			Cohesion (psf)	Friction Angle (degrees)	Cohesion (psf)	Friction Angle (degrees)
1. Waste Fill	90	95	0	26	0	26
2. LLDPE (Smooth)	NA	NA	0	11	0	11
3. LLDPE (Rough)	NA	NA	0	28	0	28
4. Clayey Soil	120	125	1,000	0	0	26
5. Sandy Soil	112	120	0	33	0	33

Notes:
1. The Unconsolidated Undrained Condition can be used to represent the end of construction case.
2. The Consolidated Drained condition was used to represent long term case analysis.

For stability analysis, GZA selected a friction angle of 11^{o} to represent the resistance between smooth 40-mil LLDPE geomembrane and soil, and a friction angle of 28^{o} to represent the resistance between textured 40-mil LLDPE geomembrane and soil. The more critical potential failure will likely occur at the geomembrane and soil interface. Therefore, the infinite slope analysis with the failure surface at the geomembrane interface was completed. The analyses result in factor of safety values of greater than 1.5 for the cases analyzed (**Attachment A.3**).

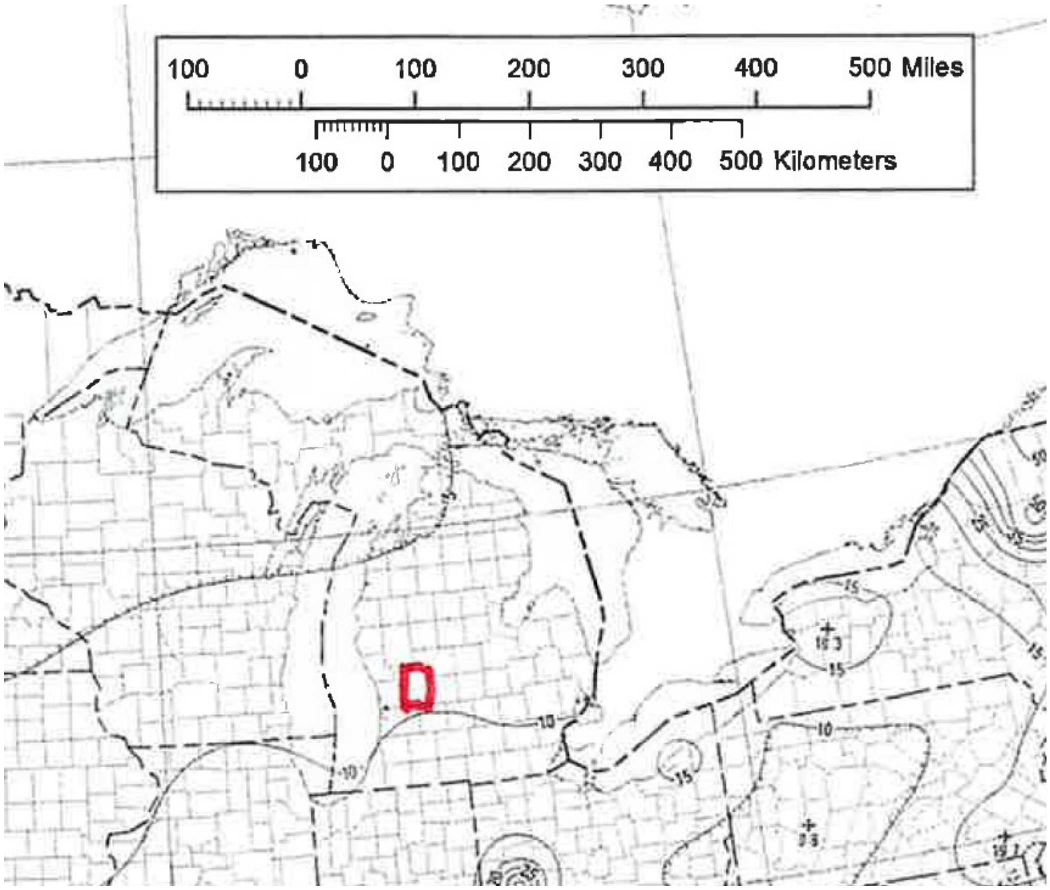
6.3.2 Seismic Slope Stability

6.3.2.1 Fault Areas

The Preliminary Map of Youngs Faults (USGS, 1991a) does not show a fault within the State of Michigan that has exhibited displacement in Holocene time. Therefore, the Site is not within 200-feet of a recorded / documented fault.

6.3.2.2 Seismic Impact Zone

The seismic impact zone is defined in the regulations as being an area with a ten percent or greater probability that the maximum horizontal acceleration (MHA) in lithified earth material will exceed 0.10 percent of gravity (g) in 250 years, as delineated on the Probabilistic Earthquake Acceleration and Velocity Maps for the United States and Puerto Rico (USGS, 1991b). House Street, within Kent County, Michigan, based on the above-referenced map and as shown on the diagram below, falls within a seismic impact zone having a projected MHA of approximately 0.09 g. Therefore, it is not within a defined seismic impact zone.



Risk Targeted Maximum Considered Earthquake Ground Motion Response Acceleration of 0.2 second Response Acceleration (5% of Critical Damping). Contour lines shown as percent of gravity.

6.4. SETTLEMENT OF THE LANDFILL BASE

Settlement of the base is expected to result from compression of the indigenous soils due to the weight of the overlying fill and cap. As mentioned earlier, with an estimated maximum load of 1,500 psf, the compression of the underlying largely granular material layer is expected to be small, less than 1 inch, and not a factor in computing settlement. Our analysis, included as Attachment A.5, indicates a conservative settlement of between 0.3 inches to 0.9 inches.

6.5. EROSION AND SEDIMENT CONTROL PLAN

Erosion and sediment control is to be implemented during construction and following Final Remedy implementation. An erosion and sediment control plan will be provided to the Kent County Road Commission to obtain a soil erosion and sedimentation control (SESC) permit agreement, which will govern activities and controls related to SESC. Temporary controls that shall be implemented during construction and operation activities to minimize erosion include:

- Limiting the area extent of disturbed / destabilized overburden at a given time to restrictions within the SESC permit agreement;
- Clearing is anticipated to be extensive given the level of vegetative growth on-site, however, the grubbing of tree roots, root balls, and grass vegetation will remain as overburden stabilization until the area is scheduled for construction activities;

- Completing sections or areas of construction in a timely manner to limit the exposure of soil materials susceptible to erosion;
- Compacting or tracking, as applicable, the exposed soil surface as soon as possible following placement; and,
- Placement of hay bales, silt fences and mulch or soil stabilization fabric.

Sediment migration will be controlled using silt fences, silt soxs or hay bales. The topsoiled areas will be seeded, fertilized and mulched as soon as possible following cap construction or perimeter containment berm construction to limit erosion. Grass growth on each mound, disturbed areas, and perimeter berm side slope will assist in limiting erosion and sedimentation. Calculations included in **Attachment A.6** to estimate soil loss indicate less than 0.5 tons per acre per year can be anticipated. This is less than the 2 tons per acre per year that is considered acceptable by the Soil Conservation Service (USDA, 1997).

6.6. RUN-ON/RUN-OFF CONTROL

Each mound will be surrounded by perimeter containment berms during construction. These berms act as the run-on control in preventing off-Site run-off from flowing onto the facility. The perimeter containment berms also act as run-off control in preventing run-off which contacts waste materials from leaving the facility.

Stormwater drainage at the Site will be consistent with an approved Site Water Management Plan. Stormwater run-off from each mound will be directed as shown on **Figure 11**. Run-off from the Central drainage area will be directed to the on-Site Retention Basin. The majority of the stormwater run-off from the North, West Central, and East drainage areas will remain on-Site within low areas generally not impacted by the construction summarized herein. In general, the Site run-off flow patterns are consistent with existing conditions, but with additional controls added. The Table below shows the approximate acreage of drainage areas pre-construction and post-construction.

Area Description	Pre-Construction Drainage Area	Post-Construction Drainage Area
North	19.9 Acres	20.2 Acres
West Central	4.8 Acres	4.3 Acres
Central	32.7 Acres	32.8 Acres
East	19.2 Acres	19.3 Acres
Total Area	76.5 Acres	76.5 Acres

GZA compared the estimated pre- and post-construction peak rates of run-off for each drainage area. Estimated peak rates of run-off were computed for the 100-year, 24-hour storm event (6.49 inches of rainfall in 24 hours). These estimates are:

Condition	Stormwater Flow (CFS)
Existing Site Condition	
North Estimated Run-off	9.9 cfs
West Central Estimated Run-off	3.0 cfs
Central Estimated Run-off	15.2 cfs
East Estimated Run-off	6.7 cfs
Condition Following Completion of the Final Remedy	
North Estimated Run-off	16.1 cfs
West Central Estimated Run-off	3.9 cfs
Central Estimated Run-off	21.6 cfs
East Estimated Run-off	14.6 cfs

Stormwater flow rates referenced above were estimated using the SCS TR-20 runoff method. Flows for the drainage channel along the south and southwest property line, and flow into the planned retention basin were estimated and modeled using SCS TR-20 within HydroCAD®. Sizing of the drainage channel along the west and south side of the Southwest Mound were done using the Manning's equation for open channel flow. The added stormwater run-off controls include:

1. Constructed drainage swale along the west and south sides of the Southwest Mound;
2. Retention basin within the south-central portion of the Site; and
3. Regrading of existing ground surface at locations adjacent to each of the mounds, and within the central portion and southeast portion of the Site.

Calculations of flow rates and run-off volume are included as **Attachment A.1**.

The retention basin constructed within the south-central portion of the Site will utilize an existing on-site depression that current collects stormwater, which infiltrates into the ground. The constructed retention basin within this general area will, in its post construction condition, be consistent with the depth of the current depression, no closer to House Street than the current depression, and be constructed with slopes that are generally 4 horizontal to 1 vertical, which are flatter than those existing on the current depression. In addition, the retention basin is designed to allow stormwater run-off to infiltrate into the ground, generally within a 24-hour time period.

6.7. EFFICIENCY

The average yearly precipitation in Kent County, MI is 33.8 inches, with a 12-month high of 50.7-inches (11/2008 – 10/2009) and a 12-month low of 17.7-inches (06/1930 – 05/1931). The amount of precipitation that infiltrates is less than the precipitation value because evaporation and soil moisture absorption reduce total infiltration.

7.0 REFERENCE LIST

Revised Feasibility Study – Remedial Options, Wolverine World Wide, Inc. – House Street Property, Plainfield Township, Kent County, Michigan, September 13, 2021

"Preliminary Map of Young Faults in the United States as a Guide to Possible Fault Activity", U.S. Geologic Survey, Map MF-916 (1991a).

"Probabilistic Earthquake Acceleration and Velocity Maps for the United States and Puerto Rico"; U.S. Geologic Survey, Map MF-2120 (1991b).

Site Development Rules, Procedures and Design Standards for Stormwater Management, Kent County Drain Commissioner, Rev 01.22.2021.

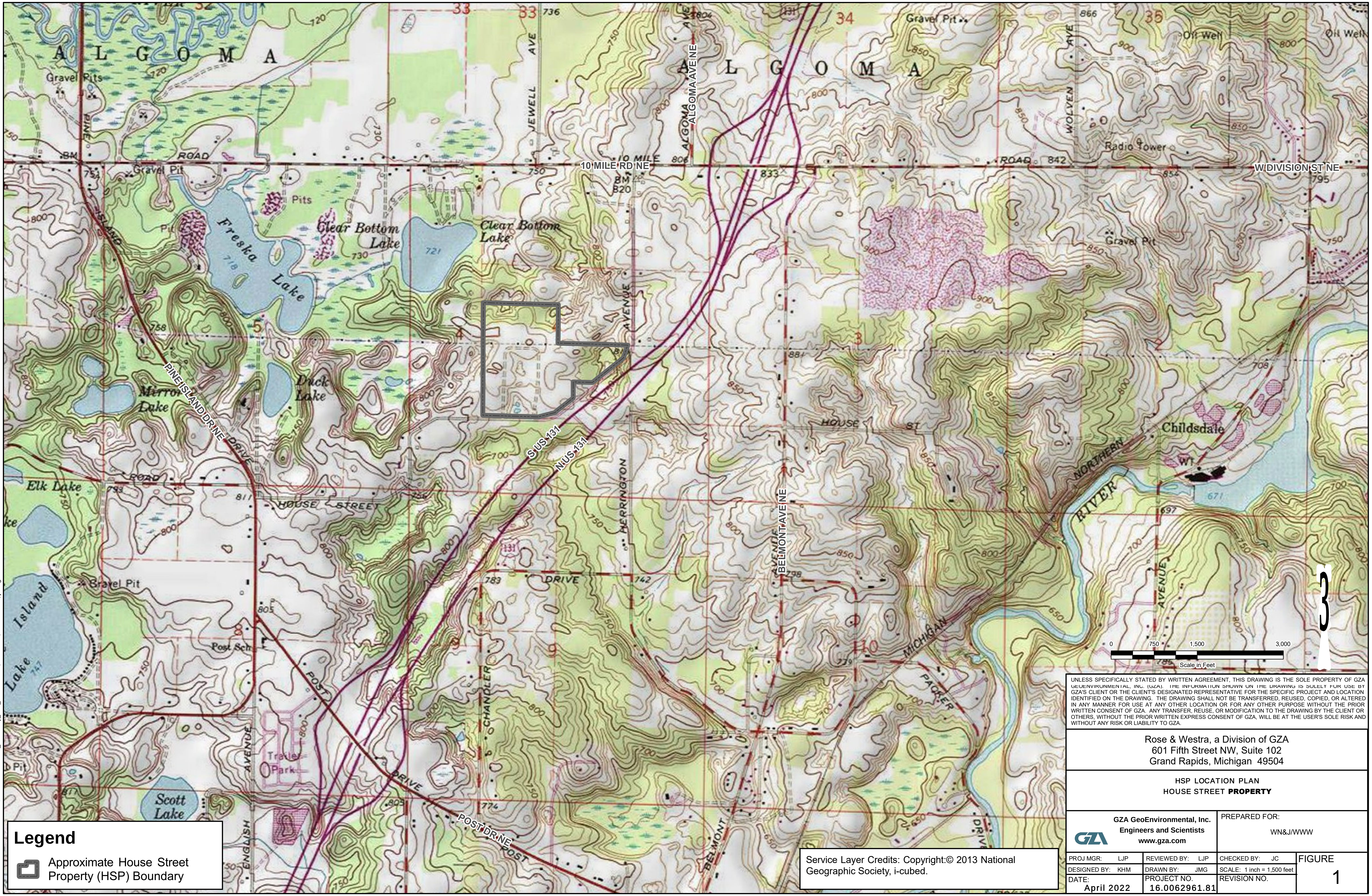
R&W/GZA. 2018. *Conceptual Site Model Update and Status Report*. February 9, 2018.

R&W/GZA. 2019. HSDS Implementation of the 2018 Work Plan Summary Report. Submitted to USEPA May 21, 2019.

R&W/GZA. 2021. HSDS Implementation of the 2019 Work Plan Summary Report. Submitted to USEPA July 22, 2021.

United States Department of Agriculture. 1997. *Predicting Soil Erosion by Water: A Guide to Conservation Planning With the Revised Universal Soil Loss Equation* (RUSLE). USDA-Agricultural Research Service Agric. Hdbk. No. 703. Renard, K.G., G. R. Foster, G.A. Weesies, D.K. McCool, and D.C. Yoder. Available online at https://www.ars.usda.gov/arsuserfiles/64080530/rusle/ah_703.pdf.

FIGURES



Legend

Approximate House Street Property (HSP) Boundary

Service Layer Credits: Copyright:© 2013 National Geographic Society, i-cubed.

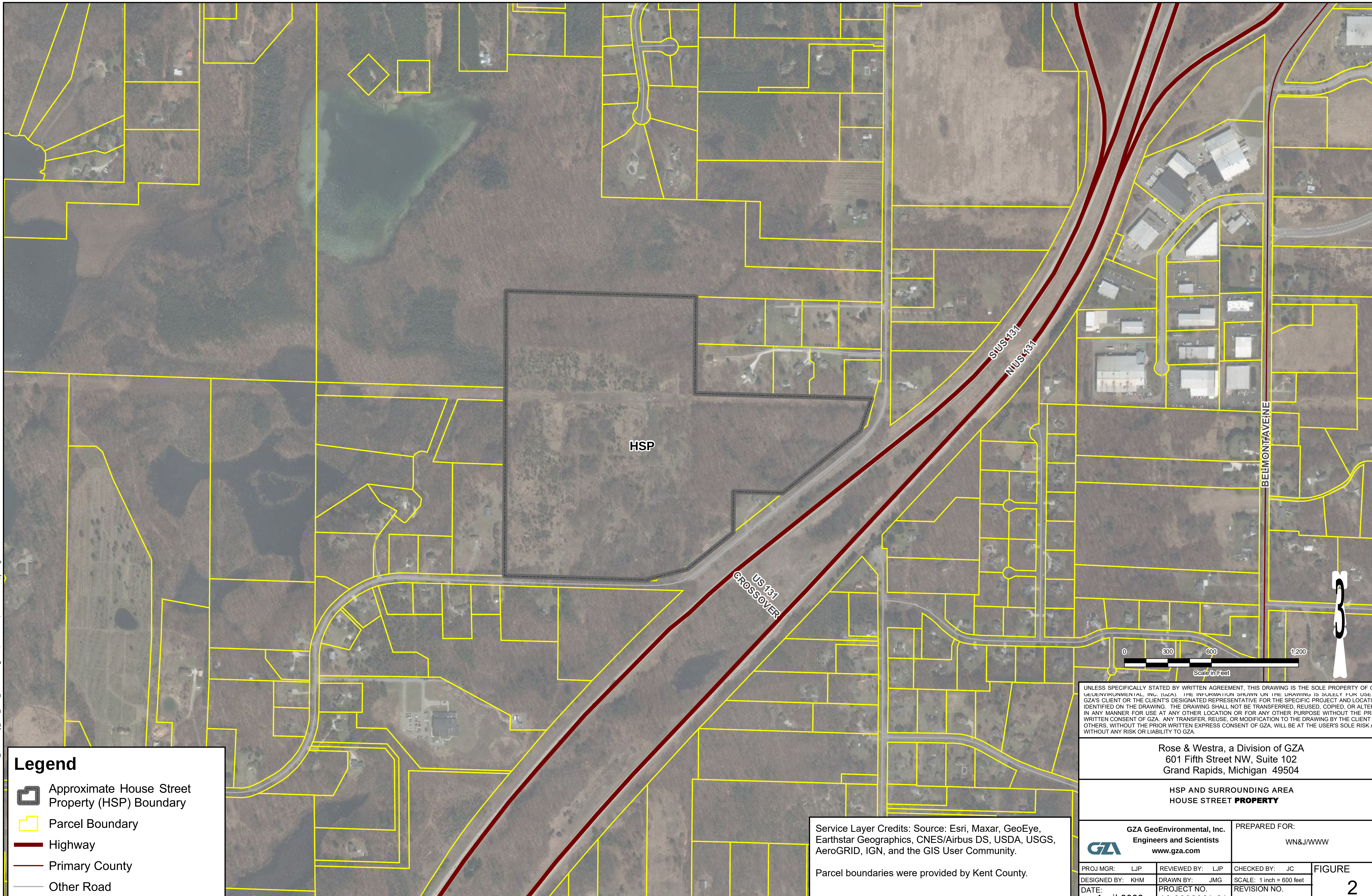
Rose & Westra, a Division of GZA
601 Fifth Street NW, Suite 102
Grand Rapids, Michigan 49504

HSP LOCATION PLAN
HOUSE STREET **PROPERTY**

GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: JMG	SCALE: 1 inch = 1,500 feet	1
DATE: April 2022	PROJECT NO. 16.0062961.81	REVISION NO.	



Legend

- Approximate House Street Property (HSP) Boundary
- Parcel Boundary
- Highway
- Primary County
- Other Road

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

Parcel boundaries were provided by Kent County.

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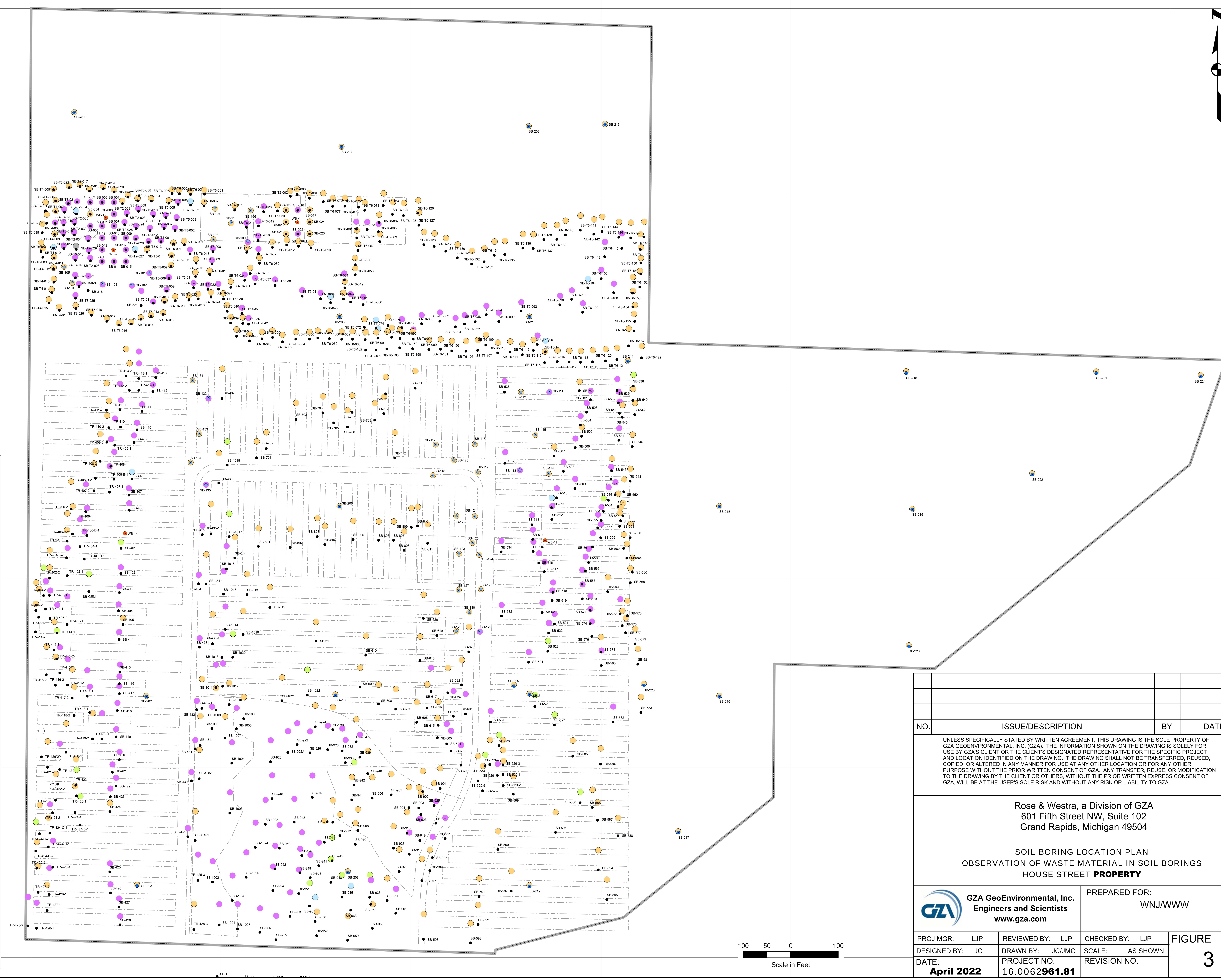
Grand Rapids, Michigan 49504

HSP AND SURROUNDING AREA
HOUSE STREET **PROPERTY**

GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: JMG	SCALE: 1 inch = 600 feet	2
DATE: April 2022	PROJECT NO. 16.0062961.81	REVISION NO.	



LEGEND

- 400 FT GRID SYSTEMATIC SAMPLE LOCATION
- ADDITIONAL BIASED SAMPLE LOCATION
- TIERED OR TRENCH SOIL BORING LOCATION
- WASTE MATERIAL OBSERVED
- XRF INDICATED ELEVATED CHROMIUM IN SOIL, NO WASTE MATERIAL OBSERVED
- NO WASTE MATERIAL OBSERVED
- NO WASTE MATERIAL OBSERVED, NOT SAMPLED
- BORING NOT COMPLETED
- PRESUMED TO CONTAIN WASTE MATERIAL, NO SOIL BORING/SAMPLING
- PREVIOUS SOURCE AREA SAMPLE LOCATION
- 1966 PROPOSED SITE PLAN
- APPROXIMATE HOUSE ST SITE BOUNDARY
- 400 FT GRID BLOCK

100 50 0 100
Scale in Feet

NO.	ISSUE/DESCRIPTION	BY	DATE

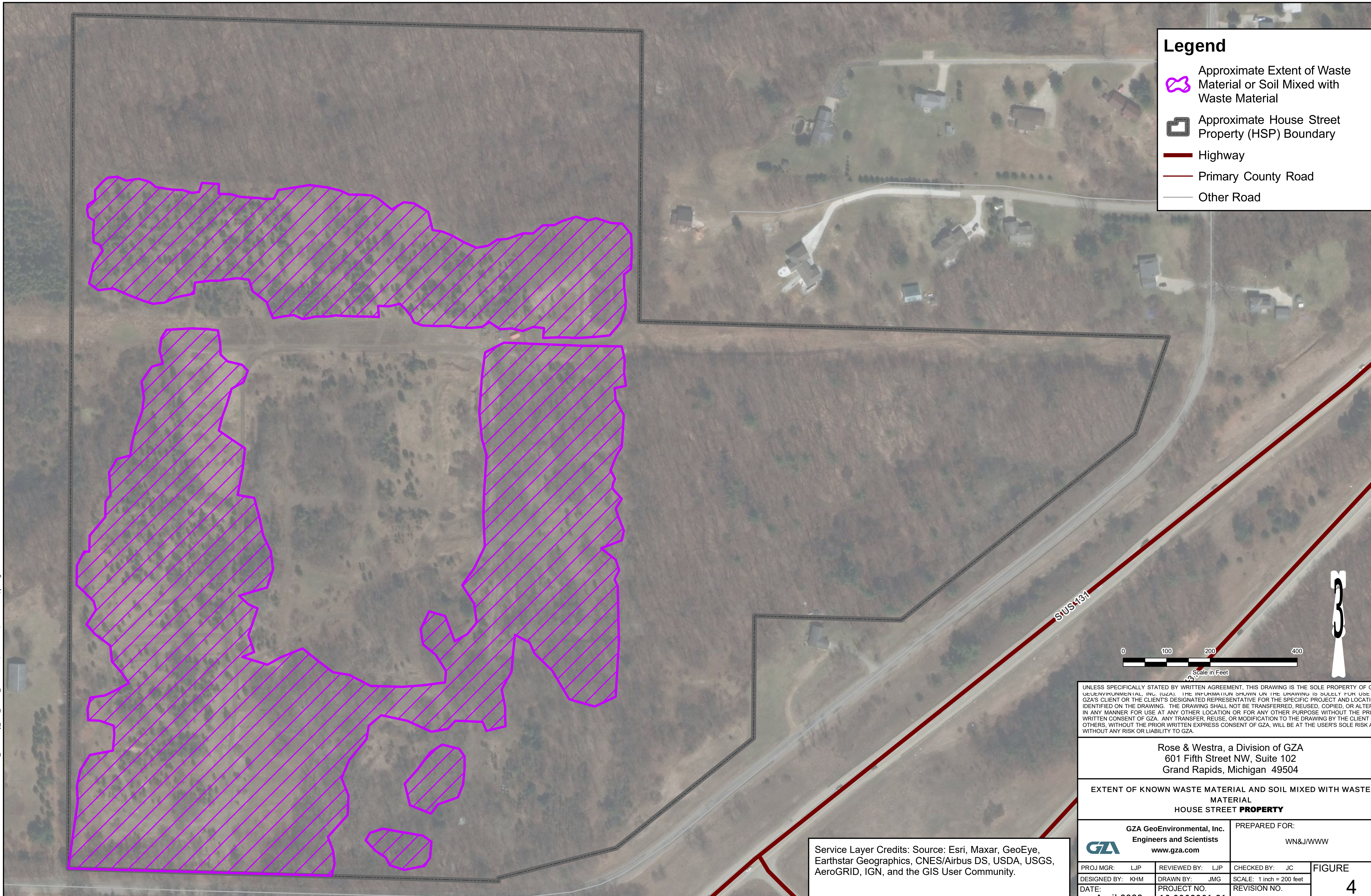
Rose & Westra, a Division of GZA
601 Fifth Street NW, Suite 102
Grand Rapids, Michigan 49504

SOIL BORING LOCATION PLAN
OBSERVATION OF WASTE MATERIAL IN SOIL BORINGS
HOUSE STREET **PROPERTY**

GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR: WNJ/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: LJP	FIGURE 3
DESIGNED BY: JC	DRAWN BY: JC/JMG	SCALE: AS SHOWN	
DATE: **April 2022**	PROJECT NO. 16.0062**961.81**	REVISION NO.	



Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

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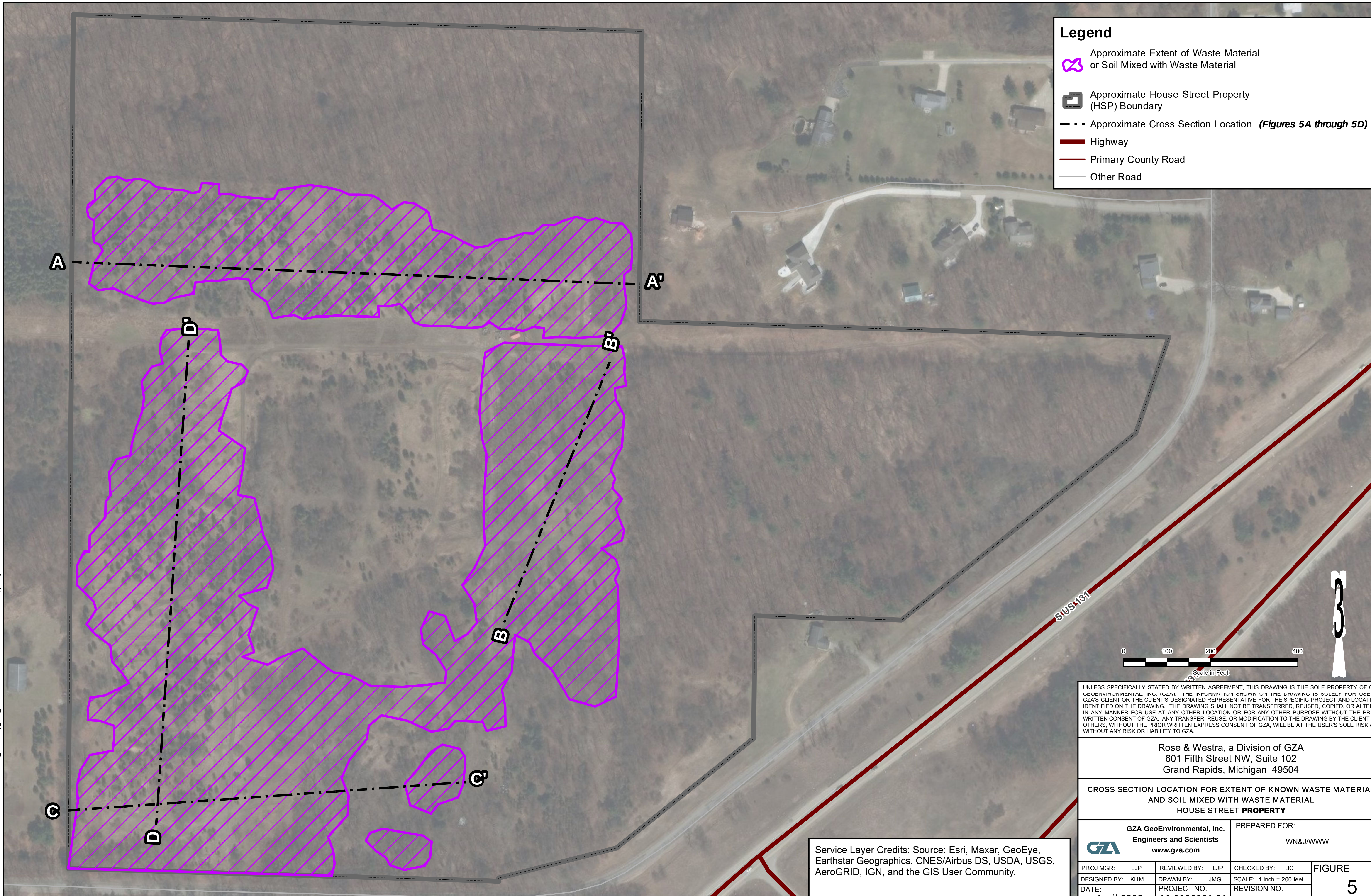
601 Fifth Street NW, Suite 102
Grand Rapids, Michigan 49504

EXTENT OF KNOWN WASTE MATERIAL AND SOIL MIXED WITH WASTE MATERIAL
HOUSE STREET **PROPERTY**

GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: JMG	SCALE: 1 inch = 200 feet	4
DATE: April 2022	PROJECT NO. 16.0062961.81	REVISION NO.	



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601 Fifth Street NW, Suite 102
Grand Rapids, Michigan 49504

CROSS SECTION LOCATION FOR EXTENT OF KNOWN WASTE MATERIAL AND SOIL MIXED WITH WASTE MATERIAL HOUSE STREET PROPERTY

GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

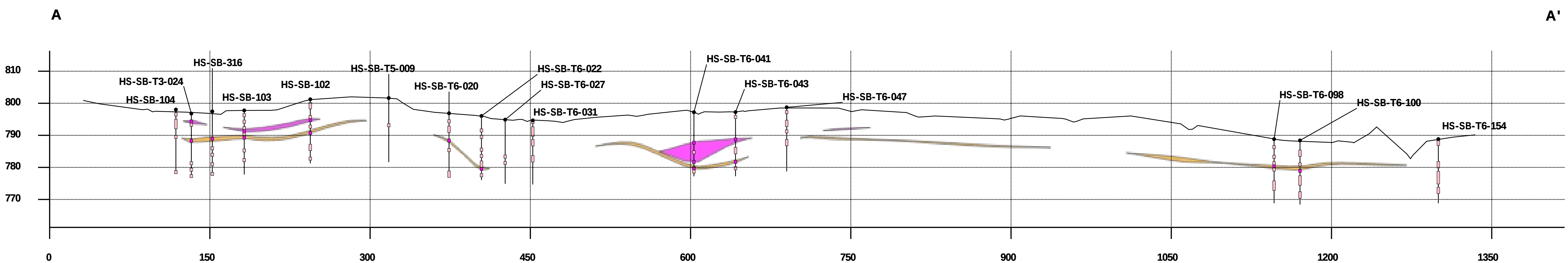
PREPARED FOR:
WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: JMG	SCALE: 1 inch = 200 feet	5
DATE: April 2022	PROJECT NO. 16.0062961.81	REVISION NO.	

Figure 6

Cross Section A - A'

View North



Legend

Observed Soil Conditions

No Waste | Waste

Modeled Waste Material

Estimated Waste Bottom | Waste

Topography

Note:

Based on measurements at permanent monitoring wells, the groundwater table at the site ranges in elevation from approximately 722 to 730 feet above mean sea level.

Location

A: 12787541, 588746

A': 12788958, 588694

Scale: 1:1,100

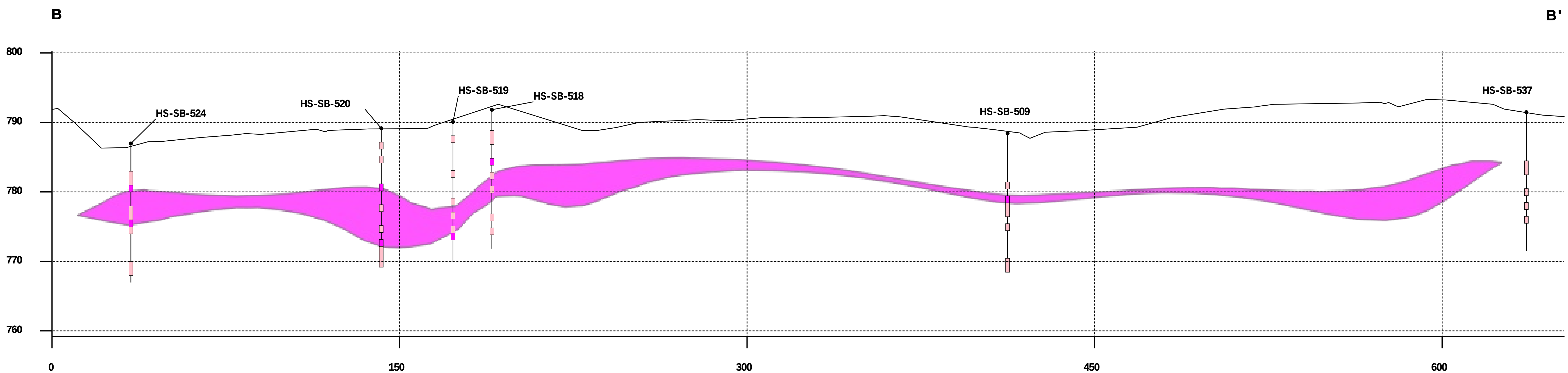
Vertical exaggeration: 3x

0ft 300ft

Figure 7

Cross Section B - B'

View West



Legend

Observed Soil Conditions

No Waste

Waste

Modeled Waste Material

Waste

Topography

Note:

Based on measurements at permanent monitoring wells, the groundwater table at the site ranges in elevation from approximately 722 to 730 feet above mean sea level.

Location

B: 12788604, 587917

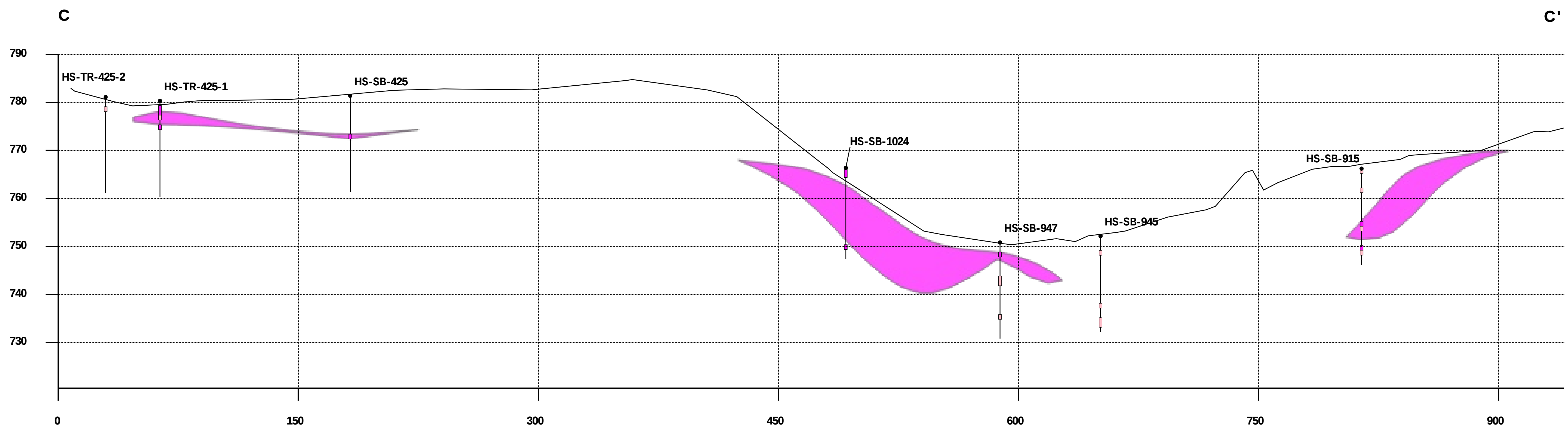
B': 12788801, 588539

Scale: 1:520

Vertical exaggeration: 3x

0 ft 75 ft

Figure 8
Cross Section C - C'
View North



Legend

Observed Soil Conditions

No Waste | Waste

Modeled Waste Material

Waste

Topography

Note:

Based on measurements at permanent monitoring wells, the groundwater table at the site ranges in elevation from approximately 722 to 730 feet above mean sea level.

Location

C: 12787556, 587496

C': 12788495, 587563

Scale: 1:800

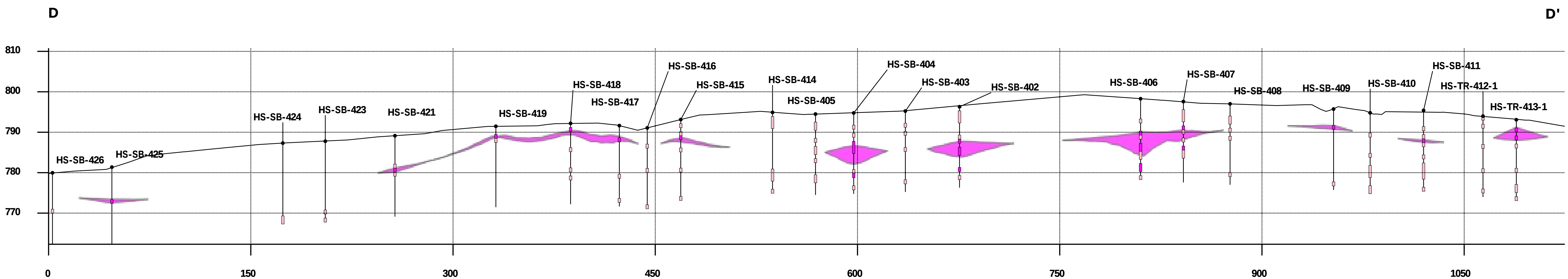
Vertical exaggeration: 3x

0ft 150ft

Figure 9

Cross Section D - D'

View West



Legend

Observed Soil Conditions

No Waste   Waste

Modeled Waste Material

Waste

Topography

Note:

Based on measurements at permanent monitoring wells, the groundwater table at the site ranges in elevation from approximately 722 to 730 feet above mean sea level.

Location

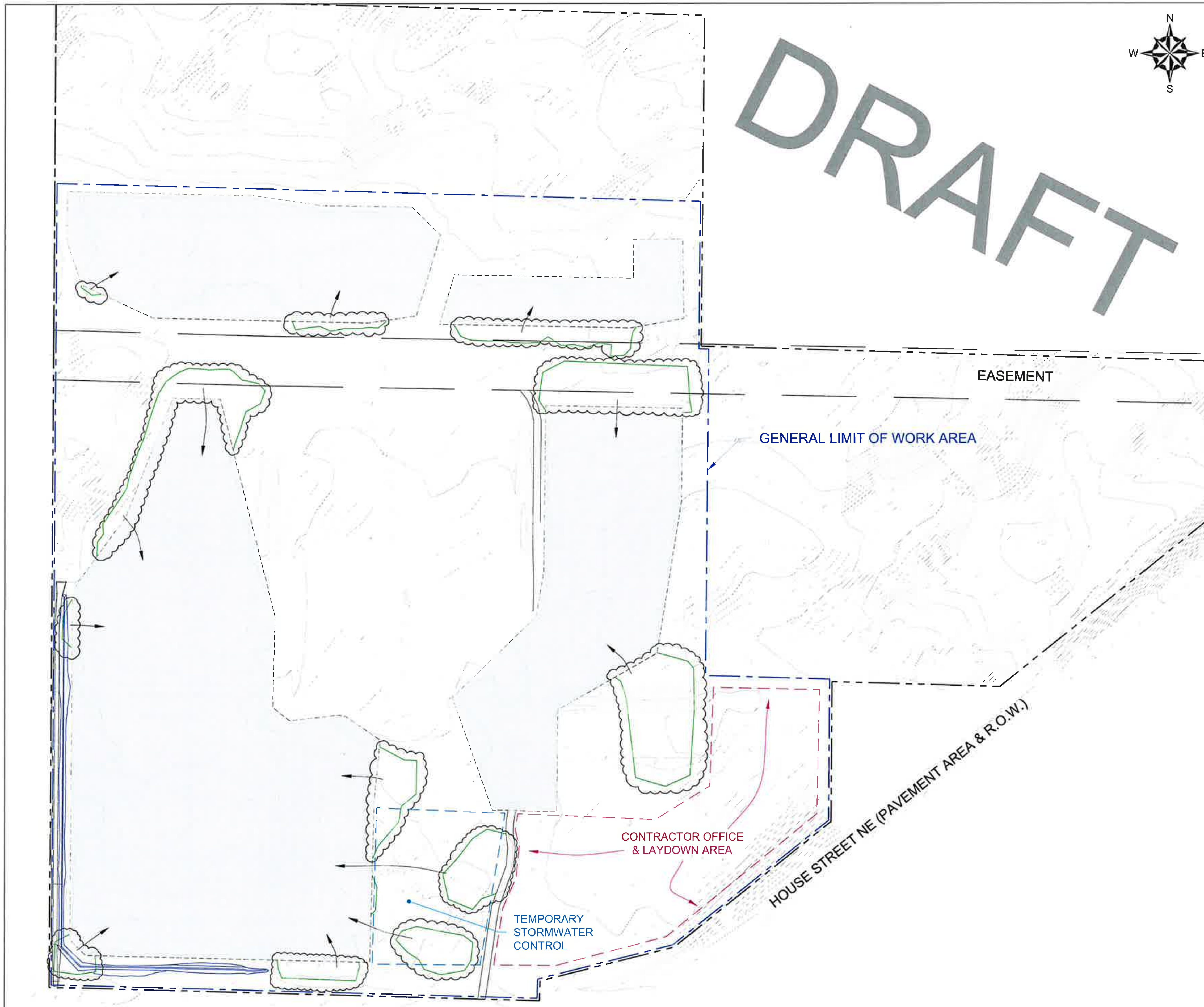
D: 12787727, 587459

D': 12787803, 588581

Scale: 1:850

Vertical exaggeration: 3x

0ft 150ft



GENERAL NOTES

1. BASE MAP TOPOGRAPHY PROVIDED BY EXXEL ENGINEERING, INC DATED OCTOBER 6, 2020.
2. STATION DATUM IS NAVD88, BASED ON GPS OBSERVATIONS USING MDOT CORS.

LEGEND

- SITE BOUNDARY
- GENERAL LIMIT OF WORK AREA
- EASEMENT
- EXISTING SITE ACCESS ROAD
- 760 EXISTING GROUND CONTOURS
- ESTIMATED EXTENT OF WASTE
- PERIMETER SWALE BREAKLINES (SW CORNER)
- 40-MIL LLDPE GEOMEMBRANE
- AREA OF IDENTIFIED WASTE MATERIAL TO BE RELOCATED TO MOUND AREAS AND CAPPED

0 50 100 200
SCALE IN FEET

NO.	ISSUE/DESCRIPTION	BY	DATE

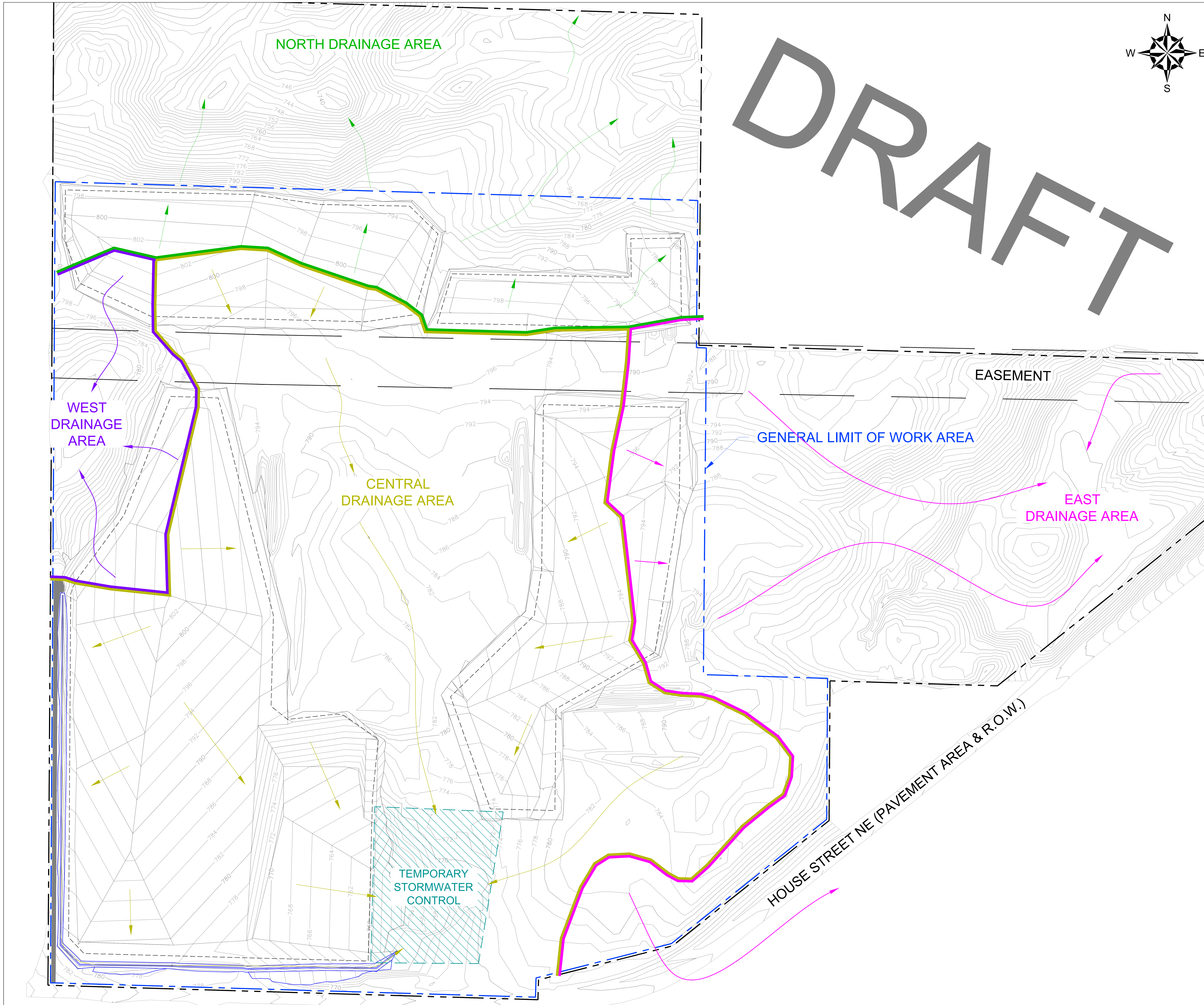
ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

EXCAVATION / WASTE RELOCATION PLAN

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: TAK	SCALE: AS SHOWN	10
DATE: APRIL 2022	PROJECT NO. 16.0062961.81	REVISION NO.	



GENERAL NOTES

1. BASE MAP TOPOGRAPHY PROVIDED BY EXXEL ENGINEERING, INC DATED OCTOBER 6, 2020.
2. STATION DATUM IS NAVD88, BASED ON GPS OBSERVATIONS USING MDOT CORS.

LEGEND

- SITE BOUNDARY
- GENERAL LIMIT OF WORK AREA
- EASEMENT
- PROPOSED SITE ACCESS ROAD
- 760 CONTOUR LINES
- PERIMETER SWALE BREAKLINES (SW CORNER)
- TOP OF CAP BREAKLINES
- LIMITS OF 40-MIL LLDPE GEOMEMBRANE

0 50 100 200
SCALE IN FEET

NO.	ISSUE/DESCRIPTION	BY	DATE

ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

GENERAL POST-CONSTRUCTION DRAINAGE PATTERN

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: WN&J/WWW

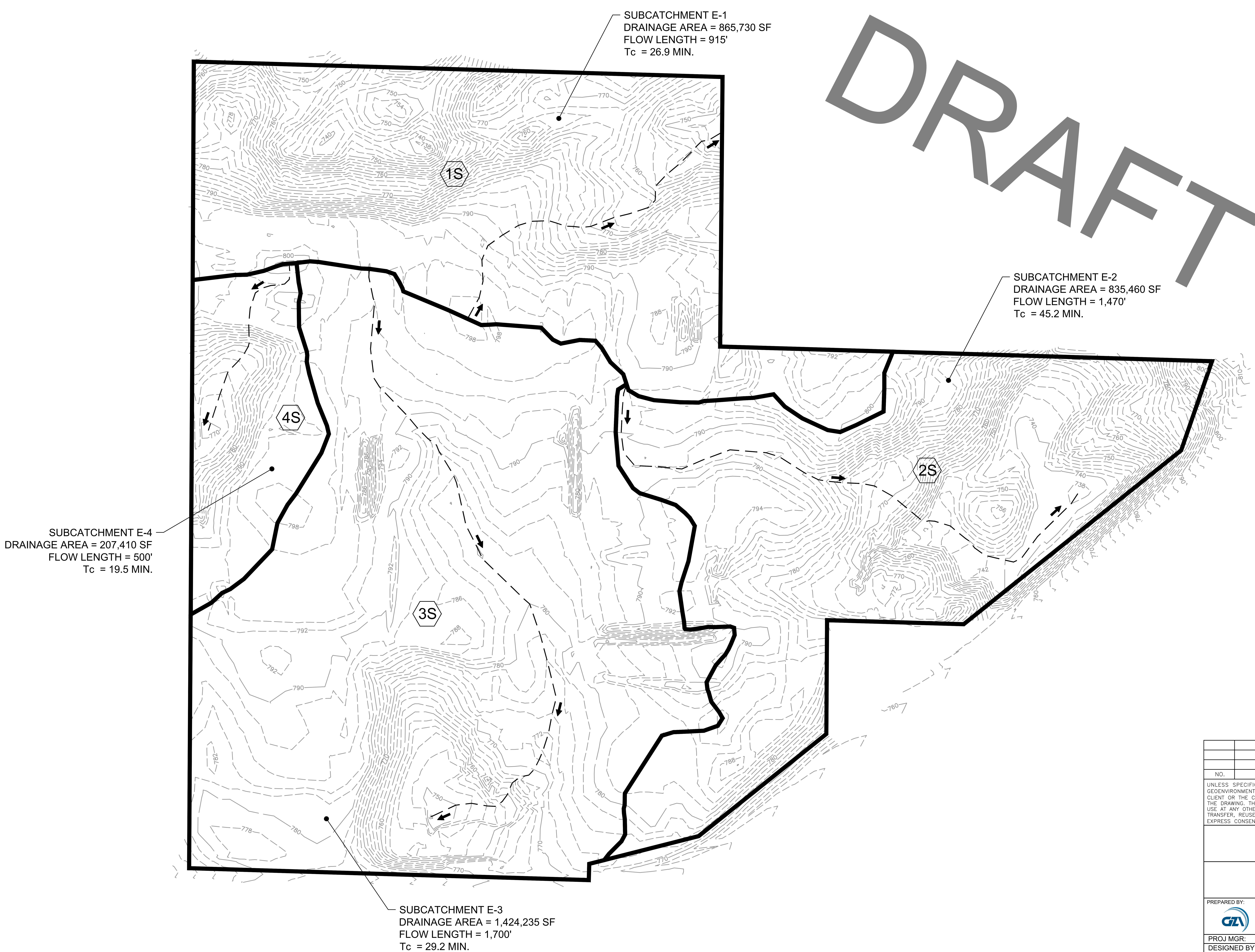
PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: TAK	SCALE: AS SHOWN	11
DATE: MARCH 2022	PROJECT NO. 16.0062961.81	REVISION NO.	

ATTACHMENT A

ENGINEERING CALCULATIONS

ATTACHMENT A.1

STORMWATER RUNOFF CALCULATIONS



LEGEND

- 738 EXISTING 2 FT CONTOUR
- 800 EXISTING 10 FT CONTOUR
- EXISTING DRAINAGE BOUNDARY
- Tc PATH
- FLOW DIRECTION
- 1S HYDROCAD® SUBCATCHMENT LABEL

GENERAL NOTES

1. BASE MAP TOPOGRAPHY PROVIDED BY EXXEL ENGINEERING, INC DATED OCTOBER 6, 2020.
2. STATION DATUM IS NAVD88, BASED ON GPS OBSERVATIONS USING MDOT CORS.

NO.	ISSUE/DESCRIPTION	BY	DATE

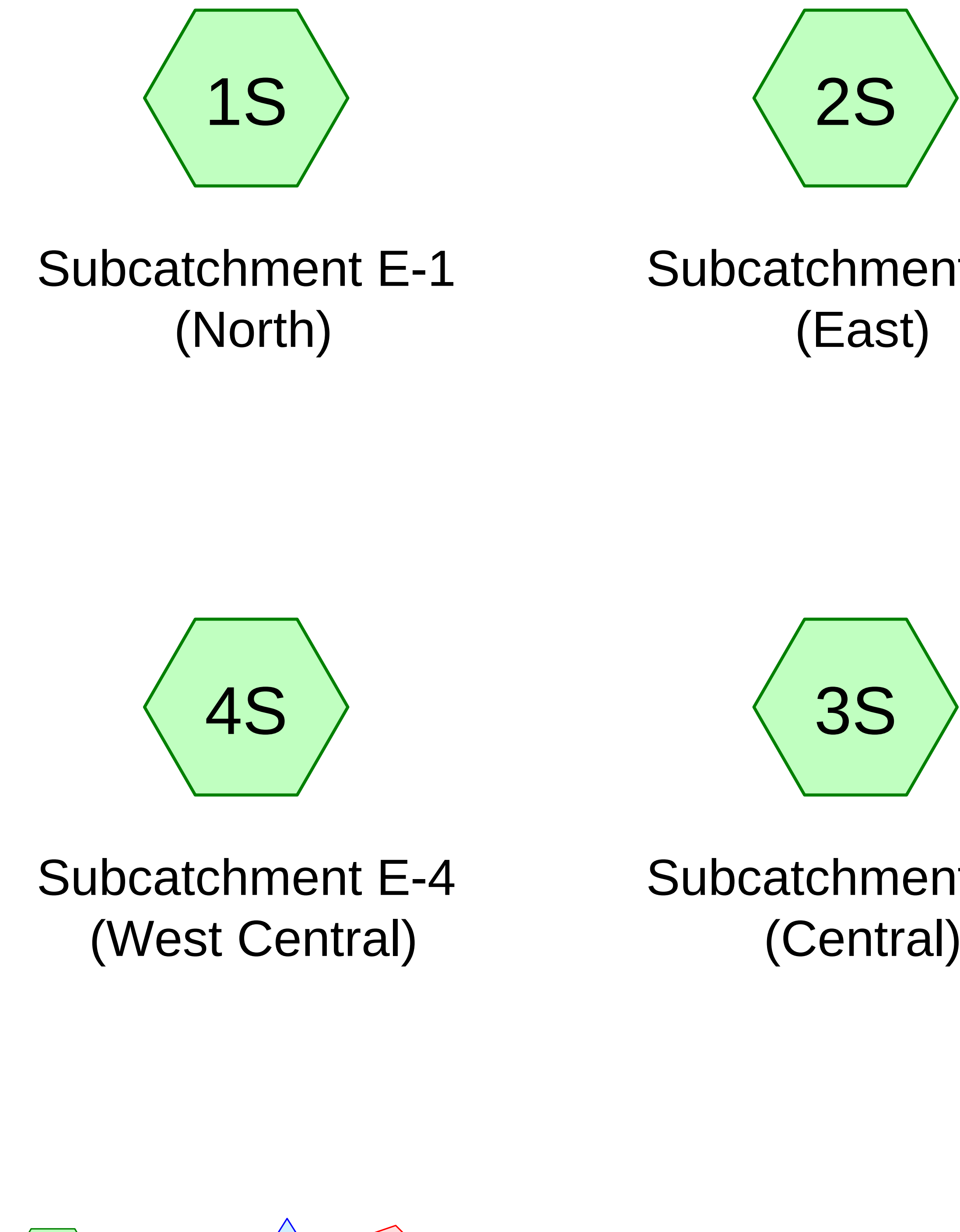
ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

PRE-DEVELOPEMENT DRAINAGE MAP

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: STD	CHECKED BY: JC	FIGURE
DESIGNED BY: STD	DRAWN BY: STD	SCALE: AS SHOWN	1
DATE: NOVEMBER 2022	PROJECT NO. 16.0062961.81	REVISION NO.	



Routing Diagram for HOUSE STREET CAP - Pre-Development
Prepared by GZA, Inc., Printed 4/8/2022

Project Notes

Rainfall events imported from "Atlas-14-Rain.txt" for 2693 MI Kent

Rainfall Events Listing (selected events)

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	100-Year	Type II 24-hr		Default	24.00	1	6.49	2

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
76.511	43	Woods/grass comb., Fair, HSG A (1S, 2S, 3S, 4S)
76.511	**43**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
76.511	HSG A	1S, 2S, 3S, 4S
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
0.000	Other	
76.511		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
76.511	0.000	0.000	0.000	0.000	76.511	Woods/grass comb., Fair	1S, 2S, 3S, 4S
76.511	**0.000**	**0.000**	**0.000**	**0.000**	**76.511**	**TOTAL AREA**	

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Subcatchment E-1 Runoff Area=865,730 sf 0.00% Impervious Runoff Depth>0.73"
Flow Length=915' Tc=26.9 min CN=43 Runoff=9.85 cfs 1.206 af

Subcatchment 2S: Subcatchment E-2 Runoff Area=835,460 sf 0.00% Impervious Runoff Depth>0.72"
Flow Length=1,470' Tc=45.2 min CN=43 Runoff=6.66 cfs 1.148 af

Subcatchment 3S: Subcatchment E-3 Runoff Area=1,424,235 sf 0.00% Impervious Runoff Depth>0.73"
Flow Length=1,700' Tc=29.5 min CN=43 Runoff=15.24 cfs 1.981 af

Subcatchment 4S: Subcatchment E-4 Runoff Area=207,410 sf 0.00% Impervious Runoff Depth>0.73"
Flow Length=500' Tc=19.5 min CN=43 Runoff=2.96 cfs 0.291 af

Total Runoff Area = 76.511 ac Runoff Volume = 4.626 af Average Runoff Depth = 0.73"
100.00% Pervious = 76.511 ac 0.00% Impervious = 0.000 ac

Summary for Subcatchment 1S: Subcatchment E-1 (North)

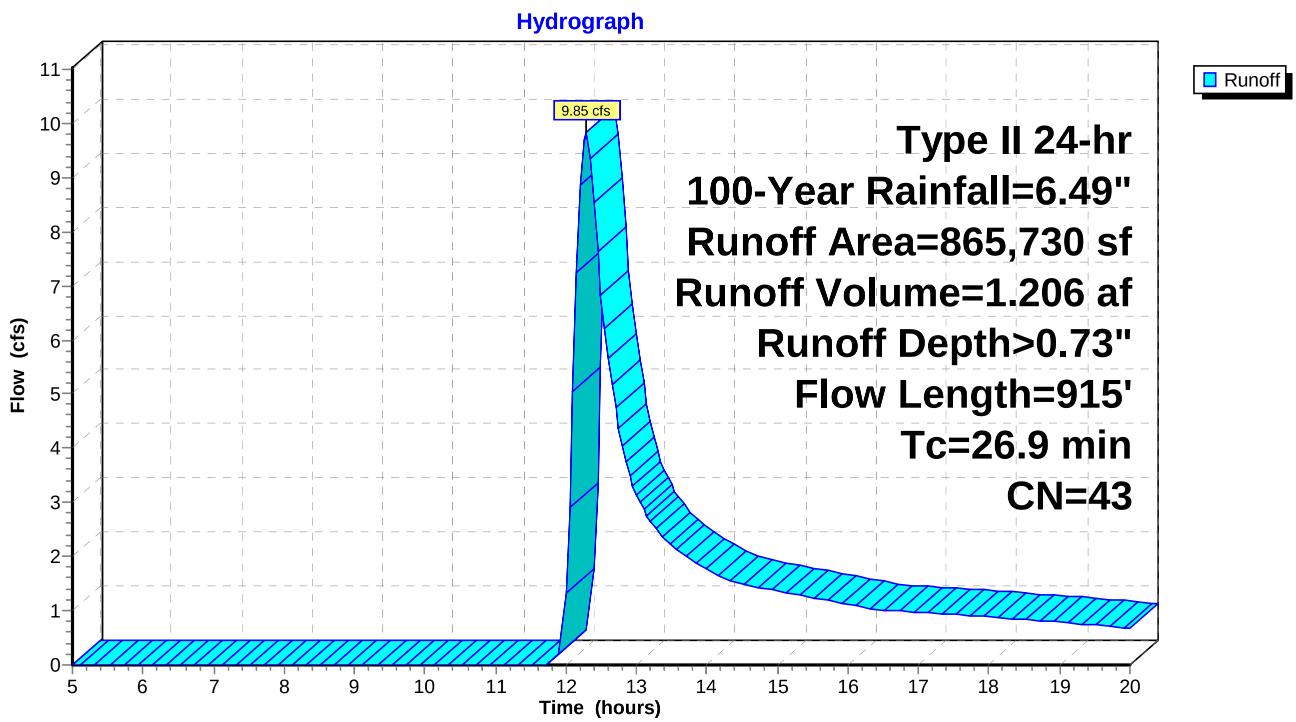
Runoff = 9.85 cfs @ 12.28 hrs, Volume= 1.206 af, Depth> 0.73"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-Year Rainfall=6.49"

Area (sf)	CN	Description
865,730	43	Woods/grass comb., Fair, HSG A
865,730		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
22.5	100	0.0260	0.07		**Sheet Flow, Segment AB** Woods: Light underbrush n= 0.400 P2= 2.37"
3.3	515	0.0260	2.60		**Shallow Concentrated Flow, Segment BC** Unpaved Kv= 16.1 fps
1.1	300	0.0570	4.61	23.05	**Channel Flow, Segment CD** Area= 5.0 sf Perim= 16.3' r= 0.31' n= 0.035 Earth, dense weeds
26.9	915	Total			

Subcatchment 1S: Subcatchment E-1 (North)



Summary for Subcatchment 2S: Subcatchment E-2 (East)

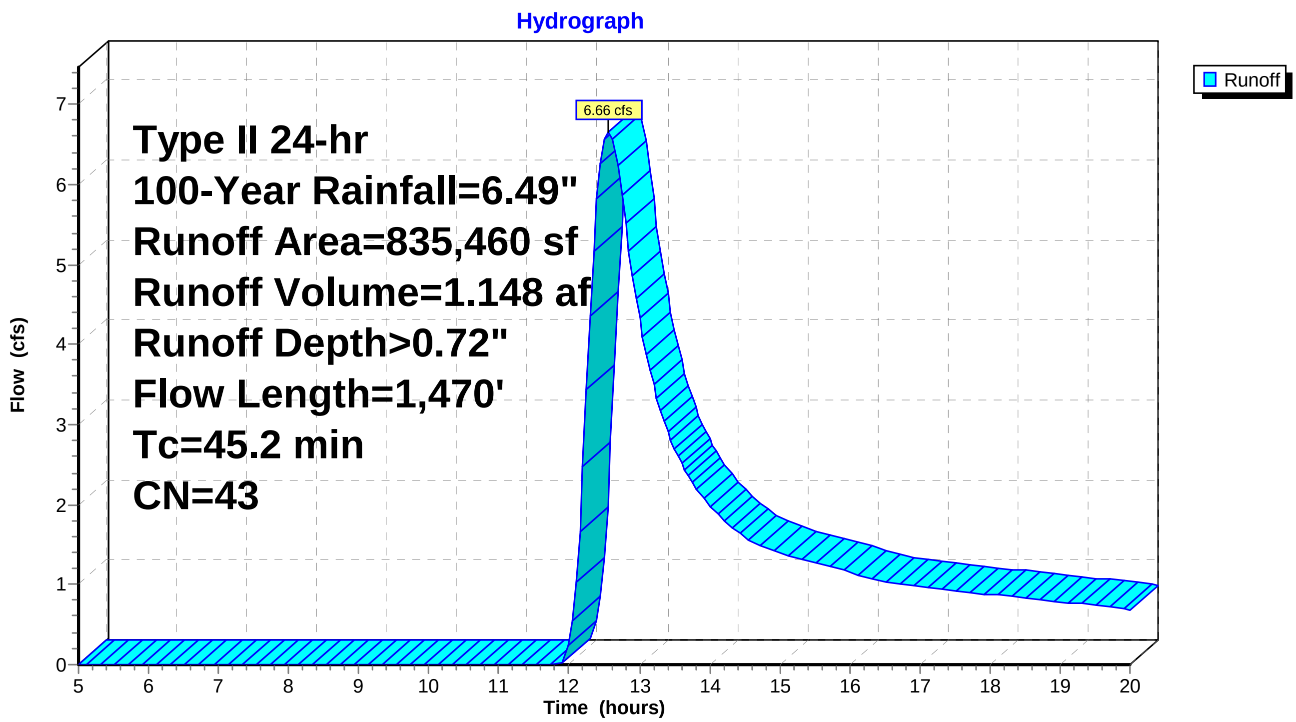
Runoff = 6.66 cfs @ 12.57 hrs, Volume= 1.148 af, Depth> 0.72"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-Year Rainfall=6.49"

Area (sf)	CN	Description
835,460	43	Woods/grass comb., Fair, HSG A
835,460		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
38.0	100	0.0070	0.04		**Sheet Flow, Segment AB** Woods: Light underbrush n= 0.400 P2= 2.37"
7.2	1,370	0.0390	3.18		**Shallow Concentrated Flow, Segment BC** Unpaved Kv= 16.1 fps
45.2	1,470	Total			

Subcatchment 2S: Subcatchment E-2 (East)



Summary for Subcatchment 3S: Subcatchment E-3 (Central)

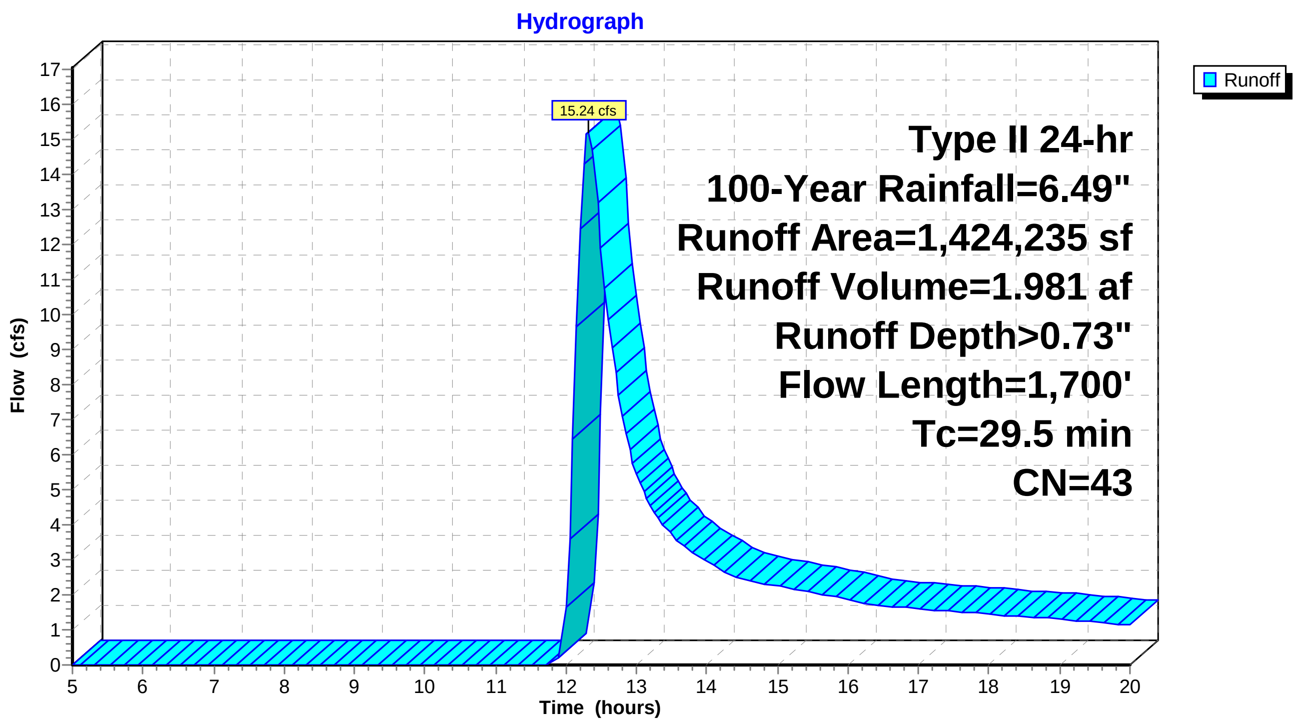
Runoff = 15.24 cfs @ 12.32 hrs, Volume= 1.981 af, Depth> 0.73"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-Year Rainfall=6.49"

Area (sf)	CN	Description
1,424,235	43	Woods/grass comb., Fair, HSG A
1,424,235		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
22.8	100	0.0250	0.07		**Sheet Flow, Segment AB** Woods: Light underbrush n= 0.400 P2= 2.37"
2.8	415	0.0230	2.44		**Shallow Concentrated Flow, Segment BC** Unpaved Kv= 16.1 fps
3.9	1,185	0.0300	5.08	60.96	**Channel Flow, Segment CD** Area= 12.0 sf Perim= 20.9' r= 0.57' n= 0.035 Earth, dense weeds
29.5	1,700	Total			

Subcatchment 3S: Subcatchment E-3 (Central)



Summary for Subcatchment 4S: Subcatchment E-4 (West Central)

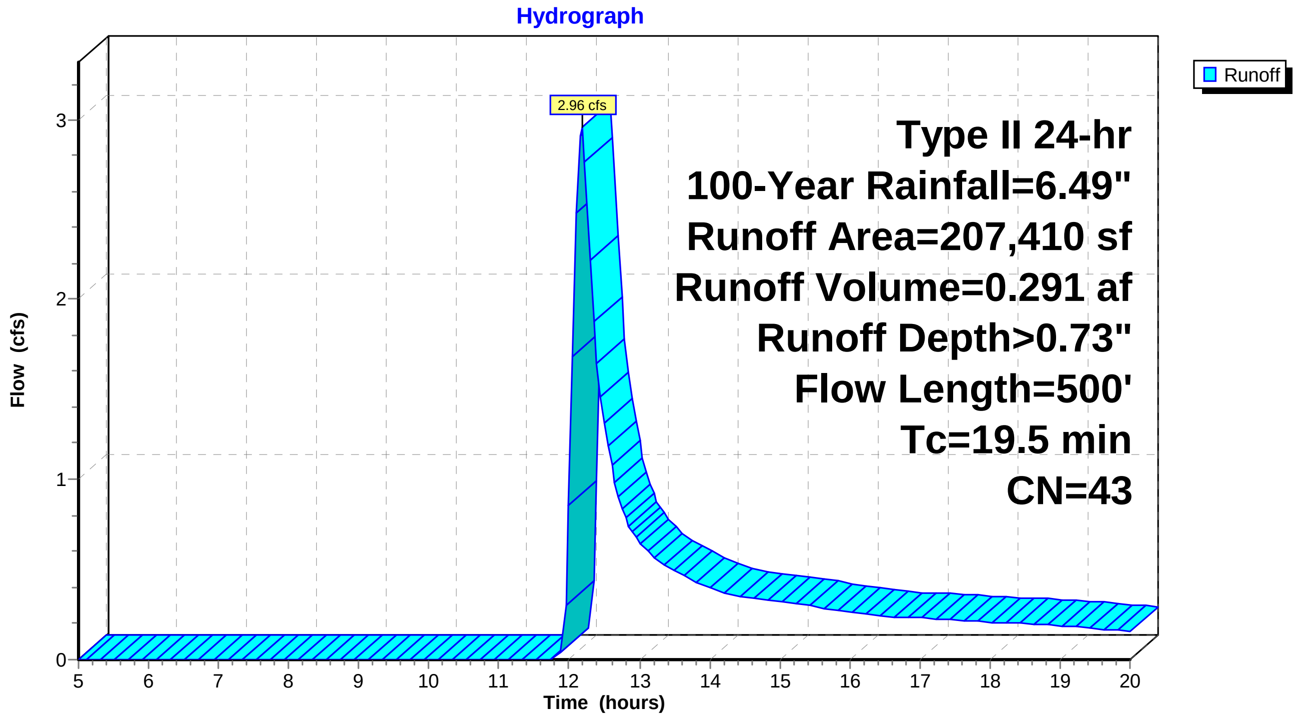
Runoff = 2.96 cfs @ 12.17 hrs, Volume= 0.291 af, Depth> 0.73"

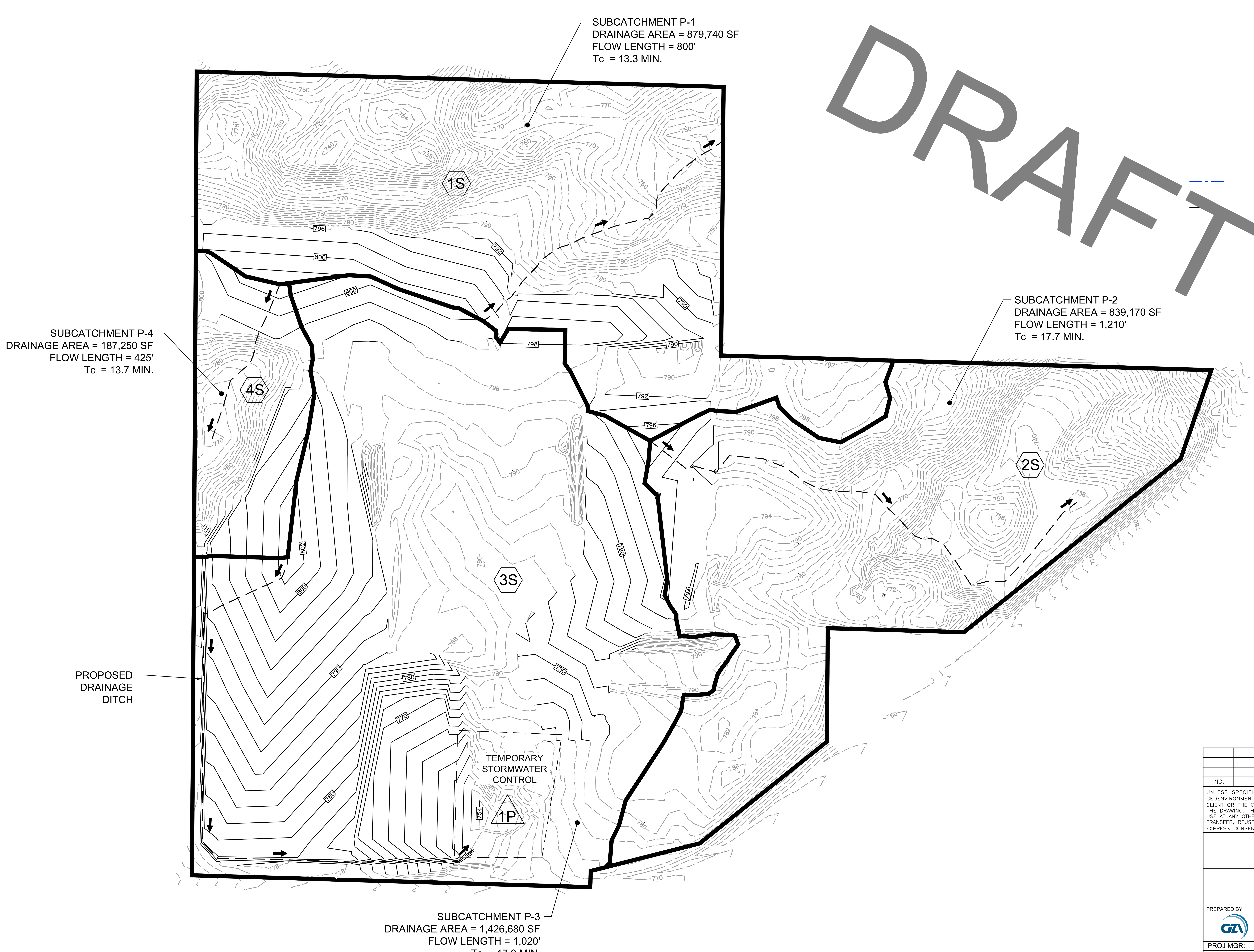
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-Year Rainfall=6.49"

Area (sf)	CN	Description
207,410	43	Woods/grass comb., Fair, HSG A
207,410		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.9	100	0.0460	0.09		**Sheet Flow, Segment AB** Woods: Light underbrush n= 0.400 P2= 2.37"
1.6	400	0.0700	4.26		**Shallow Concentrated Flow, Segment BC** Unpaved Kv= 16.1 fps
19.5	500	Total			

Subcatchment 4S: Subcatchment E-4 (West Central)





LEGEND

- 738 EXISTING 2 FT CONTOUR
- 800 EXISTING 10 FT CONTOUR
- 800 PROPOSED CONTOUR
- EXISTING DRAINAGE BOUNDARY
- Tc PATH
- FLOW DIRECTION
- 1S HYDROCAD® SUBCATCHMENT LABEL
- 1P HYDROCAD® POND LABEL

GENERAL NOTES

1. BASE MAP TOPOGRAPHY PROVIDED BY EXXEL ENGINEERING, INC DATED OCTOBER 6, 2020.
2. STATION DATUM IS NAVD88, BASED ON GPS OBSERVATIONS USING MDOT CORS.

0 60 120 240
SCALE IN FEET

NO.	ISSUE/DESCRIPTION	BY	DATE

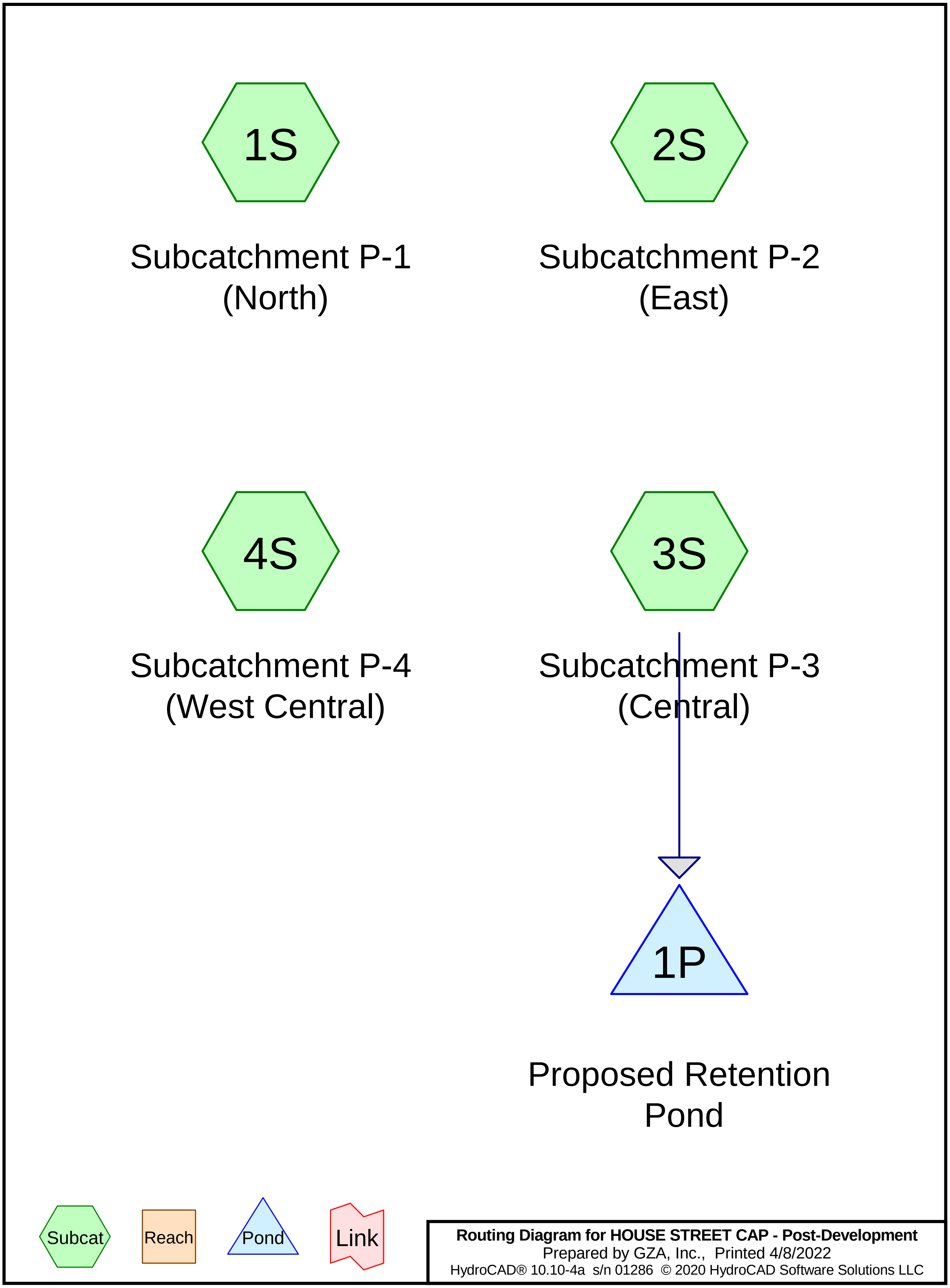
ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

POST DEVELOPEMENT DRAINAGE MAP

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: STD	CHECKED BY: JC	FIGURE 2
DESIGNED BY: STD	DRAWN BY: STD	SCALE: AS SHOWN	
DATE: NOVEMBER 2022	PROJECT NO. 16.0062961.81	REVISION NO.	


1S
Subcatchment P-1
(North)
2S
Subcatchment P-2
(East)
4S
Subcatchment P-4
(West Central)
3S
Subcatchment P-3
(Central)
1P
Proposed Retention
Pond
Subcat
Reach
Pond
Link
Routing Diagram for HOUSE STREET CAP - Post-Development
Prepared by GZA, Inc., Printed 4/8/2022
HydroCAD® 10.10-4a s/n 01286 © 2020 HydroCAD Software Solutions LLC

Project Notes

Rainfall events imported from "Atlas-14-Rain.txt" for 2693 MI Kent

Rainfall Events Listing (selected events)

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	100-Year	Type II 24-hr		Default	24.00	1	6.49	2

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
25.052	39	>75% Grass cover, Good, HSG A (1S, 2S, 3S, 4S)
25.344	48	Brush, Poor, HSG A (1S, 2S, 3S, 4S)
26.115	43	Woods/grass comb., Fair, HSG A (1S, 2S)
76.511	**43**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
76.511	HSG A	1S, 2S, 3S, 4S
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
0.000	Other	
76.511		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
25.052	0.000	0.000	0.000	0.000	25.052	>75% Grass cover, Good	1S, 2S, 3S, 4S
25.344	0.000	0.000	0.000	0.000	25.344	Brush, Poor	1S, 2S, 3S, 4S
26.115	0.000	0.000	0.000	0.000	26.115	Woods/grass comb., Fair	1S, 2S
76.511	**0.000**	**0.000**	**0.000**	**0.000**	**76.511**	**TOTAL AREA**	

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Subcatchment P-1 Runoff Area=879,740 sf 0.00% Impervious Runoff Depth>0.74"
Flow Length=800' Tc=13.3 min CN=43 Runoff=16.08 cfs 1.238 af

Subcatchment 2S: Subcatchment P-2 Runoff Area=839,170 sf 0.00% Impervious Runoff Depth>0.80"
Flow Length=1,210' Tc=17.7 min CN=44 Runoff=14.64 cfs 1.282 af

Subcatchment 3S: Subcatchment P-3 Runoff Area=1,426,680 sf 0.00% Impervious Runoff Depth>0.73"
Flow Length=1,020' Tc=17.9 min CN=43 Runoff=21.58 cfs 2.001 af

Subcatchment 4S: Subcatchment P-4 Runoff Area=187,250 sf 0.00% Impervious Runoff Depth>0.80"
Flow Length=425' Tc=13.7 min CN=44 Runoff=3.85 cfs 0.287 af

Pond 1P: Proposed Retention Pond Peak Elev=752.18' Storage=87,057 cf Inflow=21.58 cfs 2.001 af
Outflow=0.00 cfs 0.000 af

Total Runoff Area = 76.511 ac Runoff Volume = 4.807 af Average Runoff Depth = 0.75"
100.00% Pervious = 76.511 ac 0.00% Impervious = 0.000 ac

Summary for Subcatchment 1S: Subcatchment P-1 (North)

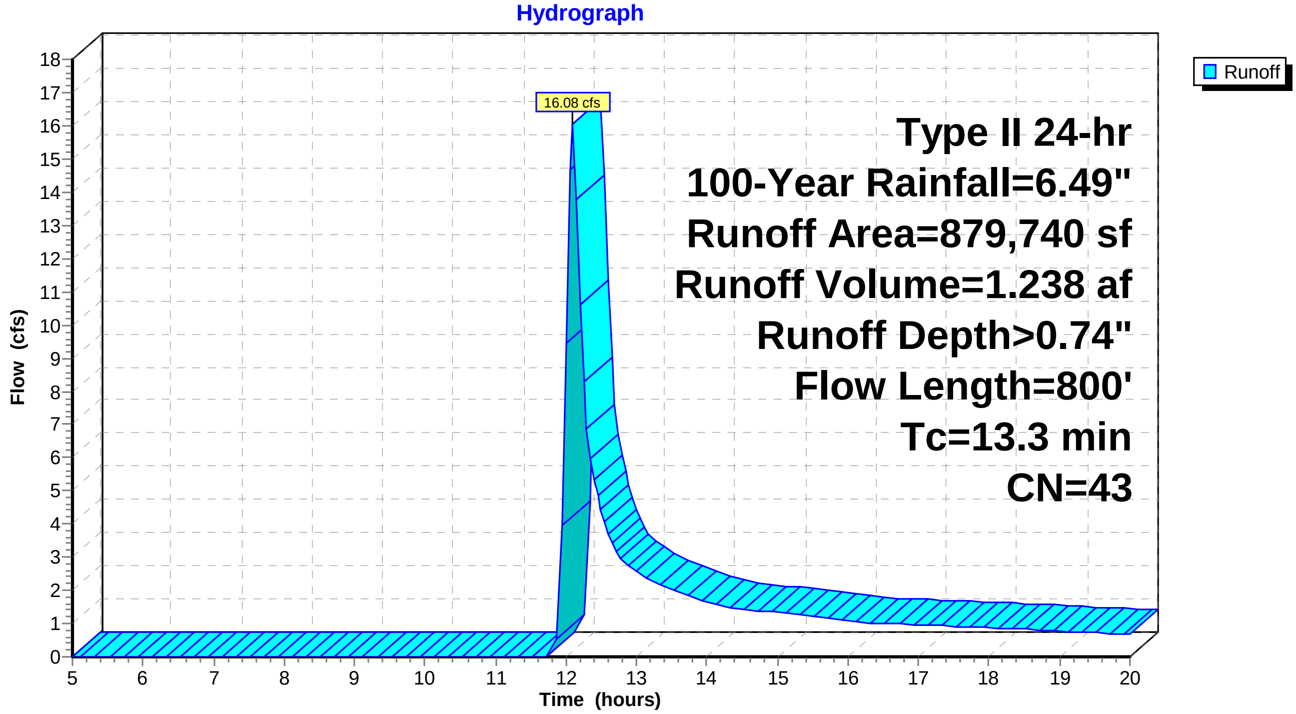
Runoff = 16.08 cfs @ 12.09 hrs, Volume= 1.238 af, Depth> 0.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-Year Rainfall=6.49"

Area (sf)	CN	Description
194,665	39	>75% Grass cover, Good, HSG A
554,920	43	Woods/grass comb., Fair, HSG A
130,155	48	Brush, Poor, HSG A
879,740	43	Weighted Average
879,740		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.7	100	0.0600	0.16		**Sheet Flow, Segment AB** Grass: Dense n= 0.240 P2= 2.37"
1.5	400	0.0750	4.41		**Shallow Concentrated Flow, Segment BC** Unpaved Kv= 16.1 fps
1.1	300	0.0570	4.61	23.05	**Channel Flow, Segment CD** Area= 5.0 sf Perim= 16.3' r= 0.31' n= 0.035 Earth, dense weeds
13.3	800	Total			

Subcatchment 1S: Subcatchment P-1 (North)



Summary for Subcatchment 2S: Subcatchment P-2 (East)

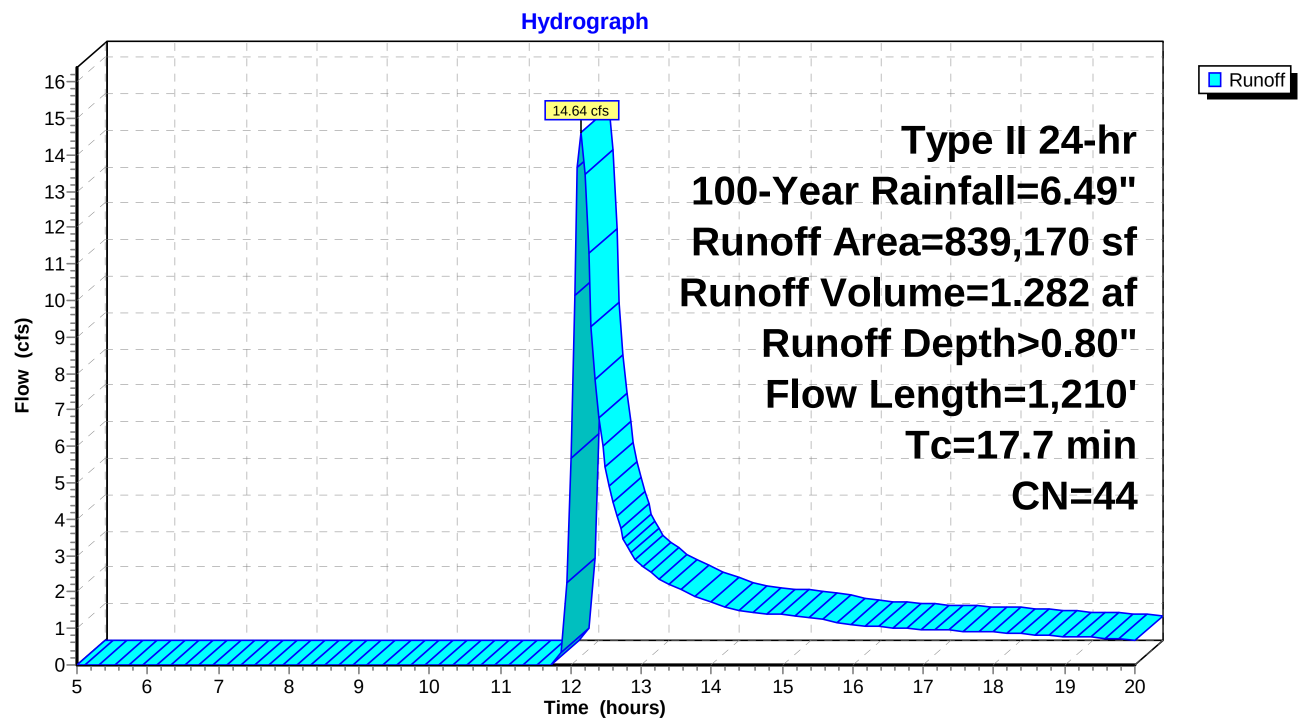
Runoff = 14.64 cfs @ 12.15 hrs, Volume= 1.282 af, Depth> 0.80"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-Year Rainfall=6.49"

Area (sf)	CN	Description
55,500	39	>75% Grass cover, Good, HSG A
582,650	43	Woods/grass comb., Fair, HSG A
201,020	48	Brush, Poor, HSG A
839,170	44	Weighted Average
839,170		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.6	100	0.0400	0.13		**Sheet Flow, Segment AB** Grass: Dense n= 0.240 P2= 2.37"
5.1	1,110	0.0500	3.60		**Shallow Concentrated Flow, Segment BC** Unpaved Kv= 16.1 fps
17.7	1,210	Total			

Subcatchment 2S: Subcatchment P-2 (East)



Summary for Subcatchment 3S: Subcatchment P-3 (Central)

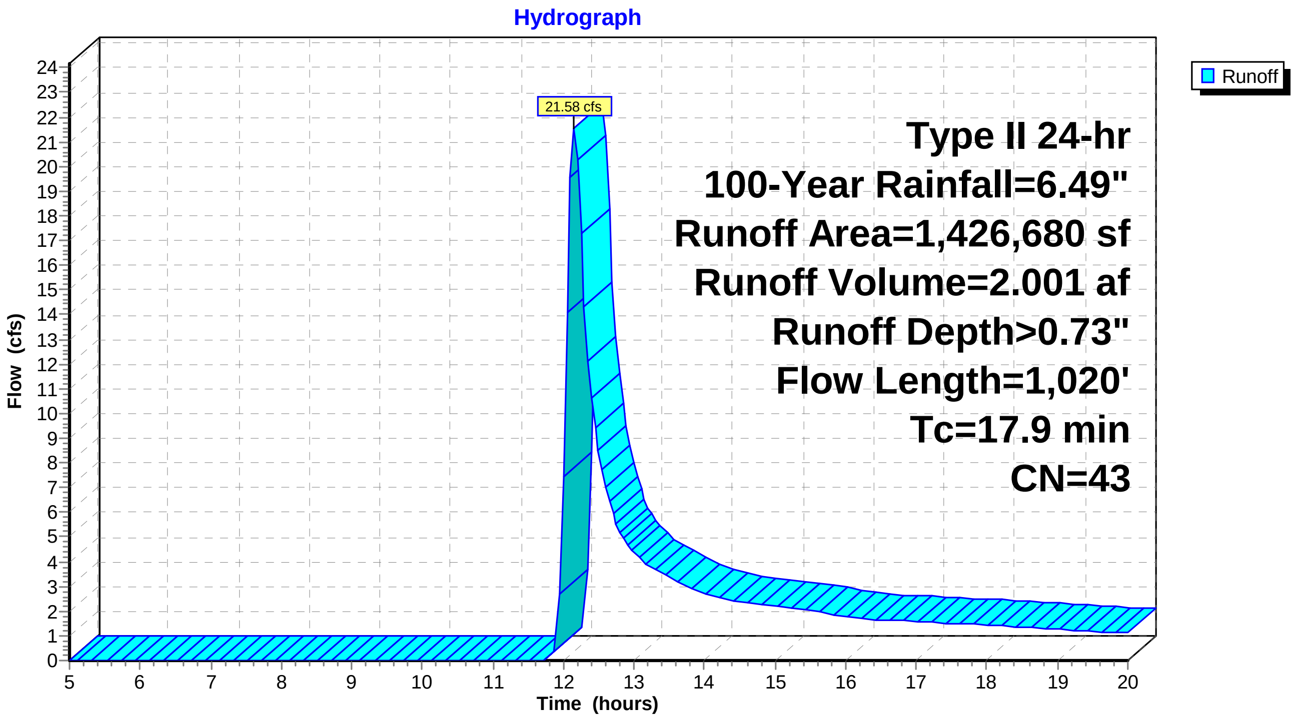
Runoff = 21.58 cfs @ 12.15 hrs, Volume= 2.001 af, Depth> 0.73"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-Year Rainfall=6.49"

Area (sf)	CN	Description
755,635	39	>75% Grass cover, Good, HSG A
671,045	48	Brush, Poor, HSG A
1,426,680	43	Weighted Average
1,426,680		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.6	100	0.0400	0.13		**Sheet Flow, Segment AB** Grass: Dense n= 0.240 P2= 2.37"
0.7	170	0.0650	4.10		**Shallow Concentrated Flow, Segment BC** Unpaved Kv= 16.1 fps
4.6	750	0.0430	2.73	32.75	**Channel Flow, Segment CD** Area= 12.0 sf Perim= 20.9' r= 0.57' n= 0.078 Riprap, 12-inch
17.9	1,020	Total			

Subcatchment 3S: Subcatchment P-3 (Central)



Summary for Subcatchment 4S: Subcatchment P-4 (West Central)

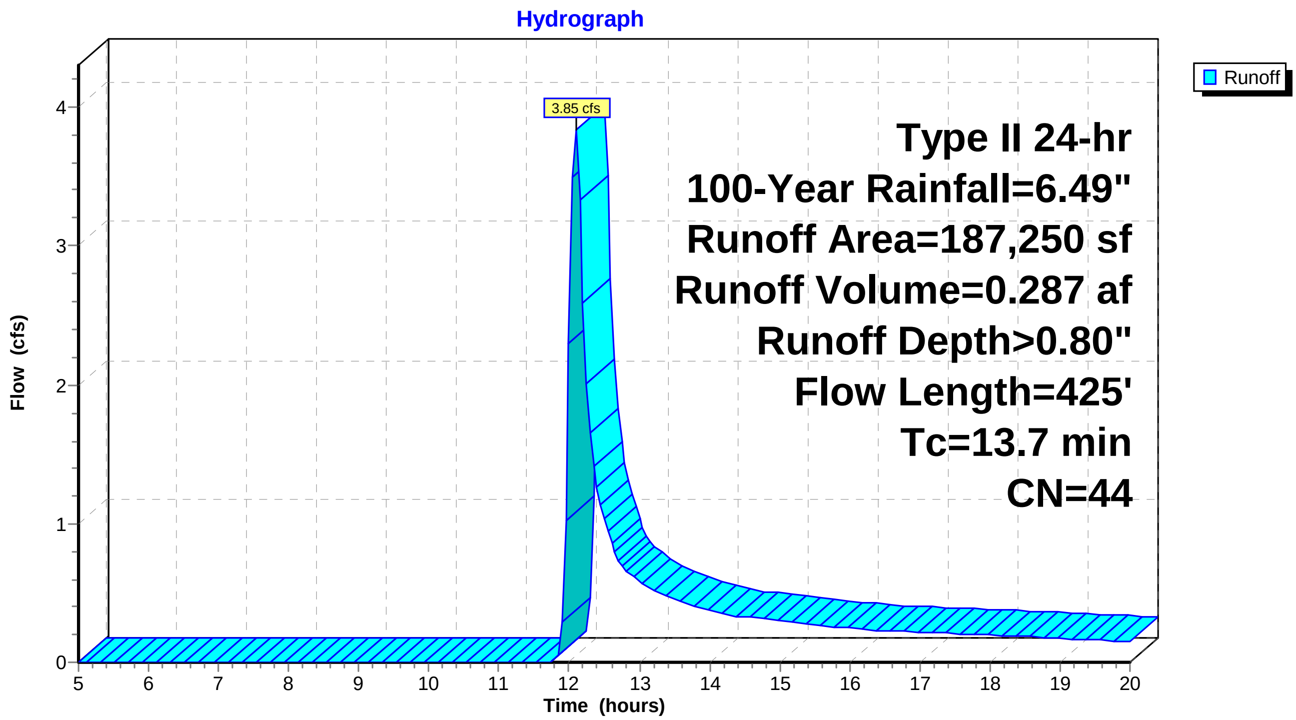
Runoff = 3.85 cfs @ 12.10 hrs, Volume= 0.287 af, Depth> 0.80"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-Year Rainfall=6.49"

Area (sf)	CN	Description
85,475	39	>75% Grass cover, Good, HSG A
101,775	48	Brush, Poor, HSG A
187,250	44	Weighted Average
187,250		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.6	100	0.0400	0.13		**Sheet Flow, Segment AB** Grass: Dense n= 0.240 P2= 2.37"
1.1	325	0.0920	4.88		**Shallow Concentrated Flow, Segment BC** Unpaved Kv= 16.1 fps
13.7	425	Total			

Subcatchment 4S: Subcatchment P-4 (West Central)



Summary for Pond 1P: Proposed Retention Pond

Inflow Area = 32.752 ac, 0.00% Impervious, Inflow Depth > 0.73" for 100-Year event
Inflow = 21.58 cfs @ 12.15 hrs, Volume= 2.001 af
Outflow = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

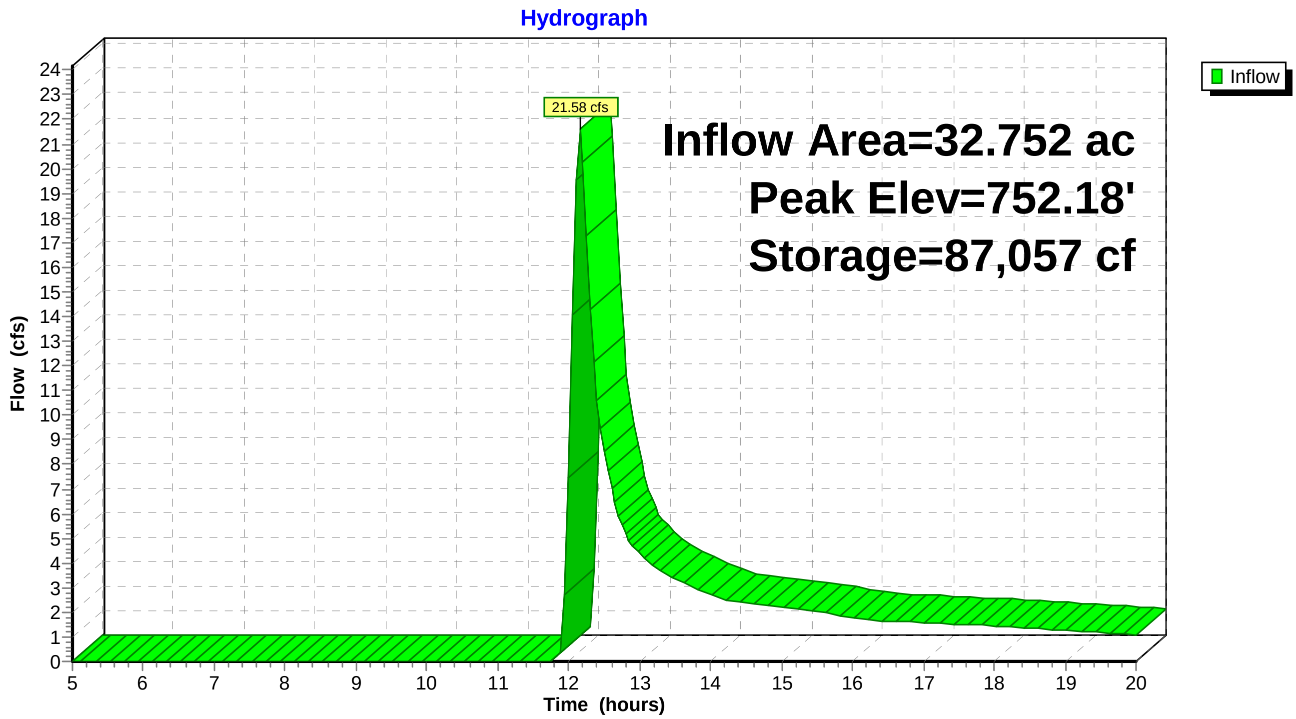
Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 752.18' @ 20.00 hrs Surf.Area= 47,458 sf Storage= 87,057 cf

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

Volume	Invert	Avail.Storage	Storage Description
#1	750.00'	669,750 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
750.00	32,350	0	0
760.00	101,600	669,750	669,750

Pond 1P: Proposed Retention Pond



ATTACHMENT A.2

STORMWATER DRAINAGE PIPE CALCULATIONS

(RESERVED)

ATTACHMENT A.3

SLOPE STABILITY CALCULATIONS

GZA
GeoEnvironmental, Inc.
17975 West Sarah Lane, Suite 100
Brookfield, WI 53045
262-754-2560
Fax 262-923-7758
http://www.gza.com

Engineers and Scientists

Slope Stability Assessment

Upper Soils for use for perimeter berm construction & for cap cover / barrier protection soil.

Soils are either fine sand or silty clay

Standard penetration test "N" values obtained from these two material types (from geotechnical test borings) are:

Sand :	GT-1 average "N" value	= 7
	GT-2	= 10
	GT-3	= 21
	GT-4	= 13
	GT-5	= 9
	GT-6	--

Average ~ 12; then assume moist unit weight at 112 pcf & 33° friction angle

Silty Clay:	GT-1 average "N" value	= 3
	GT-2	= 15
	GT-3	= 6
	GT-4	= 7
	GT-5 & GT-6	= 7

Average ~ 7; then assume moist unit weight at 120 pcf & shear strength @ 1500 psf.

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JOB House Street Cap - Slope
SHEET NO. 2 OF 5
CALCULATED BY E. Hanna DATE
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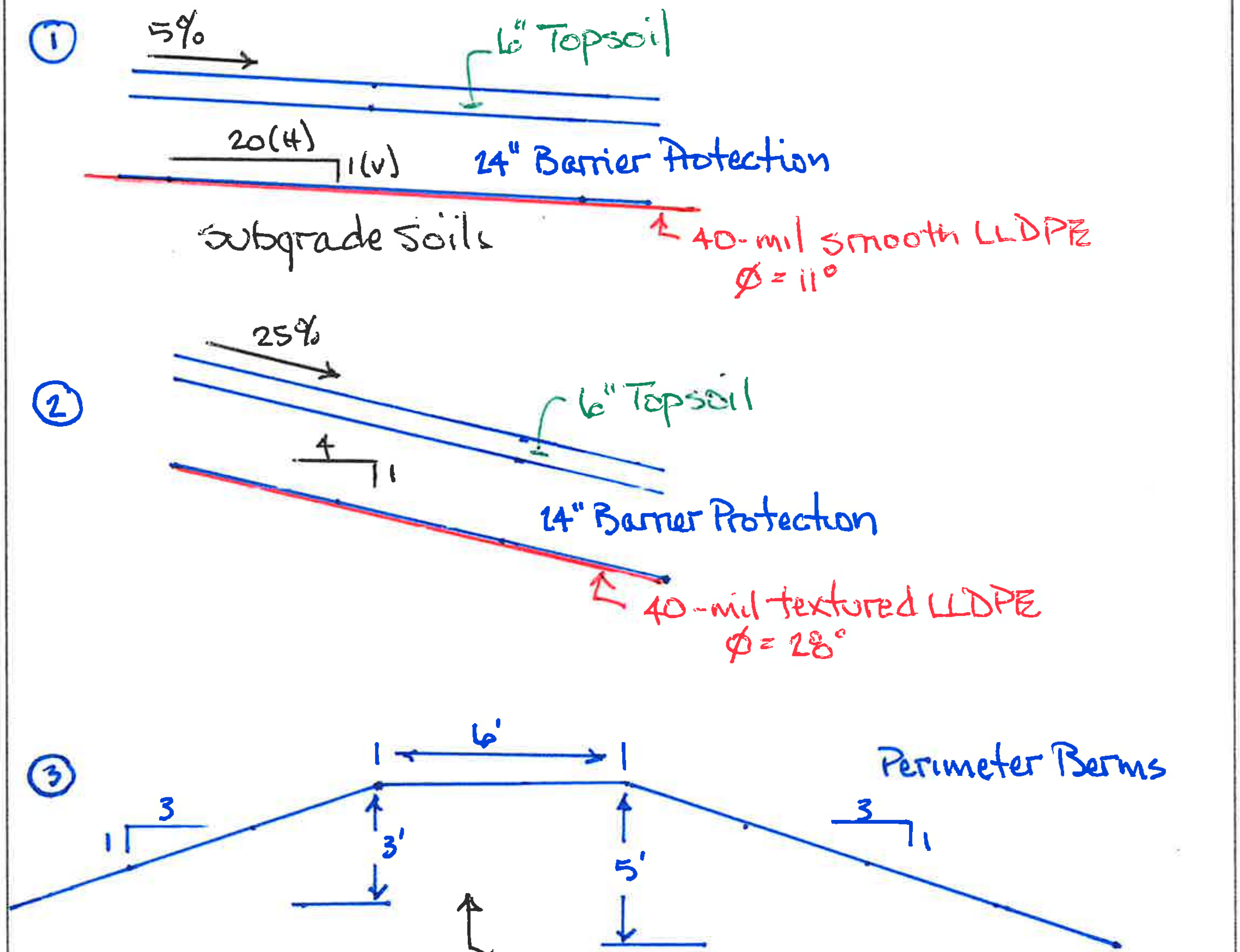
SCALE NTS

Slopes for Consideration



Controlled construction using site soils

Temporary construction, present only during construction activities

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By inspection, an infinite slope stability assessment is applicable.

$$\text{Infinite Slope Factor of Safety (FS)} = \frac{\tan \phi}{\tan \beta}$$

where ϕ = soil angle of internal friction

β = slope angle relative to horizontal

Material Type	Friction Angle (ϕ)	Tangent ϕ
Topsoil	28°	0.53
Sand	33°	0.65
Clay	26°	0.49
Smooth LLDPE	11°	0.19
Textured LLDPE	28°	0.53

Slope Angles	Slope	Angle (β)	
5%	20'(H):1'(V)	3°	0.05
25%	4'(H):1'(V)	14°	0.25
33%	3'(H):1'(V)	18°	0.33

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Infinite Slope Analysis for Various Slope Conditions

$$FS = \frac{\tan \phi}{\tan \beta}$$

Slope Condition	Material	ϕ	Tan ϕ	β	Tan β	FS
1	Topsoil	28°	0.53	3°	.05	10.6
	Barrier Protection	33°	0.65	3°	.05	13
	Smooth LLDPE	11°	0.19	3°	.05	3.8
	Subgrade	26°	0.49	3°	.05	9.8
2	Topsoil	28°	0.53	14°	.25	2.1
	Barrier Protection	33°	0.65	14°	.25	2.6
	Textured LLDPE	28°	0.53	14°	.25	2.1
	Subgrade	26°	0.49	14°	.25	2
3	Barrier Protection or Site Soils	26°	0.49	18°	.33	1.5

FS for slope conditions are greater than 1.5 ✓ Check

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Also check for seepage conditions at slope condition ① and ② with seepage acting along / above LLDPE Surface

Infinite Slope with Seepage Consideration analysis is:

$$FS = \left(\frac{\gamma_b}{\gamma_s}\right)\left(\frac{\tan\phi}{\tan\beta}\right)$$

where γ_b = bouyant unit weight of soil

γ_s = saturated unit weight of soil

Consider both Sand & clay soils

Sand: $\gamma_s = 120$ pcf $\qquad \phi = 33°$

$\gamma_b = 58$ pcf

Clay: $\gamma_s = 125$ pcf $\qquad \phi = 26°$

$\gamma_b = 63$ pcf

@ 5% Slope: Sand $FS = \left(\frac{58}{120}\right)\frac{\tan 33°}{\tan 3°} = 6$

Clay $FS = \left(\frac{63}{125}\right)\frac{\tan 26°}{\tan 3°} = 4.7$ ✓

@ 25% Slope: Clay $FS = \left(\frac{63}{125}\right)\frac{\tan 26°}{\tan 14°} = 1$

Safety Factor at 1 or greater ✓ OK

ATTACHMENT A.4

GEOSYNTHETIC CALCULATIONS

(RESERVED)

ATTACHMENT A.5

SETTLEMENT CALCULATIONS

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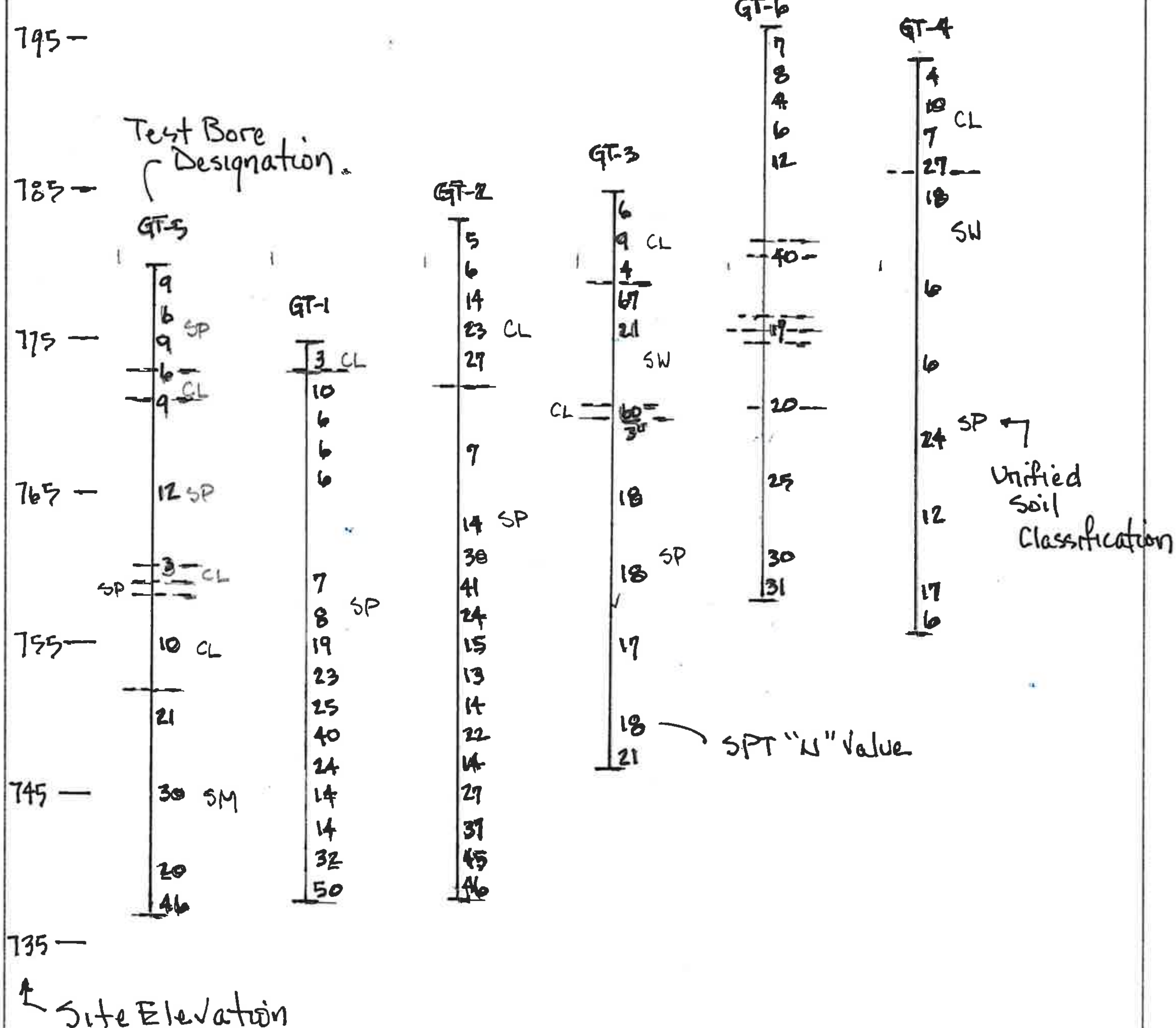
JOB House Street Cap - Settle
SHEET NO. 1 OF 7
CALCULATED BY ______ DATE ______
CHECKED BY ______ DATE ______
SCALE ______

SETTLEMENT ASSESSMENT

Six Soil Borings done for geotechnical purposes and are summarized below in stick figure format From South to North



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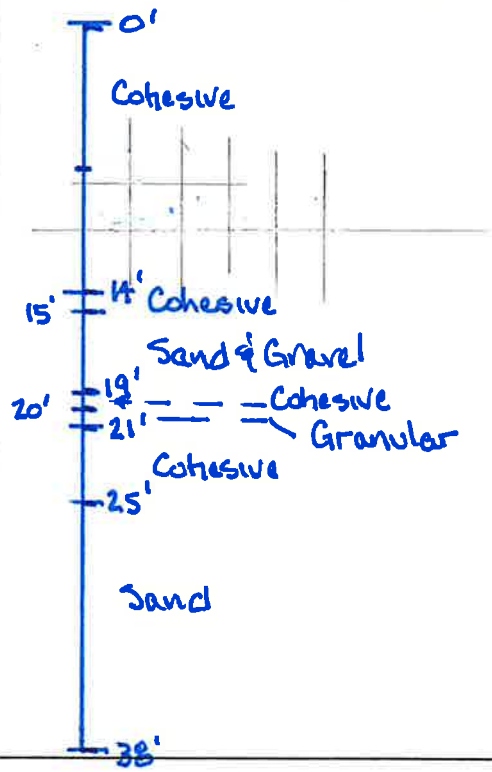
Consider first the subgrade Bearing Capacity

Test Boring Designation	Sum of SPT "N" Values in Upper 10-ft.	Average SPT "N" Value
GT-1	31	6
2	75	15
3	107	21
4	66	13
5	39	8
6	37	7

Average = 12
Median = 8

Use GT-6 Profile with Cohesive soils at surface



Consider 2 cases:

① 5' Additiona Load over infinite area

② 12' Additional load at base of depression

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JOB House Street Cap - Settlement
SHEET NO. 3 OF 7
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Section 1806
Allowable Load Bearing Values of Soils

TABLE 1806.2
ALLOWABLE FOUNDATION AND LATERAL PRESSURE

CLASS OF MATERIALS	ALLOWABLE FOUNDATION PRESSURE (psf)[d]	LATERAL BEARING (psf/f below natural grade)[d]	LATERAL SLIDING	
			Coefficient of friction[a]	Resistance (psf)[b]
1. Crystalline bedrock	12,000	1,200	0.70	—
2. Sedimentary and foliated rock	4,000	400	0.35	—
3. Sandy gravel and/or gravel (GW and GP)	3,000	200	0.35	—
4. Sand, silty sand, clayey sand, silty gravel and clayey gravel (SW, SP, SM, SC, GM and GC)	2,000	150	0.25	—
5. Clay, sandy clay, silty clay, clayey silt, silt and sandy silt (CL, ML, MH and CH)	1,500[c]	100	—	130

For SI: 1 pound per square foot = 0.0479 kPa, 1 pound per square foot per foot = 0.157 kPa/m.
a. Coefficient to be multiplied by the dead load.
b. Lateral sliding resistance value to be multiplied by the contact area, as limited by Section 1804.3.
c. Where the building official determines that in-place soils with an allowable bearing capacity of less than 1,500 psf are likely to be present at the site, the allowable bearing capacity shall be determined by a soils investigation.
d. An increase of one-third is permitted when using the alternate load combinations in Section 1605.3.2 that include wind or earthquake loads.

Consider 5' to 12' of soil load, with soil weight at 120 to 125 lbs/ft³ equals 600 lbs/ft² to 1,500 lbs/ft².

Allowable presumptive load bearing values from Building Code at 1500 lbs/ft² or greater; therefore, suitable at House St cap.

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From Additional Fill, consider stress change at mid-point of cohesive soil layer

$\Delta\sigma_v = I * q_o$

where I is a function of

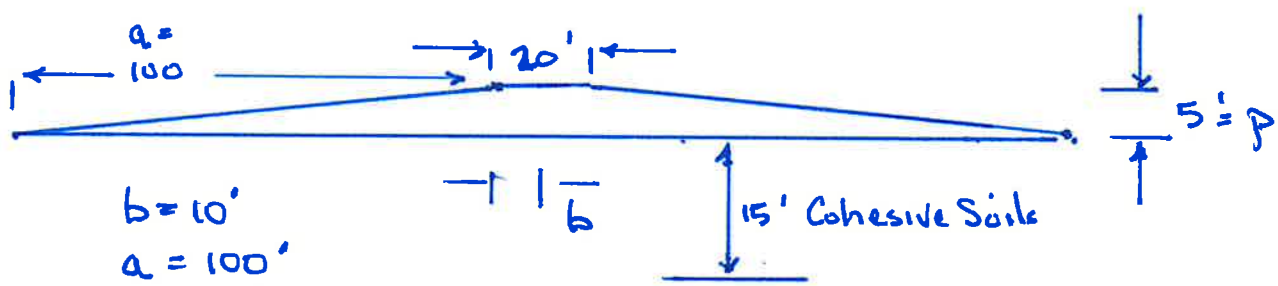
$m = \frac{X}{Z}$ X = width of loaded area

$n = \frac{Y}{Z}$ Y = length of loaded area

Z = depth to point of interest

q_o = Applied vertical stress

For infinite slope embankments, the influence factor can be determined using the following chart.



$b = 10'$
$a = 100'$
$p = 5'$
$z = 7\frac{1}{2}' = \frac{15'}{2}$

$\frac{a}{z} = \frac{100}{7\frac{1}{2}} = 13$

$\frac{b}{z} = \frac{10}{7\frac{1}{2}} = 1.3$

$I = 0.49$ $\sigma_z = I \times P = .49 * 600 \frac{lbs}{ft^2}$

$= 300 \frac{lbs}{ft^2}$

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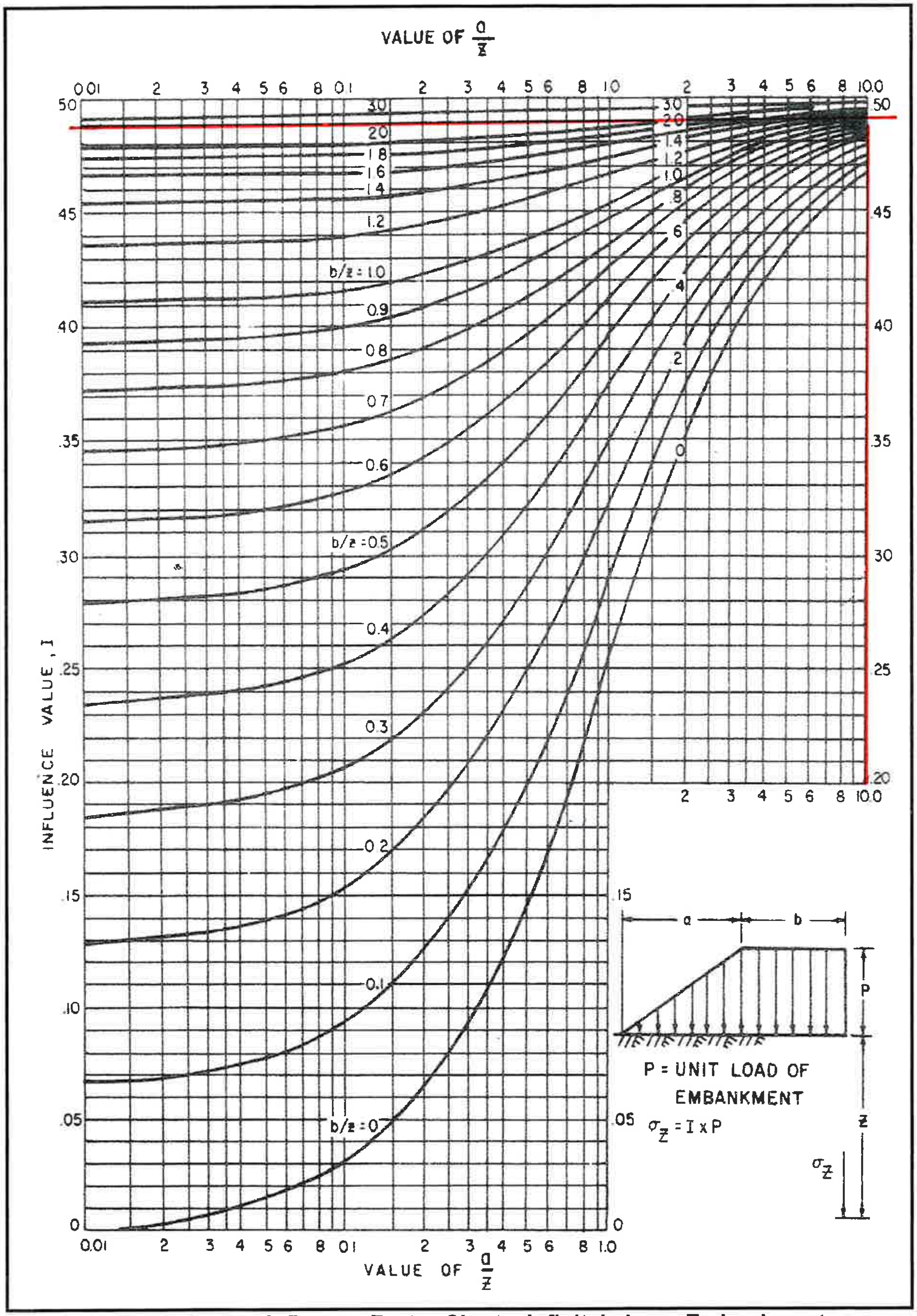
JOB House Street Cap - Settlement

SHEET NO. 5 OF 7



Influence Factor Chart – Infinitely Long Embankments (DOD (NAVFAC DM 7.1) (1982))

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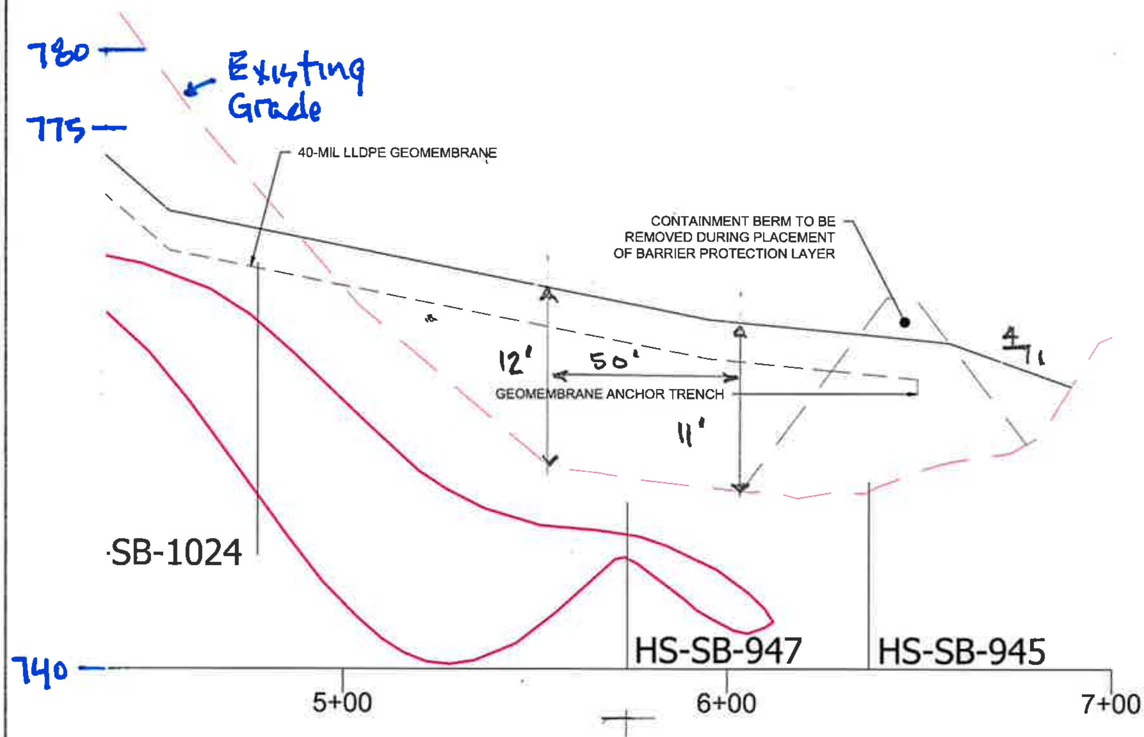
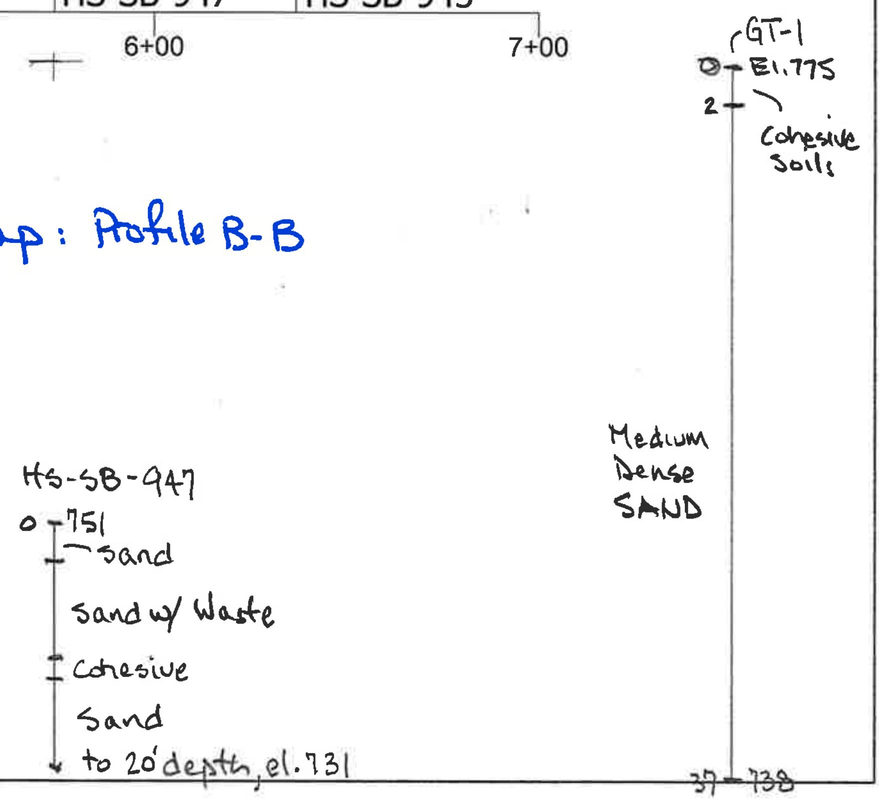
For condition ② where up to 12' of fill is placed in the depressed area, the evaluated cross-section is:



Ref: Southwest Cap: Profile B-B



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Using the Influence Factor chart and the following

$b = 25'$
$a = 70'$
$p = 11\frac{1}{2}'$
$z = 7\frac{1}{2}'$

$\frac{a}{z} = 9.3$ $\frac{b}{z} = \frac{25}{7\frac{1}{2}} = 3.3$

$I = 0.5$

$\sigma_z = (0.5)(1500 \frac{lbs}{ft^2}) = 750 \frac{lbs}{ft^2}$

Estimated Settlement

$S_i = \frac{5 q_o}{(N-1.5)(C_B)}$

where q_o = applied vertical stress $= \sigma_z$ (tons/ft^2)

N = SPT "N" Value = 7

C_B = Width Correction = 0.8

S_i = Settlement (inches)

Case 1

$S_i = \frac{(5)(0.3 \frac{tons}{ft^2})}{(7-1.5)(.8)} = \frac{1.5}{(5.5)(.8)} = \frac{1.5}{4.4} = 0.3$ in

Case 2

$S_i = \frac{(5)(0.75 \frac{tons}{ft^2})}{(7-1.5)(.8)} = \frac{3.75}{(5.5)(.8)} = 0.9$ in

ATTACHMENT A.6

SOIL EROSION LOSS

SOIL LOSS ESTIMATION

REF. ① "Predicting Rainfall Erosion Losses", USDA Agriculture Handbook No. 537, December 1978

② Guidelines for Use of the Universal Soil Loss Equation in Michigan; from various internet locations (http://www.iwr.msu.edu)

Soil Loss is estimated using: $A = R \times K \times L \times S \times C \times P$

where: A = Soil Loss (tons/acre/year)

R = Rainfall Erosion Index = 95 for Kent County

K = Soil Erodibility Index, Udipsamments = 0.15

L = Slope Length Factor

Slopes range from 75'+/- to about 600'

S = Slope Steepness, Slope varies from 4% to 25%

LS Estimated based on longer flowpaths on Southwest mound; Selected value of 1.69 based on 600-ft length and average slope of 6%.

C = ~~.005~~ .01 for continuous grass

P = Erosion Control Practice = 1 for no Practice post construction

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JOB House Street Cap - Soil Loss

SHEET NO 2 OF

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Therefore:

Soil Loss Estimation = $A = (95)(0.15)(1.69)(\cancel{.005}\ .01)(1)$

$= 0.\cancel{12}\ .24$ tons/acre/year

< 2 tons/acre/year

ok

"R" FACTORS
Rainfall erosion factors to be used with
the Revised Universal Soil Loss Equation

FIGURE 2

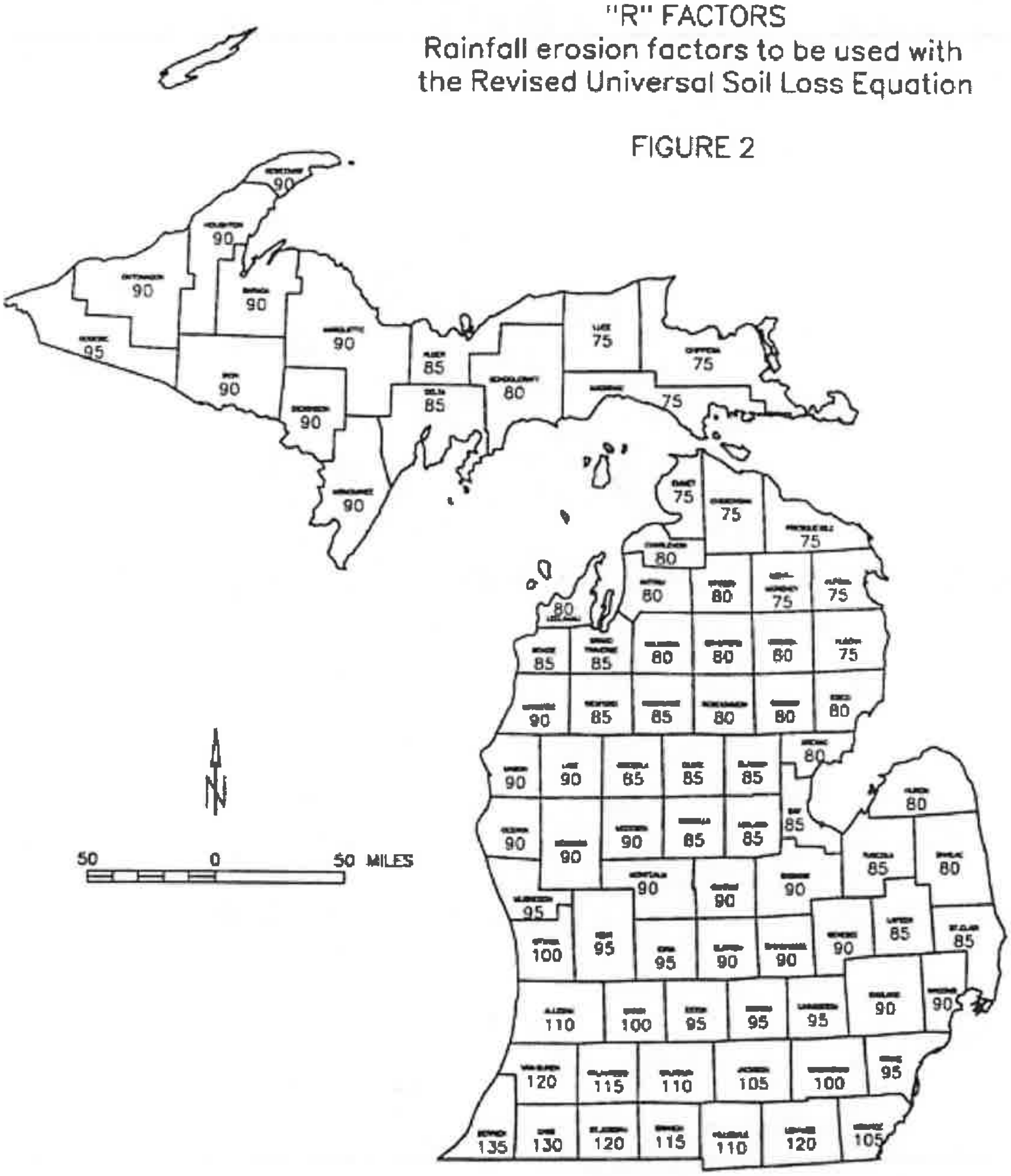


TABLE 2 - CROPLAND

Values for Topographic Factor, LS, for Moderate Ratio of Rill to Interrill Erosion 1/

	Horizontal Slope Length (ft)																
Slope (%)	**<3**	**6**	**9**	**12**	**15**	**25**	**50**	**75**	**100**	**150**	**200**	**250**	**300**	**400**	**600**	**800**	**1,000**
0.2	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06
0.5	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10
1.0	0.11	0.11	0.11	0.11	0.11	0.12	0.13	0.14	0.14	0.15	0.16	0.17	0.17	0.18	0.19	0.20	0.20
2.0	0.17	0.17	0.17	0.17	0.17	0.19	0.22	0.25	0.27	0.29	0.31	0.33	0.35	0.37	0.41	0.44	0.47
3.0	0.22	0.22	0.22	0.22	0.22	0.25	0.32	0.36	0.39	0.44	0.48	0.52	0.55	0.60	0.68	0.75	0.80
4.0	0.26	0.26	0.26	0.26	0.26	0.31	0.40	0.47	0.52	0.60	0.67	0.72	0.77	0.86	0.99	1.10	1.19
5.0	0.30	0.30	0.30	0.30	0.30	0.37	0.49	0.58	0.65	0.76	0.85	0.93	1.01	1.13	1.33	1.49	1.63
6.0	0.34	0.34	0.34	0.34	0.34	0.43	0.58	0.69	0.78	0.93	1.05	1.16	1.25	1.42	$\boxed{1.69}$	1.91	2.11
8.0	0.42	0.42	0.42	0.42	0.42	0.53	0.74	0.91	1.04	1.26	1.45	1.62	1.77	2.03	2.47	2.83	3.15
10.0	0.46	0.48	0.50	0.51	0.52	0.67	0.97	1.19	1.38	1.71	1.98	2.22	2.44	2.84	3.50	4.06	4.56
12.0	0.47	0.53	0.58	0.61	0.64	0.84	1.23	1.53	1.79	2.23	2.61	2.95	3.26	3.81	4.75	5.56	6.28
14.0	0.48	0.58	0.65	0.70	0.75	1.00	1.48	1.86	2.19	2.76	3.25	3.69	4.09	4.82	6.07	7.15	8.11
16.0	0.49	0.63	0.72	0.79	0.85	1.15	1.73	2.20	2.60	3.30	3.90	4.45	4.95	5.86	7.43	8.79	10.02
20.0	0.52	0.71	0.85	0.96	1.06	1.45	2.22	2.85	3.40	4.36	5.21	5.97	6.68	7.97	10.23	12.20	13.99
25.0	0.56	0.80	1.00	1.16	1.30	1.81	2.82	3.65	4.39	5.69	6.83	7.88	8.86	10.65	13.80	16.58	19.13
30.0	0.59	0.89	1.13	1.34	1.53	2.15	3.39	4.42	5.34	6.98	8.43	9.76	11.01	13.30	17.37	20.99	24.31
40.0	0.65	1.05	1.38	1.68	1.95	2.77	4.45	5.87	7.14	9.43	11.47	13.37	15.14	18.43	24.32	29.60	34.48
50.0	0.71	1.18	1.59	1.97	2.32	3.32	5.40	7.17	8.78	11.66	14.26	16.67	18.94	23.17	30.78	37.65	44.02
60.0	0.76	1.30	1.78	2.23	2.65	3.81	6.24	8.33	10.23	13.65	16.76	19.64	22.36	27.45	36.63	44.96	52.70

1/ Such as for row-cropped agricultural and other moderately consolidated soil conditions with little to moderate cover (not applicable to thawing soil).

TABLE 4 EXCERPTS

MI0573	TOOGOOD	S	220	0.15	0.15	5	33.3	33.3
MI0573	TOOGOOD	LS	134	0.17	0.17	5	29.4	29.4
MI0168	TRENARY	VFSL	86	0.24	0.24	5	20.8	20.8
MI0168	TRENARY	FSL	86	0.24	0.24	5	20.8	20.8
MI0329	TRENARY	VFSL	86	0.24	0.24	5	20.8	20.8
MI0329	TRENARY	FSL SL	86	0.24	0.24	5	20.8	20.8
MI0366	TRENARY	STV-FSL	0	0.17	0.24	5	29.4	20.8
MI0630	TRENARY	ST-FSL ST-VFSL	86	0.17	0.24	5	29.4	20.8
MI0553	TRIMOUNTAIN	CB-LFS	134	0.1	0.17	4	40.0	23.5
MI0553	TRIMOUNTAIN	GR-FSL GR-SL GR-LFS	86	0.15	0.24	4	26.7	16.7
MI0553	TRIMOUNTAIN	CB-FSL CB-VFSL	86	0.17	0.24	4	23.5	16.7
MI0554	TRIMOUNTAIN	CB-FSL CB-VFSL	0	0.17	0.24	4	23.5	16.7
MI0554	TRIMOUNTAIN	GR-FSL GR-SL GR-LFS	0	0.17	0.24	4	23.5	16.7
MI0554	TRIMOUNTAIN	CB-LFS	0	0.1	0.17	4	40.0	23.5
MI0116	TULA	CB-VFSL CB-FSL	86	0.28	0.37	4	14.3	10.8
MI0169	TULA	CB-VFSL CB-FSL	86	0.28	0.37	4	14.3	10.8
MI0009	TUSCOLA	LFS	134	0.17	0.17	5	29.4	29.4
MI0009	TUSCOLA	SIL L	56	0.32	0.32	5	15.6	15.6
MI0009	TUSCOLA	FSL SL VFSL	86	0.24	0.24	5	20.8	20.8
MI0488	TUSCOLA	L	56	0.32	0.32	5	15.6	15.6
WI0069	TUSTIN	LFS LS	134	0.17	0.17	5	29.4	29.4
WI0069	TUSTIN	FS S	250	0.15	0.15	5	33.3	33.3
MI0223	TWINING	SL	86	0.24	0.24	5	20.8	20.8
MI0223	TWINING	L	56	0.32	0.32	5	15.6	15.6

Table 4

K, T, T/K, and I Values for Soil Series used in Michigan for use in the Revised Universal Soil Loss Equation and Wind Erosion Equation

Record	Series or Family	Surface Texture	I	K	Kf	T	T/K	T/Kf
MI5004	TYPIC DYSTROCHREPTS	SL FSL	86	0.24	0.24	5	20.8	20.8
MI5004	TYPIC DYSTROCHREPTS	SIL L	56	0.37	0.37	5	13.5	13.5
MI5005	TYPIC DYSTROCHREPTS	SL FSL	86	0.24	0.24	4	16.7	16.7
MI5005	TYPIC DYSTROCHREPTS	SIL L	56	0.37	0.37	4	10.8	10.8
MI5007	TYPIC DYSTROCHREPTS	SL FSL	86	0.24	0.24	4	16.7	16.7
MI5007	TYPIC DYSTROCHREPTS	SIL L	56	0.37	0.37	4	10.8	10.8
MI5047	TYPIC FRAGIAQUODS	SIL L	56	0.32	0.32	3	9.4	9.4
MI5047	TYPIC FRAGIAQUODS	FSL SL	86	0.24	0.24	3	12.5	12.5
MI5047	TYPIC FRAGIAQUODS	VFSL	86	0.37	0.37	3	8.1	8.1
MI5073	TYPIC HAPLAQUODS	MK-S	220	0.15	0.15	5	33.3	33.3
MI5073	TYPIC HAPLAQUODS	S	220	0.15	0.15	5	33.3	33.3
MI6020	TYPIC HAPLAQUODS	MK-S	220	0.15	0.15	5	33.3	0.0
MI5069	TYPIC HAPLAQUOLLS	MUCK	134	NONE	NONE	5	0.0	0.0
MI5018	TYPIC HAPLORTHODS	S LS	220	0.15	0.15	5	33.3	33.3
MI5018	TYPIC HAPLORTHODS	SL FSL	86	0.2	0.24	5	25.0	20.8
MI6022	TYPIC HAPLORTHODS	S	220	0.15	0.15	5	33.3	33.3
MI6024	TYPIC HAPLORTHODS	S	220	0.15	0.15	5	33.3	33.3
MI5051	TYPIC UDIPSAMMENTS	S	220	0.15	0.15	5	33.3	33.3
MI5052	TYPIC UDIPSAMMENTS	S	220	0.15	0.15	5	33.3	33.3
MI5053	TYPIC UDIPSAMMENTS	S	220	0.15	0.15	5	33.3	33.3
MI5054	TYPIC UDIPSAMMENTS	S	220	0.15	0.15	5	33.3	33.3

TABLE 4 EXCERPTS

MI6026	TYPIC UDIPSAMMENTS	S	220	0.15	0.15	5	33.3	33.3
MI6027	TYPIC UDIPSAMMENTS	S	220	0.15	0.15	5	33.3	33.3
MI6028	TYPIC UDIPSAMMENTS	S	220	0.15	0.15	5	33.3	33.3
MI6029	TYPIC UDIPSAMMENTS	S	220	0.15	0.15	5	33.3	33.3
MI0207	TYRE	LS	134	0.17	0.17	3	17.6	17.6
MI0207	TYRE	S	220	0.15	0.15	3	20.0	20.0
MI0200	UBLY	LS	134	0.17	0.17	5	29.4	29.4
MI0200	UBLY	SL	86	0.24	0.24	5	20.8	20.8
MI0298	UBLY	LS	134	0.17	0.17	5	29.4	29.4
MI0298	UBLY	SL	86	0.24	0.24	5	20.8	20.8
MI0447	UBLY	VFSL	86	0.37	0.37	4	10.8	10.8
MI8007	UDIPSAMMENTS	S COS LS	220	0.12	0.15	5	41.7	33.3
NE0523	UDIPSAMMENTS	COS GR-S	134	0.02	0.02	5	250.0	250.0
NE0523	UDIPSAMMENTS	LFS LS VFS	134	0.1	0.02	5	50.0	50.0
NE0523	UDIPSAMMENTS	FS S LCOS	310	0.02	0.02	5	250.0	250.0
MI8001	UDORTHENTS	GR-SL L SL	86	0.24	0.24	5	20.8	20.8
MI8001	UDORTHENTS	SCL SICL CL	86	0.32	0.32	5	15.6	15.6
MI8001	UDORTHENTS	C SIC	86	0.32	0	5	15.6	15.6
NE0524	UDORTHENTS	FSL L VFSL	86	0.24	0.28	5	20.8	17.9
NE0524	UDORTHENTS	SCL SICL CL	48	0.32	0.37	5	15.6	13.5
MI0631	VANRIPER	CB-VFSL	86	0.28	0.37	5	17.9	13.5
MI0631	VANRIPER	CBV-VFSL	0	0.28	0.37	5	17.9	13.5
MI0715	VANRIPER	BYV-SIL	0	0.28	0.37	5	17.9	13.5
MI0341	VELVET	STV-LS	0	0.1	0.15	3	30.0	20.0
MI0456	VELVET	GRV-LS GR-LFS GRV-S	0	0.1	0.17	3	30.0	17.6
MI0456	VELVET	STV-LS CB-LFS CBV-S	0	0.1	0.17	3	30.0	17.6

Table 4

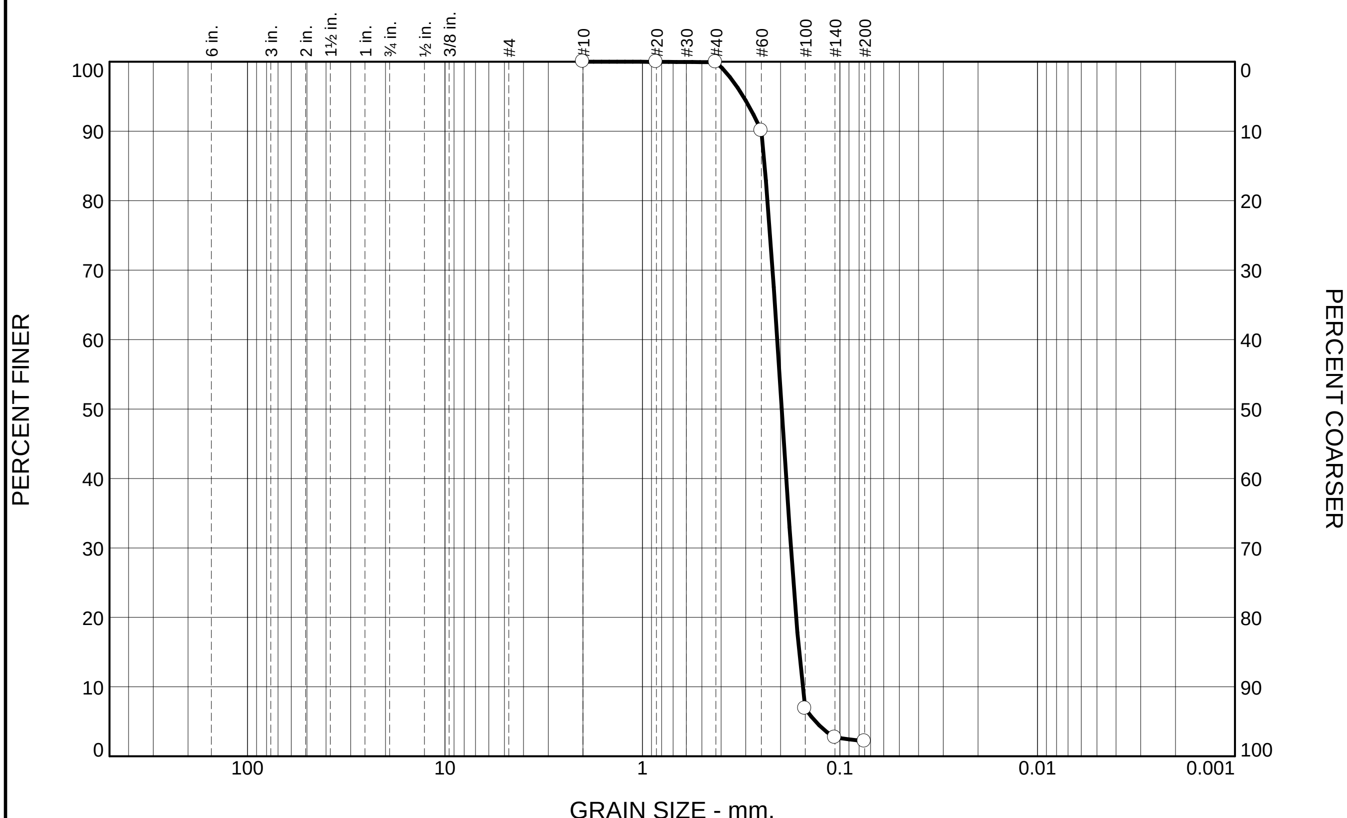
K, T, T/K, and I Values for Soil Series used in Michigan for use in the Revised Universal Soil Loss Equation and Wind Erosion Equation

Record	Series or Family	Surface Texture	I	K	Kf	T	T/K	T/Kf
MI0270	VESTABURG	LS	134	0.17	0.17	5	29.4	29.4
MI0270	VESTABURG	SL	86	0.24	0.24	5	20.8	20.8
MI0270	VESTABURG	S	220	0.15	0.15	5	33.3	33.3
MI0494	VESTABURG	MK-S	220	0.15	0.15	5	33.3	33.3
MI0494	VESTABURG	MK-LS	134	0.17	0.17	5	29.4	29.4
WI0242	VILAS	S	250	0.15	0.15	5	33.3	33.3
WI0242	VILAS	LS	134	0.17	0.17	5	29.4	29.4
WI0493	VILAS	S	250	0.15	0.15	5	33.3	33.3
WI0493	VILAS	LS	134	0.17	0.17	5	29.4	29.4
WI0340	WABENO	SIL	56	0.37	0.37	4	10.8	10.8
WI0341	WABENO	ST-FSL	56	0.24	0.24	4	16.7	16.7
WI0341	WABENO	ST-SIL	48	0.37	0.37	4	10.8	10.8
WI0394	WABENO	SIL	56	0.37	0.37	4	10.8	10.8
WI0418	WABENO	SIL	56	0.37	0.37	4	10.8	10.8
WI0418	WABENO	FSL	86	0.24	0.24	4	16.7	16.7
MI0729	WABUN	S	220	0.15	0.15	4	26.7	26.7
MI0729	WABUN	MK-S	134	0.15	0.15	4	26.7	26.7
MI0212	WAINOLA	LFS	134	0.17	0.17	5	29.4	29.4
MI0212	WAINOLA	FS	250	0.15	0.15	5	33.3	33.3

ATTACHMENT A.7

SUBSURFACE EXPLORATION DATA & RETENTION BASIN DRAINAGE

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.1	97.7	2.2	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	100.0		
#40	99.9		
#60	90.1		
#100	6.9		
#140	2.7		
#200	2.2		

* (no specification provided)

Material Description

light brown poorly graded SAND

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.2499 D_{85}= 0.2405 D_{60}= 0.2077
D_{50}= 0.1972 D_{30}= 0.1772 D_{15}= 0.1611
D_{10}= 0.1547 C_u= 1.34 C_c= 0.98

Classification

USCS= SP AASHTO=

Remarks

Lab No.: 167

Location: GT-1
Sample Number: S-4 **Depth:** 6.0' - 8.0' **Date:** 4/1/22

7NT

Client: GZA
Project: House Street RAP - House Street, Michigan
Project No: L193-MI **File**

GRAIN SIZE DISTRIBUTION TEST DATA

4/1/2022

Client: GZA
Project: House Street RAP - House Street, Michigan
Project Number: L193-MI
Location: GT-1
Depth: 6.0' - 8.0' **Sample Number:** S-4
Material Description: light brown poorly graded SAND
Date: 4/1/22
USCS Classification: SP
Testing Remarks: Lab No.: 167

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer	Percent Retained
357.91	15.85	0.00	#10	0.00	100.0	0.0
100.72	0.00	0.00	#20	0.02	100.0	0.0
			#40	0.08	99.9	0.1
			#60	10.00	90.1	9.9
			#100	93.79	6.9	93.1
			#140	97.99	2.7	97.3
			#200	98.54	2.2	97.8

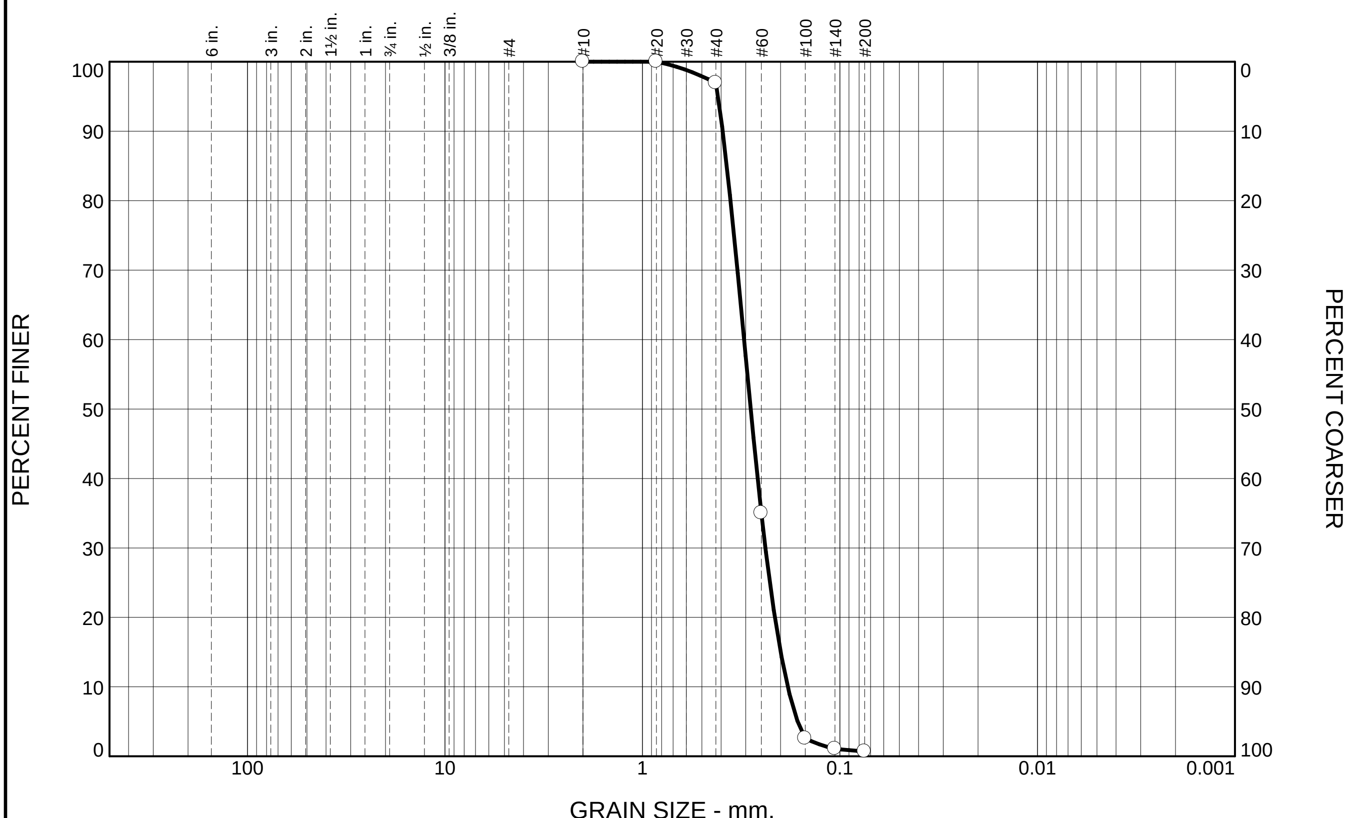
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.0	0.0	0.0	0.1	97.7	97.8			2.2

D_{5}	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
0.1328	0.1547	0.1611	0.1668	0.1772	0.1871	0.1972	0.2077	0.2327	0.2405	0.2499	0.3086

Fineness Modulus	C_u	C_c
0.99	1.34	0.98

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	3.1	96.2	0.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	100.0		
#40	96.9		
#60	35.0		
#100	2.6		
#140	1.1		
#200	0.7		

* (no specification provided)

Material Description

light brown poorly graded SAND

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.3925 D_{85}= 0.3741 D_{60}= 0.3057
D_{50}= 0.2831 D_{30}= 0.2385 D_{15}= 0.1996
D_{10}= 0.1838 C_u= 1.66 C_c= 1.01

Classification

USCS= SP AASHTO=

Remarks

Lab No.: 167

Location: GT-1
Sample Number: S-7 **Depth:** 17.0' - 19.0' **Date:** 4/1/22

7NT

Client: GZA
Project: House Street RAP - House Street, Michigan
Project No: L193-MI **File**

GRAIN SIZE DISTRIBUTION TEST DATA

4/1/2022

Client: GZA
Project: House Street RAP - House Street, Michigan
Project Number: L193-MI
Location: GT-1
Depth: 17.0' - 19.0' **Sample Number:** S-7
Material Description: light brown poorly graded SAND
Date: 4/1/22
USCS Classification: SP
Testing Remarks: Lab No.: 167

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer	Percent Retained
349.10	13.95	0.00	#10	0.00	100.0	0.0
107.70	0.00	0.00	#20	0.00	100.0	0.0
			#40	3.31	96.9	3.1
			#60	70.00	35.0	65.0
			#100	104.91	2.6	97.4
			#140	106.54	1.1	98.9
			#200	106.96	0.7	99.3

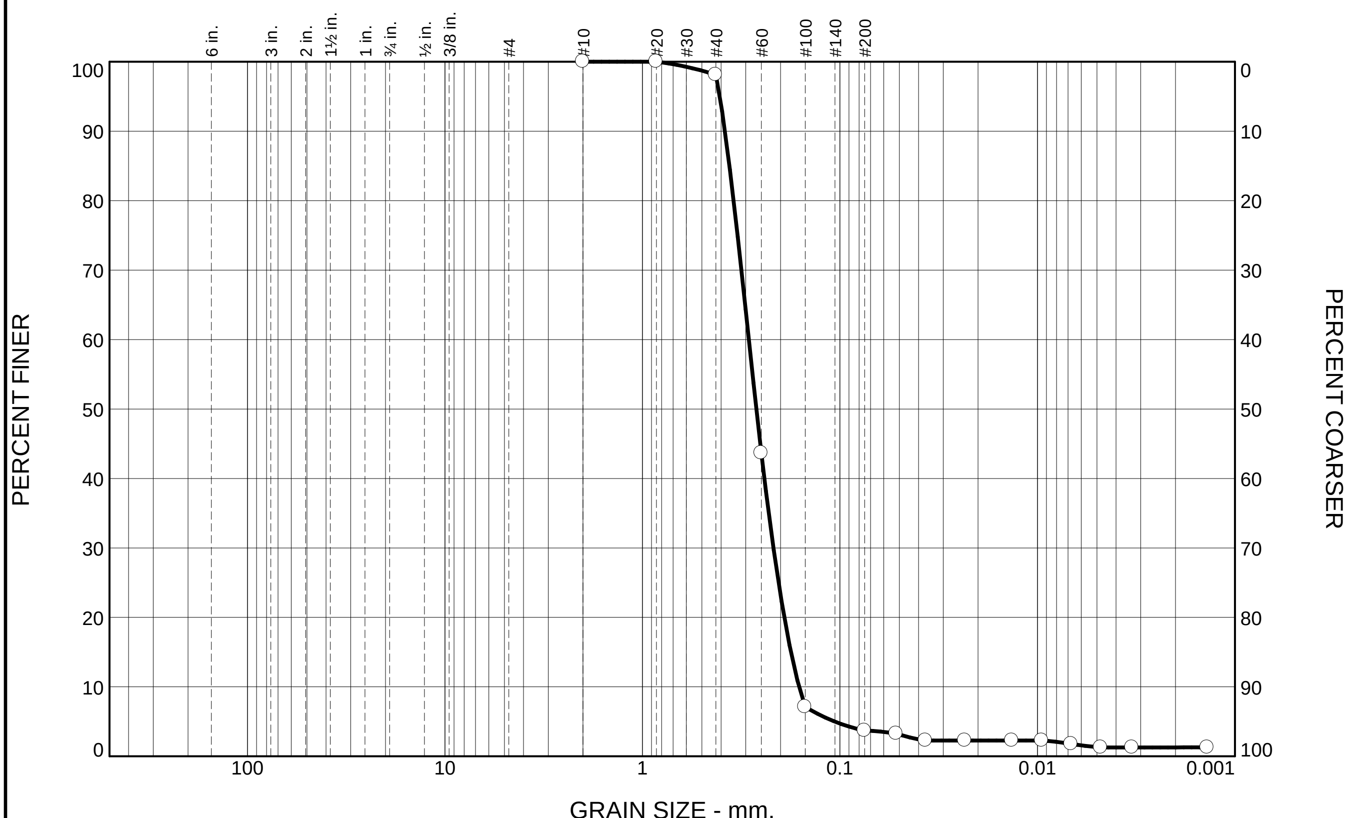
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.0	0.0	0.0	3.1	96.2	99.3			0.7

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
0.1638	0.1838	0.1996	0.2136	0.2385	0.2611	0.2831	0.3057	0.3581	0.3741	0.3925	0.4147

Fineness Modulus	C_u	C_c
1.41	1.66	1.01

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	1.9	94.4	2.4	1.3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	100.0		
#40	98.1		
#60	43.6		
#100	7.1		
#200	3.7		

* (no specification provided)

Material Description

brown poorly graded SAND

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 0.3823 D_{85}= 0.3625 D_{60}= 0.2892
D_{50}= 0.2650 D_{30}= 0.2171 D_{15}= 0.1771
D_{10}= 0.1611 C_u= 1.80 C_c= 1.01

Classification

USCS= SP AASHTO= A-3

Remarks

Lab No.: 167

Location: GT-1
Sample Number: S-10 **Depth:** 23.0' - 25.0' **Date:** 4/8/22

7NT

Client: GZA
Project: House Street RAP - House Street, Michigan

Project No: L193-MI **File**

GRAIN SIZE DISTRIBUTION TEST DATA

4/8/2022

Client: GZA
Project: House Street RAP - House Street, Michigan
Project Number: L193-MI
Location: GT-1
Depth: 23.0' - 25.0' **Sample Number:** S-10
Material Description: brown poorly graded SAND
Date: 4/8/22 **PL:** NP **LL:** NV **PI:** NP
USCS Classification: SP **AASHTO Classification:** A-3
Testing Remarks: Lab No.: 167

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer	Percent Retained
358.92	15.85	0.00	#10	0.00	100.0	0.0
101.67	0.00	0.00	#20	0.00	100.0	0.0
			#40	1.92	98.1	1.9
			#60	57.30	43.6	56.4
			#100	94.44	7.1	92.9
			#200	97.90	3.7	96.3

Hydrometer Test Data

Hydrometer test uses material passing #10
Percent passing #10 based upon complete sample = 100.0
Weight of hydrometer sample =101.67
Hygroscopic moisture correction:
Moist weight and tare = 127.28
Dry weight and tare = 127.24
Tare weight = 30.81
Hygroscopic moisture = 0.0%
Automatic temperature correction
Composite correction (fluid density and meniscus height) at 20 deg. C = -5.0
Meniscus correction only = 0.0
Specific gravity of solids = 2.65
Hydrometer type = 152H
Hydrometer effective depth equation: L = 16.294964 - 0.164 **x Rm**

Elapsed Time (min.)	Temp. (deg. C.)	Actual Reading	Corrected Reading	K	Rm	Eff. Depth	Diameter (mm.)	Percent Finer	Percent Retained
1.00	21.6	8.0	3.3	0.0134	8.0	15.0	0.0518	3.3	96.7
2.00	21.6	7.0	2.3	0.0134	7.0	15.1	0.0368	2.3	97.7
5.00	21.6	7.0	2.3	0.0134	7.0	15.1	0.0233	2.3	97.7
15.00	21.6	7.0	2.3	0.0134	7.0	15.1	0.0134	2.3	97.7
30.00	21.6	7.0	2.3	0.0134	7.0	15.1	0.0095	2.3	97.7
60.00	21.6	6.5	1.8	0.0134	6.5	15.2	0.0067	1.8	98.2
120.00	21.6	6.0	1.3	0.0134	6.0	15.3	0.0048	1.3	98.7
250.00	21.5	6.0	1.3	0.0134	6.0	15.3	0.0033	1.3	98.7
1440.00	21.6	6.0	1.3	0.0134	6.0	15.3	0.0014	1.3	98.7

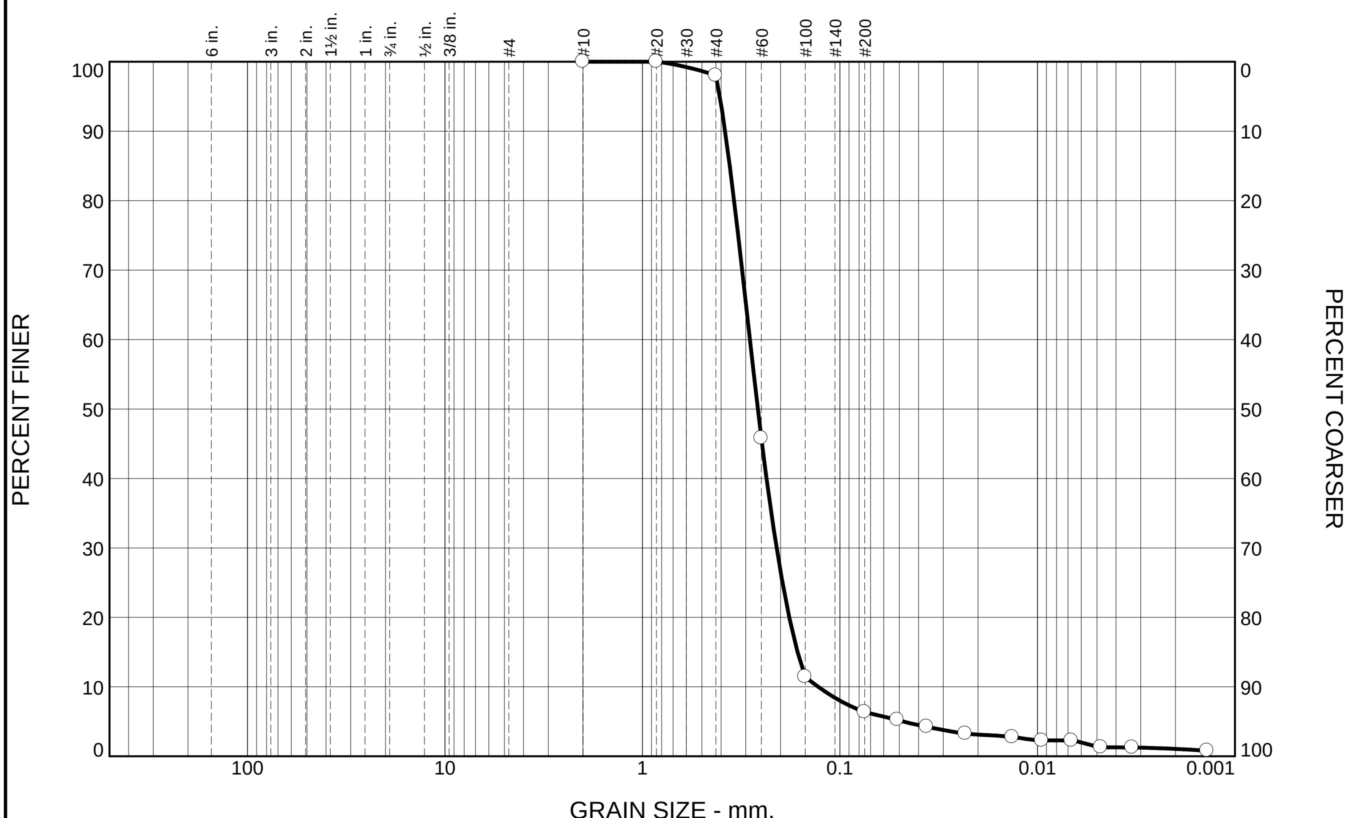
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.0	0.0	0.0	1.9	94.4	96.3	2.4	1.3	3.7

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
0.1062	0.1611	0.1771	0.1913	0.2171	0.2414	0.2650	0.2892	0.3452	0.3625	0.3823	0.4062

Fineness Modulus	C_u	C_c
1.29	1.80	1.01

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	2.0	91.6	5.0	1.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	100.0		
#40	98.0		
#60	45.8		
#100	11.5		
#200	6.4		

* (no specification provided)

Material Description

brown poorly graded SAND with silt (visual)

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.3814 D_{85}= 0.3611 D_{60}= 0.2856
D_{50}= 0.2605 D_{30}= 0.2093 D_{15}= 0.1640
D_{10}= 0.1288 C_u= 2.22 C_c= 1.19

Classification

USCS= AASHTO=

Remarks

Lab No.: 167

Location: GT-1
Sample Number: S-11 **Depth:** 25.0' - 27.0' **Date:** 4/8/22

Client: GZA
Project: House Street RAP - House Street, Michigan
Project No: L193-MI **File**

GRAIN SIZE DISTRIBUTION TEST DATA

4/8/2022

Client: GZA
Project: House Street RAP - House Street, Michigan
Project Number: L193-MI
Location: GT-1
Depth: 25.0' - 27.0' **Sample Number:** S-11
Material Description: brown poorly graded SAND with silt (visual)
Date: 4/8/22
Testing Remarks: Lab No.: 167

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer	Percent Retained
373.94	14.57	0.00	#10	0.00	100.0	0.0
101.17	0.00	0.00	#20	0.00	100.0	0.0
			#40	2.00	98.0	2.0
			#60	54.84	45.8	54.2
			#100	89.58	11.5	88.5
			#200	94.72	6.4	93.6

Hydrometer Test Data

Hydrometer test uses material passing #10
Percent passing #10 based upon complete sample = 100.0
Weight of hydrometer sample =101.17
Hygroscopic moisture correction:
Moist weight and tare = 128.28
Dry weight and tare = 128.23
Tare weight = 29.73
Hygroscopic moisture = 0.1%
Automatic temperature correction
Composite correction (fluid density and meniscus height) at 20 deg. C = -5.0
Meniscus correction only = 0.0
Specific gravity of solids = 2.65
Hydrometer type = 152H
Hydrometer effective depth equation: L = 16.294964 - 0.164 **x Rm**

Elapsed Time (min.)	Temp. (deg. C.)	Actual Reading	Corrected Reading	K	Rm	Eff. Depth	Diameter (mm.)	Percent Finer	Percent Retained
1.00	21.6	10.0	5.3	0.0134	10.0	14.7	0.0512	5.3	94.7
2.00	21.6	9.0	4.3	0.0134	9.0	14.8	0.0364	4.3	95.7
5.00	21.6	8.0	3.3	0.0134	8.0	15.0	0.0232	3.3	96.7
15.00	21.6	7.5	2.8	0.0134	7.5	15.1	0.0134	2.8	97.2
30.00	21.6	7.0	2.3	0.0134	7.0	15.1	0.0095	2.3	97.7
60.00	21.6	7.0	2.3	0.0134	7.0	15.1	0.0067	2.3	97.7
120.00	21.6	6.0	1.3	0.0134	6.0	15.3	0.0048	1.3	98.7
250.00	21.5	6.0	1.3	0.0134	6.0	15.3	0.0033	1.3	98.7
1440.00	21.6	5.5	0.8	0.0134	5.5	15.4	0.0014	0.8	99.2

Fractional Components

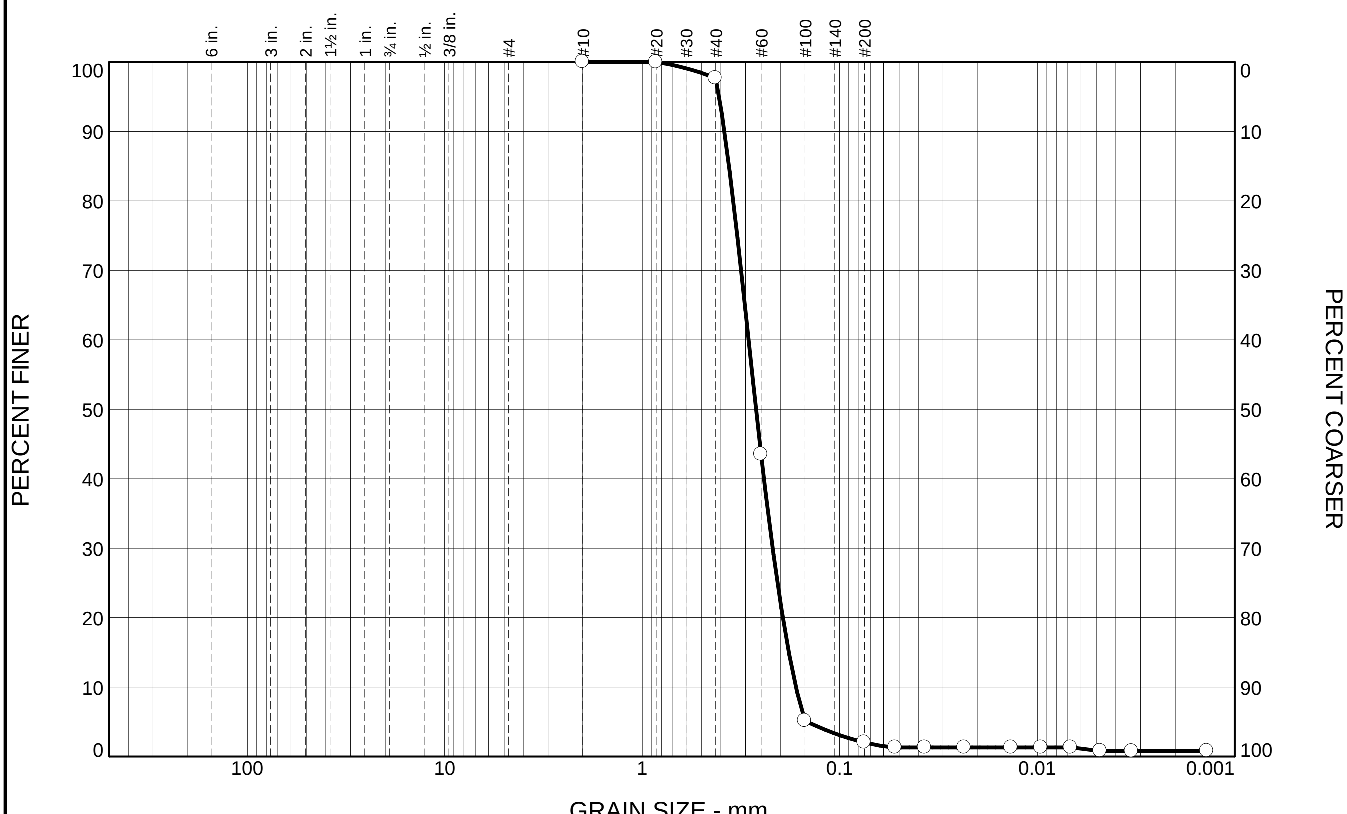
Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.0	0.0	0.0	2.0	91.6	93.6	5.0	1.4	6.4

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
0.0477	0.1288	0.1640	0.1806	0.2093	0.2354	0.2605	0.2856	0.3433	0.3611	0.3814	0.4061

Fineness Modulus	C_u	C_c
1.24	2.22	1.19

7NT

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	2.3	95.7	1.1	0.9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	100.0		
#40	97.7		
#60	43.5		
#100	5.2		
#200	2.0		

* (no specification provided)

Material Description

brown poorly graded SAND

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 0.3837 D_{85}= 0.3634 D_{60}= 0.2893
D_{50}= 0.2652 D_{30}= 0.2185 D_{15}= 0.1810
D_{10}= 0.1667 C_u= 1.74 C_c= 0.99

Classification

USCS= SP AASHTO= A-3

Remarks

Lab No.: 167

Location: GT-1
Sample Number: Bucket **Depth:** 25.0' - 35.0' **Date:** 4/8/22

7NT

Client: GZA
Project: House Street RAP - House Street, Michigan
Project No: L193-MI **File**

GRAIN SIZE DISTRIBUTION TEST DATA

4/8/2022

Client: GZA
Project: House Street RAP - House Street, Michigan
Project Number: L193-MI
Location: GT-1
Depth: 25.0' - 35.0' **Sample Number:** Bucket
Material Description: brown poorly graded SAND
Date: 4/8/22 **PL:** NP **LL:** NV **PI:** NP
USCS Classification: SP **AASHTO Classification:** A-3
Testing Remarks: Lab No.: 167

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer	Percent Retained
546.25	13.81	0.00	#10	0.00	100.0	0.0
100.62	0.00	0.00	#20	0.01	100.0	0.0
			#40	2.34	97.7	2.3
			#60	56.86	43.5	56.5
			#100	95.42	5.2	94.8
			#200	98.56	2.0	98.0

Hydrometer Test Data

Hydrometer test uses material passing #10
Percent passing #10 based upon complete sample = 100.0
Weight of hydrometer sample =100.62
Hygroscopic moisture correction:
Moist weight and tare = 121.46
Dry weight and tare = 121.41
Tare weight = 31.02
Hygroscopic moisture = 0.1%
Automatic temperature correction
Composite correction (fluid density and meniscus height) at 20 deg. C = -5.0
Meniscus correction only = 0.0
Specific gravity of solids = 2.65
Hydrometer type = 152H
Hydrometer effective depth equation: L = 16.294964 - 0.164 **x Rm**

Elapsed Time (min.)	Temp. (deg. C.)	Actual Reading	Corrected Reading	K	Rm	Eff. Depth	Diameter (mm.)	Percent Finer	Percent Retained
1.00	21.6	6.0	1.3	0.0134	6.0	15.3	0.0523	1.3	98.7
2.00	21.6	6.0	1.3	0.0134	6.0	15.3	0.0370	1.3	98.7
5.00	21.6	6.0	1.3	0.0134	6.0	15.3	0.0234	1.3	98.7
15.00	21.6	6.0	1.3	0.0134	6.0	15.3	0.0135	1.3	98.7
30.00	21.6	6.0	1.3	0.0134	6.0	15.3	0.0096	1.3	98.7
60.00	21.6	6.0	1.3	0.0134	6.0	15.3	0.0068	1.3	98.7
120.00	21.6	5.5	0.8	0.0134	5.5	15.4	0.0048	0.8	99.2
250.00	21.5	5.5	0.8	0.0134	5.5	15.4	0.0033	0.8	99.2
1440.00	21.6	5.5	0.8	0.0134	5.5	15.4	0.0014	0.8	99.2

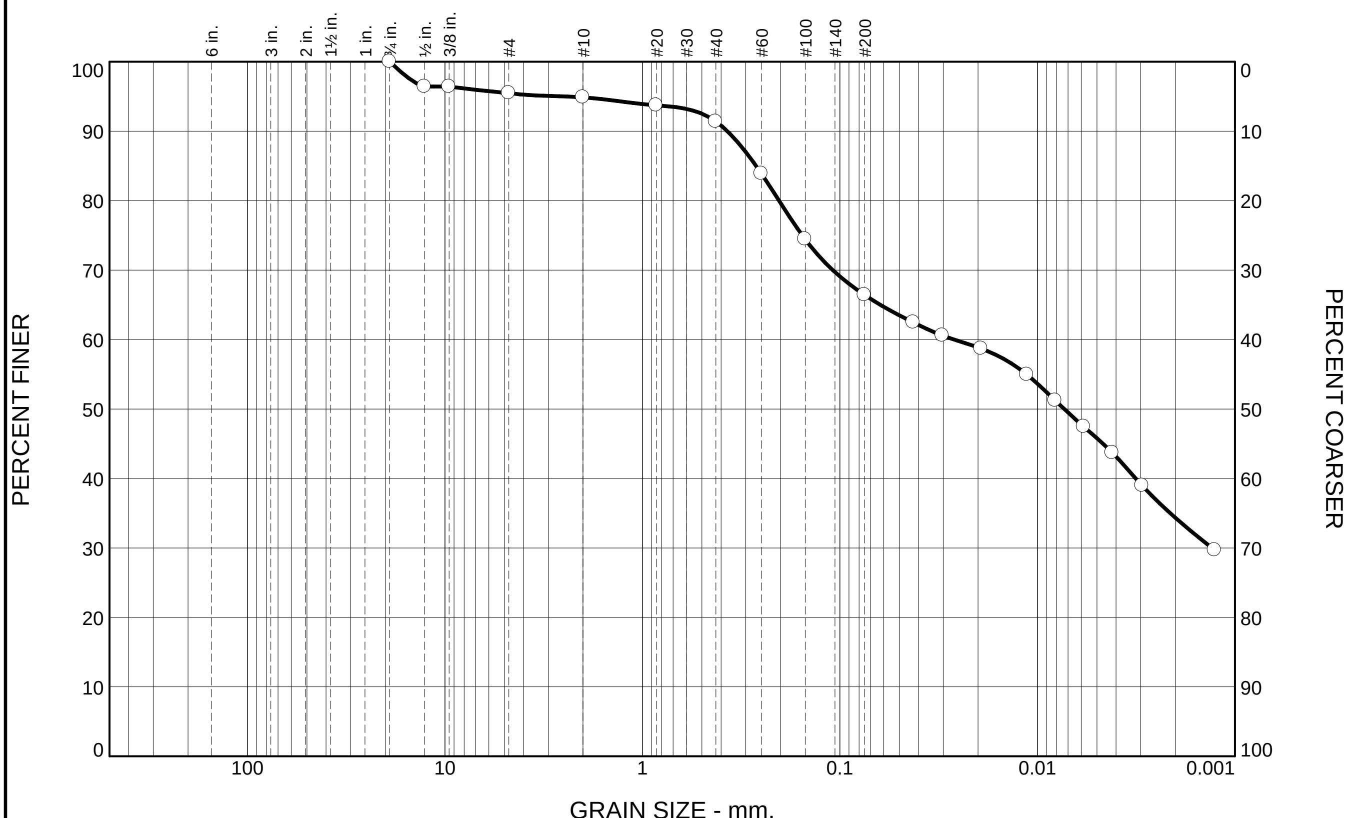
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.0	0.0	0.0	2.3	95.7	98.0	1.1	0.9	2.0

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
0.1459	0.1667	0.1810	0.1941	0.2185	0.2419	0.2652	0.2893	0.3458	0.3634	0.3837	0.4084

Fineness Modulus	C_u	C_c
1.32	1.74	0.99

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	4.5	0.6	3.5	25.0	20.6	45.8

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
0.75	100.0		
0.5	96.4		
0.375	96.4		
#4	95.5		
#10	94.9		
#20	93.7		
#40	91.4		
#60	83.9		
#100	74.4		
#200	66.4		

* (no specification provided)

Material Description

brown sandy lean CLAY

Atterberg Limits

PL= 13 LL= 34 PI= 21

Coefficients

D_{90}= 0.3720 D_{85}= 0.2660 D_{60}= 0.0265
D_{50}= 0.0073 D_{30}= 0.0013 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(11)

Remarks

Lab No.: 167

Location: GT-2
Sample Number: S-4 **Depth:** 6.0' - 8.0' **Date:** 4/8/22

7NT

Client: GZA
Project: House Street RAP - House Street, Michigan

Project No: L193-MI **File**

GRAIN SIZE DISTRIBUTION TEST DATA

4/8/2022

Client: GZA
Project: House Street RAP - House Street, Michigan
Project Number: L193-MI
Location: GT-2
Depth: 6.0' - 8.0' **Sample Number:** S-4
Material Description: brown sandy lean CLAY
Date: 4/8/22 **PL:** 13 **LL:** 34 **PI:** 21
USCS Classification: CL **AASHTO Classification:** A-6(11)
Testing Remarks: Lab No.: 167

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer	Percent Retained
255.42	15.86	0.00	0.75	0.00	100.0	0.0
			0.5	8.58	96.4	3.6
			0.375	8.58	96.4	3.6
			#4	10.83	95.5	4.5
			#10	12.33	94.9	5.1
51.33	0.00	0.00	#20	0.62	93.7	6.3
			#40	1.88	91.4	8.6
			#60	5.93	83.9	16.1
			#100	11.05	74.4	25.6
			#200	15.39	66.4	33.6

Hydrometer Test Data

Hydrometer test uses material passing #10
Percent passing #10 based upon complete sample = 94.9
Weight of hydrometer sample =51.33
Hygroscopic moisture correction:
Moist weight and tare = 53.29
Dry weight and tare = 52.99
Tare weight = 32.34
Hygroscopic moisture = 1.5%
Automatic temperature correction
Composite correction (fluid density and meniscus height) at 20 deg. C = -5.0
Meniscus correction only = 0.0
Specific gravity of solids = 2.65
Hydrometer type = 152H
Hydrometer effective depth equation: L = 16.294964 - 0.164 **x Rm**

Elapsed Time (min.)	Temp. (deg. C.)	Actual Reading	Corrected Reading	K	Rm	Eff. Depth	Diameter (mm.)	Percent Finer	Percent Retained
1.00	21.6	38.0	33.3	0.0134	38.0	10.1	0.0424	62.5	37.5
2.00	21.6	37.0	32.3	0.0134	37.0	10.2	0.0303	60.6	39.4
5.00	21.6	36.0	31.3	0.0134	36.0	10.4	0.0193	58.7	41.3
15.00	21.6	34.0	29.3	0.0134	34.0	10.7	0.0113	55.0	45.0
30.00	21.6	32.0	27.3	0.0134	32.0	11.0	0.0081	51.2	48.8
60.00	21.6	30.0	25.3	0.0134	30.0	11.4	0.0058	47.5	52.5
120.00	21.6	28.0	23.3	0.0134	28.0	11.7	0.0042	43.7	56.3
250.00	21.5	25.5	20.8	0.0134	25.5	12.1	0.0029	39.0	61.0

Hydrometer Test Data (continued)

Elapsed Time (min.)	Temp. (deg. C.)	Actual Reading	Corrected Reading	K	Rm	Eff. Depth	Diameter (mm.)	Percent Finer	Percent Retained
1440.00	21.7	20.5	15.8	0.0134	20.5	12.9	0.0013	29.7	70.3

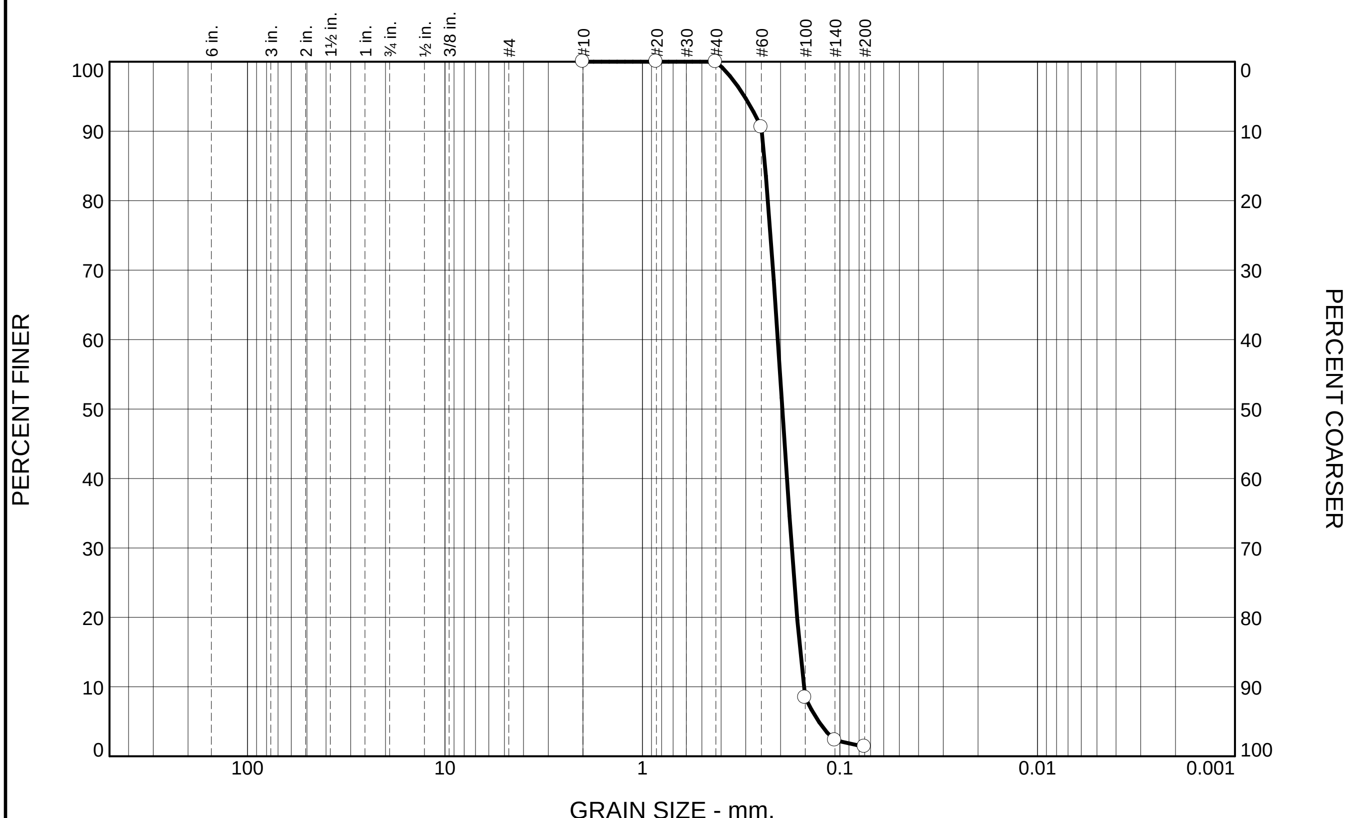
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	4.5	4.5	0.6	3.5	25.0	29.1	20.6	45.8	66.4

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
				0.0013	0.0032	0.0073	0.0265	0.2035	0.2660	0.3720	2.5333

Fineness Modulus
0.64

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.0	98.6	1.4	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	100.0		
#40	100.0		
#60	90.6		
#100	8.5		
#140	2.3		
#200	1.4		

* (no specification provided)

Material Description

light brown poorly graded SAND

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.2488 D_{85}= 0.2395 D_{60}= 0.2064
D_{50}= 0.1957 D_{30}= 0.1755 D_{15}= 0.1590
D_{10}= 0.1524 C_u= 1.35 C_c= 0.98

Classification

USCS= SP AASHTO=

Remarks

Lab No.: 167

Location: GT-2
Sample Number: S-6 **Depth:** 14.0' - 16.0' **Date:** 4/1/22

7NT

Client: GZA
Project: House Street RAP - House Street, Michigan
Project No: L193-MI **File**

GRAIN SIZE DISTRIBUTION TEST DATA

4/1/2022

Client: GZA
Project: House Street RAP - House Street, Michigan
Project Number: L193-MI
Location: GT-2
Depth: 14.0' - 16.0' **Sample Number:** S-6
Material Description: light brown poorly graded SAND
Date: 4/1/22
USCS Classification: SP
Testing Remarks: Lab No.: 167

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer	Percent Retained
326.54	13.92	0.00	#10	0.00	100.0	0.0
101.14	0.00	0.00	#20	0.00	100.0	0.0
			#40	0.02	100.0	0.0
			#60	9.54	90.6	9.4
			#100	92.58	8.5	91.5
			#140	98.80	2.3	97.7
			#200	99.74	1.4	98.6

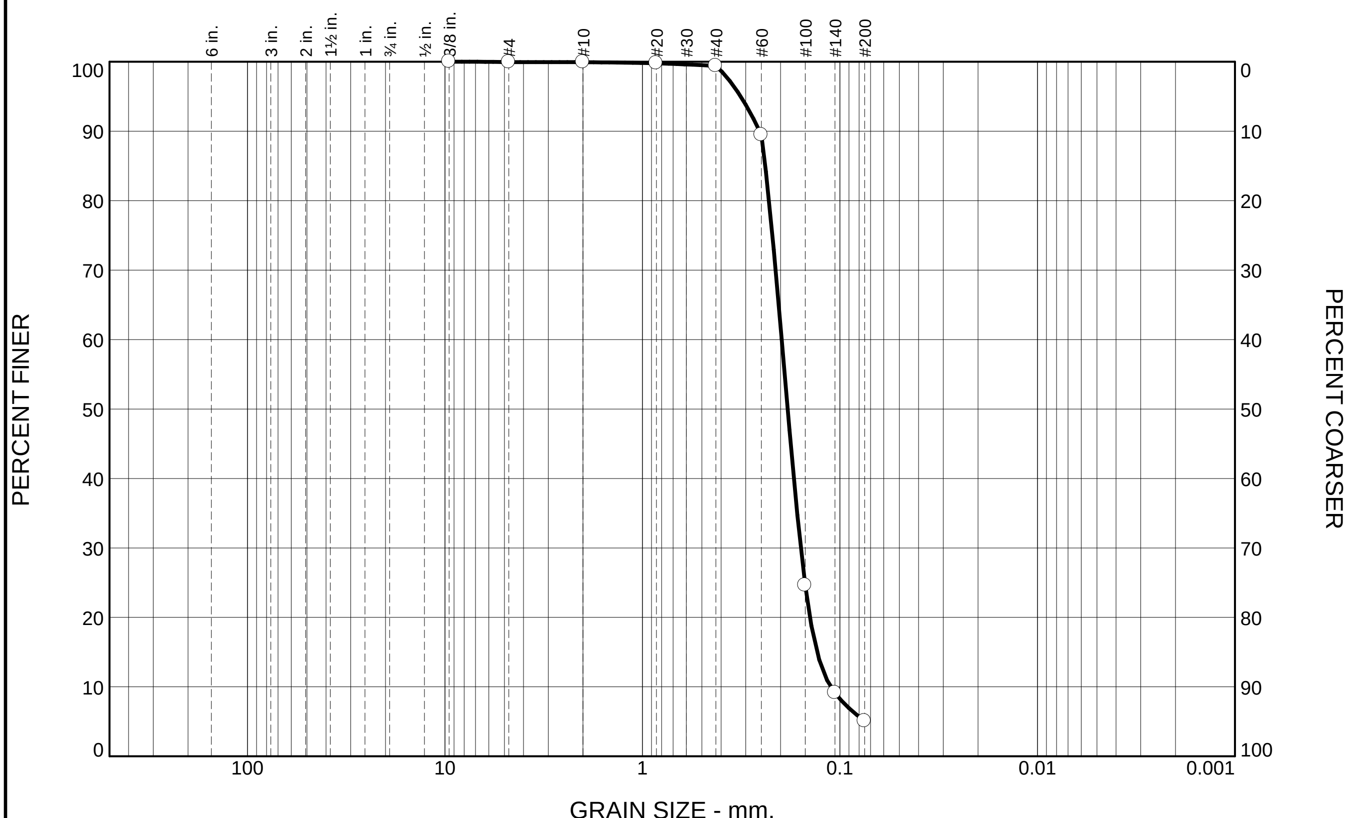
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.0	0.0	0.0	0.0	98.6	98.6			1.4

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
0.1280	0.1524	0.1590	0.1649	0.1755	0.1856	0.1957	0.2064	0.2315	0.2395	0.2488	0.3042

Fineness Modulus	C_u	C_c
0.97	1.35	0.98

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.1	0.0	0.5	94.3	5.1	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
0.375	100.0		
#4	99.9		
#10	99.9		
#20	99.8		
#40	99.4		
#60	89.5		
#100	24.6		
#140	9.1		
#200	5.1		

* (no specification provided)

Material Description

light brown poorly graded SAND with silt (visual)

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.2551 D_{85}= 0.2389 D_{60}= 0.1972
D_{50}= 0.1840 D_{30}= 0.1580 D_{15}= 0.1305
D_{10}= 0.1112 C_u= 1.77 C_c= 1.14

Classification

USCS= AASHTO=

Remarks

Lab No.: 167

Location: GT-2
Sample Number: S-8 **Depth:** 21.0' - 23.0' **Date:** 4/1/22

7NT

Client: GZA
Project: House Street RAP - House Street, Michigan
Project No: L193-MI **File**

GRAIN SIZE DISTRIBUTION TEST DATA

4/1/2022

Client: GZA
Project: House Street RAP - House Street, Michigan
Project Number: L193-MI
Location: GT-2
Depth: 21.0' - 23.0' **Sample Number:** S-8
Material Description: light brown poorly graded SAND with silt (visual)
Date: 4/1/22
Testing Remarks: Lab No.: 167

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer	Percent Retained
346.81	13.76	0.00	0.375	0.00	100.0	0.0
			#4	0.24	99.9	0.1
			#10	0.24	99.9	0.1
108.93	0.00	0.00	#20	0.17	99.8	0.2
			#40	0.59	99.4	0.6
			#60	11.40	89.5	10.5
			#100	82.08	24.6	75.4
			#140	98.96	9.1	90.9
			#200	103.38	5.1	94.9

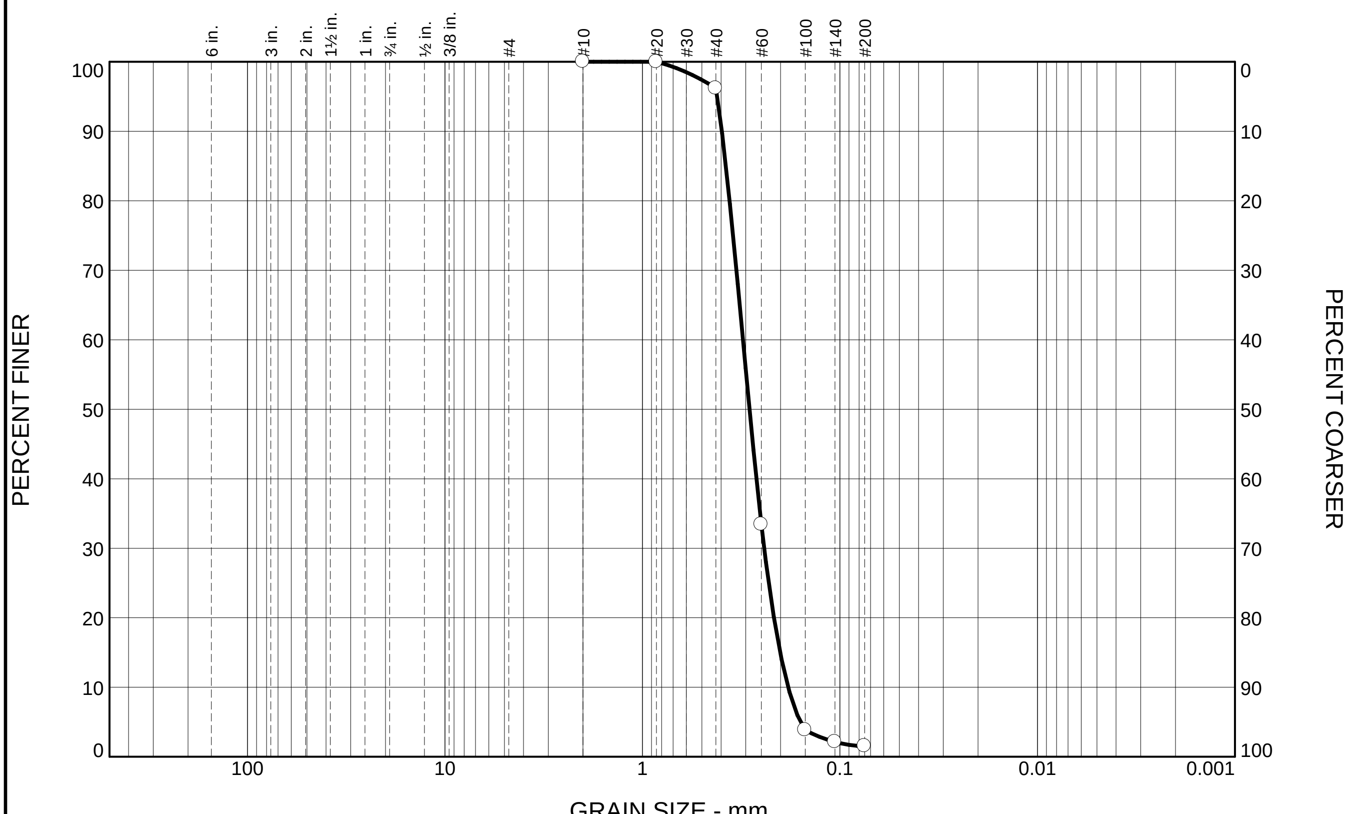
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.1	0.1	0.0	0.5	94.3	94.8			5.1

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
	0.1112	0.1305	0.1419	0.1580	0.1712	0.1840	0.1972	0.2286	0.2389	0.2551	0.3180

Fineness Modulus	C_u	C_c
0.82	1.77	1.14

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	3.8	94.7	1.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	100.0		
#40	96.2		
#60	33.4		
#100	3.8		
#140	2.1		
#200	1.5		

* (no specification provided)

Material Description

light brown poorly graded SAND

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.3964 D_{85}= 0.3780 D_{60}= 0.3096
D_{50}= 0.2869 D_{30}= 0.2419 D_{15}= 0.2007
D_{10}= 0.1829 C_u= 1.69 C_c= 1.03

Classification

USCS= SP AASHTO=

Remarks

Lab No.: 167

Location: GT-2
Sample Number: S-11 **Depth:** 27.0' - 29.0' **Date:** 4/1/22

7NT

Client: GZA
Project: House Street RAP - House Street, Michigan

Project No: L193-MI **File**

GRAIN SIZE DISTRIBUTION TEST DATA

4/1/2022

Client: GZA
Project: House Street RAP - House Street, Michigan
Project Number: L193-MI
Location: GT-2
Depth: 27.0' - 29.0' **Sample Number:** S-11
Material Description: light brown poorly graded SAND
Date: 4/1/22
USCS Classification: SP
Testing Remarks: Lab No.: 167

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer	Percent Retained
341.48	15.77	0.00	#10	0.00	100.0	0.0
102.82	0.00	0.00	#20	0.01	100.0	0.0
			#40	3.93	96.2	3.8
			#60	68.45	33.4	66.6
			#100	98.88	3.8	96.2
			#140	100.62	2.1	97.9
			#200	101.24	1.5	98.5

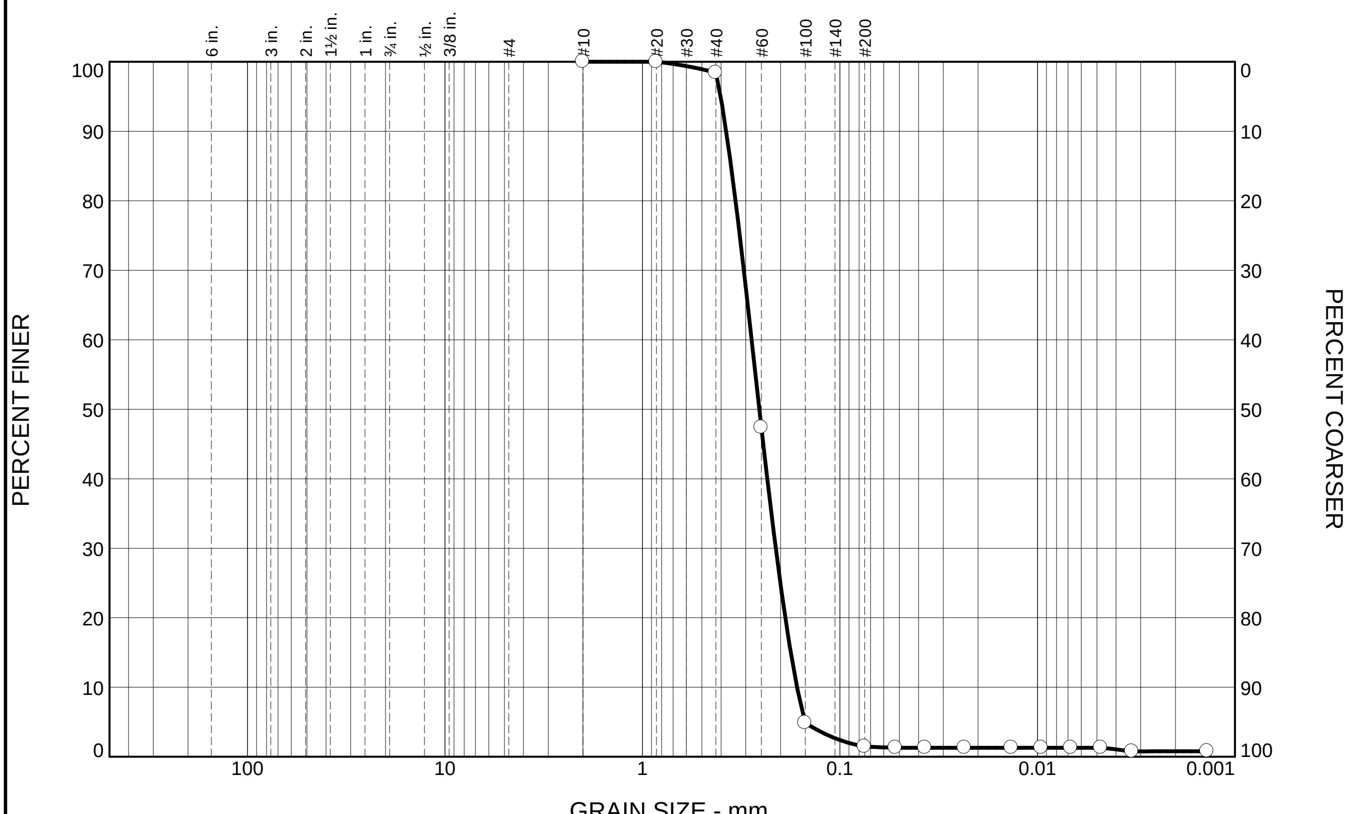
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.0	0.0	0.0	3.8	94.7	98.5			1.5

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
0.1585	0.1829	0.2007	0.2159	0.2419	0.2649	0.2869	0.3096	0.3619	0.3780	0.3964	0.4188

Fineness Modulus	C_u	C_c
1.42	1.69	1.03

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	1.6	96.9	0.2	1.3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	100.0		
#40	98.4		
#60	47.4		
#100	4.9		
#200	1.5		

* (no specification provided)

Material Description

brown poorly graded SAND

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 0.3766 D_{85}= 0.3556 D_{60}= 0.2800
D_{50}= 0.2560 D_{30}= 0.2113 D_{15}= 0.1775
D_{10}= 0.1650 C_u= 1.70 C_c= 0.97

Classification

USCS= SP AASHTO= A-3

Remarks

Lab No.: 167

Location: GT-2
Sample Number: Bucket **Depth:** 30.0' - 40.0' **Date:** 4/8/22

7NT

Client: GZA
Project: House Street RAP - House Street, Michigan
Project No: L193-MI **File**

GRAIN SIZE DISTRIBUTION TEST DATA

4/8/2022

Client: GZA
Project: House Street RAP - House Street, Michigan
Project Number: L193-MI
Location: GT-2
Depth: 30.0' - 40.0' **Sample Number:** Bucket
Material Description: brown poorly graded SAND
Date: 4/8/22 **PL:** NP **LL:** NV **PI:** NP
USCS Classification: SP **AASHTO Classification:** A-3
Testing Remarks: Lab No.: 167

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer	Percent Retained
536.09	13.76	0.00	#10	0.00	100.0	0.0
101.19	0.00	0.00	#20	0.01	100.0	0.0
			#40	1.60	98.4	1.6
			#60	53.23	47.4	52.6
			#100	96.26	4.9	95.1
			#200	99.69	1.5	98.5

Hydrometer Test Data

Hydrometer test uses material passing #10
Percent passing #10 based upon complete sample = 100.0
Weight of hydrometer sample =101.19
Hygroscopic moisture correction:
Moist weight and tare = 124.78
Dry weight and tare = 124.72
Tare weight = 32.55
Hygroscopic moisture = 0.1%
Automatic temperature correction
Composite correction (fluid density and meniscus height) at 20 deg. C = -5.0
Meniscus correction only = 0.0
Specific gravity of solids = 2.65
Hydrometer type = 152H
Hydrometer effective depth equation: L = 16.294964 - 0.164 **x Rm**

Elapsed Time (min.)	Temp. (deg. C.)	Actual Reading	Corrected Reading	K	Rm	Eff. Depth	Diameter (mm.)	Percent Finer	Percent Retained
1.00	21.6	6.0	1.3	0.0134	6.0	15.3	0.0523	1.3	98.7
2.00	21.6	6.0	1.3	0.0134	6.0	15.3	0.0370	1.3	98.7
5.00	21.6	6.0	1.3	0.0134	6.0	15.3	0.0234	1.3	98.7
15.00	21.6	6.0	1.3	0.0134	6.0	15.3	0.0135	1.3	98.7
30.00	21.6	6.0	1.3	0.0134	6.0	15.3	0.0096	1.3	98.7
60.00	21.6	6.0	1.3	0.0134	6.0	15.3	0.0068	1.3	98.7
120.00	21.6	6.0	1.3	0.0134	6.0	15.3	0.0048	1.3	98.7
250.00	21.5	5.5	0.8	0.0134	5.5	15.4	0.0033	0.8	99.2
1440.00	21.6	5.5	0.8	0.0134	5.5	15.4	0.0014	0.8	99.2

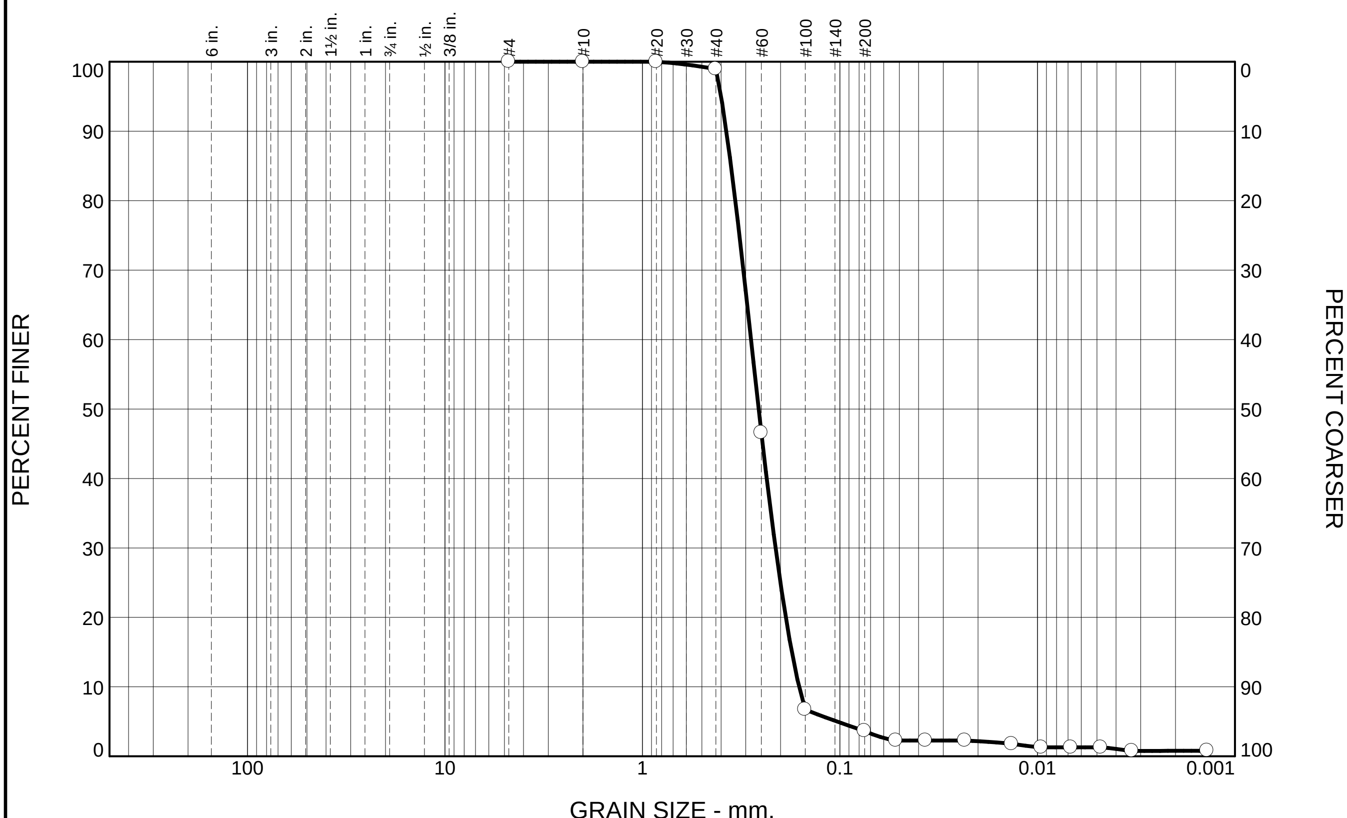
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.0	0.0	0.0	1.6	96.9	98.5	0.2	1.3	1.5

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
0.1504	0.1650	0.1775	0.1891	0.2113	0.2334	0.2560	0.2800	0.3375	0.3556	0.3766	0.4023

Fineness Modulus	C_u	C_c
1.28	1.70	0.97

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	1.1	95.2	2.4	1.3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	100.0		
#20	100.0		
#40	98.9		
#60	46.6		
#100	6.7		
#200	3.7		

* (no specification provided)

Material Description

brown poorly graded SAND

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 0.3759 D_{85}= 0.3558 D_{60}= 0.2820
D_{50}= 0.2580 D_{30}= 0.2119 D_{15}= 0.1753
D_{10}= 0.1611 C_u= 1.75 C_c= 0.99

Classification

USCS= SP AASHTO= A-3

Remarks

Lab No.: 167

Location: GT-2
Sample Number: S-14 **Depth:** 33.0' - 35.0' **Date:** 4/8/22

7NT

Client: GZA
Project: House Street RAP - House Street, Michigan
Project No: L193-MI **File**

GRAIN SIZE DISTRIBUTION TEST DATA

4/8/2022

Client: GZA
Project: House Street RAP - House Street, Michigan
Project Number: L193-MI
Location: GT-2
Depth: 33.0' - 35.0' **Sample Number:** S-14
Material Description: brown poorly graded SAND
Date: 4/8/22 **PL:** NP **LL:** NV **PI:** NP
USCS Classification: SP **AASHTO Classification:** A-3
Testing Remarks: Lab No.: 167

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer	Percent Retained
366.99	13.80	0.00	#4	0.00	100.0	0.0
			#10	0.03	100.0	0.0
101.75	0.00	0.00	#20	0.00	100.0	0.0
			#40	1.07	98.9	1.1
			#60	54.36	46.6	53.4
			#100	94.90	6.7	93.3
			#200	98.03	3.7	96.3

Hydrometer Test Data

Hydrometer test uses material passing #10
Percent passing #10 based upon complete sample = 100.0
Weight of hydrometer sample =101.75
Hygroscopic moisture correction:
Moist weight and tare = 124.21
Dry weight and tare = 124.17
Tare weight = 30.44
Hygroscopic moisture = 0.0%
Automatic temperature correction
Composite correction (fluid density and meniscus height) at 20 deg. C = -5.0
Meniscus correction only = 0.0
Specific gravity of solids = 2.65
Hydrometer type = 152H
Hydrometer effective depth equation: L = 16.294964 - 0.164 **x Rm**

Elapsed Time (min.)	Temp. (deg. C.)	Actual Reading	Corrected Reading	K	Rm	Eff. Depth	Diameter (mm.)	Percent Finer	Percent Retained
1.00	21.6	7.0	2.3	0.0134	7.0	15.1	0.0521	2.3	97.7
2.00	21.6	7.0	2.3	0.0134	7.0	15.1	0.0368	2.3	97.7
5.00	21.6	7.0	2.3	0.0134	7.0	15.1	0.0233	2.3	97.7
15.00	21.6	6.5	1.8	0.0134	6.5	15.2	0.0135	1.8	98.2
30.00	21.6	6.0	1.3	0.0134	6.0	15.3	0.0096	1.3	98.7
60.00	21.6	6.0	1.3	0.0134	6.0	15.3	0.0068	1.3	98.7
120.00	21.6	6.0	1.3	0.0134	6.0	15.3	0.0048	1.3	98.7
250.00	21.5	5.5	0.8	0.0134	5.5	15.4	0.0033	0.8	99.2
1440.00	21.6	5.5	0.8	0.0134	5.5	15.4	0.0014	0.8	99.2

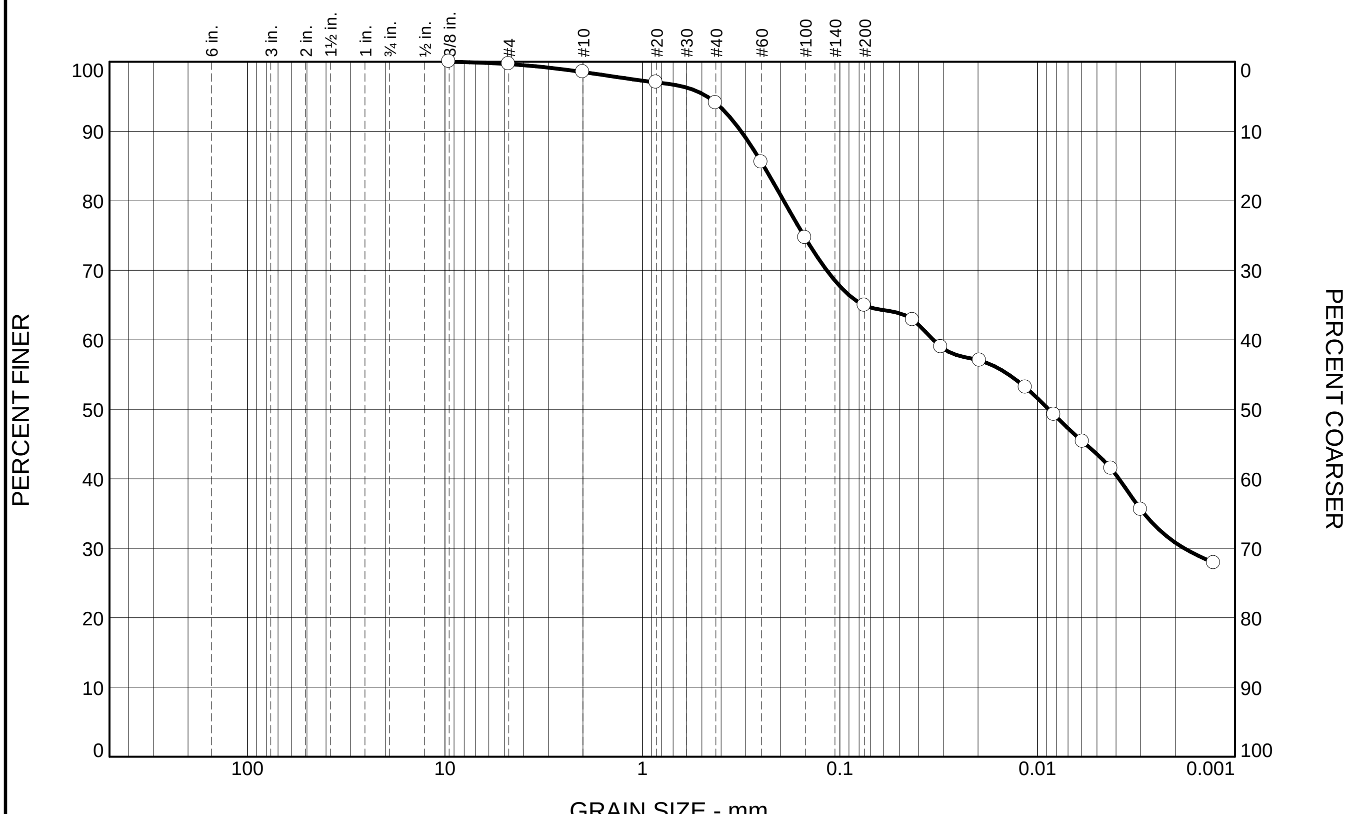
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.0	0.0	0.0	1.1	95.2	96.3	2.4	1.3	3.7

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
0.1032	0.1611	0.1753	0.1881	0.2119	0.2349	0.2580	0.2820	0.3383	0.3558	0.3759	0.4002

Fineness Modulus	C_u	C_c
1.27	1.75	0.99

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.3	1.2	4.4	29.2	21.3	43.6

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
0.375	100.0		
#4	99.7		
#10	98.5		
#20	97.0		
#40	94.1		
#60	85.6		
#100	74.7		
#200	64.9		

* (no specification provided)

Material Description

brown sandy lean CLAY

Atterberg Limits

PL= 12 LL= 31 PI= 19

Coefficients

D_{90}= 0.3167 D_{85}= 0.2433 D_{60}= 0.0338
D_{50}= 0.0088 D_{30}= 0.0018 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(9)

Remarks

Lab No.: 167

Location: GT-3
Sample Number: S-3 **Depth:** 4.0' - 6.0' **Date:** 4/8/22

7NT

Client: GZA
Project: House Street RAP - House Street, Michigan
Project No: L193-MI **File**

GRAIN SIZE DISTRIBUTION TEST DATA

4/8/2022

Client: GZA
Project: House Street RAP - House Street, Michigan
Project Number: L193-MI
Location: GT-3
Depth: 4.0' - 6.0' **Sample Number:** S-3
Material Description: brown sandy lean CLAY
Date: 4/8/22 **PL:** 12 **LL:** 31 **PI:** 19
USCS Classification: CL **AASHTO Classification:** A-6(9)
Testing Remarks: Lab No.: 167

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer	Percent Retained
306.07	13.67	0.00	0.375	0.00	100.0	0.0
			#4	1.00	99.7	0.3
			#10	4.35	98.5	1.5
51.40	0.00	0.00	#20	0.78	97.0	3.0
			#40	2.32	94.1	5.9
			#60	6.76	85.6	14.4
			#100	12.44	74.7	25.3
			#200	17.52	64.9	35.1

Hydrometer Test Data

Hydrometer test uses material passing #10
Percent passing #10 based upon complete sample = 98.5
Weight of hydrometer sample =51.40
Hygroscopic moisture correction:
Moist weight and tare = 52.44
Dry weight and tare = 52.11
Tare weight = 29.80
Hygroscopic moisture = 1.5%
Automatic temperature correction
Composite correction (fluid density and meniscus height) at 20 deg. C = -5.0
Meniscus correction only = 0.0
Specific gravity of solids = 2.65
Hydrometer type = 152H
Hydrometer effective depth equation: L = 16.294964 - 0.164 **x Rm**

Elapsed Time (min.)	Temp. (deg. C.)	Actual Reading	Corrected Reading	K	Rm	Eff. Depth	Diameter (mm.)	Percent Finer	Percent Retained
1.00	21.6	37.0	32.3	0.0134	37.0	10.2	0.0428	62.8	37.2
2.00	21.6	35.0	30.3	0.0134	35.0	10.6	0.0307	59.0	41.0
5.00	21.6	34.0	29.3	0.0134	34.0	10.7	0.0196	57.0	43.0
15.00	21.6	32.0	27.3	0.0134	32.0	11.0	0.0115	53.1	46.9
30.00	21.6	30.0	25.3	0.0134	30.0	11.4	0.0082	49.2	50.8
60.00	21.6	28.0	23.3	0.0134	28.0	11.7	0.0059	45.3	54.7
120.00	21.6	26.0	21.3	0.0134	26.0	12.0	0.0042	41.5	58.5
250.00	21.5	23.0	18.3	0.0134	23.0	12.5	0.0030	35.6	64.4
1440.00	21.7	19.0	14.3	0.0134	19.0	13.2	0.0013	27.9	72.1

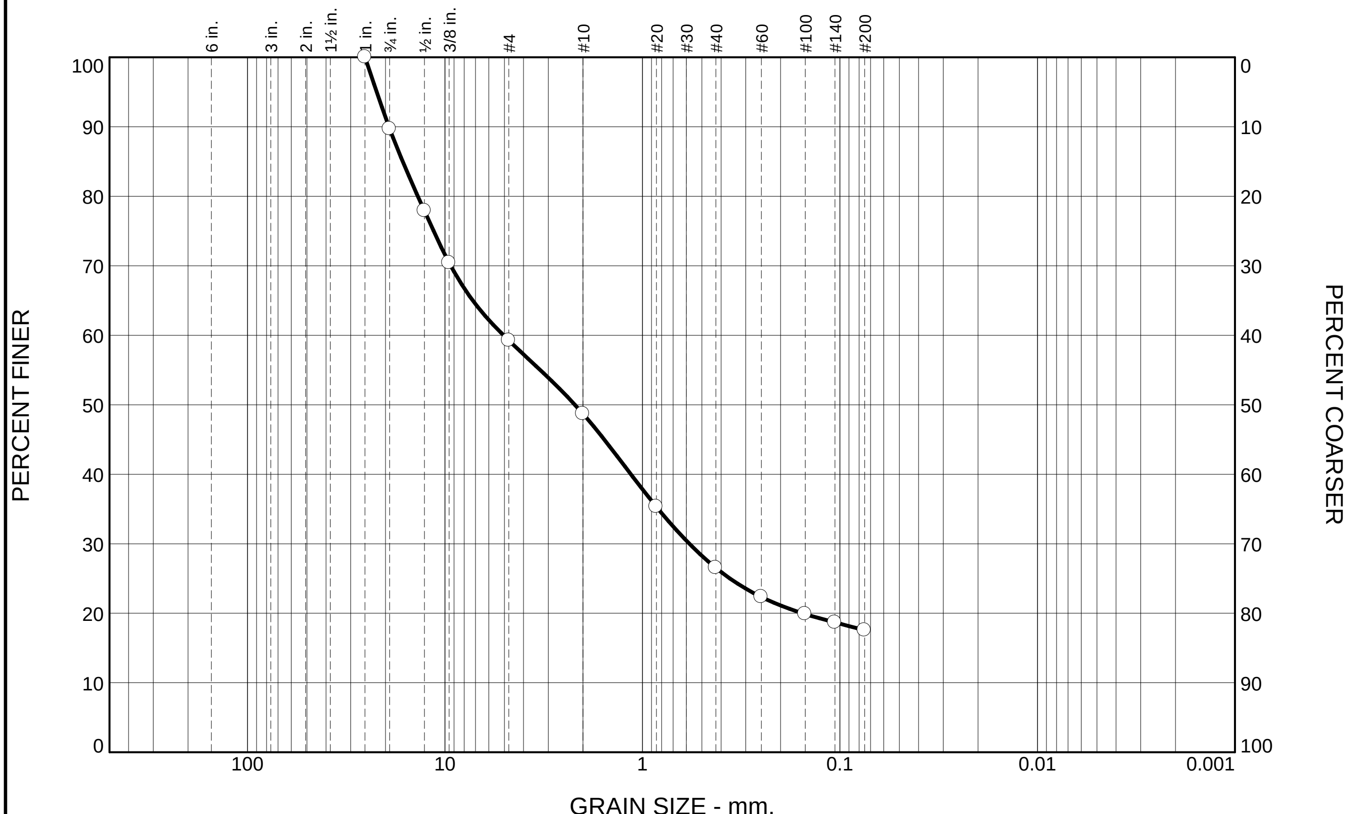
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.3	0.3	1.2	4.4	29.2	34.8	21.3	43.6	64.9

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
				0.0018	0.0039	0.0088	0.0338	0.1927	0.2433	0.3167	0.4716

Fineness Modulus
0.44

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	10.3	30.4	10.6	22.2	8.9	17.6	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.0	100.0		
0.75	89.7		
0.5	77.9		
0.375	70.4		
#4	59.3		
#10	48.7		
#20	35.3		
#40	26.5		
#60	22.3		
#100	19.9		
#140	18.7		
#200	17.6		

* (no specification provided)

Material Description

gray sility, sandy CLAY with gravel (visual)

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 19.2252 D_{85}= 16.3765 D_{60}= 5.0514
D_{50}= 2.1989 D_{30}= 0.5785 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= AASHTO=

Remarks

Lab No.: 167
*Sample Size is not representative

Location: GT-3
Sample Number: S-4 (Bottom) **Depth:** 6.0'-8.0' **Date:** 4/8/22

7NT

Client: GZA
Project: House Street RAP - House Street, Michigan
Project No: L193-MI **File**

GRAIN SIZE DISTRIBUTION TEST DATA

4/8/2022

Client: GZA
Project: House Street RAP - House Street, Michigan
Project Number: L193-MI
Location: GT-3
Depth: 6.0'-8.0' **Sample Number:** S-4 (Bottom)
Material Description: gray sility, sandy CLAY with gravel (visual)
Date: 4/8/22
Testing Remarks: Lab No.: 167
*Sample Size is not representative

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer	Percent Retained
227.61	13.89	0.00	1.0	0.00	100.0	0.0
			0.75	22.02	89.7	10.3
			0.5	47.24	77.9	22.1
			0.375	63.22	70.4	29.6
			#4	87.07	59.3	40.7
			#10	109.65	48.7	51.3
98.87	0.00	0.00	#20	27.15	35.3	64.7
			#40	45.01	26.5	73.5
			#60	53.52	22.3	77.7
			#100	58.50	19.9	80.1
			#140	60.94	18.7	81.3
			#200	63.23	17.6	82.4

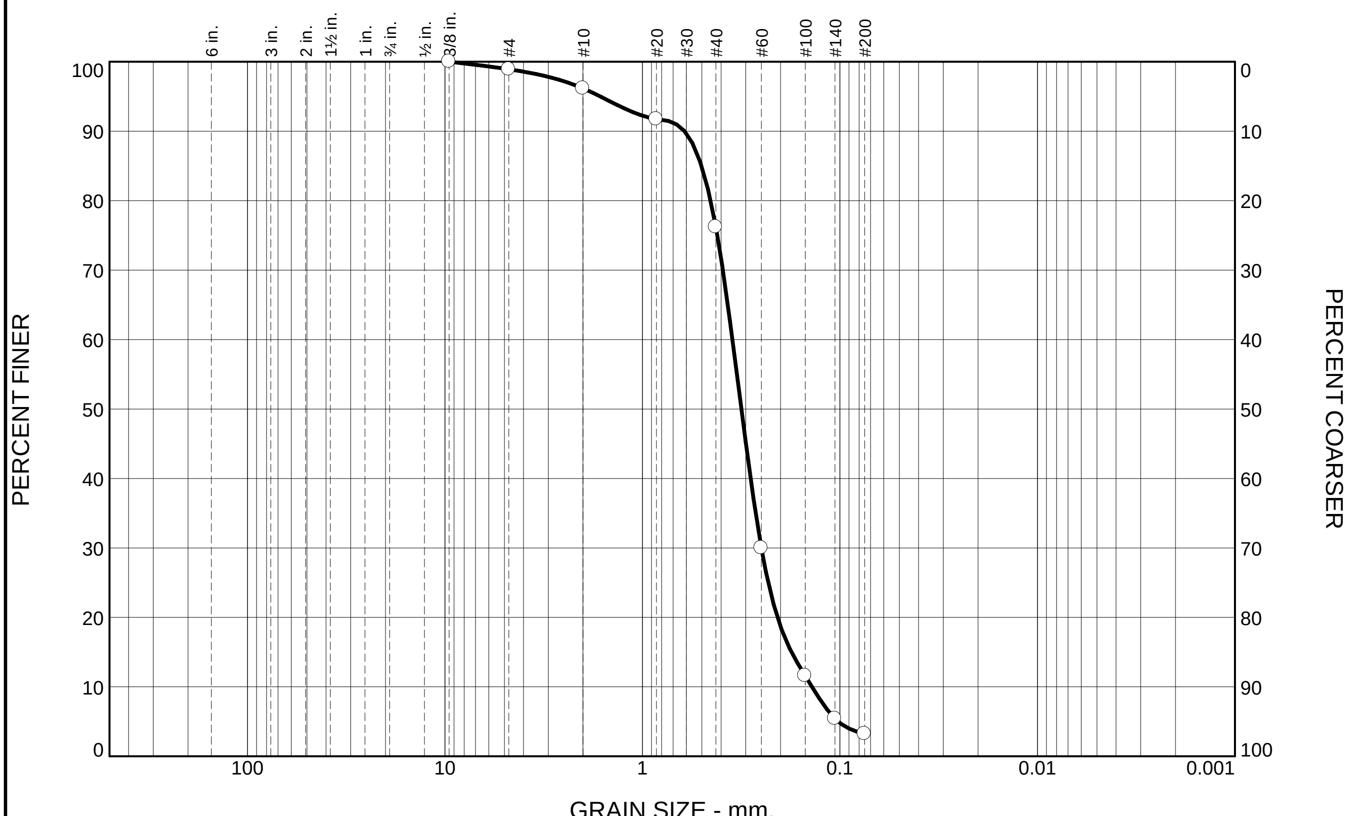
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	10.3	30.4	40.7	10.6	22.2	8.9	41.7			17.6

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
			0.1546	0.5785	1.1442	2.1989	5.0514	13.7169	16.3765	19.2252	22.1822

Fineness Modulus
4.15

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	1.1	2.7	20.0	73.0	3.2	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
0.375	100.0		
#4	98.9		
#10	96.2		
#20	91.7		
#40	76.2		
#60	30.0		
#100	11.6		
#140	5.4		
#200	3.2		

* (no specification provided)

Material Description

light brown poorly graded SAND

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.6124 D_{85}= 0.5025 D_{60}= 0.3501
D_{50}= 0.3153 D_{30}= 0.2500 D_{15}= 0.1761
D_{10}= 0.1385 C_u= 2.53 C_c= 1.29

Classification

USCS= SP AASHTO=

Remarks

Lab No.: 167

Location: GT-3
Sample Number: S-7 **Depth:** 19.0' - 21.0' **Date:** 4/1/22

7NT

Client: GZA
Project: House Street RAP - House Street, Michigan
Project No: L193-MI **File**

GRAIN SIZE DISTRIBUTION TEST DATA

4/1/2022

Client: GZA
Project: House Street RAP - House Street, Michigan
Project Number: L193-MI
Location: GT-3
Depth: 19.0' - 21.0' **Sample Number:** S-7
Material Description: light brown poorly graded SAND
Date: 4/1/22
USCS Classification: SP
Testing Remarks: Lab No.: 167

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer	Percent Retained
365.90	13.70	0.00	0.375	0.00	100.0	0.0
			#4	3.86	98.9	1.1
			#10	13.54	96.2	3.8
102.83	0.00	0.00	#20	4.73	91.7	8.3
			#40	21.35	76.2	23.8
			#60	70.76	30.0	70.0
			#100	90.42	11.6	88.4
			#140	97.03	5.4	94.6
			#200	99.37	3.2	96.8

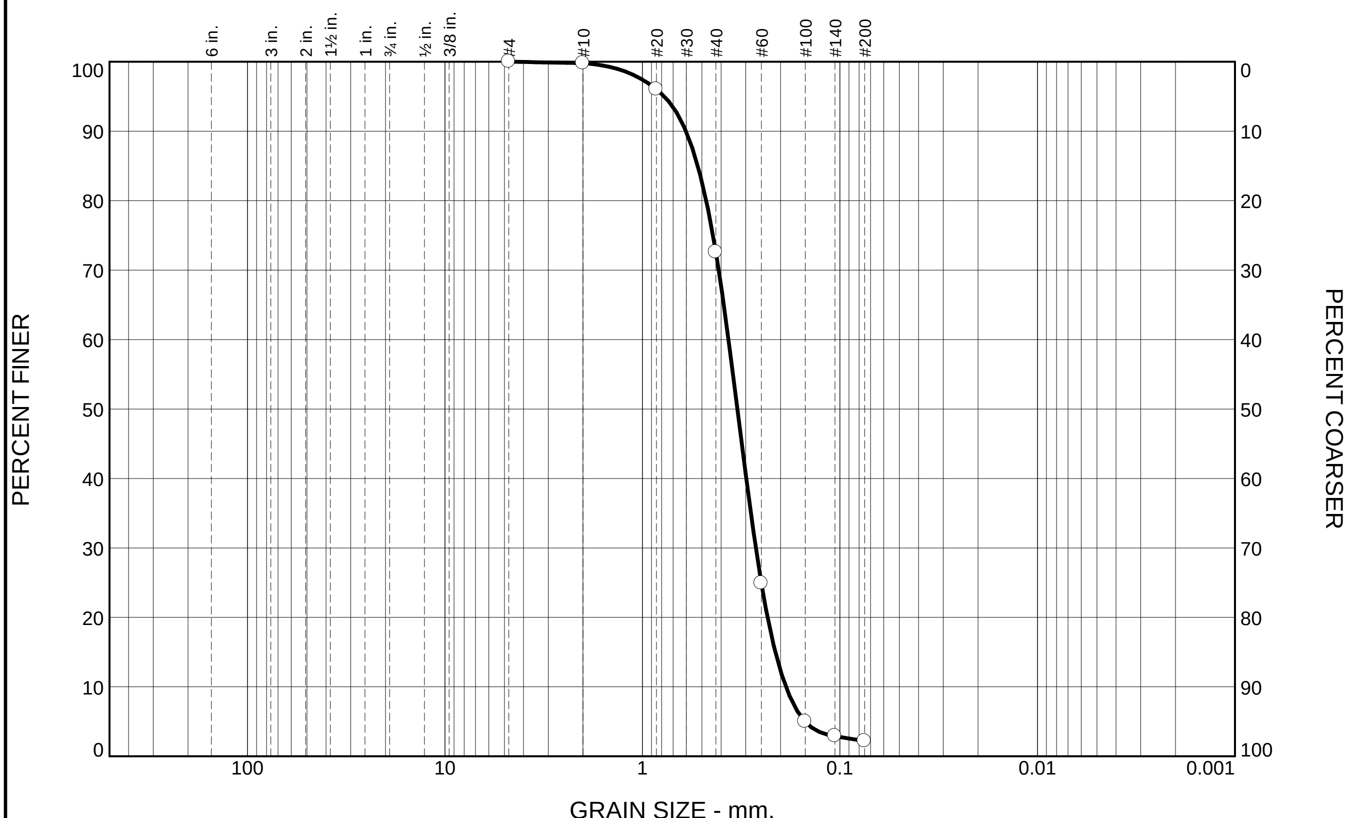
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	1.1	1.1	2.7	20.0	73.0	95.7			3.2

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
0.1021	0.1385	0.1761	0.2072	0.2500	0.2832	0.3153	0.3501	0.4518	0.5025	0.6124	1.6400

Fineness Modulus	C_u	C_c
1.65	2.53	1.29

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.2	27.2	70.4	2.2	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	99.8		
#20	96.0		
#40	72.6		
#60	24.9		
#100	5.0		
#140	2.9		
#200	2.2		

* (no specification provided)

Material Description

light brown poorly graded SAND

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.6020 D_{85}= 0.5247 D_{60}= 0.3668
D_{50}= 0.3304 D_{30}= 0.2666 D_{15}= 0.2124
D_{10}= 0.1878 C_u= 1.95 C_c= 1.03

Classification

USCS= SP AASHTO=

Remarks

Lab No.: 167

Location: GT-3
Sample Number: S-10 **Depth:** 34.0' - 36.0' **Date:** 4/1/22

7NT

Client: GZA
Project: House Street RAP - House Street, Michigan
Project No: L193-MI **File**

GRAIN SIZE DISTRIBUTION TEST DATA

4/1/2022

Client: GZA
Project: House Street RAP - House Street, Michigan
Project Number: L193-MI
Location: GT-3
Depth: 34.0' - 36.0' **Sample Number:** S-10
Material Description: light brown poorly graded SAND
Date: 4/1/22
USCS Classification: SP
Testing Remarks: Lab No.: 167

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer	Percent Retained
368.70	13.91	0.00	#4	0.00	100.0	0.0
			#10	0.73	99.8	0.2
106.10	0.00	0.00	#20	4.01	96.0	4.0
			#40	28.93	72.6	27.4
			#60	79.62	24.9	75.1
			#100	100.80	5.0	95.0
			#140	103.00	2.9	97.1
			#200	103.77	2.2	97.8

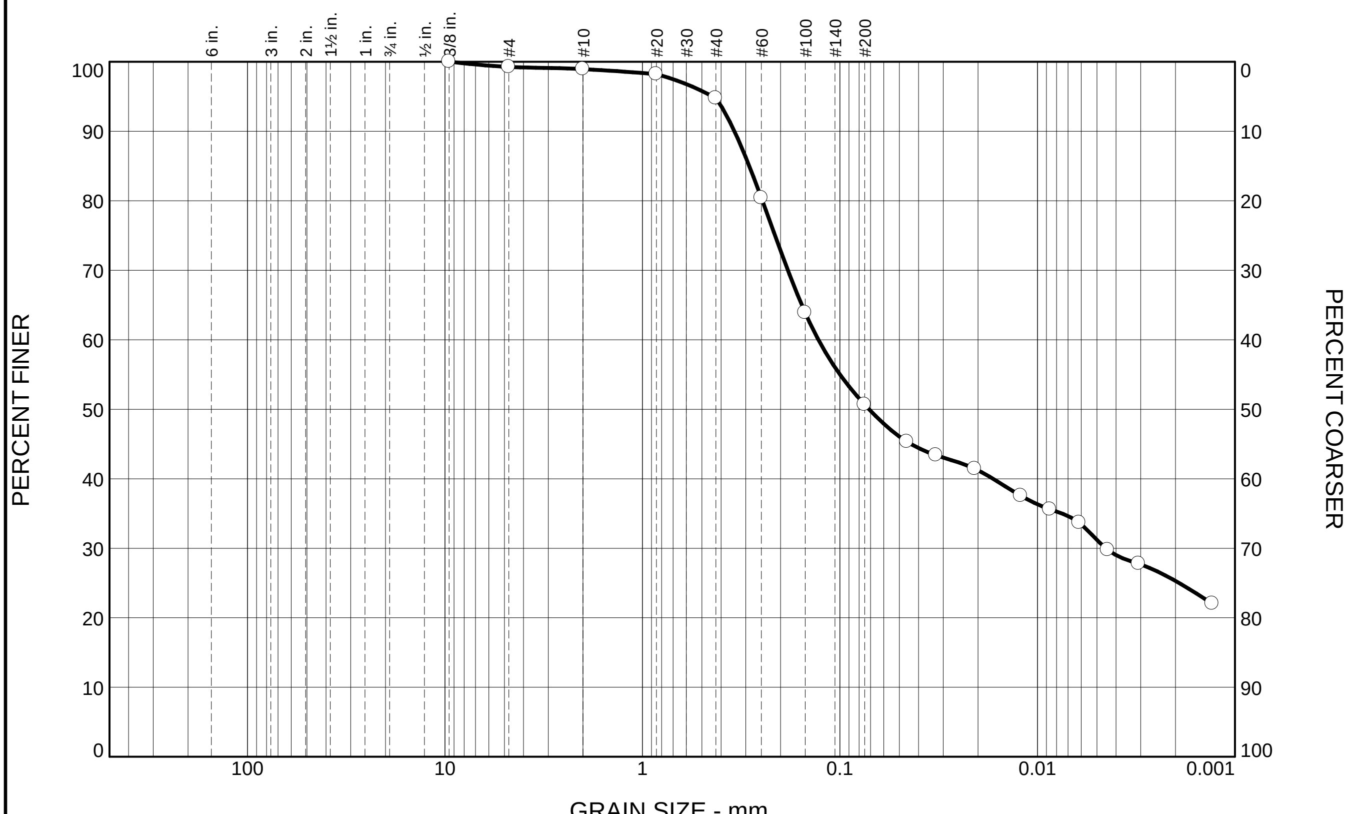
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.0	0.0	0.2	27.2	70.4	97.8			2.2

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
0.1502	0.1878	0.2124	0.2326	0.2666	0.2979	0.3304	0.3668	0.4755	0.5247	0.6020	0.7753

Fineness Modulus	C_u	C_c
1.66	1.95	1.03

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.7	0.4	4.2	44.0	19.5	31.2

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
0.375	100.0		
#4	99.3		
#10	98.9		
#20	98.2		
#40	94.7		
#60	80.4		
#100	63.9		
#200	50.7		

* (no specification provided)

Material Description

brown sandy lean CLAY

Atterberg Limits

PL= 12 LL= 27 PI= 15

Coefficients

D_{90}= 0.3421 D_{85}= 0.2879 D_{60}= 0.1286
D_{50}= 0.0713 D_{30}= 0.0045 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(4)

Remarks

Lab No.: 167

Location: GT-4
Sample Number: S-1 **Depth:** 0.0' - 2.0' **Date:** 4/8/22

7NT

Client: GZA
Project: House Street RAP - House Street, Michigan
Project No: L193-MI **File**

GRAIN SIZE DISTRIBUTION TEST DATA

4/8/2022

Client: GZA
Project: House Street RAP - House Street, Michigan
Project Number: L193-MI
Location: GT-4
Depth: 0.0' - 2.0' **Sample Number:** S-1
Material Description: brown sandy lean CLAY
Date: 4/8/22 **PL:** 12 **LL:** 27 **PI:** 15
USCS Classification: CL **AASHTO Classification:** A-6(4)
Testing Remarks: Lab No.: 167

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer	Percent Retained
281.12	13.72	0.00	0.375	0.00	100.0	0.0
			#4	2.00	99.3	0.7
			#10	2.86	98.9	1.1
51.55	0.00	0.00	#20	0.38	98.2	1.8
			#40	2.18	94.7	5.3
			#60	9.65	80.4	19.6
			#100	18.26	63.9	36.1
			#200	25.15	50.7	49.3

Hydrometer Test Data

Hydrometer test uses material passing #10
Percent passing #10 based upon complete sample = 98.9
Weight of hydrometer sample =51.55
Hygroscopic moisture correction:
Moist weight and tare = 52.37
Dry weight and tare = 52.10
Tare weight = 31.55
Hygroscopic moisture = 1.3%
Automatic temperature correction
Composite correction (fluid density and meniscus height) at 20 deg. C = -5.0
Meniscus correction only = 0.0
Specific gravity of solids = 2.65
Hydrometer type = 152H
Hydrometer effective depth equation: L = 16.294964 - 0.164 **x Rm**

Elapsed Time (min.)	Temp. (deg. C.)	Actual Reading	Corrected Reading	K	Rm	Eff. Depth	Diameter (mm.)	Percent Finer	Percent Retained
1.00	21.6	28.0	23.3	0.0134	28.0	11.7	0.0458	45.3	54.7
2.00	21.6	27.0	22.3	0.0134	27.0	11.9	0.0326	43.4	56.6
5.00	21.6	26.0	21.3	0.0134	26.0	12.0	0.0208	41.4	58.6
15.00	21.6	24.0	19.3	0.0134	24.0	12.4	0.0121	37.6	62.4
30.00	21.6	23.0	18.3	0.0134	23.0	12.5	0.0086	35.6	64.4
60.00	21.6	22.0	17.3	0.0134	22.0	12.7	0.0062	33.7	66.3
120.00	21.6	20.0	15.3	0.0134	20.0	13.0	0.0044	29.8	70.2
250.00	21.5	19.0	14.3	0.0134	19.0	13.2	0.0031	27.8	72.2
1440.00	21.7	16.0	11.3	0.0134	16.0	13.7	0.0013	22.0	78.0

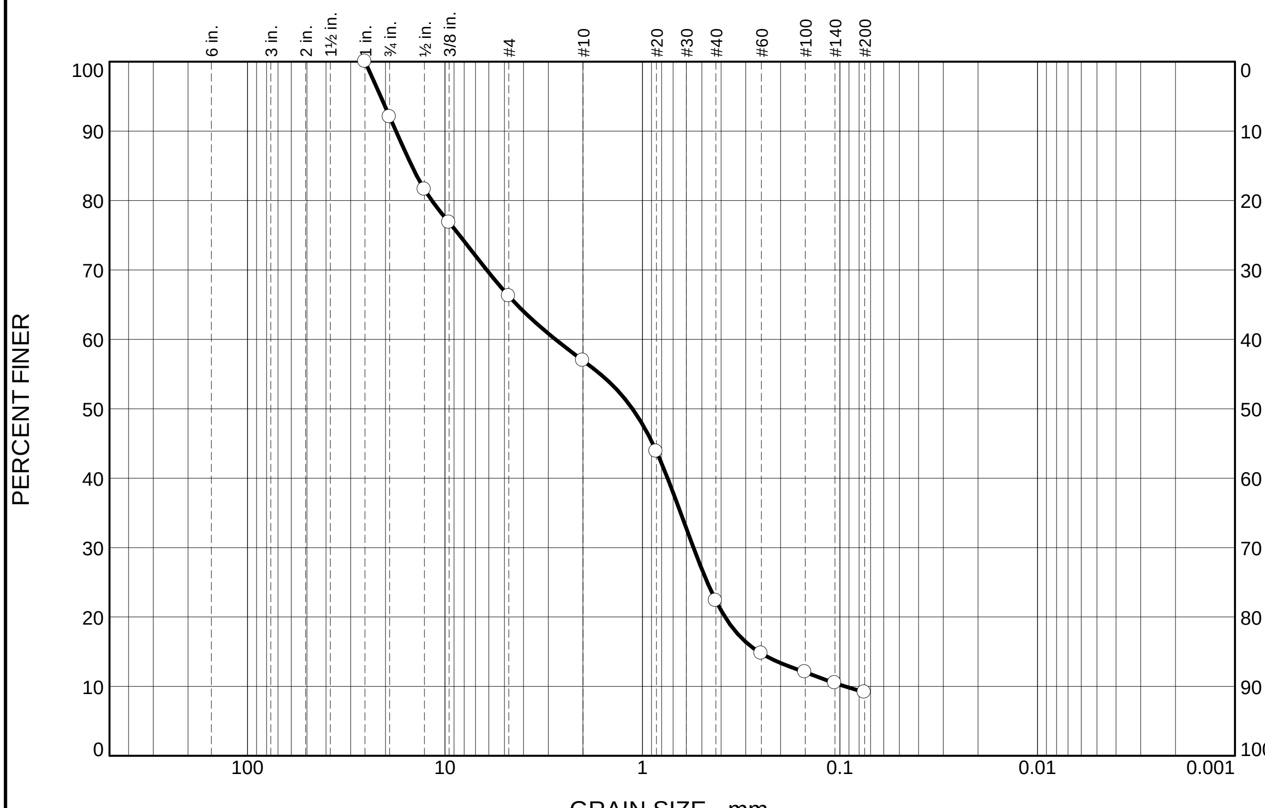
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.7	0.7	0.4	4.2	44.0	48.6	19.5	31.2	50.7

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
				0.0045	0.0168	0.0713	0.1286	0.2470	0.2879	0.3421	0.4413

Fineness Modulus
0.56

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	8.0	25.8	9.3	34.6	13.1	9.2	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.00	100.0		
0.75	92.0		
0.50	81.6		
0.375	76.8		
#4	66.2		
#10	56.9		
#20	43.9		
#40	22.3		
#60	14.8		
#100	12.0		
#140	10.5		
#200	9.2		

* (no specification provided)

Material Description

brown well graded SAND with silt and gravel (visual)

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 17.7149 D_{85}= 14.7264 D_{60}= 2.7600
D_{50}= 1.1236 D_{30}= 0.5517 D_{15}= 0.2581
D_{10}= 0.0942 C_u= 29.30 C_c= 1.17

Classification

USCS= AASHTO=

Remarks

Lab No.: 167

Location: GT-4
Sample Number: S-5 **Depth:** 8.0' - 10.0' **Date:** 4/1/22

7NT

Client: GZA
Project: House Street RAP - House Street, Michigan
Project No: L193-MI **File**

GRAIN SIZE DISTRIBUTION TEST DATA

4/1/2022

Client: GZA
Project: House Street RAP - House Street, Michigan
Project Number: L193-MI
Location: GT-4
Depth: 8.0' - 10.0' **Sample Number:** S-5
Material Description: brown well graded SAND with silt and gravel (visual)
Date: 4/1/22
Testing Remarks: Lab No.: 167

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer	Percent Retained
305.57	0.00	0.00	1.00	0.00	100.0	0.0
			0.75	24.31	92.0	8.0
			0.50	56.27	81.6	18.4
			0.375	70.80	76.8	23.2
			#4	103.18	66.2	33.8
			#10	131.60	56.9	43.1
133.39	0.00	0.00	#20	30.62	43.9	56.1
			#40	81.05	22.3	77.7
			#60	98.82	14.8	85.2
			#100	105.16	12.0	88.0
			#140	108.84	10.5	89.5
			#200	111.95	9.2	90.8

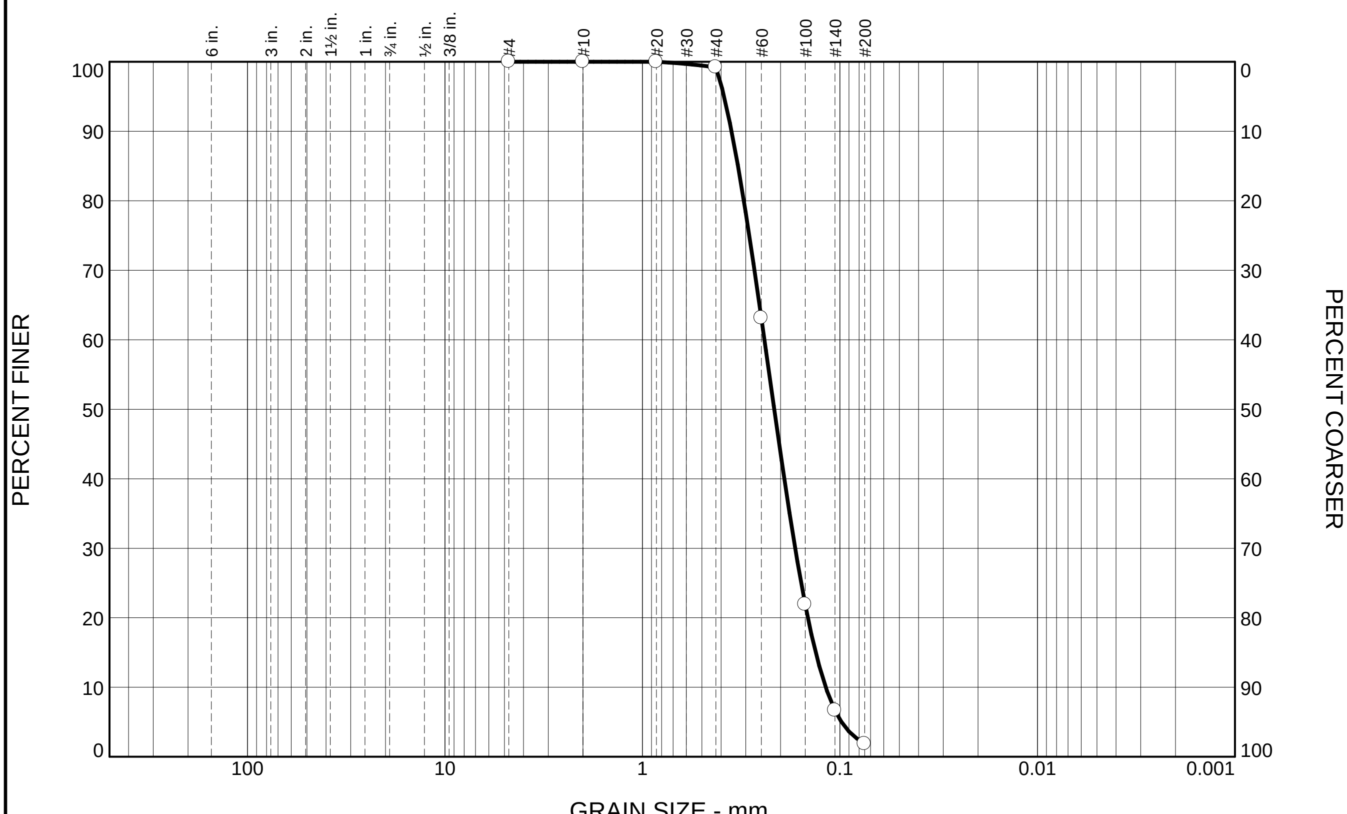
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	8.0	25.8	33.8	9.3	34.6	13.1	57.0			9.2

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
	0.0942	0.2581	0.3817	0.5517	0.7458	1.1236	2.7600	11.6696	14.7264	17.7149	21.1811

Fineness Modulus	C_u	C_c
3.94	29.30	1.17

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.8	97.4	1.8	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	100.0		
#20	100.0		
#40	99.2		
#60	63.1		
#100	21.9		
#140	6.7		
#200	1.8		

* (no specification provided)

Material Description

light brown poorly graded SAND

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.3536 D_{85}= 0.3281 D_{60}= 0.2412
D_{50}= 0.2151 D_{30}= 0.1686 D_{15}= 0.1326
D_{10}= 0.1180 C_u= 2.04 C_c= 1.00

Classification

USCS= SP AASHTO=

Remarks

Lab No.: 167

Location: GT-4
Sample Number: S-7 **Depth:** 19.0' - 21.0' **Date:** 4/1/22

7NT

Client: GZA
Project: House Street RAP - House Street, Michigan
Project No: L193-MI **File**

GRAIN SIZE DISTRIBUTION TEST DATA

4/1/2022

Client: GZA
Project: House Street RAP - House Street, Michigan
Project Number: L193-MI
Location: GT-4
Depth: 19.0' - 21.0' **Sample Number:** S-7
Material Description: light brown poorly graded SAND
Date: 4/1/22
USCS Classification: SP
Testing Remarks: Lab No.: 167

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer	Percent Retained
354.08	13.76	0.00	#4	0.00	100.0	0.0
			#10	0.02	100.0	0.0
102.83	0.00	0.00	#20	0.01	100.0	0.0
			#40	0.82	99.2	0.8
			#60	37.91	63.1	36.9
			#100	80.30	21.9	78.1
			#140	95.97	6.7	93.3
			#200	100.93	1.8	98.2

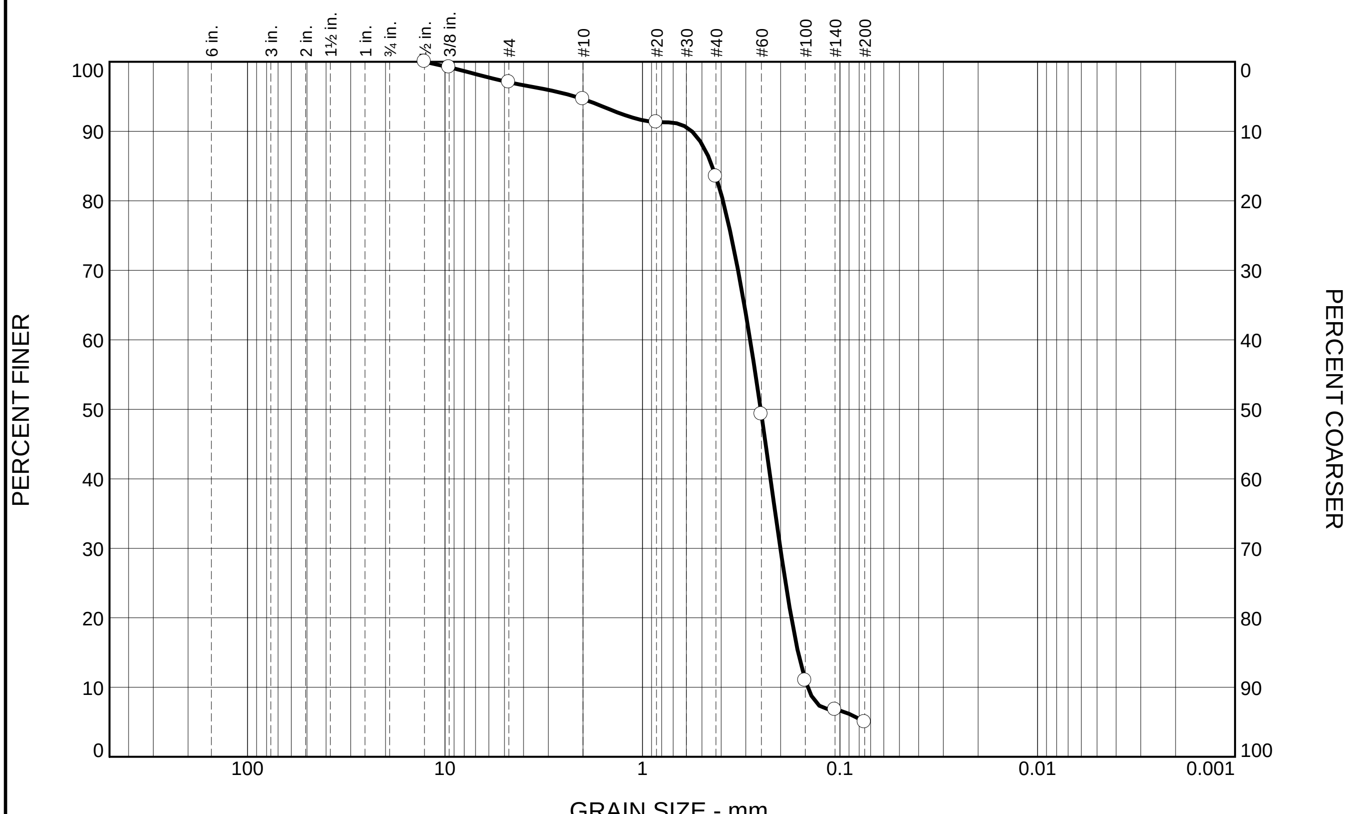
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.0	0.0	0.0	0.8	97.4	98.2			1.8

D_{5}	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
0.0983	0.1180	0.1326	0.1454	0.1686	0.1913	0.2151	0.2412	0.3066	0.3281	0.3536	0.3861

Fineness Modulus	C_u	C_c
1.00	2.04	1.00

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	2.9	2.5	11.1	78.5	5.0	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
0.50	100.0		
0.375	99.2		
#4	97.1		
#10	94.6		
#20	91.3		
#40	83.5		
#60	49.3		
#100	11.0		
#140	6.8		
#200	5.0		

* (no specification provided)

Material Description

light brown poorly graded SAND with silt (visual)

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.5624 D_{85}= 0.4437 D_{60}= 0.2851
D_{50}= 0.2521 D_{30}= 0.2005 D_{15}= 0.1631
D_{10}= 0.1459 C_u= 1.95 C_c= 0.97

Classification

USCS= AASHTO=

Remarks

Lab No.: 167

Location: GT-5
Sample Number: S-2 **Depth:** 2.0' - 4.0' **Date:** 4/1/22

7NT

Client: GZA
Project: House Street RAP - House Street, Michigan
Project No: L193-MI **File**

GRAIN SIZE DISTRIBUTION TEST DATA

4/1/2022

Client: GZA
Project: House Street RAP - House Street, Michigan
Project Number: L193-MI
Location: GT-5
Depth: 2.0' - 4.0' **Sample Number:** S-2
Material Description: light brown poorly graded SAND with silt
Date: 4/1/22
Testing Remarks: Lab No.: 167

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer	Percent Retained
379.46	15.82	0.00	0.50	0.00	100.0	0.0
			0.375	2.94	99.2	0.8
			#4	10.71	97.1	2.9
			#10	19.53	94.6	5.4
106.44	0.00	0.00	#20	3.73	91.3	8.7
			#40	12.53	83.5	16.5
			#60	51.00	49.3	50.7
			#100	94.09	11.0	89.0
			#140	98.81	6.8	93.2
			#200	100.81	5.0	95.0

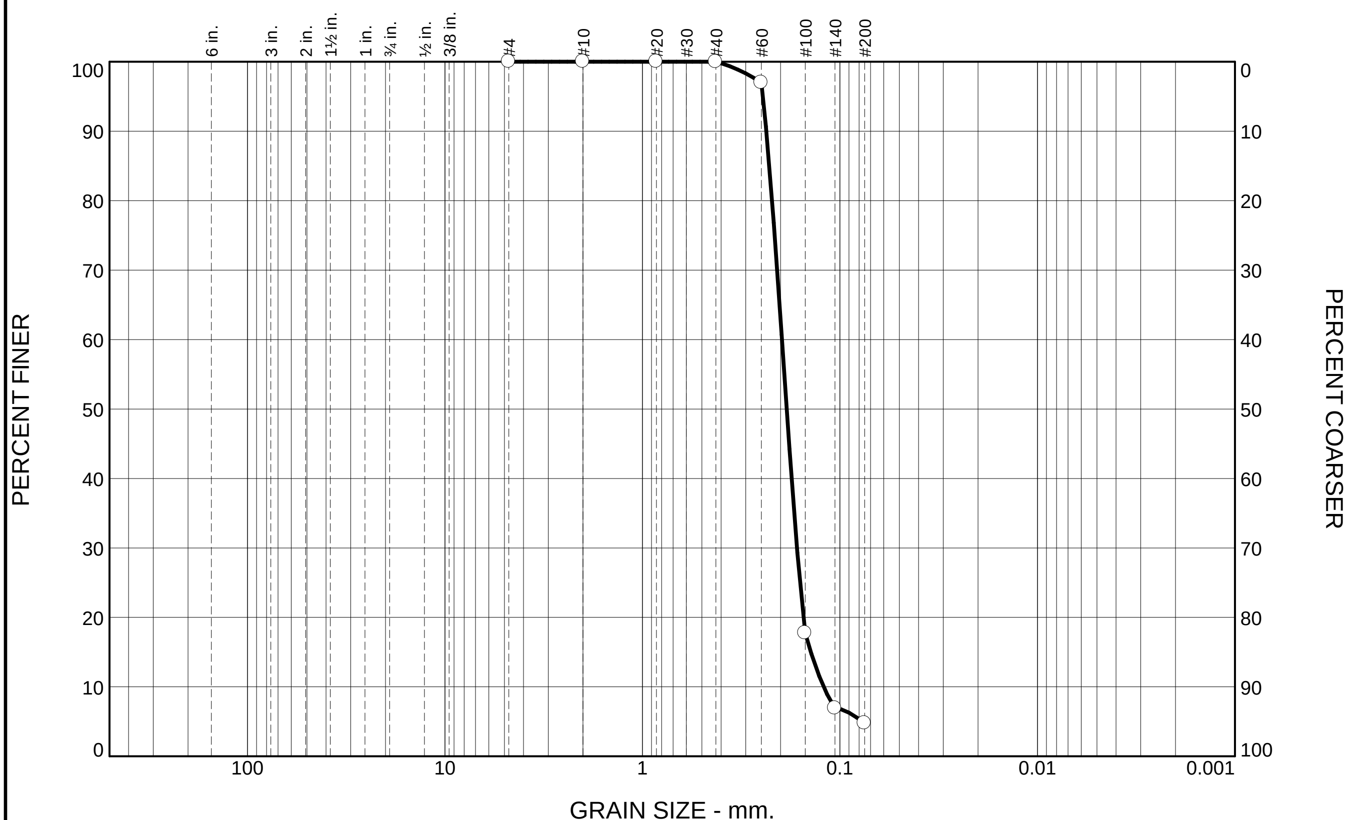
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	2.9	2.9	2.5	11.1	78.5	92.1			5.0

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
	0.1459	0.1631	0.1764	0.2005	0.2249	0.2521	0.2851	0.3915	0.4437	0.5624	2.1981

Fineness Modulus	C_u	C_c
1.51	1.95	0.97

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.0	95.2	4.8	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	100.0		
#20	100.0		
#40	100.0		
#60	97.0		
#100	17.7		
#140	6.9		
#200	4.8		

* (no specification provided)

Material Description

light brown poorly graded SAND

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.2359 D_{85}= 0.2278 D_{60}= 0.1967
D_{50}= 0.1861 D_{30}= 0.1652 D_{15}= 0.1404
D_{10}= 0.1209 C_u= 1.63 C_c= 1.15

Classification

USCS= SP AASHTO=

Remarks

Lab No.: 167

Location: GT-6
Sample Number: S-9 **Depth:** 29.0' - 31.0' **Date:** 4/1/22

7NT

Client: GZA
Project: House Street RAP - House Street, Michigan
Project No: L193-MI **File**

GRAIN SIZE DISTRIBUTION TEST DATA

4/1/2022

Client: GZA
Project: House Street RAP - House Street, Michigan
Project Number: L193-MI
Location: GT-6
Depth: 29.0' - 31.0' **Sample Number:** S-9
Material Description: light brown poorly graded SAND
Date: 4/1/22
USCS Classification: SP
Testing Remarks: Lab No.: 167

Sieve Test Data

Dry Sample and Tare (grams)	Tare (grams)	Cumulative Pan Tare Weight (grams)	Sieve Opening Size	Cumulative Weight Retained (grams)	Percent Finer	Percent Retained
361.39	13.58	0.00	#4	0.00	100.0	0.0
			#10	0.00	100.0	0.0
101.96	0.00	0.00	#20	0.00	100.0	0.0
			#40	0.01	100.0	0.0
			#60	3.07	97.0	3.0
			#100	83.87	17.7	82.3
			#140	94.90	6.9	93.1
			#200	97.10	4.8	95.2

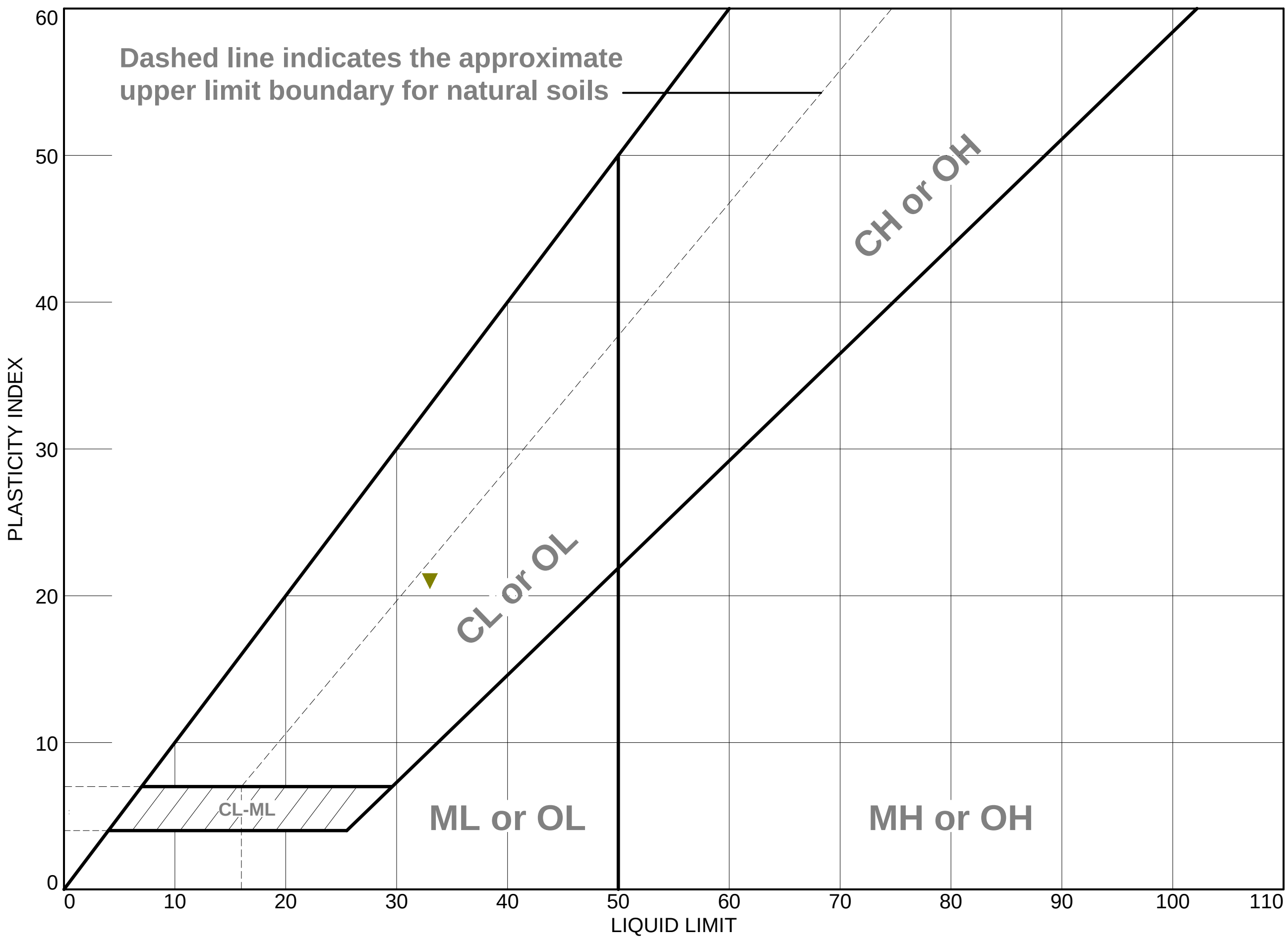
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.0	0.0	0.0	0.0	95.2	95.2			4.8

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
0.0770	0.1209	0.1404	0.1532	0.1652	0.1758	0.1861	0.1967	0.2206	0.2278	0.2359	0.2455

Fineness Modulus	C_u	C_c
0.84	1.63	1.15

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	light brown poorly graded SAND	NV	NP	NP	99.9	2.2	SP
■	light brown poorly graded SAND	NV	NP	NP	96.9	0.7	SP
▲	brown poorly graded SAND	NV	NP	NP	98.1	3.7	SP
◆	brown poorly graded SAND	NV	NP	NP	97.7	2.0	SP
▼	brown lean CLAY (visual)	33	12	21			

Project No. L193-MI **Client:** GZA

Project: House Street RAP - House Street, Michigan

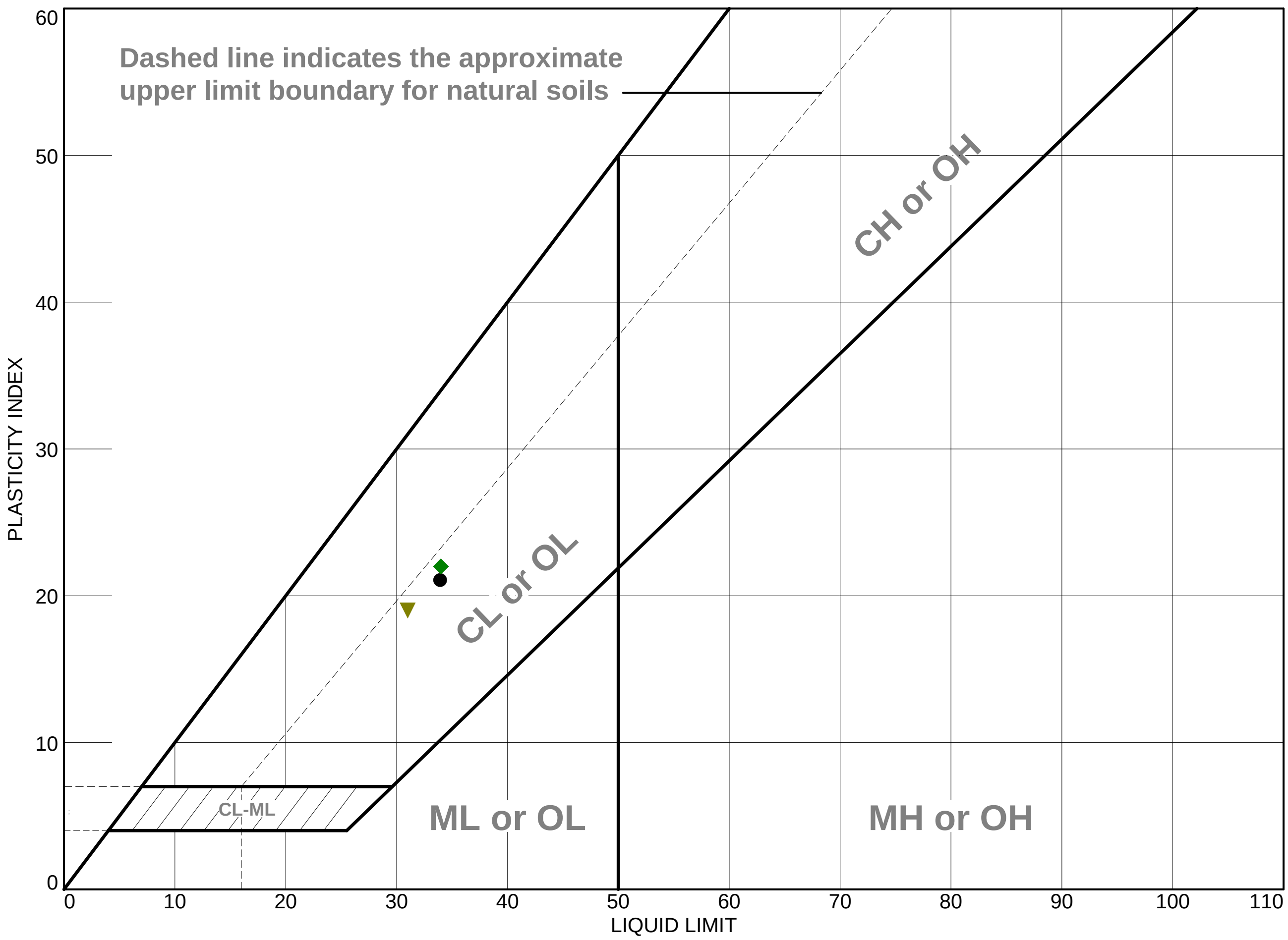
●**Location:** GT-1 **Depth:** 6.0' - 8.0' **Sample Number:** S-4
■**Location:** GT-1 **Depth:** 17.0' - 19.0' **Sample Number:** S-7
▲**Location:** GT-1 **Depth:** 23.0' - 25.0' **Sample Number:** S-10
◆**Location:** GT-1 **Depth:** 25.0' - 35.0' **Sample Number:** Bucket
▼**Location:** GT-2 **Depth:** 2.0' - 4.0' **Sample Number:** S-2

7NT

Remarks:
▼Lab No.: 167

File

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	brown sandy lean CLAY	34	13	21	91.4	66.4	CL
■	brown poorly graded SAND	NV	NP	NP	98.4	1.5	SP
▲	brown poorly graded SAND	NV	NP	NP	98.9	3.7	SP
◆	brown lean CLAY (visual)	34	12	22			
▼	brown sandy lean CLAY	31	12	19	94.1	64.9	CL

Project No. L193-MI **Client:** GZA

Project: House Street RAP - House Street, Michigan

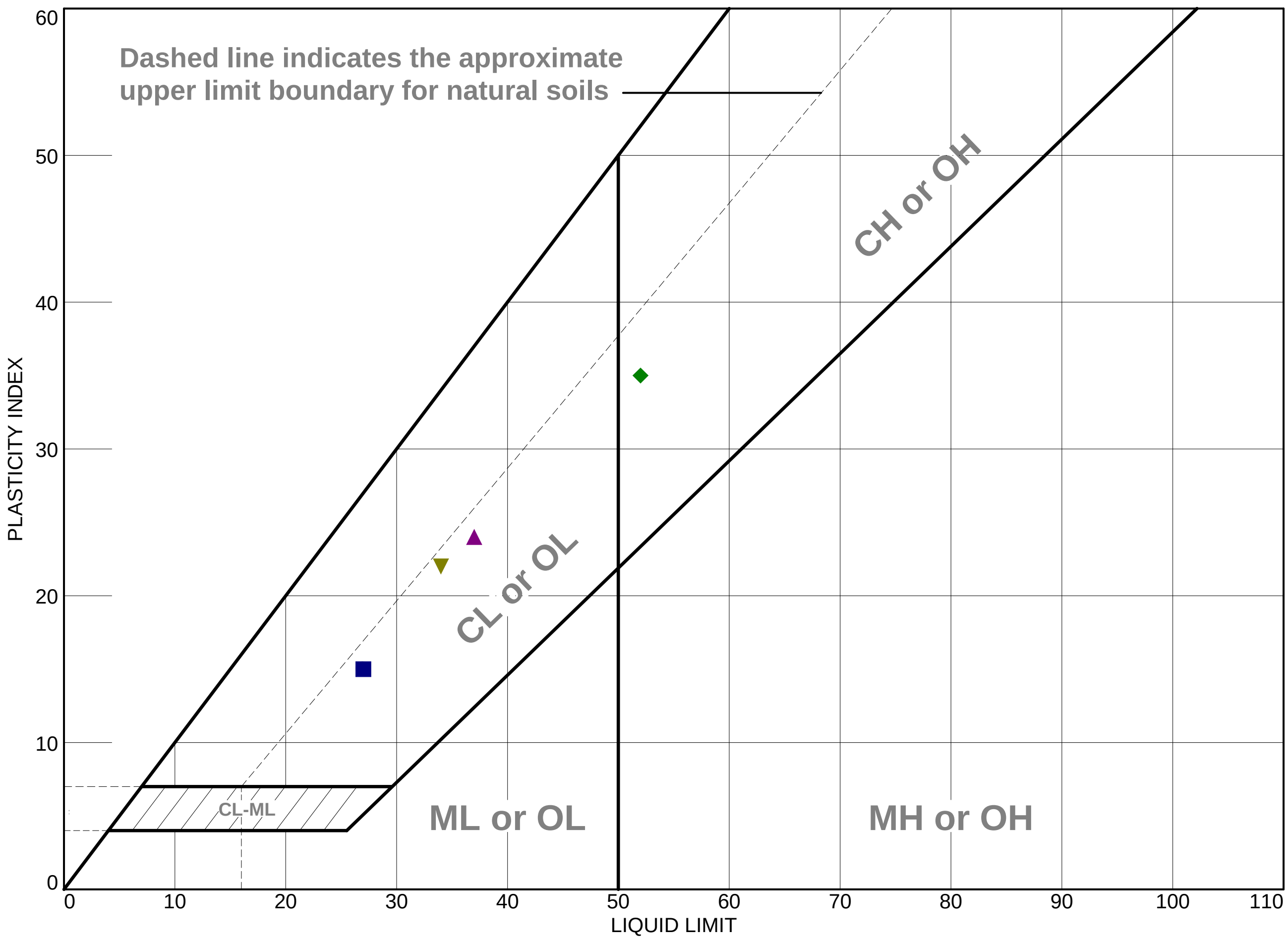
●**Location:** GT-2 **Depth:** 6.0' - 8.0' **Sample Number:** S-4
■**Location:** GT-2 **Depth:** 30.0' - 40.0' **Sample Number:** Bucket
▲**Location:** GT-2 **Depth:** 33.0' - 35.0' **Sample Number:** S-14
◆**Location:** GT-3 **Depth:** 2.0' - 4.0' **Sample Number:** S-2
▼**Location:** GT-3 **Depth:** 4.0' - 6.0' **Sample Number:** S-3

7NT

Remarks:
●Lab No.: 167
◆Lab No.: 167
▼Lab No.: 167

File

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	brown lean CLAY (visual)	27	12	15			
■	brown sandy lean CLAY	27	12	15	94.7	50.7	CL
▲	brown lean CLAY (visual)	37	13	24			
◆	brown fat CLAY (visual)	52	17	35			
▼	brown lean CLAY (visual)	34	12	22			

Project No. L193-MI **Client:** GZA

Project: House Street RAP - House Street, Michigan

●**Location:** GT-3 **Depth:** 6.0' - 8.0' **Sample Number:** S-4 (Top)
■**Location:** GT-4 **Depth:** 0.0' - 2.0' **Sample Number:** S-1
▲**Location:** GT-4 **Depth:** 4.0' - 6.0' **Sample Number:** S-3
◆**Location:** GT-5 **Depth:** 24.0' - 26.0' **Sample Number:** S-8
▼**Location:** GT-6 **Depth:** 4.0' - 6.0' **Sample Number:** S-3

7NT

Remarks:
●Lab No.: 167
Top 7" of Sample
■Lab No.: 167
▲Lab No.: 167
◆Lab No.: 167
▼Lab No.: 167

File

7NT

ASTM D2216 - Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

Client: GZA
Project: House Street RAP - House Street, Michigan

Lab No.: 167
Project No.: L193-MI
Date: 4/8/2022

Boring Number	Sample Number	Depth (ft)	Depth (m)	Moisture Content (%)	Comments
GT-1	S-4	6.0 - 8.0	1.8 - 2.4	7.9	
GT-1	S-7	17.0 - 19.0	5.2 - 5.8	6.2	
GT-1	S-10	23.0 - 25.0	7.0 - 7.6	3.4	
GT-1	S-11	25.0 - 27.0	7.6 - 8.2	15.2	
GT-2	S-2	2.0 - 4.0	0.6 - 1.2	14.5	
GT-2	S-4	6.0 - 8.0	1.8 - 2.4	12.0	
GT-2	S-6	14.0 - 16.0	4.3 - 4.9	4.0	
GT-2	S-8	21.0 - 23.0	6.4 - 7.0	2.8	
GT-2	S-11	27.0 - 29.0	8.2 - 8.8	1.9	
GT-2	S-14	33.0 - 35.0	10.1 - 10.7	19.3	
GT-3	S-2	2.0 - 4.0	0.6 - 1.2	17.1	
GT-3	S-3	4.0 - 6.0	1.2 - 1.8	16.9	
GT-4	S-1	0.0 - 2.0	0.0 - 0.6	13.7	
GT-4	S-3	4.0 - 6.0	1.2 - 1.8	16.6	
GT-5	S-8	24.0 - 26.0	7.3 - 7.9	24.7	
GT-6	S-3	4.0 - 6.0	1.2 - 1.8	19.7	

Planned Retention Basin Drainage (via Infiltration)

From StormWater Run-off Estimation

Water Volume in retention Basin from 24-hr, 100-yr storm — $87,100 \text{ ft}^3$

Reten Basin Footprint @ El. 750 — $32,000 \text{ ft}^2$

Water Depth at Peak Water Storage — 2.7 ft.

Time estimate for Retention Basin Drainage (use infiltration rate of $1 \times 10^{-3} \frac{cm}{sec}$)

$$\left(\frac{87{,}100 \text{ ft}^3}{32{,}000 \text{ ft}^2}\right)\left(\frac{1}{1\times10^{-3}\ \frac{cm}{sec}}\right)\left(\frac{2.54 \text{ cm}}{in}\right)\left(\frac{12 \text{ in}}{ft}\right)\left(\frac{1 \text{ min}}{60 \text{ sec}}\right)\left(\frac{1 \text{ hr}}{60 \text{ min}}\right)\left(\frac{1 \text{ day}}{24 \text{ hrs}}\right) = 1 \text{ day}$$

Infiltration rate of $1 \times 10^{-3} \frac{cm}{sec}$ is conservative.

Field & Laboratory estimates of permeability range from:

Soils Lab permeability tests (2): $2.6 \times 10^{-2} \frac{cm}{sec}$ and $9.8 \times 10^{-3} \frac{cm}{sec}$
(samples retrieved from El. 750 – El. 740)

Falling Head Test w/i Drill Augers (2) $1.3 \times 10^{-2} \frac{cm}{sec}$ and $8.8 \times 10^{-2} \frac{cm}{sec}$

Kozeny-Carman Approximation from Soils Lab Gradation Tests $8.1 \times 10^{-3} \frac{cm}{sec}$ to $3.6 \times 10^{-2} \frac{cm}{sec}$.

GeoTesting EXPRESS

Client:	7NT Engineering, LLC		
Project Name:	House Street RAP		
Project Location:	Michigan		
GTX #:	315374		
Start Date:	05/06/22	Tested By:	sjt
End Date:	05/11/22	Checked By:	jsc
Boring #:	GT-1		
Sample #:	Bucket		
Depth:	25-35		
Visual Description:	Moist, yellow sand		

Permeability of Granular Soils (Constant Head) by ASTM D2434

Sample Type: Remolded

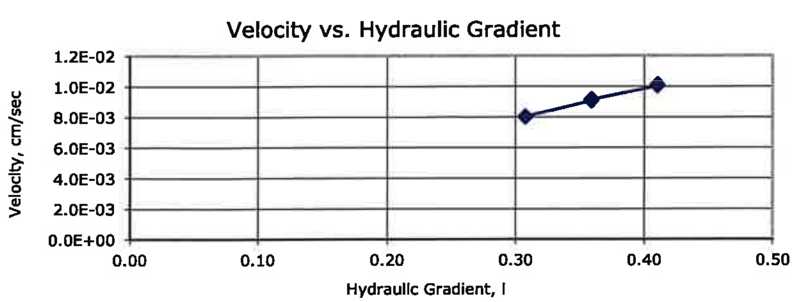
Sample Information:

Maximum Dry Density:	--- pcf	
Optimum Moisture Content:	--- %	
Compaction Test Method:	---	
Classification (ASTM D2487):	---	
Assumed Specific Gravity:	2.65	

Sample Preparation / Test Setup: Test specimen compacted with medium effort at air-dried moisture content.

Parameter	Initial	Final
Height, in	4.00	3.90
Diameter, in	4.00	4.00
Area, in^2	12.6	12.6
Volume, in^3	50.3	49.0
Mass, g	1290	1588
Bulk Density, pcf	97.8	123.4
Moisture Content, %	0.3	23.8
Dry Density, pcf	97.5	99.7
Degree of Saturation, %	---	95.6
Void Ratio, e	---	0.66

Date	Reading #	Volume of Flow, cc	Time of Flow, sec	Flow Rate, cc/sec	Gradient	Permeability, cm/sec	Temp., °C	Correction Factor	Permeability @ 20 °C, cm/sec
5/10	1	19.5	30	0.65	0.31	2.6E-02	19.0	1.025	2.7E-02
5/10	2	19.4	30	0.65	0.31	2.6E-02	19.0	1.025	2.7E-02
5/10	3	19.5	30	0.65	0.31	2.6E-02	19.0	1.025	2.7E-02
5/10	4	22.0	30	0.73	0.36	2.5E-02	19.1	1.023	2.6E-02
5/10	5	22.2	30	0.74	0.36	2.5E-02	19.1	1.023	2.6E-02
5/10	6	22.2	30	0.74	0.36	2.5E-02	19.1	1.023	2.6E-02
5/10	7	24.3	30	0.81	0.41	2.4E-02	19.1	1.023	2.5E-02
5/10	8	24.4	30	0.81	0.41	2.4E-02	19.1	1.023	2.5E-02
5/10	9	24.5	30	0.82	0.41	2.5E-02	19.1	1.023	2.5E-02



PERMEABILITY @ 20 °C = 2.6×10^{-2} cm/sec

GeoTesting EXPRESS

Client:	7NT Engineering, LLC		
Project Name:	House Street RAP		
Project Location:	Michigan		
GTX #:	315374		
Start Date:	05/06/22	Tested By:	sjt
End Date:	05/11/22	Checked By:	jsc
Boring #:	GT-2		
Sample #:	Bucket		
Depth:	30-40		
Visual Description:	Moist, yellow sand		

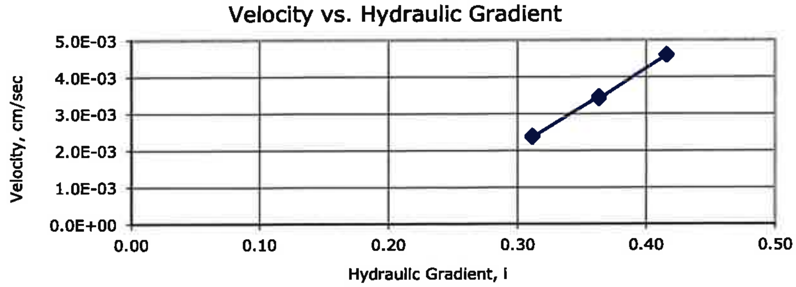
Permeability of Granular Soils (Constant Head) by ASTM D2434

Sample Type:	Remolded	
Sample Information:	Maximum Dry Density:	--- pcf
	Optimum Moisture Content:	--- %
	Compaction Test Method:	---
	Classification (ASTM D2487):	---
	Assumed Specific Gravity:	2.65
Sample Preparation / Test Setup:	Test specimen compacted with medium effort at air-dried moisture content.	

Parameter	Initial	Final
Height, in	4.00	3.85
Diameter, in	4.00	4.00
Area, in^2	12.6	12.6
Volume, in^3	50.3	48.4
Mass, g	1275	1572
Bulk Density, pcf	96.7	123.8
Moisture Content, %	0.1	23.9
Dry Density, pcf	96.6	99.9
Degree of Saturation, %	---	96.5
Void Ratio, e	---	0.66

Date	Reading #	Volume of Flow, cc	Time of Flow, sec	Flow Rate, cc/sec	Gradient	Permeability, cm/sec	Temp., °C	Correction Factor	Permeability @ 20 °C, cm/sec
5/10	1	5.8	30	0.19	0.31	7.7E-03	17.8	1.057	8.1E-03
5/10	2	5.8	30	0.19	0.31	7.7E-03	17.8	1.057	8.1E-03
5/10	3	5.8	30	0.19	0.31	7.6E-03	17.8	1.057	8.0E-03
5/10	4	8.4	30	0.28	0.36	9.5E-03	18.1	1.049	1.0E-02
5/10	5	8.3	30	0.28	0.36	9.4E-03	18.1	1.049	9.9E-03
5/10	6	8.3	30	0.28	0.36	9.4E-03	18.1	1.049	9.8E-03
5/10	7	11.1	30	0.37	0.42	1.1E-02	18.2	1.046	1.2E-02
5/10	8	11.2	30	0.37	0.42	1.1E-02	18.2	1.046	1.2E-02
5/10	9	11.2	30	0.37	0.42	1.1E-02	18.2	1.046	1.2E-02

Velocity vs. Hydraulic Gradient



PERMEABILITY @ 20 °C =

9.8 x 10^{-3} cm/sec

ATTACHMENT B

CONSTRUCTION QUALITY ASSURANCE AND QUALITY CONTROL PLAN

Rose & Westra
A Division of GZA

GEOTECHNICAL
ENVIRONMENTAL
ECOLOGICAL
WATER
CONSTRUCTION MANAGEMENT

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Grand Rapids, MI 49504
T: 616.956.6123
F: 616.288.3327
www.rosewestra.com
www.gza.com

HOUSE STREET FINAL REMEDY
CQA PLAN

1855 HOUSE STREET NE
Plainfield Township, Kent County, Michigan

December 2022
File No. 16.0062961.81

PREPARED FOR:
Wolverine World Wide, Inc.
Rockford, Michigan

Rose & Westra, a Division of GZA GeoEnvironmental, Inc.
601 Fifth Street NW | Suite 102 | Grand Rapids, MI 49504
616-956-6123

30 Offices Nationwide
www.GZA.com

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ACRONYMS

ASTM	American Society for Testing and materials
CQA	Construction Quality Assurance
CQAP	Construction Quality Assurance And Quality Control Plan
cy	Cubic Yards
EGLE	Michigan Department of Environment, Great Lakes and Energy
FE	Field Engineer/Technician
HSP	House Street Property, also referred to as Site
LLDPE	Linear Low-Density Polyethylene
LM	Laboratory Manager
MDOT	Michigan Department of Transportation
mph	Miles Per Hour
PIC	Principal-In-Charge
PM	Project Manager
psi	pounds per square inch
QA	Quality Assurance
QA/QC	Quality Assurance/Quality Control
RAP	Remedial Action Plan
R&W/GZA	Rose & Westra, a Division of GZA GeoEnvironmental, Inc.
USACOE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency

1.0 INTRODUCTION

This Construction Quality Assurance (CQA) Plan has been prepared for the House Street Property (HSP) Cap final remedy construction estimated to be completed from 2023 through 2026 . The plan presents the CQA Program, which has been developed and will be implemented under the direction of a CQA Officer who is a registered professional engineer. This CQA Plan presents the staffing organization for monitoring construction of this project, the reporting chain-of-command, and the project and experience requirements of individuals. The plan also addresses the CQA requirements for each material/component in the cap or final cover system design planned as the final remedy. Testing and sampling frequency, test methods (field and laboratory), equipment calibration standards, and criteria for satisfactory test performance are discussed.

2.0 STAFF ORGANIZATION

This section describes the CQA staff organization and reporting procedures for monitoring the final remedy construction of the HSP Cap. The responsibilities and typical experience backgrounds of the CQA staff are described below.

2.1 PRINCIPAL-IN-CHARGE (PIC)

The Principal-in-Charge, also referred to generically as the Engineer in this document, is responsible for technical and administrative aspects of the construction monitoring program. The PIC reviews work done by the project manager and consults with the project manager regularly. This individual must be experienced in capping and remedial action engineering projects. The PIC is required to be a civil engineer with over 20 years of experience and hold a license to practice engineering in the State of Michigan.

2.2 PROJECT MANAGER (PM)

The Project Manager manages the day-to-day technical and administrative aspects of the project and reports directly to the PIC. The PM directly supervises the field (QA/QC) testing and sampling, coordinates the sub-consultant activities (if any) and monitors the laboratory testing. The PM is also the primary contact with the Owner, Contractor, and the State of Michigan, Department of Environment, Great Lakes, and Energy (EGLE). The PM performs in-house quality control for the CQA staff by reviewing the technical issues presented in reports and designs and recommendations presented in correspondence. This individual must have demonstrated experience in engineering and construction aspects related to remedial action and/or capping engineering projects.

2.3 CONSTRUCTION QUALITY ASSURANCE ENGINEER

This individual is the lead field representative responsible for implementing the field CQA program and coordinating CQA for laboratory testing. The Construction Quality Assurance (CQA) Engineer reports directly to the PM, with at least daily updates. The individual's duties vary depending on the construction activities occurring. Where there are several construction activities occurring concurrently, the project engineer may at times supervise several field engineers/technicians. The CQA staff is responsible for assigning these individuals to the various construction activities, supervising field tests, collecting soil and geomembrane samples for laboratory testing and delivering samples to the laboratory. This individual is also required to prepare daily field summary reports that describe each day's construction and construction monitoring activities. The CQA staff coordinates sub-consultant field activities and is responsible for reporting field test data to the Owner and the sub-consultant’s field representative, if applicable. If the project has only one construction activity in progress that requires field testing, this individual will perform the duties of a field engineer/technician described below.

The CQA staff will be a Professional Engineer licensed in the State of Michigan or under the direction of a Professional Engineer licensed in the State of Michigan, experienced with remedial action engineering and construction.

2.4 FIELD ENGINEER/TECHNICIAN (FE)

This individual is responsible for implementing the QA/QC program in the field by making in-place measurements and collecting soil and geomembrane destructive samples at the specified frequency. The FE prepares daily field reports summarizing the construction activity and the field test results. The FE reports directly to the Project Engineer and submits a copy of the field test data to the Contractor's Representative.

This individual is typically a civil engineer, an engineering technician, or other personnel with appropriate experience.

2.5 SOILS LABORATORY

All laboratory tests on soil samples for this project are expected to be done in a qualified independent geotechnical laboratory. Tests will be completed in general accordance with the American Society for Testing and Materials (ASTM) standards listed below.

Test Designation	Standard No.
Method for Particle Size Analysis of Soils	ASTM D422
Test Method for Moisture-Density Relations of Soils and Soil Aggregate Mixtures Using 10-pound (4.54 kg) Rammer and 18-inch (457 mm) Drop	ASTM D1557
Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil Aggregate Mixtures	ASTM D2216
Practice for Wet Preparation of Soil Samples for Particle Size Analysis and Determination of Soil Constants	ASTM D2217
Test Method for Permeability of Granular Soils (Constant Head)	ASTM D2434
Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils	ASTMD4318
Test Method Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter	ASTM D5084

Equipment used for the above listed tests will be calibrated in accordance with the applicable, accepted standards. Scales used in the tests will be calibrated annually using weights traceable to the National Bureau of Standards. Pressure gauges and transducers are typically calibrated annually.

Soil tests in the laboratory will be performed by or supervised by the laboratory manager (LM), who will have 5 or more years of soils laboratory testing experience. The LM reports the data and testing status to the Project Manager.

Geomembrane samples are to be tested by a subcontracted testing laboratory. The testing laboratory must have documented experienced with geomembrane testing and testing must be performed by experienced technicians. Test procedures generally follow ASTM D 6392/GRI GM19/D 4437/NSF 54/882 mod.

3.0 WASTE GRADE PREPARATION AND EXCAVATION

3.1. WASTE GRADE PREPARATION

The Contractor is responsible for completing all Site work necessary to comply with the project design and specifications. This work includes but is not limited to: filling and grading the waste material mounds to their approximate design grades and slopes prior to construction of the cover system; working the final surface to match the design grades; and removing any protrusions, sharp objects, and irregularities to provide a stable, uniform surface to construct the cover system. The CQA staff will monitor the waste material mound grade preparation to verify through periodic spot checks that the surface appears stable and uniform and that irregularities and other unsuitable materials have been removed from the surface.

Prior to placement of the geomembrane (40-mil limited low density polyethylene (LLDPE)), the waste mound finished grade will be checked to confirm it is in a stable condition and tracked or rolled with a static smooth drum roller (without vibration). Representative samples of the finish grade waste mound surface shall be collected at a frequency of 1-sample per acre and tested for gradation and permeability. Permeability testing shall demonstrate a surface layer with a permeability of greater (more permeable) than or equal to 1×10^{-3} cm/sec.

3.2. EXCAVATION

The Contractor is required to perform all necessary excavation to construct the cover system, anchor trenches, drainage structures and other Site improvements. The CQA staff, or designee, will observe the condition of the subgrade surface following excavation and before placement of overlying fill. Excavation subgrades will be verified by survey for proper dimensions and subgrade conditions for tie-in of the cover system to the existing Site grades. Areas that reveal deleterious materials or disturbed or weathered (softened and/or desiccated) subgrade conditions will be identified by CQA staff to the Contractor so that these areas can be properly excavated before fill placement.

3.3. SURVEY MEASUREMENTS

An independent, Michigan-licensed professional Surveyor will make pre-construction survey measurements prior to construction activities, then again after the Site mounds have been re-graded to the final waste material grades, but before final cover system construction begins. The Surveyor will establish a grid or baseline system to take ground surface elevation measurements at a 50-foot grid or less. Measurements will also be made at changes in slope and angle points. These data shall be compared to post-construction data to assist in determining compliance with the general intent of the RAP. Survey measurements will also be conducted following placement of cover soil and topsoil to document the cap component thicknesses. Auger probes, survey standpipes, or other suitable methods may be necessary to measure final cover system component thicknesses if survey measurements indicate settlement has occurred. The Contractor will be required to complete all auger probes, standpipe installations and any other methods used to supplement optical survey measurements in the presence of the Project Engineer and/or the Surveyor.

In addition, the Surveyor will survey the limits of excavations of waste material outside of the mound limits to document the waste relocation that occurs. These measurements will be compared to pre-construction survey data to estimate the quantity of waste relocated. Waste relocation will occur prior to survey measurements of the final top-of-waste / bottom-of-cap surface.

Locations not within design tolerances shall be re-graded and re-measured.

4.0 GAS VENT RISER INSTALLATION

4.1. EXCAVATION

The CQA staff will monitor installation of the gas venting risers (and associated piezometers, as applicable) to check that the bottom of the riser pipe extends as shown and specified.

4.2. GAS VENT PIPE

The CQA staff will observe the pipe used for the gas vents and collection/transfer lines and the installation procedures and compare those to the plans and specifications. Additional QA/QC requirements for the gas venting pipes are presented in Section 7.00, Pipes.

4.3. SURVEY MEASUREMENTS

The Surveyor will stake the locations of the gas vents and the CQA staff will verify that the bottom of the gas vent riser extends a sufficient depth below the top of waste to the design depth. Following construction of the gas vent riser pipes, the Surveyor will measure the location of each gas vent riser, with bottom of gas vent riser depth/elevation and record all gas vent riser pipe locations and elevations on the Project Record Drawings.

5.0 SOIL MATERIALS

5.1 REFERENCE STANDARDS

Test methods for all soil materials will be carried out in accordance with procedures developed by the ASTM, United States Army Corps of Engineers (USACOE) and United States Environmental Protection Agency (USEPA), as applicable. **Table 1** lists the tests that may be required during this project and the appropriate test method reference. Substitution of a method other than that specified in **Table 1** for a particular test is subject to the approval of the Engineer. Also, the use of test methods for those tests not listed in **Table 1** that are deemed necessary for the work during construction are subject to the approval of the Engineer.

TABLE 1
ACCEPTED REFERENCES FOR TESTING OF CONSTRUCTION MATERIALS

Test Designation	Reference
Particle-Size Analysis of Soils, Combined Sieve and Hydrometer Analysis	ASTM D-422
Moisture-Density-Relations of Soil and Soil-Aggregate Using 5.5lb Rammer and 12-inch Drop (Standard Proctor)	ASTM D-698
Moisture-Density-Relations of Soil and Soil-Aggregate mixtures using 10-pound. Rammer and 18-inch Drop-(Modified Proctor)	ASTM D-1557
Specific Gravity of Soils	ASTM D-854
Amount of Material in Soils Finer than the No. 200 Sieve	ASTM D-1140
Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil- Aggregate Mixtures	ASTM D-2216
Permeability of Granular Soils (Constant Head)	ASTM D-2434
Density of Soil and Soil Aggregate in Place by Nuclear Methods (Shallow Depth)	ASTM D-2922
Moisture Content of Soil and Soil-Aggregate in-Place by Nuclear Methods(Shallow Depth)	ASTM D-3017
Maximum Index Density of Soils Using a Vibratory Table	ASTM D-4253
Minimum Index Density of Soils and Calculation of Relative Density	ASTM D-4254

Liquid Limit, Plastic Limit and Plasticity Index of Soils	ASTMD-4318
Consolidated Drained and Consolidated Undrained Triaxial Compressive Strength	USACOE EM 1110-2-1906
Permeability Test (Constant Head in Triaxial cell with Back Pressure Saturation)	ASTM D-5084
Organic Content of Soils	ASTM D-2974
pH of Soils	ASTM D-4972

5.2 GAS VENT RISER STONE

5.2.1 Pre-Construction Material Evaluation

It is expected that gas vent riser stone shall be obtained from a Michigan Department of Transportation (MDOT) approved source. If a non-approved source is proposed, then the Contractor shall be required to provide additional pre-construction laboratory test data to demonstrate that the proposed source meets MDOT standards, as specified.

The CQA staff will collect one sample of the gas vent riser stone from the proposed source before construction. The gradation of the sample and its permeability shall be measured to estimate the material conformance to specifications.

5.2.2 Construction Quality Evaluation

5.2.2.1 Sampling

The CQA staff will observe and document the particle size distribution of the gas vent riser stone as it is placed and estimate its compliance with specifications. If it appears that the particle size distribution has changed, the CQA staff will be required to collect a sample for testing. One sample of the gas vent riser stone is to be collected as a minimum during construction for laboratory testing. It is estimated that under 50 cubic yards (cy) of gas vent riser stone are required during HSP Cap installation. Therefore, 3 samples will be collected for grain size analysis and one sample collected for permeability testing.

5.2.2.2 Laboratory Testing

Collected samples of the gas vent riser stone will be tested for gradation and permeability prior to installation. If gas vent riser stone/coarse aggregate particle size distribution data fail to meet the required criteria, the CQA staff will notify the Contractor to replace the stone with material that satisfies the project specifications.

5.2.3 Measurements

The CQA staff will verify that the gas vent riser stone is generally placed to the design lines and grades.

5.3 BARRIER PROTECTION LAYER

5.3.1 Preconstruction Material Evaluation

The Contractor will collect one sample of the barrier protection layer material from the proposed source before construction and deliver it to the soil's laboratory for testing. The particle size distribution and Atterberg limits of the sample will be measured to estimate the material's conformance to specifications. If the sample satisfies the specifications, then the soil will be tested for the moisture-density relationship using the modified Proctor test to establish parameters for field control. Reconstituted permeability testing will also be done.

5.3.2 Construction Quality Evaluation

5.3.2.1 Field Tests and Sampling

The CQA staff is responsible to collect one (1) bulk sample of barrier protection layer material for each 10,000 cy placed during construction. If significant changes in the material are visually noticed, then additional samples will be collected.

The CQA staff will observe the barrier protection layer material being placed to check that the material is placed in a manner that does not damage the underlying geosynthetics. The CQA staff will measure the in-place dry density and moisture content of the compacted barrier protection layer at a rate of nine tests per lift per acre of material placed to assess conformance with the specifications. If a test fails to satisfy the specified dry density or moisture criteria, the CQA staff will require additional tests be made around the location having the failing test data to identify the extent of material that is not in compliance with the specifications.

The Contractor will make additional compactor passes and adjusting the moisture content as needed to remediate the non-compliant area. Verification that the remedial efforts were successful will depend upon the in-place dry density and moisture content measurements obtained by the CQA staff.

5.3.2.2 Laboratory Testing

Each bulk sample collected will be tested for Atterberg limits, gradation, modified Proctor and reconstituted permeability. If the test results are comparable to preconstruction test results, no further action is needed. However, should the test results indicate the soil properties have changed, the field control parameters will be reviewed, modified and additional samples will be collected for further testing.

5.3.3 Survey Measurements

The Surveyor will measure the elevation of the top of the barrier protection layer following construction in the same horizontal location that measurements were made after final grading of the top of waste was completed, to calculate the thickness of the barrier protection layer. Hand auger methods and/or standpipes may be used to supplement the layer thickness measurements for reasons described previously. Any excavation method used to supplement optical survey measurements will be done by the Contractor in the presence of the CQA staff or the Surveyor. Locations not within design tolerances shall be re-graded and locations re-measured.

5.4 <u>TOPSOIL</u>

5.4.1 Preconstruction Material Evaluation

Topsoil from both on-Site and from an off-Site source shall be sampled and tested. It is estimated that about 30,000 CY of topsoil will be placed/regraded. Therefore, a sample shall be collected for every 5,000 CY of topsoil placed/regraded. Each sample will be tested for PFAS, gradation, pH, and organic content to evaluate the suitability of each proposed source to satisfy the project specifications.

5.4.2 Construction Quality Evaluation

As noted above, one (1) sample of topsoil material for each 5,000 cy placed will be collected during prior to construction and tested for PFAS, gradation, pH and organic content to evaluate suitability. Additional samples will be collected if the CQA staff visually observes that the material is not likely to meet the specifications. Should the soil laboratory test results not meet the required criteria, The CQA staff will notify the Owner and Contractor and recommend procedures to remediate topsoil placed that may not be in compliance with project specifications. Only topsoil that meets the specified criteria will be placed.

5.4.3 Survey Measurements

The Surveyor will measure the elevation of the topsoil following construction in the same locations that measurements were made after the barrier protection layer construction was completed to calculate the thickness of the topsoil layer. Hand auger methods and/or standpipes may be used to supplement the layer thickness measurements for reasons described previously. Locations not within design tolerances shall be regraded and the locations remeasured. Excavation methods used to supplement optical survey measurements will be done by the Contractor in the presence of the CQA staff and/or Surveyor. The Surveyor will also measure the limit and thickness of topsoil placed outside the limit of the final cover system.

5.5 <u>COARSE AGGREGATE</u>

5.5.1 Pre-Construction Material Evaluation

It is expected that coarse aggregate will be obtained from a MDOT-approved source. If a non-approved source is proposed, then the Contractor is required to provide additional pre-construction laboratory test data to demonstrate that the proposed source meets MDOT standards, as specified.

The CQA staff will collect one sample of the coarse aggregate from the proposed source before construction to estimate the material conformance to specifications.

5.5.2 Pre-Construction Material Evaluation

5.5.2.1 Sampling

The CQA staff will visually observe the particle size distribution of the coarse aggregate as it is placed and estimate its compliance with specifications. If it appears that the particle size distribution has changed, The CQA staff will collect a sample for testing. One sample of the coarse aggregate will be collected at a minimum during construction for laboratory testing.

5.5.2.2 Laboratory Testing

The coarse aggregate sample collected will be tested for gradation. If coarse aggregate particle size distribution data fail to meet the required criteria, the Contractor will be notified, and no additional material placed until material is supplied which meets the specified requirements.

5.5.3 Measurements

The CQA staff, or designee, will document the locations of the coarse aggregate following construction and compare them to the design. Locations not within design compliance will be re-graded and the locations re-measured as appropriate.

5.6 <u>CRUSHED STONE</u>

5.6.1 Pre-Construction Material Evaluation

Crushed stone will be obtained from a MDOT-approved source. No pre-construction samples are required.

5.6.2 Construction Quality Evaluation

No construction samples are required.

5.6.3 Measurements

The CQA staff will verify that the crushed stone is generally placed to meet the design intent.

5.7 RIP RAP

5.7.1 Pre-Construction Material Evaluation

It is expected that riprap will be supplied by a MDOT-approved source. The Contractor will provide a certificate of compliance from the riprap supplier, along with gradation test data to confirm the supplied riprap meets the project specifications. If a non-approved source is proposed, then the Contractor will be required to provide additional laboratory test data to demonstrate that the proposed source meets the MDOT standards, as specified.

5.7.2 Construction Quality Evaluation

5.7.2.1 Field Tests and Sampling

The CQA staff will visually observe the riprap as it is unloaded at the Site and compare the visual observations to the appropriate gradation specification. The QA Engineer will require additional samples of riprap be tested for gradation during construction if visual observations suggest that the riprap is not in compliance with the specifications.

6.0 GEOSYNTHETICS

6.1. GEOTEXTILE

6.1.1 Preconstruction Material Evaluation

Prior to product delivery to the Site, the geotextile supplier will furnish certificates of compliance for the geotextile delivered to the Site. The geotextile supplier/ manufacturer will provide copies of manufacturer's conformance test data, and Independent Laboratory test data of the Geotextile for the parameters specified, at the sample rates shown in the specifications.

The CQA staff will review the test data and compare them to the specifications. Rolls not meeting specifications will be identified and the CQA staff will notify the Contractor that those rolls are not to be installed. The CQA staff will observe the storage of rolls delivered to the Site and the procedures used to shelter them from sunlight, storm water and construction traffic.

6.1.2 Construction Quality Evaluation

The CQA staff will observe the deployment of each geotextile roll and will advise the Contractor of observed defects, punctures, and tears so that repairs can be made. The CQA staff will also observe seams/overlaps and check them against specifications. Defective seams/overlaps and patches will be identified to the Contractor so that repairs can be made before covering.

6.1.3 Measurements

The CQA staff, or designee, will document the extents of the separation geotextile placement for pay quantity measurements.

6.2. GEOMEMBRANE

6.2.1 Pre-Construction Material Evaluation

The geomembrane supplier will test the 40-mil linear low-density polyethylene (LLDPE) liner for the parameters specified and will provide copies of manufacturer's conformance test data, and Independent Laboratory test data of the geomembrane for the parameters specified, at the sample rates shown in the specifications. The data will be provided to The CQA staff for review prior to delivery of material to the Site.

The liner installer will be required to submit a liner deployment plan for review before beginning deployment.

6.2.2 Construction Quality Evaluation

The CQA staff will monitor construction of the geomembrane liner to check for conformance to the project specifications. Additional construction QA/QC requirements are as follows.

6.2.3 Responsibilities of the Liner Installer

- Observe the surface of the subgrade to check for stones, clumps of dry clayey soil, and wet areas before deploying the roll of liner.
- Observe that the geomembrane liner subgrade is free of ruts (track made by wheels of passing vehicles with a depth of 1 inch or greater).
- Notify the Engineer that the subgrade surface is not satisfactory for covering with the LLDPE liner, if applicable.
- Submit a certificate to the Engineer stating that the subgrade surface was checked and that its condition is satisfactory for covering with liner.
- Check the condition of each roll for defects and imperfections as it is deployed and repair or remove defects to the satisfaction of the Engineer.
- Geomembrane seams will be oriented parallel to slopes (perpendicular to the contour lines), as often as possible.
- Ensure that fueling/refueling of equipment and vehicles, of any type, are not allowed on the liner.
- Ensure that personnel working on the geomembrane do not smoke or wear damaging shoes or engage in other activities that could damage the geomembrane.
- Repair or replace any liner damaged by equipment, material handling, trafficking, leakage of hydrocarbons, or any other means, to the satisfaction of the Engineer.
- Check seaming equipment daily by destructive-testing seam specimens with a tensiometer. Three specimens will be tested for both peel and shear. The seams should not fail in the weld for both peel and shear with the minimum test values stated below under destructive sample requirements (elongation measurements are not required for field tests). Seaming equipment will be checked:
    - In the morning before beginning work;
    - After extended breaks;
    - After five hours of seaming;

- After lunch;
- After equipment changes;
- After operator changes; and
- After significant changes in ambient or geomembrane temperatures (refer to **Section 6.2.5** for additional details).

- Ensure that seaming is done under the approved seaming conditions noted below.
- Ensure that non-destructive testing and destructive testing in conformance with project specification is completed.

6.2.4 Responsibilities of the Field CQA Staff

- Observe the subgrade surface and inform the installer of areas that, in the Field CQA Staff's opinion, are unsatisfactory for covering.
- Advise the earthwork contractor of unsatisfactory subgrade conditions so that the areas can be repaired before deploying the liner. The prepared surface underlying the geomembrane will not be allowed to deteriorate after acceptance and will remain acceptable during and after geomembrane placement.
- Observe the condition of each sheet as it is being deployed; defects will be marked on the sheet and will be noted in field reports. Each defect will be patched, and the patch seam will be non-destructively tested, as described below. The date of the successful non-destructive test will be marked on the liner and will be noted in field reports.
- Observe geomembrane placement and seam orientation for conformance with permit requirements.
- Observe the destructive testing of test specimens and record the results in field reports.
- Check that destructive and non-destructive testing is completed in accordance with the operation/construction permit and record observations/measurements on the daily field reports.
- Have the Surveyor record the location of each sheet as each sheet is deployed and its respective seams.

6.2.5 Approved Seaming Conditions

- The geomembrane liner will be seamed only when air temperatures are greater than or equal to 32°F and less than or equal to 120°F and when the sheet temperature is less than or equal to 158°F and in accordance with Manufacturer Certification Requirements. Ambient air temperatures shall be measured either on-site or as reported from the nearest airport and will be recorded at a minimum frequency of twice a day. If temperatures approach the lower or higher limits, the temperature will be monitored more frequently using an on-Site thermometer. Sheet temperatures are measured directly on the sheet. If heated enclosures or canopies are used for on-sheet heating or cooling, ambient temperatures shall be measured 18-inches above the sheet.
- All seaming will be done during daylight hours or will be done under artificial light if done at night.
- The geomembrane liner will not be seamed if there is precipitation unless tents are used to direct precipitation away from the seaming area. The manufacturer or installer, to its satisfaction, will wipe and heat the seam dry prior to welding.
- The geomembrane liner will not be seamed if winds exceed 20 miles per hour (mph), measured on-Site using a hand-held anemometer, unless the seaming is done in tents or behind wind screens. Wind speed behind the screen or within the tents will be monitored at the liner surface to verify that the wind speed has been reduced to below 20 mph.

6.2.6 Non-Destructive Testing

Non-destructive testing will be done on all field seams to measure the integrity of the seam. Seams made by extrusion welding will be tested with a vacuum box (ASTM D4437) and seams made with a double hot wedge will be either pressure tested or tested with a vacuum box. The results of each test will be recorded in daily field reports and the results (with the test date) will be marked on the liner next to the seam to allow a visual inspection of the liner upon completion. Seams where leaks are detected by the non-destructive test method will be re-seamed and retested until non-destructive test results are satisfactory, as specified.

<u>Air Pressure Tests of Fusion-Welded Seams</u>: Following a 2-minute pressurized stabilization period, pressure losses over a measurement period of 5 minutes will not exceed 2 pounds per square inch (psi). At no time during the test will the pressure drop below 30 psi to be considered a passing test. At end of the test, air pressure will be released from the end of the test seam opposite the pressure source. If air is not released through this point, the seam will be checked to identify any clogging, then repaired and retested.

If a pressure loss greater than 2 psi occurs during the test and it is determined that the pressure loss is not due to testing apparatus malfunction, the seam will be pressurized, and a soap solution will be applied to the seam. The seam will be observed by the geomembrane installer and Engineer to check for leaks. Where a leak is observed, the geomembrane installer will repair the leak by placement of a cap strip and retest the seam by pressure test.

If a leak is determined to be on the underneath side of the seam, a progressive search of the seam will be made until that portion of the leaking seam is found. The leaking section of seam will be repaired with a cap strip. The remaining section of seam not capped will be documented to pass the air pressure test. Sections of the seam damaged by the leak search will be repaired with cap strips.

<u>Extrusion Welded Seams</u>: Seams that are not accessible for vacuum testing, such as those used for welding the geomembrane pipe boot to the gas vent riser pipes, will be visually inspected to the satisfaction of the CQA staff. Spark testing will not be done due to explosion/flammability concerns from off-gassing.

6.2.7 Destructive Seam Testing

Destructive seam samples will be collected at the rate of one sample per every 1,000 feet of seam or at least one sample for each seaming unit on each day seaming takes place at locations selected by the CQA staff The location of each sample will be measured by the Surveyor and will be plotted on the geomembrane record drawings.

Each sample will be split into three pieces, each 18 inches long (parallel to the seam) and 12 inches wide. One piece will be field-tested by the Contractor, one piece will be tested by the QA Engineer (or a subcontracted independent laboratory) and one piece will be retained by Engineer If the Contractor’s field test meets the strength requirements listed below, then the QA Engineer will send its’ sample piece to the independent lab for testing. If the Contractor’s field test does not meet the strength requirements listed below, the liner seam will be investigated and repaired as described below, with no independent lab test done for follow-up of the failed field sample test. Test samples will be cut into ten l-inch wide strips perpendicular to the seam orientation. Five strips will be tested for peel strength and five for shear strength (ASTM D4437). All five strips must satisfy the strength and peel separation and elongation requirements listed below.

OT WEDGE SEAMS	
TEST	**REQUIRED VALUE**
Seam Shear Strength (lbs/in.)	60 min.
Seam Shear Elongation (1) (%)	50 min.
Seam Peel Strength (lbs/in.)	50 min.

Seam Peel Separation (%)	25 max.
EXTRUSION FILLET SEAMS	
TEST	**MINIMUM VALUE**
Seam Shear Strength (lbs/in.)	60 min.
Seam Shear Elongation [(1)] (%)	50 min.
Seam Peel Strength (lbs/in.)	44 min.
Seam Peel Separation (%)	25 max.

Note: (1) Elongation measurements omitted for field testing.

Remediation is required for any failing destructive test sample. The installer will:

- Patch the seam over the non-conforming destructive test sample location and extend the patch to the nearest adjacent conforming destructive test sample location, or
- Collect and destructive test an additional sample a minimum 10 feet from each side of the failing destructive test sample location to identify the limits of the defective seam. A patch would then be placed over the seam between the two passing destructive test locations.

The repair locations and locations of destructive test samples will be located on the geomembrane record drawings produced by the Surveyor.

6.2.8 Post-Construction

The Geomembrane Contractor will be required to submit a certification following construction that the liner was installed according to specifications and all QC testing was done. The certification statement will be included in the construction monitoring report. The Surveyor will measure and record the limits of LLDPE deployment, locations of LLDPE liner seams, destructive test samples, and all leak and patch locations for installation of the LLDPE liner on top of the landfill. The Surveyor will measure all patch locations for any necessary repairs of the existing high density polyethylene landfill base liner along the containment berms. The Surveyor will also provide a record drawing of the geomembrane installation for inclusion in the construction monitoring report.

7.0 PIPES

7.1 <u>GAS VENT RISERS</u>

7.1.1 Pre-Construction Material Evaluation

The gas vent risers, piezometer screens, and pipe supplier(s) will furnish copies of manufacturer's conformance test data and certificates of compliance for the pipe and fittings delivered to the Site. The CQA Engineer will review the above data and compare them to the specifications. Pipe and fittings which do not meet the specifications will be identified, and the Contractor will not be permitted to use those materials.

7.1.2 Construction Quality Evaluation

The CQA staff will observe the storage and handling of the pipe and fittings. Any damaged material will not be permitted to be used. The CQA staff will also observe the joining of the pipe and fittings and the backfilling of the pipe. The CQA staff will check that all required fittings and components have been supplied and installed. Pipe that is improperly joined or damaged during backfilling will be repaired or replaced.

7.1.3 Survey Measurements

The Surveyor will measure the location of the gas vent riser pipes as they are being installed. The Surveyor will measure and record the location of the gas vent riser pipes.

8.0 SEEDING AND MULCH

8.1 PRE-CONSTRUCTION MATERIAL EVALUATION

The suppliers of seed and fertilizer will be required to submit documentation showing that the seed and fertilizer mixes conform to the project specifications. Mixes that do not meet the specifications will be identified and the Contractor will not be permitted to use those materials.

8.2 CONSTRUCTION QUALITY EVALUATION

The CQA staff will observe the areas to be seeded and will evaluate their suitability for seeding. The Contractor will be notified of areas requiring additional harrowing or disking, or of low areas which may hold water and require re-grading. The CQA staff will observe that fertilizer, seed, and mulch are applied as specified and evenly distributed. The CQA staff will check that erosion protection devices are in place. Areas which erode or where a uniform stand of grass does not develop will be repaired and reseeded as specified. The Owner, Engineer's Representative, and Contractor will observe the seeded areas six to nine months following initial seeding and will determine if areas require repair and/or additional seeding as specified.

ATTACHMENT C

PRELIMINARY DRAWINGS

WOLVERINE WORLD WIDE, INC.
HOUSE STREET REMEDIAL ACTION

CAPPING SYSTEM DESIGN DRAWINGS

1855 HOUSE STREET NORTHEAST
PLAINFIELD TOWNSHIP, KENT COUNTY, MICHIGAN

SITE LOCATION PLAN
NOTE: BASE MAP ADAPTED AUTOCAD CIVIL 3D 2018

NO.	ISSUE/DESCRIPTION	BY	DATE

ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

COVER SHEET AND DRAWING INDEX

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: LJP	FIGURE
DESIGNED BY: JC	DRAWN BY: TAK	SCALE: AS SHOWN	PE-001
DATE: DECEMBER 2022	PROJECT NO. 16.0062961.82	REVISION NO.	

GZA GeoEnvironmental

GENERAL NOTES

1. AERIAL IMAGE ADAPTED FROM AUTOCAD CIVIL 3D 2018.

LEGEND

- SITE BOUNDARY
- GENERAL LIMIT OF WORK AREA
- EASEMENT
- EXISTING EASEMENT POWER POLE

NO.	ISSUE/DESCRIPTION	BY	DATE

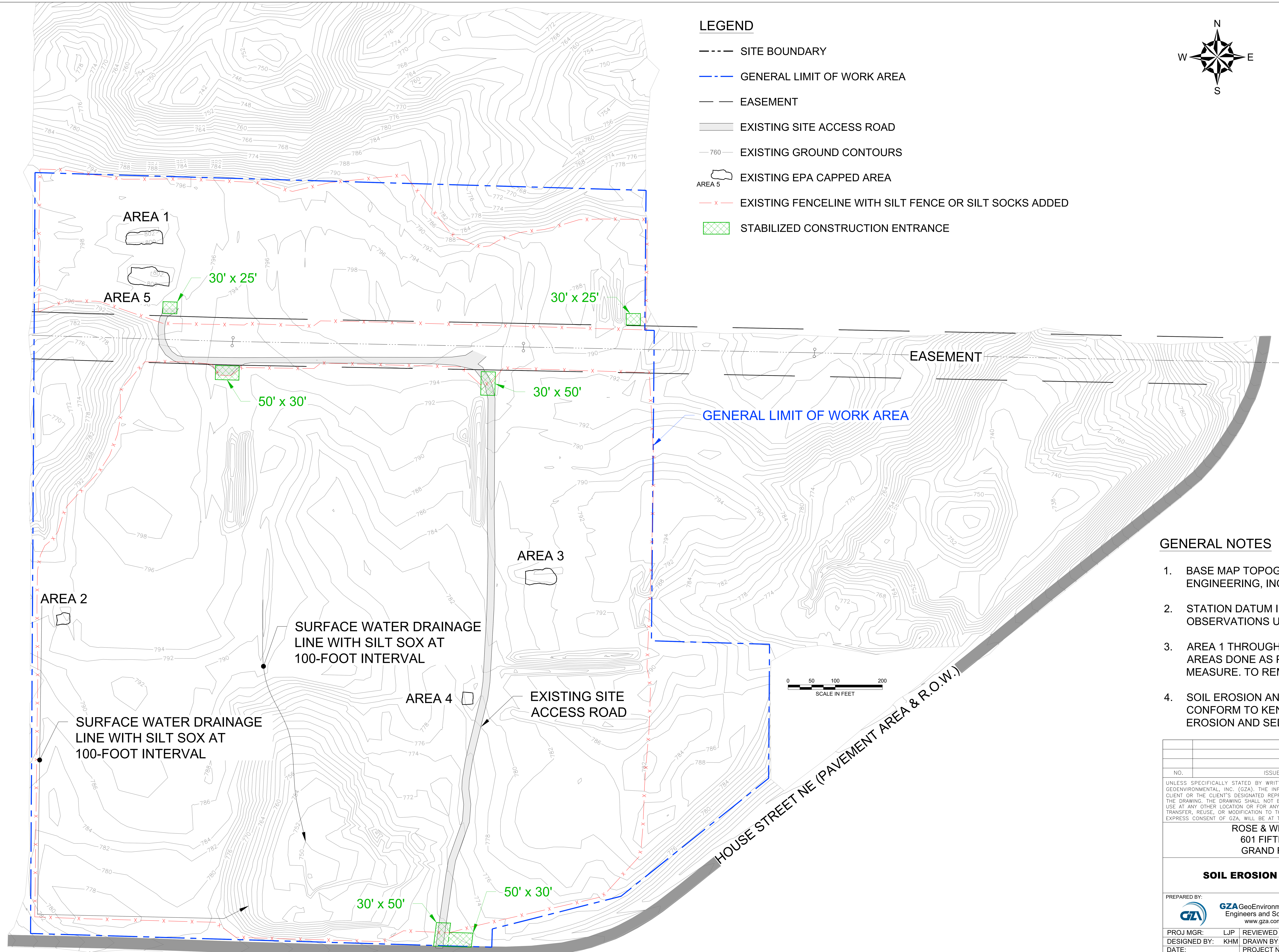
ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

SITE PLAN

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE PE-002
DESIGNED BY: KHM	DRAWN BY: TAK	SCALE: AS SHOWN	
DATE: DECEMBER 2022	PROJECT NO. 16.0062961.82	REVISION NO.	



LEGEND

- SITE BOUNDARY
- GENERAL LIMIT OF WORK AREA
- EASEMENT
- EXISTING SITE ACCESS ROAD
- 760 EXISTING GROUND CONTOURS
- AREA 5 EXISTING EPA CAPPED AREA
- EXISTING FENCELINE WITH SILT FENCE OR SILT SOCKS ADDED
- STABILIZED CONSTRUCTION ENTRANCE

GENERAL NOTES

1. BASE MAP TOPOGRAPHY PROVIDED BY EXXEL ENGINEERING, INC DATED OCTOBER 6, 2020.
2. STATION DATUM IS NAVD88, BASED ON GPS OBSERVATIONS USING MDOT CORS.
3. AREA 1 THROUGH AREA 5 ARE LIMITED CAPPED AREAS DONE AS PART OF AN INTERIM REMEDIAL MEASURE. TO REMAIN AND BE CAPPED OVER.
4. SOIL EROSION AND SEDIMENT CONTROL TO CONFORM TO KENT COUNTY AGREEMENT FOR SOIL EROSION AND SEDIMENT CONTROL FOR THE SITE.

NO.	ISSUE/DESCRIPTION	BY	DATE

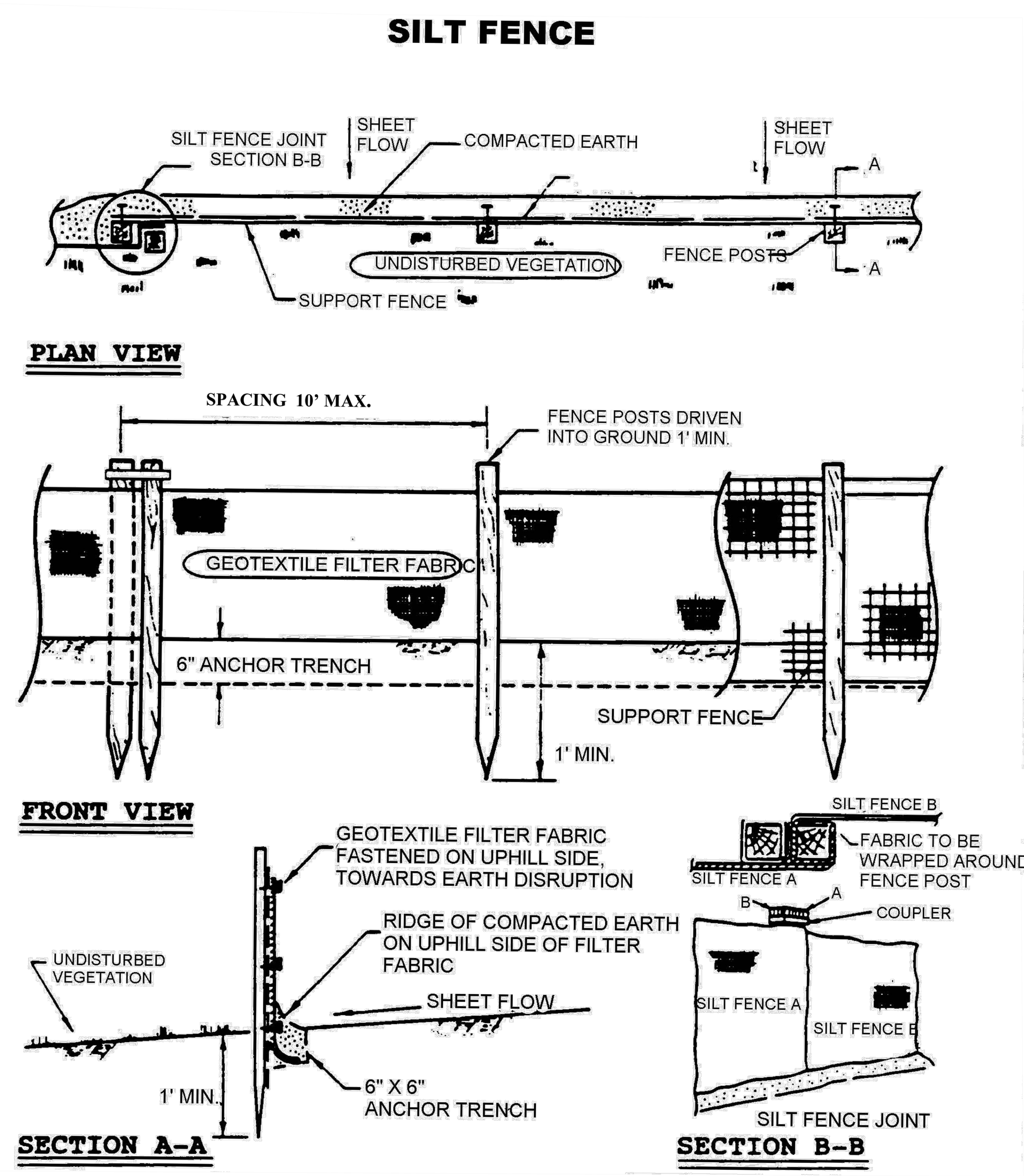
ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

SOIL EROSION & SEDIMENT CONTROL PLAN

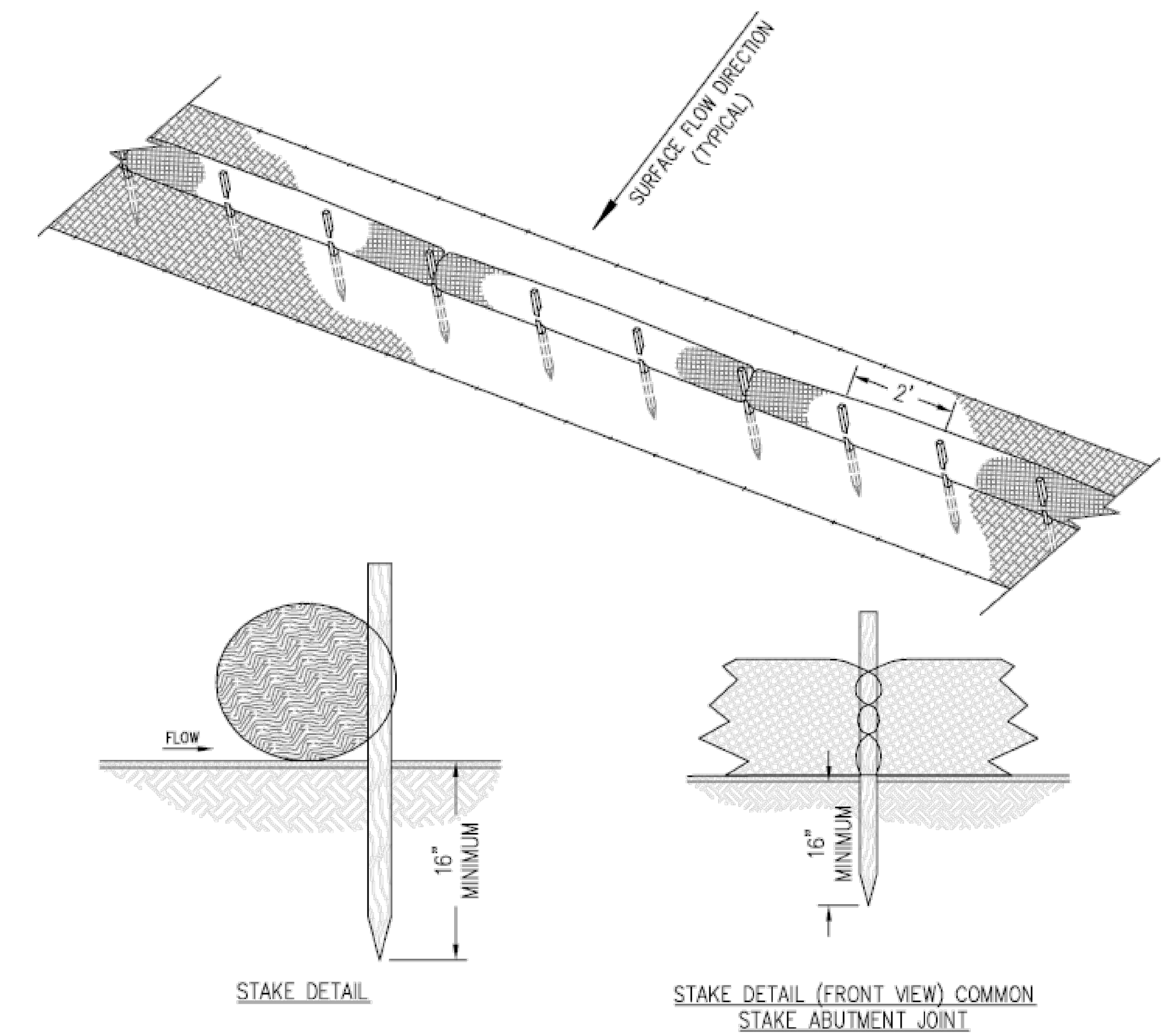
PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: WN&J/WWW

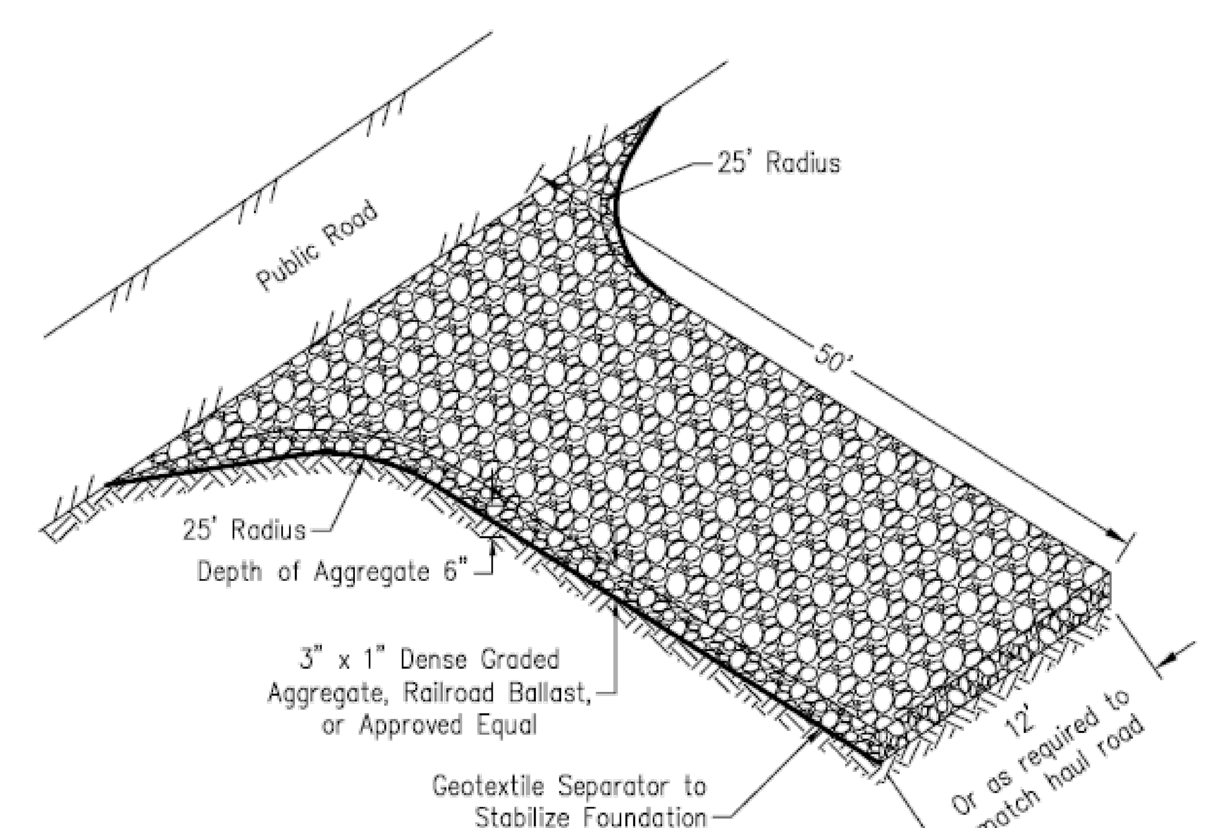
PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: TAK	SCALE: AS SHOWN	PE-003-A
DATE: DECEMBER 2022	PROJECT NO. 16.0062961.82	REVISION NO.	



TYPICAL SILT FENCE



TYPICAL WATTLE SETTLEMENT LOG / SILT SOX



TYPICAL CONSTRUCTION ENTRANCE

GENERAL NOTES

1. SOIL EROSION AND SEDIMENT CONTROL TO CONFORM TO KENT COUNTY AGREEMENT FOR SOIL EROSION AND SEDIMENT CONTROL FOR THE SITE.

NO.	ISSUE/DESCRIPTION	BY	DATE

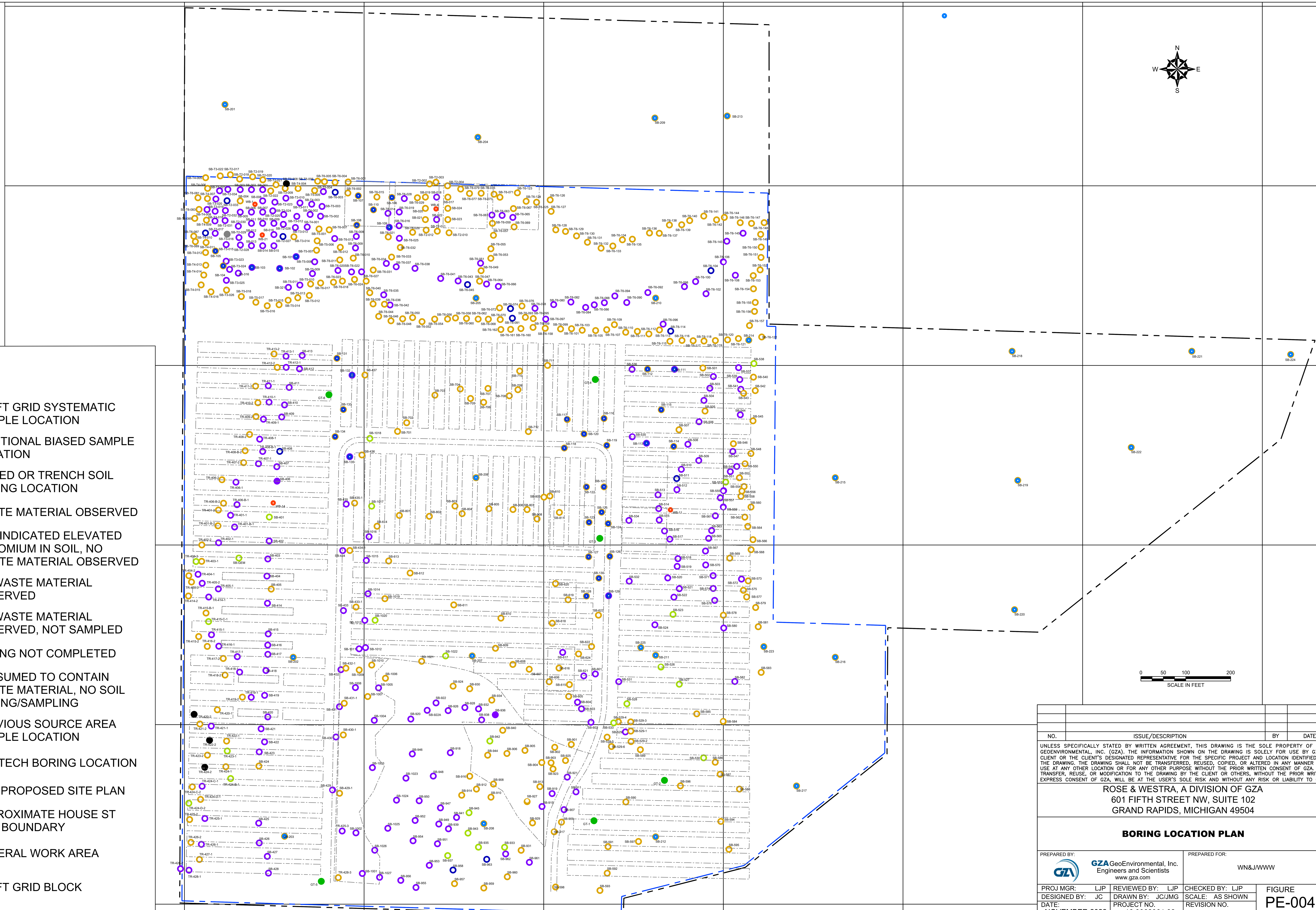
ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

SOIL EROSION & SEDIMENT CONTROL - TYPICAL DETAILS

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: TAK	SCALE: AS SHOWN	PE-003-B
DATE: DECEMBER 2022	PROJECT NO. 16.0062961.82	REVISION NO.	



LEGEND

- 400 FT GRID SYSTEMATIC SAMPLE LOCATION
- ADDITIONAL BIASED SAMPLE LOCATION
- TIERED OR TRENCH SOIL BORING LOCATION
- WASTE MATERIAL OBSERVED
- XRF INDICATED ELEVATED CHROMIUM IN SOIL, NO WASTE MATERIAL OBSERVED
- NO WASTE MATERIAL OBSERVED
- NO WASTE MATERIAL OBSERVED, NOT SAMPLED
- BORING NOT COMPLETED
- PRESUMED TO CONTAIN WASTE MATERIAL, NO SOIL BORING/SAMPLING
- PREVIOUS SOURCE AREA SAMPLE LOCATION
- GEOTECH BORING LOCATION
- 1966 PROPOSED SITE PLAN
- APPROXIMATE HOUSE ST SITE BOUNDARY
- GENERAL WORK AREA
- 400 FT GRID BLOCK

NO.	ISSUE/DESCRIPTION	BY	DATE

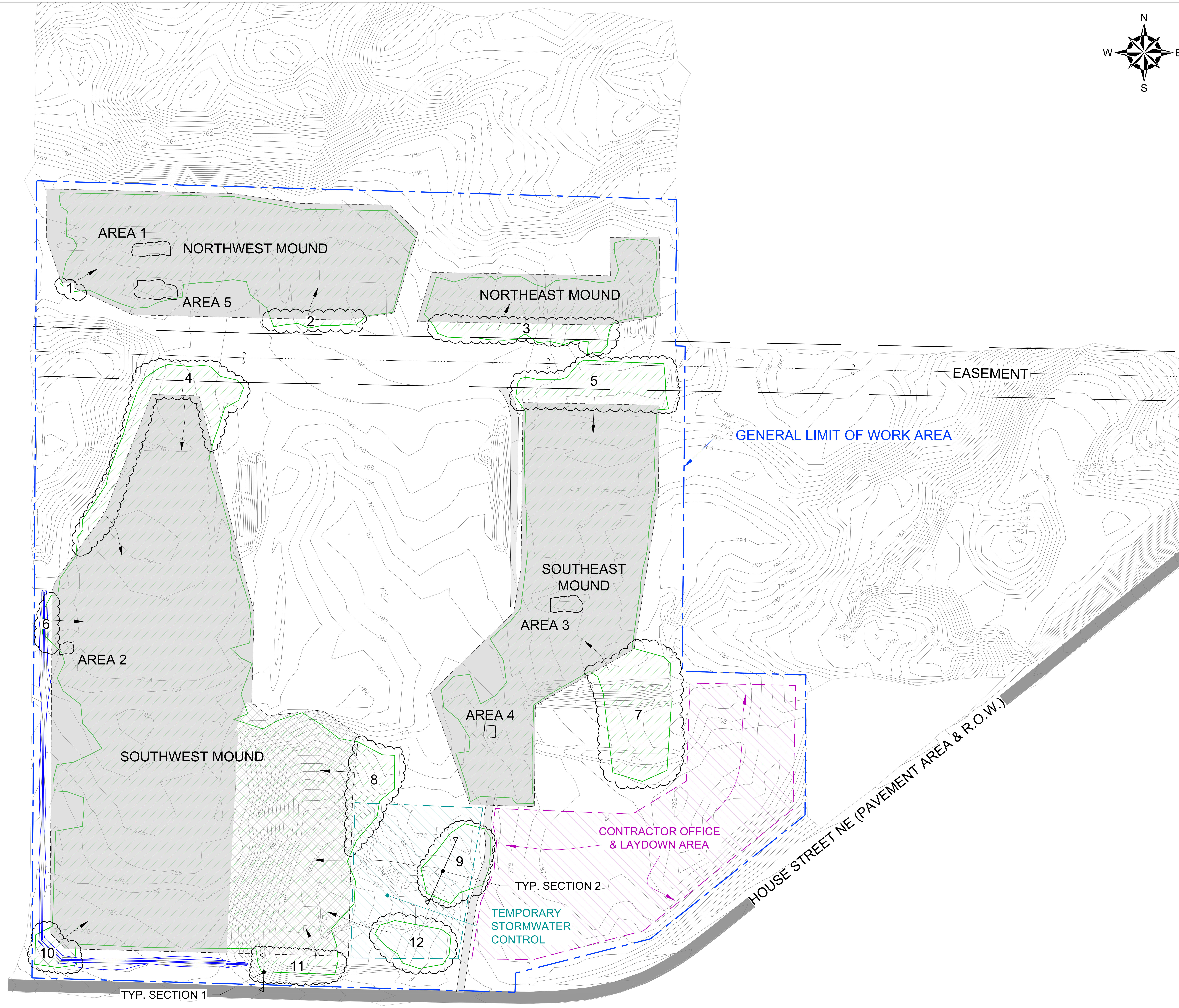
ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

BORING LOCATION PLAN

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: LJP	FIGURE PE-004
DESIGNED BY: JC	DRAWN BY: JC/JMG	SCALE: AS SHOWN	
DATE: NOVEMBER 2022	PROJECT NO. 16.0062961.82	REVISION NO.	



LEGEND

- SITE BOUNDARY
- GENERAL LIMIT OF WORK AREA
- EASEMENT
- EXISTING SITE ACCESS ROAD
- 760 EXISTING GROUND CONTOURS
- ESTIMATED EXTENT OF WASTE
- PERIMETER SWALE BREAKLINES (SW CORNER)
- 40-MIL LLDPE GEOMEMBRANE
- 40-MIL LLDPE DOUBLE SIDE TEXTURED GEOMEMBRANE
- AREA OF IDENTIFIED WASTE MATERIAL TO BE RELOCATED TO MOUND AREAS AND CAPPED
- TYPICAL WASTE EXCAVATION SECTION (SEE PE-016)
- AREA 5 EXISTING EPA CAPPED AREA

GENERAL NOTES

1. BASE MAP TOPOGRAPHY PROVIDED BY EXXEL ENGINEERING, INC DATED OCTOBER 6, 2020.
2. STATION DATUM IS NAVD88, BASED ON GPS OBSERVATIONS USING MDOT CORS.
3. SEE TYPICAL DETAIL OF WASTE EXCAVATION FROM OUTSIDE MOUND AREAS.
4. AREA 1 THROUGH AREA 5 ARE LIMITED CAPPED AREAS DONE AS PART OF AN INTERIM REMEDIAL MEASURE. TO REMAIN AND BE CAPPED OVER.

ESTIMATED WASTE RELOCATION QUANTITIES

1)	200 CY	7)	3,000 CY
2)	300 CY	8)	1,000 CY
3)	3,000 CY	9)	7,000 CY
4)	3,000 CY	10)	500 CY
5)	3,000 CY	11)	5,000 CY
6)	500 CY	12)	1,000 CY

ESTIMATED TOTAL: 24,500 CY ±

0 50 100 200
SCALE IN FEET

NO.	ISSUE/DESCRIPTION	BY	DATE

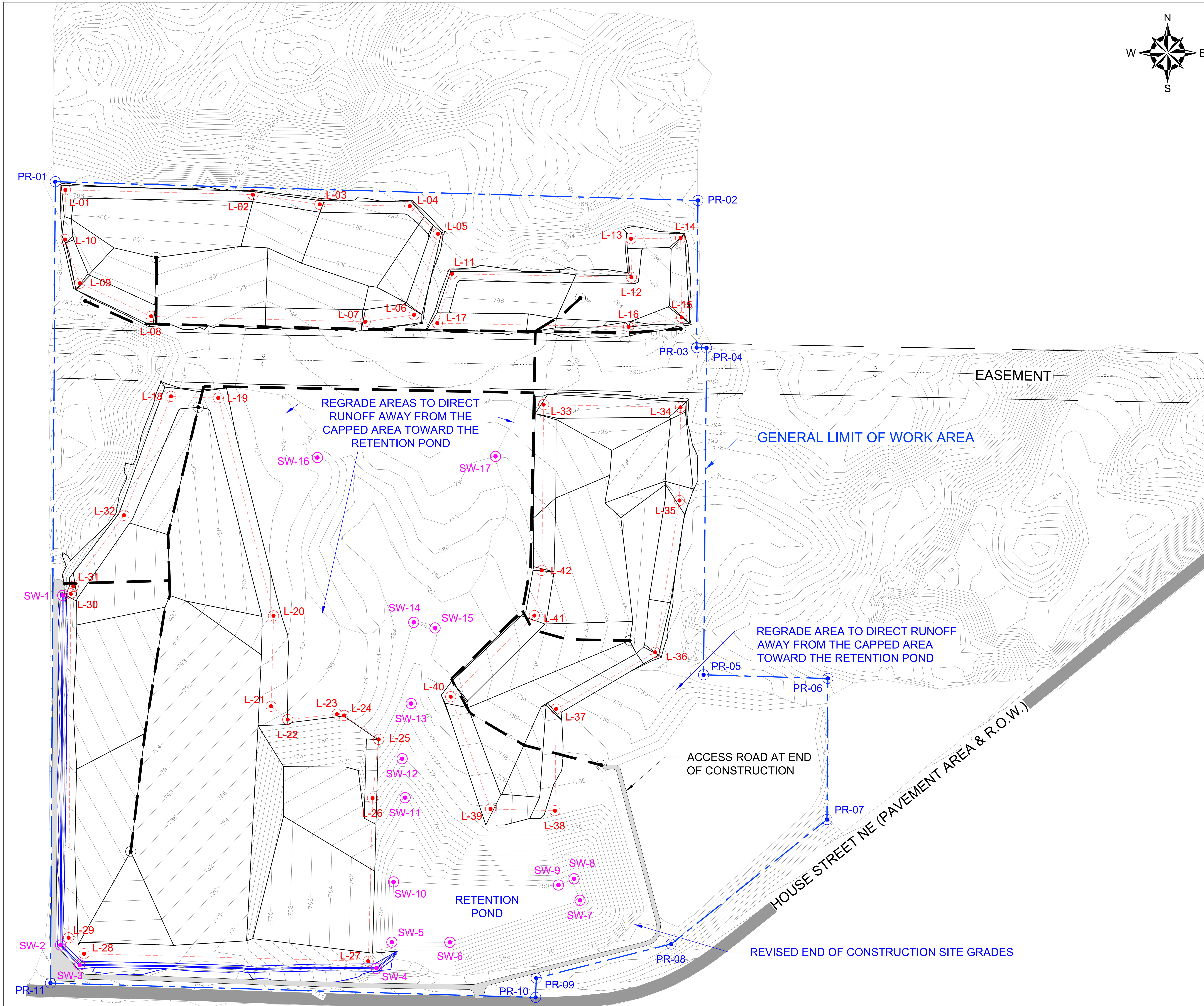
ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

EXCAVATION / WASTE RELOCATION PLAN

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: TAK	SCALE: AS SHOWN	PE-005-A
DATE: DECEMBER 2022	PROJECT NO. 16.0062961.82	REVISION NO.	



GENERAL NOTES

1. BASE MAP TOPOGRAPHY PROVIDED BY EXXEL ENGINEERING, INC DATED OCTOBER 6, 2020.
2. STATION DATUM IS NAVD88, BASED ON GPS OBSERVATIONS USING MDOT CORS.

LEGEND

- SITE BOUNDARY
- GENERAL LIMIT OF WORK AREA
- EASEMENT
- PROPOSED SITE ACCESS ROAD
- 760 CONTOUR LINES
- PERIMETER SWALE BREAKLINES (SW CORNER)
- TOP OF CAP BREAKLINES
- LIMITS OF 40-MIL LLDPE GEOMEMBRANE
- CONTROL POINTS FOR CONSTRUCTION (LIMITS OF LLDPE) : L-1 TO L-42
- CONTROL POINTS FOR CONSTRUCTION (STORMWATER RUN-OFF) : SW-1 TO SW-17
- CONTROL POINTS FOR CONSTRUCTION (WORK AREA LIMITS) : PR-1 TO PR-11
- CONCEPTUAL SITE ACCESS & TURN AROUND LOCATIONS

0 50 100 200
SCALE IN FEET

NO.	ISSUE/DESCRIPTION	BY	DATE

ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

CONTROL POINTS AND SITE ACCESS

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com
PREPARED FOR: WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: TAK	SCALE: AS SHOWN	PE-005-B
DATE: DECEMBER 2022	PROJECT NO. 16.0062961.82	REVISION NO.	

LLDPE LIMIT - CONTROL POINTS		
POINT ID	EASTING (X)	NORTHING (Y)
L-01	12787597.7	588930.5
L-02	12787975.4	588921.1
L-03	12788110.4	588901.1
L-04	12788291.7	588897.8
L-05	12788348.9	588841.8
L-06	12788300.4	588678.9
L-07	12788202.1	588664.7
L-08	12787770.7	588675.6
L-09	12787626.6	588742.4
L-10	12787596.9	588830.5
L-11	12788377.1	588761.4
L-12	12788738.6	588754.5
L-13	12788737.6	588832.1
L-14	12788837.6	588833.4
L-15	12788839.7	588673.5
L-16	12788732.8	588654.5
L-17	12788347.5	588662.0
L-18	12787810.4	588514.3
L-19	12787905.9	588511.3
L-20	12788017.2	588072.4
L-21	12788012.3	587890.0
L-22	12788045.8	587863.3
L-23	12788144.9	587874.3
L-24	12788159.4	587871.5
L-25	12788229.2	587823.4
L-26	12788216.8	587705.1
L-27	12788208.2	587376.5
L-28	12787635.3	587391.7
L-29	12787604.2	587423.8
L-30	12787608.5	588116.7
L-31	12787613.6	588131.6
L-32	12787715.8	588274.9
L-33	12788561.5	588497.9
L-34	12788837.5	588492.4
L-35	12788835.5	588304.8
L-36	12788786.5	587998.7
L-37	12788586.7	587884.7
L-38	12788584.5	587679.7
L-39	12788454.5	587683.2
L-40	12788374.2	587909.3
L-41	12788543.0	588072.9
L-42	12788557.9	588163.8

STORMWATER RUN-OFF LIMIT - CONTROL POINTS			
POINT ID	EASTING (X)	NORTHING (Y)	ELEVATION (Z)
SW-1	12787592.3	588113.6	790.7
SW-2	12787587.9	587409.2	777.7
SW-3	12787626.5	587369.2	776.8
SW-4	12788224.5	587362.2	756.9
SW-5	12788255.8	587415.0	750.0
SW-6	12788372.6	587414.6	750.0
SW-7	12788634.9	587499.2	750.0
SW-8	12788622.9	587542.7	750.0
SW-9	12788591.4	587529.9	750.0
SW-10	12788259.1	587536.3	750.0
SW-11	12788282.4	587706.0	760.0
SW-12	12788276.4	587784.5	770.0
SW-13	12788294.6	587895.5	776.0
SW-14	12788299.8	588059.2	780.0
SW-15	12788342.7	588047.9	780.0
SW-16	12788105.6	588391.2	790.0
SW-17	12788464.6	588393.4	790.0

WORK AREA LIMIT - CONTROL POINTS		
POINT ID	EASTING (X)	NORTHING (Y)
PR-01	12787577.2	588947.0
PR-02	12788872.6	588909.2
PR-03	12788869.9	588612.7
PR-04	12788889.8	588612.1
PR-05	12788884.0	587953.6
PR-06	12789134.3	587946.2
PR-07	12789132.5	587662.0
PR-08	12788818.5	587410.9
PR-09	12788546.7	587342.4
PR-10	12788545.5	587303.6
PR-11	12787567.6	587332.7

GENERAL NOTES

1. COORDINATES ARE REPRESENTED IN NAD83 MICHIGAN SOUTH STATE PLANE INTERNATIONAL FEET & NAVD88.

NO.	ISSUE/DESCRIPTION	BY	DATE

ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

CONTROL POINT COORDINATES

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: TAK	SCALE: AS SHOWN	PE-005-C
DATE: DECEMBER 2022	PROJECT NO. 16.0062961.82	REVISION NO.	

LEGEND

- SITE BOUNDARY
- GENERAL LIMIT OF WORK AREA
- EASEMENT
- EXISTING SITE ACCESS ROAD
- 760 EXISTING GROUND CONTOURS
- 760 TOP OF IMPACTED MATERIAL CONTOURS
- BERM DESIGN BREAKLINES (GENERAL TOE AND TOP OF BERM)
- TOP OF IMPACTED MATERIAL BREAKLINES
- CONTROL POINTS FOR CONSTRUCTION (LIMITS OF LLDPE). SEE DRAWING PE-005-C FOR COORDINATES.
- CONTROL POINTS FOR CONSTRUCTION (GRADE BREAKS)

TOP OF IMPACTED MATERIAL (NW) - CONTROL POINTS

POINT ID	EASTING (X)	NORTHING (Y)	ELEVATION (Z)
BP-NW-01	12787624.0	588907.3	796.0
BP-NW-02	12787973.6	588900.2	795.2
BP-NW-03	12788108.6	588879.1	793.2
BP-NW-04	12788279.8	588875.6	791.3
BP-NW-05	12788306.3	588855.4	791.9
BP-NW-06	12788322.7	588834.1	791.9
BP-NW-07	12788276.9	588707.1	797.5
BP-NW-08	12788199.6	588695.8	796.8
BP-NW-09	12788001.6	588699.9	793.1
BP-NW-10	12787778.0	588705.9	797.0
BP-NW-11	12787650.3	588765.3	797.4
BP-NW-12	12787616.8	588866.8	798.1
BP-NW-13	12787695.6	588813.7	800.5
BP-NW-14	12787780.4	588794.2	801.1
BP-NW-15	12787951.6	588816.8	799.4
BP-NW-16	12788005.9	588813.6	798.4
BP-NW-17	12788073.5	588782.9	798.3
BP-NW-18	12788208.8	588736.9	798.9
BP-NW-19	12788225.0	588734.6	798.8

GENERAL NOTES

0 15 30 60
SCALE IN FEET

1. BASE MAP TOPOGRAPHY PROVIDED BY EXXEL ENGINEERING, INC DATED OCTOBER 6, 2020.
2. STATION DATUM IS NAVD88, BASED ON GPS OBSERVATIONS USING MDOT CORS.
3. COORDINATES ARE REPRESENTED IN NAD83 MICHIGAN SOUTH STATE PLANE INTERNATIONAL FEET & NAVD88.
4. BREAKLINES AND CONTROL POINTS WILL BE ADJUSTED BASED ON ENCOUNTERED FIELD CONDITIONS

NO.	ISSUE/DESCRIPTION	BY	DATE

ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

TOP OF PREPARED SUBGRADE / BOTTOM OF CAPPING MATERIALS (NORTHWEST MOUND)

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC
DESIGNED BY: KHM	DRAWN BY: TAK	SCALE: AS SHOWN
DATE: DECEMBER 2022	PROJECT NO. 16.0062961.82	REVISION NO.

FIGURE
PE-006-A

LEGEND

- SITE BOUNDARY
- GENERAL LIMIT OF WORK AREA
- EASEMENT
- EXISTING SITE ACCESS ROAD
- 760 EXISTING GROUND CONTOURS
- 760 TOP OF IMPACTED MATERIAL CONTOURS
- BERM DESIGN BREAKLINES (GENERAL TOE AND TOP OF BERM)
- TOP OF IMPACTED MATERIAL BREAKLINES
- CONTROL POINTS FOR CONSTRUCTION (LIMITS OF LLDPE). SEE DRAWING PE-005-C FOR COORDINATES.
- CONTROL POINTS FOR CONSTRUCTION (GRADE BREAKS)

TOP OF IMPACTED MATERIAL (NE) - CONTROL POINTS

POINT ID	EASTING (X)	NORTHING (Y)	ELEVATION (Z)
BP-NE-01	12788395.3	588739.4	794.1
BP-NE-02	12788593.3	588736.3	793.7
BP-NE-03	12788616.9	588737.9	793.5
BP-NE-04	12788758.2	588736.1	788.6
BP-NE-05	12788768.2	588805.1	785.8
BP-NE-06	12788810.3	588806.1	784.3
BP-NE-07	12788807.8	588702.3	788.0
BP-NE-08	12788731.7	588673.2	791.7
BP-NE-09	12788590.7	588679.8	796.5
BP-NE-10	12788531.5	588689.8	796.2
BP-NE-11	12788383.3	588692.2	796.5

GENERAL NOTES

0 10 20 40
SCALE IN FEET

1. BASE MAP TOPOGRAPHY PROVIDED BY EXXEL ENGINEERING, INC DATED OCTOBER 6, 2020.
2. STATION DATUM IS NAVD88, BASED ON GPS OBSERVATIONS USING MDOT CORS.
3. COORDINATES ARE REPRESENTED IN NAD83 MICHIGAN SOUTH STATE PLANE INTERNATIONAL FEET & NAVD88.
4. BREAKLINES AND CONTROL POINTS WILL BE ADJUSTED BASED ON ENCOUNTERED FIELD CONDITIONS

NO.	ISSUE/DESCRIPTION	BY	DATE

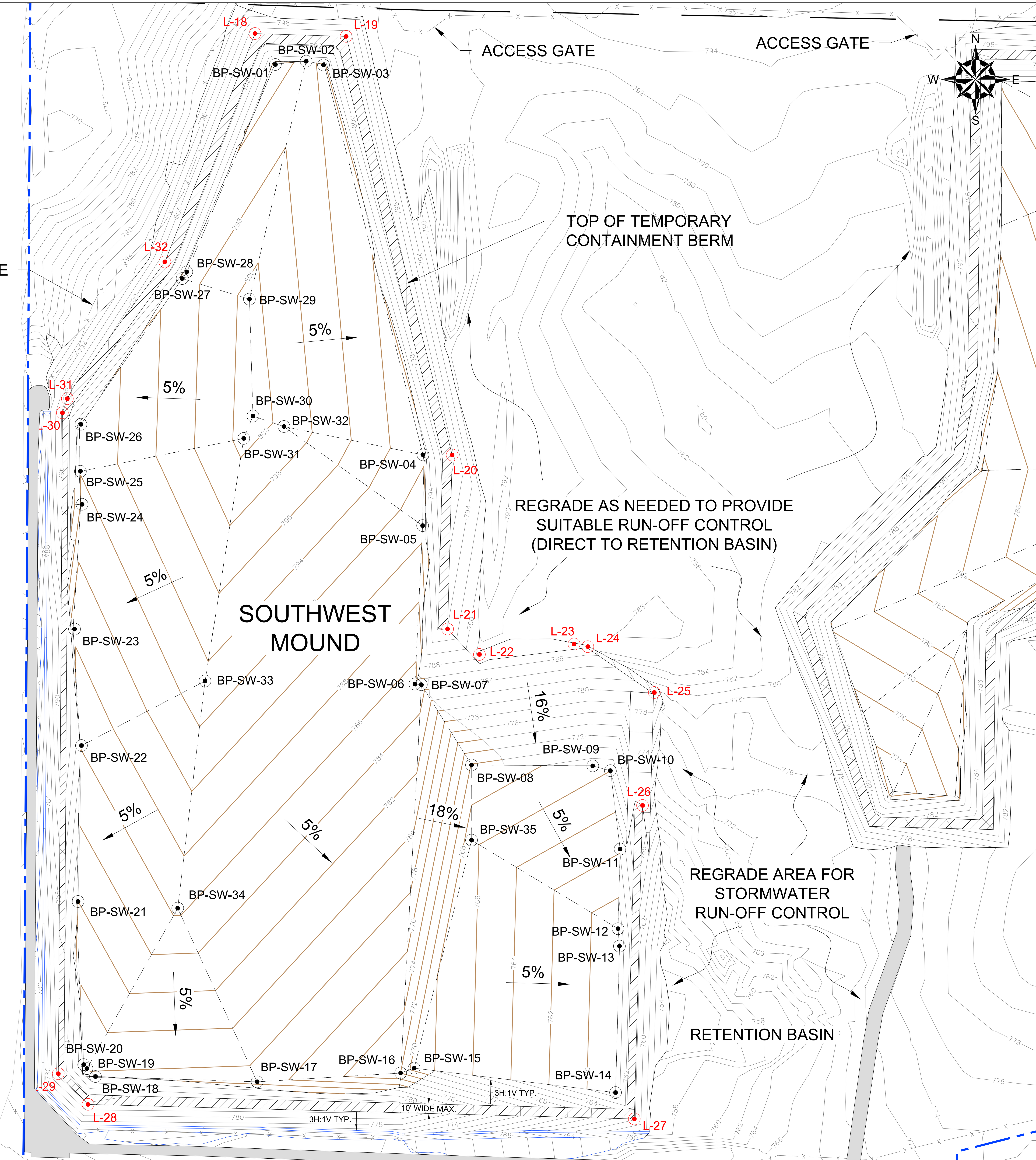
ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

TOP OF PREPARED SUBGRADE / BOTTOM OF CAPPING MATERIALS (NORTHEAST MOUND)

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: TAK	SCALE: AS SHOWN	PE-006-B
DATE: DECEMBER 2022	PROJECT NO. 16.0062961.82	REVISION NO.	



TOP OF IMPACTED MATERIAL (SW) - CONTROL POINTS			
POINT ID	EASTING (X)	NORTHING (Y)	ELEVATION (Z)
BP-SW-01	12787831.8	588481.8	795.2
BP-SW-02	12787864.1	588485.3	796.5
BP-SW-03	12787882.3	588481.3	795.6
BP-SW-04	12787986.6	588072.6	792.3
BP-SW-05	12787986.1	587998.5	790.6
BP-SW-06	12787978.1	587832.4	785.2
BP-SW-07	12787984.9	587831.7	785.0
BP-SW-08	12788037.5	587747.5	769.8
BP-SW-09	12788164.5	587746.5	766.7
BP-SW-10	12788183.0	587741.5	766.0
BP-SW-11	12788193.2	587659.3	762.2
BP-SW-12	12788191.0	587575.9	758.6
BP-SW-13	12788192.6	587557.6	758.5
BP-SW-14	12788188.5	587404.1	758.5
BP-SW-15	12787977.3	587429.7	769.1
BP-SW-16	12787963.2	587424.6	771.9
BP-SW-17	12787812.6	587415.4	777.1
BP-SW-18	12787643.2	587420.9	777.7
BP-SW-19	12787634.2	587429.2	778.1
BP-SW-20	12787630.8	587433.3	778.1
BP-SW-21	12787624.9	587604.4	782.0
BP-SW-22	12787628.5	587767.9	786.1
BP-SW-23	12787621.1	587890.0	788.3
BP-SW-24	12787629.1	588020.7	791.4
BP-SW-25	12787627.4	588055.3	792.1
BP-SW-26	12787627.9	588104.6	792.0
BP-SW-27	12787734.1	588257.4	797.1
BP-SW-28	12787738.9	588264.4	797.1
BP-SW-29	12787804.6	588235.8	800.6
BP-SW-30	12787808.2	588113.3	801.0
BP-SW-31	12787798.6	588089.8	800.6
BP-SW-32	12787840.7	588102.3	799.4
BP-SW-33	12787758.0	587835.6	793.4
BP-SW-34	12787729.3	587597.4	786.4
BP-SW-35	12788037.5	587668.6	766.4

GENERAL NOTES

1. BASE MAP TOPOGRAPHY PROVIDED BY EXXEL ENGINEERING, INC DATED OCTOBER 6, 2020.
2. STATION DATUM IS NAVD88, BASED ON GPS OBSERVATIONS USING MDOT CORS.
3. COORDINATES ARE REPRESENTED IN NAD83 MICHIGAN SOUTH STATE PLANE INTERNATIONAL FEET & NAVD88.
4. BREAKLINES AND CONTROL POINTS TO BE ADJUSTED BASED ON FIELD CONDITIONS ENCOUNTERED.

LEGEND

- SITE BOUNDARY
- GENERAL LIMIT OF WORK AREA
- EASEMENT
- PROPOSED ACCESS ROAD
- 760 EXISTING GROUND CONTOURS
- 760 TOP OF IMPACTED MATERIAL CONTOURS
- PERIMETER SWALE BREAKLINES (SW CORNER)
- BERM DESIGN BREAKLINES (GENERAL TOE AND TOP OF BERM)
- TOP OF IMPACTED MATERIAL BREAKLINES
- CONTROL POINTS FOR CONSTRUCTION (LIMITS OF LLDPE). SEE DRAWING PE-005-C FOR COORDINATES.
- CONTROL POINTS FOR CONSTRUCTION (GRADE BREAKS)

0 30 60 120
SCALE IN FEET

NO.	ISSUE/DESCRIPTION	BY	DATE

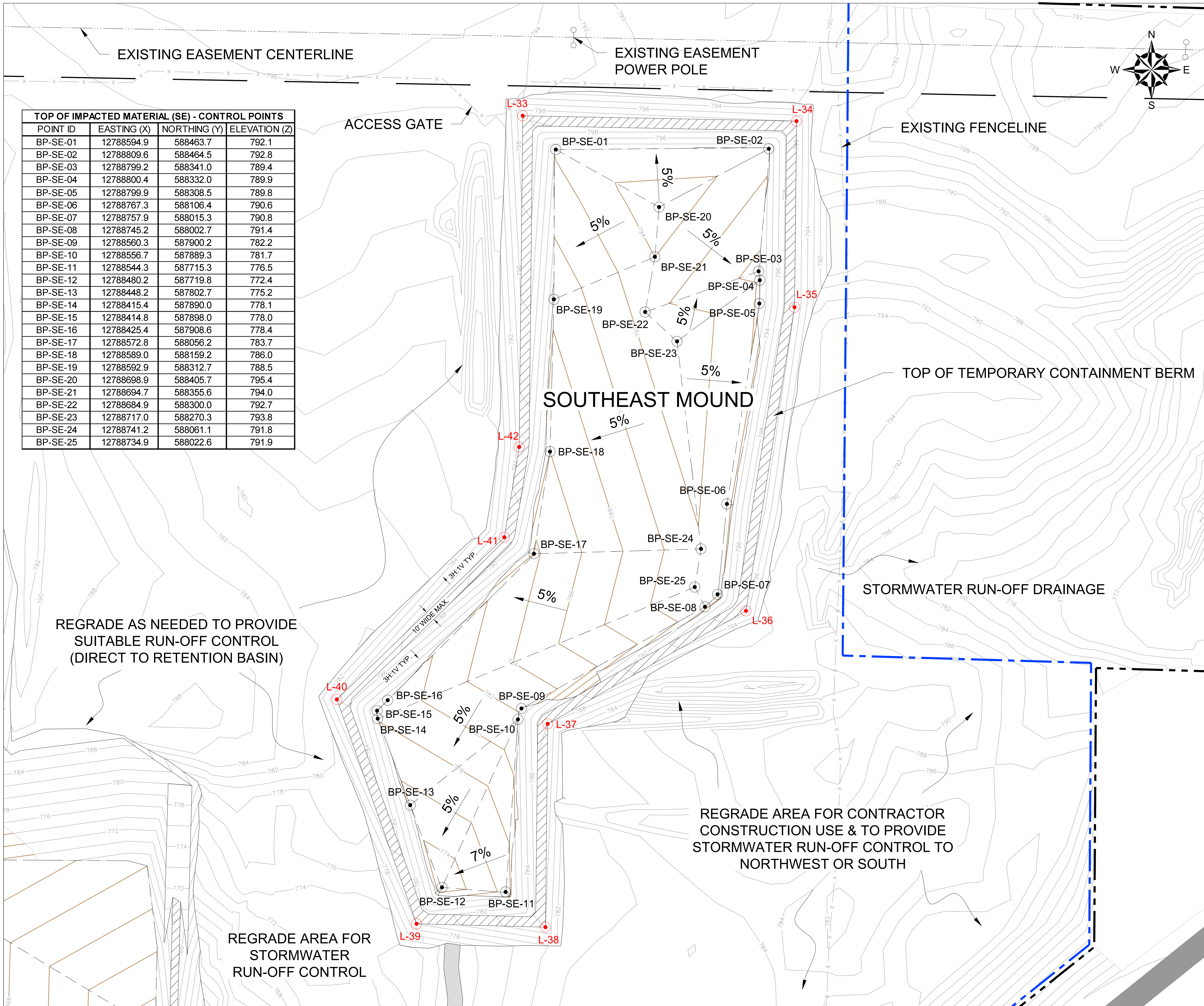
ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

TOP OF PREPARED SUBGRADE / BOTTOM OF CAPPING MATERIALS (SOUTHWEST MOUND)

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: TAK	SCALE: AS SHOWN	PE-006-C
DATE: DECEMBER 2022	PROJECT NO. 16.0062961.82	REVISION NO.	



TOP OF IMPACTED MATERIAL (SE) - CONTROL POINTS

POINT ID	EASTING (X)	NORTHING (Y)	ELEVATION (Z)
BP-SE-01	12788594.9	588463.7	792.1
BP-SE-02	12788809.6	588464.5	792.8
BP-SE-03	12788799.2	588341.0	789.4
BP-SE-04	12788800.4	588332.0	789.9
BP-SE-05	12788799.9	588308.5	789.8
BP-SE-06	12788767.3	588106.4	790.6
BP-SE-07	12788757.9	588015.3	790.8
BP-SE-08	12788745.2	588002.7	791.4
BP-SE-09	12788560.3	587900.2	782.2
BP-SE-10	12788556.7	587889.3	781.7
BP-SE-11	12788544.3	587715.3	776.5
BP-SE-12	12788480.2	587719.8	772.4
BP-SE-13	12788448.2	587802.7	775.2
BP-SE-14	12788415.4	587890.0	778.1
BP-SE-15	12788414.8	587898.0	778.0
BP-SE-16	12788425.4	587908.6	778.4
BP-SE-17	12788572.8	588056.2	783.7
BP-SE-18	12788589.0	588159.2	786.0
BP-SE-19	12788592.9	588312.7	788.5
BP-SE-20	12788698.9	588405.7	795.4
BP-SE-21	12788694.7	588355.6	794.0
BP-SE-22	12788684.9	588300.0	792.7
BP-SE-23	12788717.0	588270.3	793.8
BP-SE-24	12788741.2	588061.1	791.8
BP-SE-25	12788734.9	588022.6	791.9

GENERAL NOTES

1. BASE MAP TOPOGRAPHY PROVIDED BY EXXEL ENGINEERING, INC DATED OCTOBER 6, 2020.
2. STATION DATUM IS NAVD88, BASED ON GPS OBSERVATIONS USING MDOT CORS.
3. COORDINATES ARE REPRESENTED IN NAD83 MICHIGAN SOUTH STATE PLANE INTERNATIONAL FEET & NAVD88.
4. BREAKLINES AND CONTROL POINTS TO BE ADJUSTED BASED ON FIELD CONDITIONS ENCOUNTERED.

LEGEND

- SITE BOUNDARY
- GENERAL LIMIT OF WORK AREA
- EASEMENT
- PROPOSED ACCESS ROAD
- 760 EXISTING GROUND CONTOURS
- 760 TOP OF IMPACTED MATERIAL CONTOURS
- BERM DESIGN BREAKLINES (GENERAL TOE AND TOP OF BERM)
- TOP OF IMPACTED MATERIAL BREAKLINES
- CONTROL POINTS FOR CONSTRUCTION (LIMITS OF LLDPE). SEE DRAWING PE-005-C FOR COORDINATES.
- CONTROL POINTS FOR CONSTRUCTION (GRADE BREAKS)

NO.	ISSUE/DESCRIPTION	BY	DATE

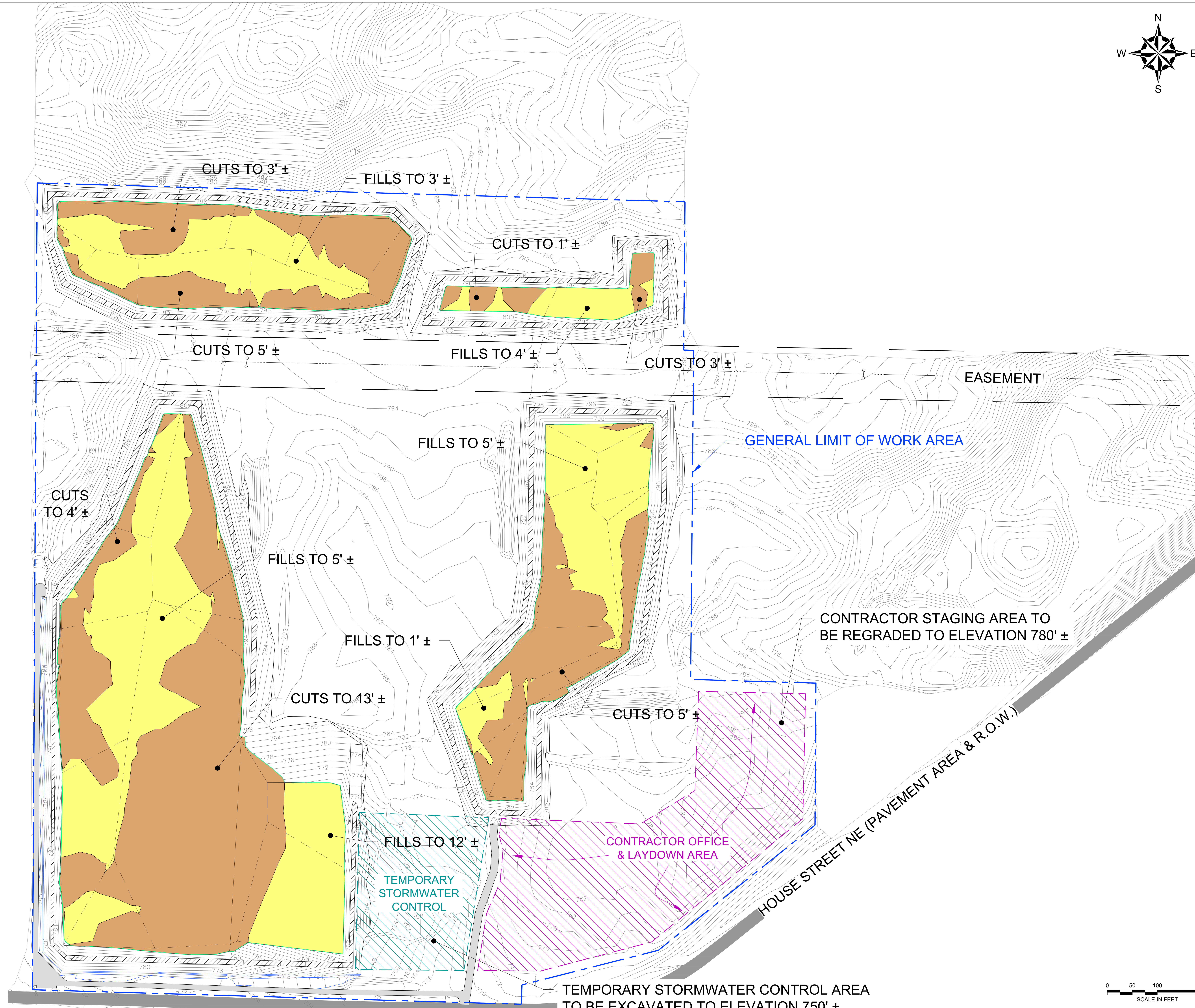
ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

TOP OF PREPARED SUBGRADE / BOTTOM OF CAPPING MATERIALS (SOUTHEAST MOUND)

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: TAK	SCALE: AS SHOWN	PE-006-D
DATE: DECEMBER 2022	PROJECT NO. 16.0062961.82	REVISION NO.	



GENERAL NOTES

1. BASE MAP TOPOGRAPHY PROVIDED BY EXXEL ENGINEERING, INC DATED OCTOBER 6, 2020.
2. STATION DATUM IS NAVD88, BASED ON GPS OBSERVATIONS USING MDOT CORS.
3. PROPOSED GAS VENT AND PIEZOMETER SHALL E CO-LOCATED, SHOWN HERE AS SEPARATE FOR CLARITY.

LEGEND

- SITE BOUNDARY
- GENERAL LIMIT OF WORK AREA
- EASEMENT
- PROPOSED SITE ACCESS ROAD
- 760 EXISTING GROUND CONTOURS
- PERIMETER SWALE BREAKLINES (SW CORNER)
- BERM DESIGN BREAKLINES
- TOP OF IMPACTED MATERIAL BREAKLINES
- CUT AREA
- FILL AREA

NO.	ISSUE/DESCRIPTION	BY	DATE

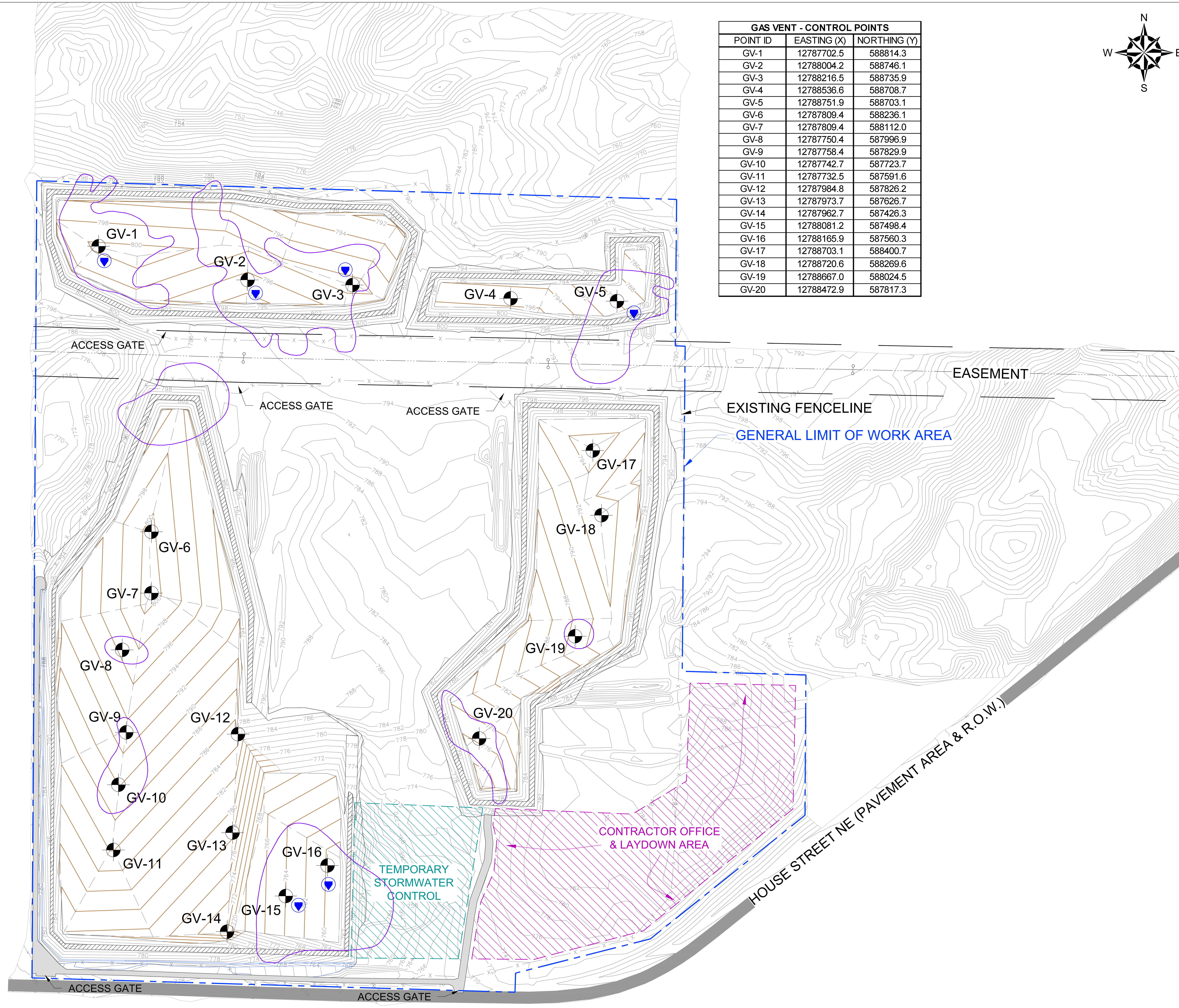
ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

APPROXIMATE CUT AND FILL AREAS

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: TAK	SCALE: AS SHOWN	PE-007
DATE: DECEMBER 2022	PROJECT NO. 16.0062961.82	REVISION NO.	



GAS VENT - CONTROL POINTS		
POINT ID	EASTING (X)	NORTHING (Y)
GV-1	12787702.5	588814.3
GV-2	12788004.2	588746.1
GV-3	12788216.5	588735.9
GV-4	12788536.6	588708.7
GV-5	12788751.9	588703.1
GV-6	12787809.4	588236.1
GV-7	12787809.4	588112.0
GV-8	12787750.4	587996.9
GV-9	12787758.4	587829.9
GV-10	12787742.7	587723.7
GV-11	12787732.5	587591.6
GV-12	12787984.8	587826.2
GV-13	12787973.7	587626.7
GV-14	12787962.7	587426.3
GV-15	12788081.2	587498.4
GV-16	12788165.9	587560.3
GV-17	12788703.1	588400.7
GV-18	12788720.6	588269.6
GV-19	12788667.0	588024.5
GV-20	12788472.9	587817.3

GENERAL NOTES

1. BASE MAP TOPOGRAPHY PROVIDED BY EXXEL ENGINEERING, INC DATED OCTOBER 6, 2020.
2. STATION DATUM IS NAVD88, BASED ON GPS OBSERVATIONS USING MDOT CORS.
3. PROPOSED GAS VENT AND PIEZOMETER SHALL BE CO-LOCATED, SHOWN HERE AS SEPARATE FOR CLARITY.
4. IF PERCHED WATER IS ENCOUNTERED DURING CONSTRUCTION, IT SHALL BE HANDLED IN ACCORDANCE WITH THE APPROVED SITE CONSTRUCTION WATER MANAGEMENT PLAN.
5. COORDINATES ARE REPRESENTED IN NAD83 MICHIGAN SOUTH STATE PLANE INTERNATIONAL FEET & NAVD88.

LEGEND

- SITE BOUNDARY
- GENERAL LIMIT OF WORK AREA
- EASEMENT
- PROPOSED ACCESS ROAD
- 760 EXISTING GROUND CONTOURS
- 760 TOP OF IMPACTED MATERIAL CONTOURS
- PERIMETER SWALE BREAKLINES (SW CORNER)
- BERM DESIGN BREAKLINES
- TOP OF IMPACTED MATERIAL BREAKLINES
- PROPOSED GAS VENT LOCATION & DESIGNATOR
- PROPOSED PIEZOMETER IN HOUSE ST. CAP
- ESTIMATED EXTENT OF PERCHED GROUNDWATER OBSERVED IN 2018-2019. PERCHED GROUNDWATER AT DEPTH GREATER THAN 10-FEET BELOW EXISTING GROUND SURFACE (BGS)

0 50 100 200
SCALE IN FEET

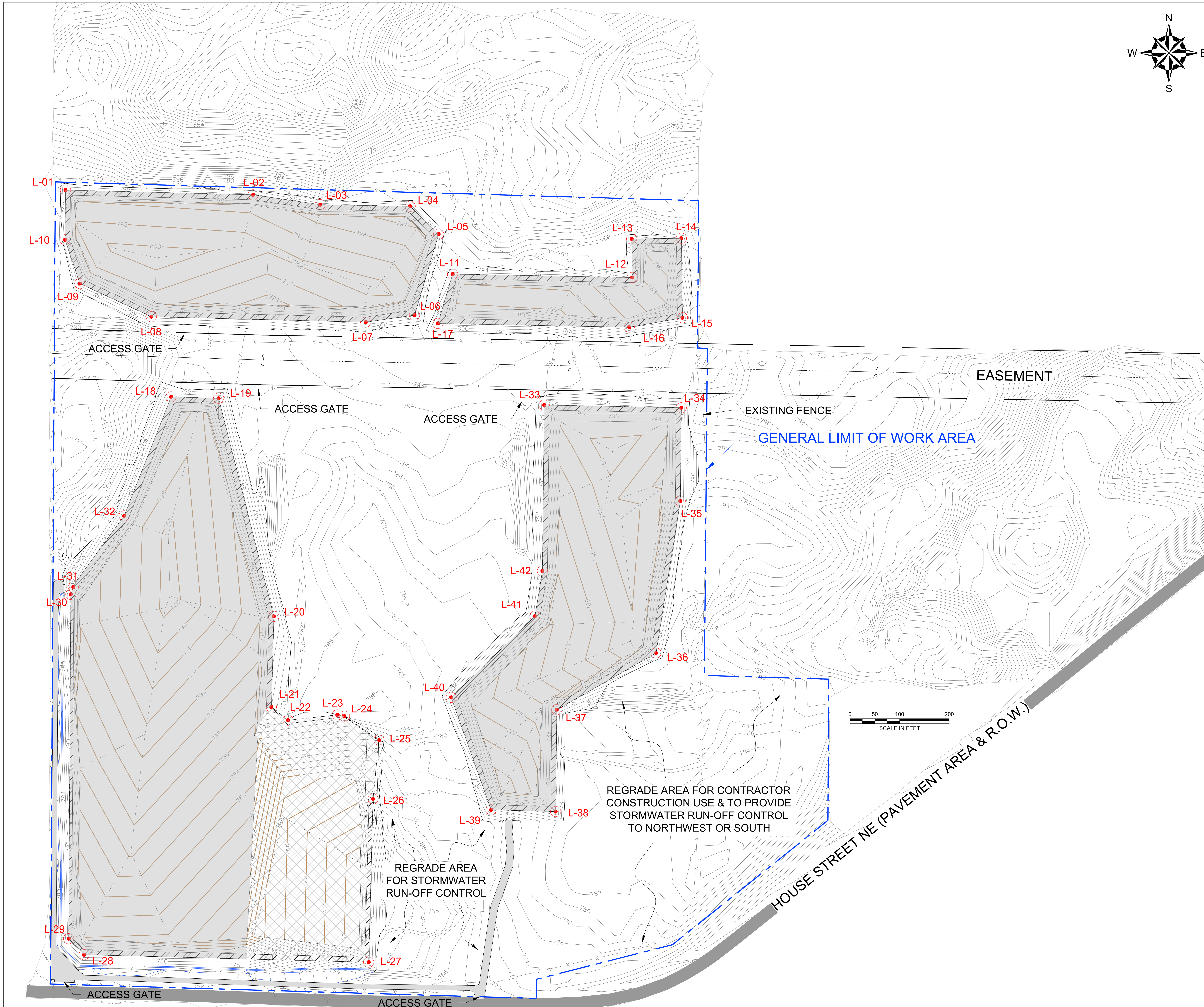
NO.	ISSUE/DESCRIPTION	BY	DATE

ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

TOP OF PREPARED SUBGRADE / BOTTOM OF CAPPING MATERIALS WITH GAS VENT & PIEZOMETER LOCATIONS

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com
PREPARED FOR: WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: TAK	SCALE: AS SHOWN	PE-008
DATE: DECEMBER 2022	PROJECT NO. 16.0062961.82	REVISION NO.	



GENERAL NOTES

1. BASE MAP TOPOGRAPHY PROVIDED BY EXXEL ENGINEERING, INC DATED OCTOBER 6, 2020.
2. STATION DATUM IS NAVD88, BASED ON GPS OBSERVATIONS USING MDOT CORS.
3. TOTAL LINED AREA ESTIMATED AT 918,000 SQUARE FEET (SF) BROKEN DOWN BY:
   492,000 SF FOR SOUTHWEST MOUND
   201,000 SF FOR SOUTEAST MOUND
   55,000 SF FOR NORTHEAST MOUND
   170,000 SF FOR NORTHWEST MOUND

LEGEND

- SITE BOUNDARY
- GENERAL LIMIT OF WORK AREA
- EASEMENT
- PROPOSED ACCESS ROAD
- 760 EXISTING GROUND CONTOURS
- 760 TOP OF IMPACTED MATERIAL CONTOURS
- PERIMETER SWALE BREAKLINES (SW CORNER)
- BERM DESIGN BREAKLINES
- TOP OF IMPACTED MATERIAL BREAKLINES
- 40-MIL LLDPE GEOMEMBRANE
- 40-MIL LLDPE DOUBLE SIDE TEXTURED GEOMEMBRANE
- CONTROL POINTS FOR CONSTRUCTION (LIMITS OF LLDPE). SEE DRAWING PE-005-C FOR COORDINATES.

NO.	ISSUE/DESCRIPTION	BY	DATE

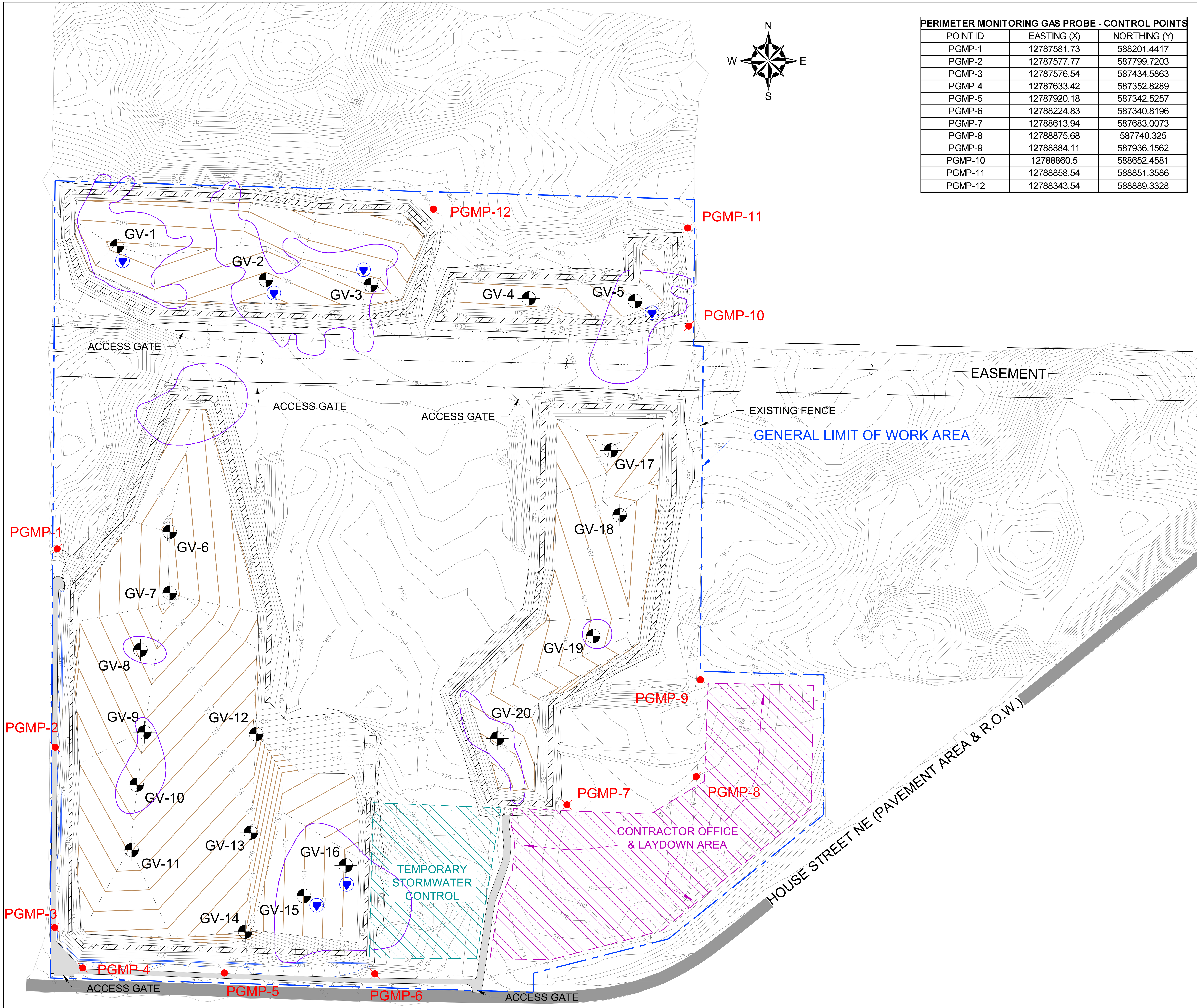
ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

LIMITS OF 40-MIL LLDPE GEOMEMBRANE

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: TAK	SCALE: AS SHOWN	PE-009
DATE: DECEMBER 2022	PROJECT NO. 16.0062961.82	REVISION NO.	



PERIMETER MONITORING GAS PROBE - CONTROL POINTS		
POINT ID	EASTING (X)	NORTHING (Y)
PGMP-1	12787581.73	588201.4417
PGMP-2	12787577.77	587799.7203
PGMP-3	12787576.54	587434.5863
PGMP-4	12787633.42	587352.8289
PGMP-5	12787920.18	587342.5257
PGMP-6	12788224.83	587340.8196
PGMP-7	12788613.94	587683.0073
PGMP-8	12788875.68	587740.325
PGMP-9	12788884.11	587936.1562
PGMP-10	12788860.5	588652.4581
PGMP-11	12788858.54	588851.3586
PGMP-12	12788343.54	588889.3328

GENERAL NOTES

1. BASE MAP TOPOGRAPHY PROVIDED BY EXXEL ENGINEERING, INC DATED OCTOBER 6, 2020.
2. STATION DATUM IS NAVD88, BASED ON GPS OBSERVATIONS USING MDOT CORS.
3. PROPOSED GAS VENT AND PIEZOMETER SHALL BE CO-LOCATED, SHOWN HERE AS SEPARATE FOR CLARITY.
4. IF PERCHED WATER IS ENCOUNTERED DURING CONSTRUCTION, IT SHALL BE HANDLED IN ACCORDANCE WITH THE APPROVED SITE CONSTRUCTION WATER MANAGEMENT PLAN.
5. COORDINATES ARE REPRESENTED IN NAD83 MICHIGAN SOUTH STATE PLANE INTERNATIONAL FEET & NAVD88.

LEGEND

- SITE BOUNDARY
- GENERAL LIMIT OF WORK AREA
- EASEMENT
- PROPOSED ACCESS ROAD
- 760 EXISTING GROUND CONTOURS
- PERIMETER SWALE BREAKLINES (SW CORNER)
- BERM DESIGN BREAKLINES
- TOP OF IMPACTED MATERIAL BREAKLINES
- PROPOSED GAS VENT LOCATION. SEE DRAWING PE-008 FOR COORDINATES.
- PROPOSED PIEZOMETER IN HOUSE ST. CAP
- ESTIMATED EXTENT OF PERCHED GROUNDWATER OBSERVED IN 2018-2019. PERCHED GROUNDWATER AT DEPTHS GREATER THAN 10 FEET BELOW GROUND SURFACE (BGS).
- PERIMETER GAS MONITORING PROBE (PGMP)

0 50 100 200
SCALE IN FEET

NO.	ISSUE/DESCRIPTION	BY	DATE

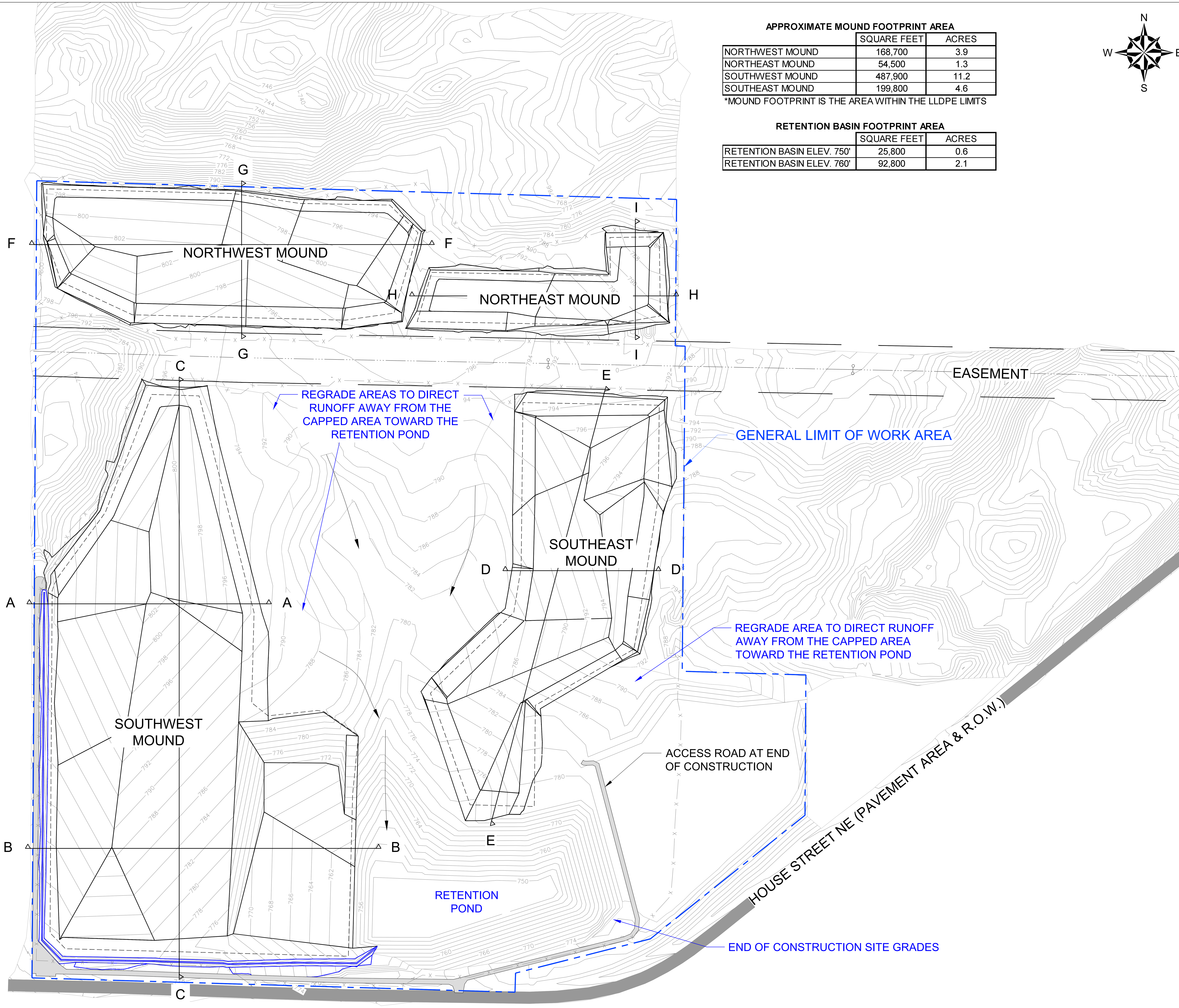
ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

LANDFILL GAS MONITORING PROBE LOCATIONS

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE PE-010
DESIGNED BY: KHM	DRAWN BY: TAK	SCALE: AS SHOWN	
DATE: DECEMBER 2022	PROJECT NO. 16.0062961.82	REVISION NO.	



APPROXIMATE MOUND FOOTPRINT AREA

	SQUARE FEET	ACRES
NORTHWEST MOUND	168,700	3.9
NORTHEAST MOUND	54,500	1.3
SOUTHWEST MOUND	487,900	11.2
SOUTHEAST MOUND	199,800	4.6

*MOUND FOOTPRINT IS THE AREA WITHIN THE LLDPE LIMITS

RETENTION BASIN FOOTPRINT AREA

	SQUARE FEET	ACRES
RETENTION BASIN ELEV. 750'	25,800	0.6
RETENTION BASIN ELEV. 760'	92,800	2.1

GENERAL NOTES

1. BASE MAP TOPOGRAPHY PROVIDED BY EXXEL ENGINEERING, INC DATED OCTOBER 6, 2020.
2. STATION DATUM IS NAVD88, BASED ON GPS OBSERVATIONS USING MDOT CORS.

LEGEND

- SITE BOUNDARY
- GENERAL LIMIT OF WORK AREA
- EASEMENT
- PROPOSED SITE ACCESS ROAD
- 760 CONTOUR LINES
- PERIMETER SWALE BREAKLINES (SW CORNER)
- TOP OF CAP BREAKLINES
- TOP OF IMPACTED MATERIAL BREAKLINES
- LIMITS OF 40-MIL LLDPE GEOMEMBRANE

NO.	ISSUE/DESCRIPTION	BY	DATE

ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

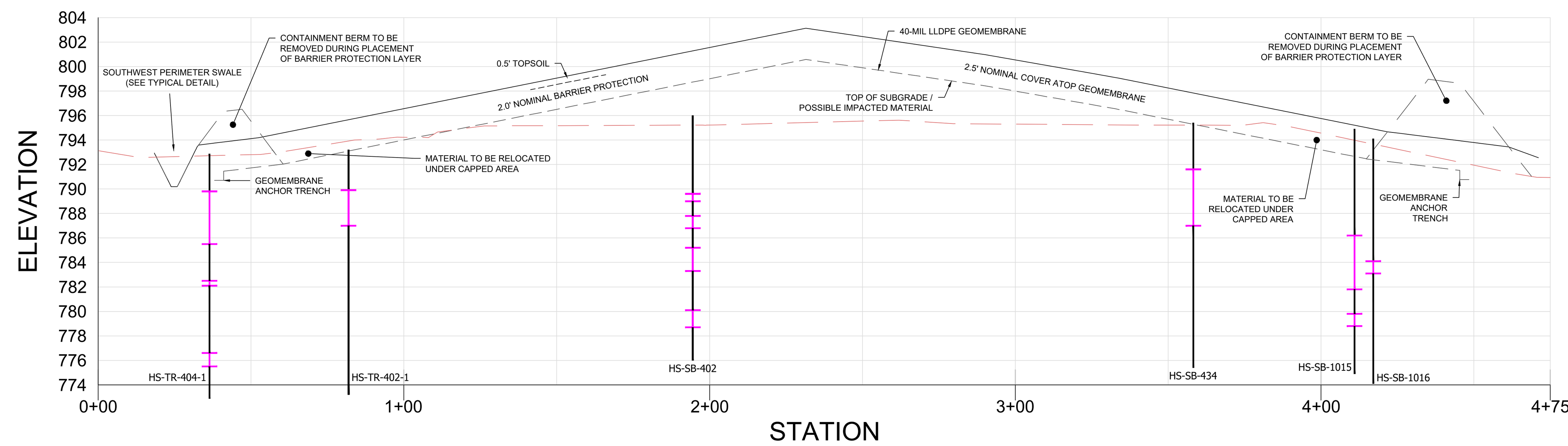
TOP OF FINISH GRADE
(CAPPING TOPSOIL AND DRAINAGE SWALE)

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

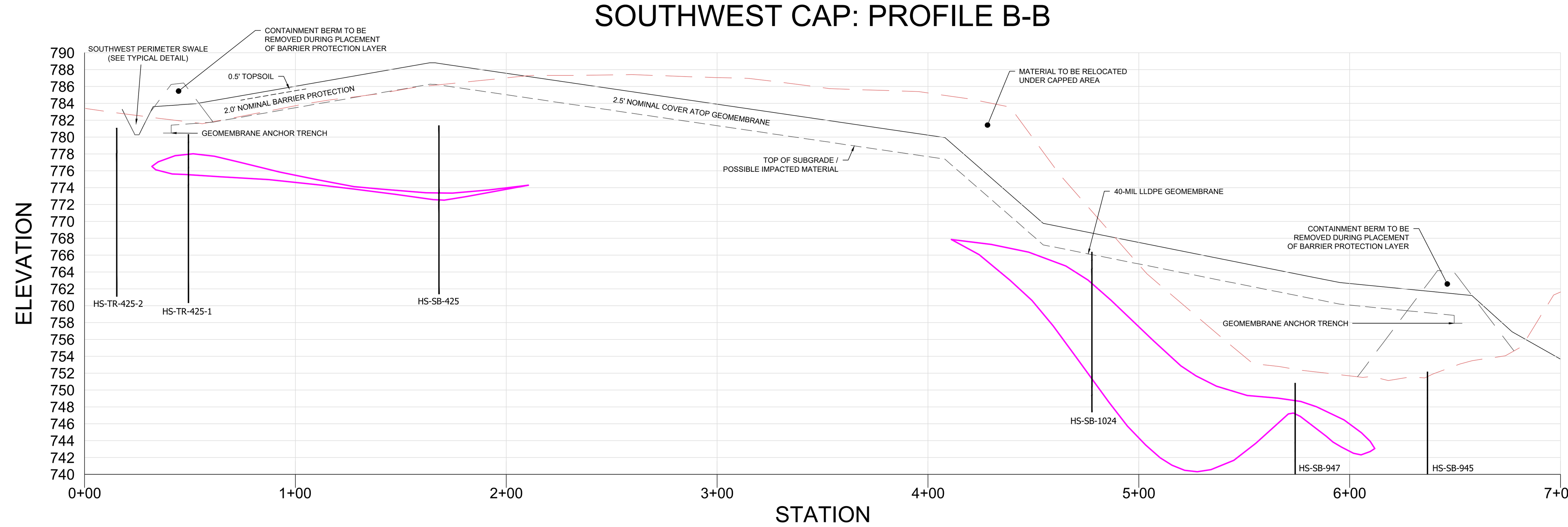
PREPARED FOR: WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: TAK	SCALE: AS SHOWN	PE-011
DATE: DECEMBER 2022	PROJECT NO. 16.0062961.82	REVISION NO.	

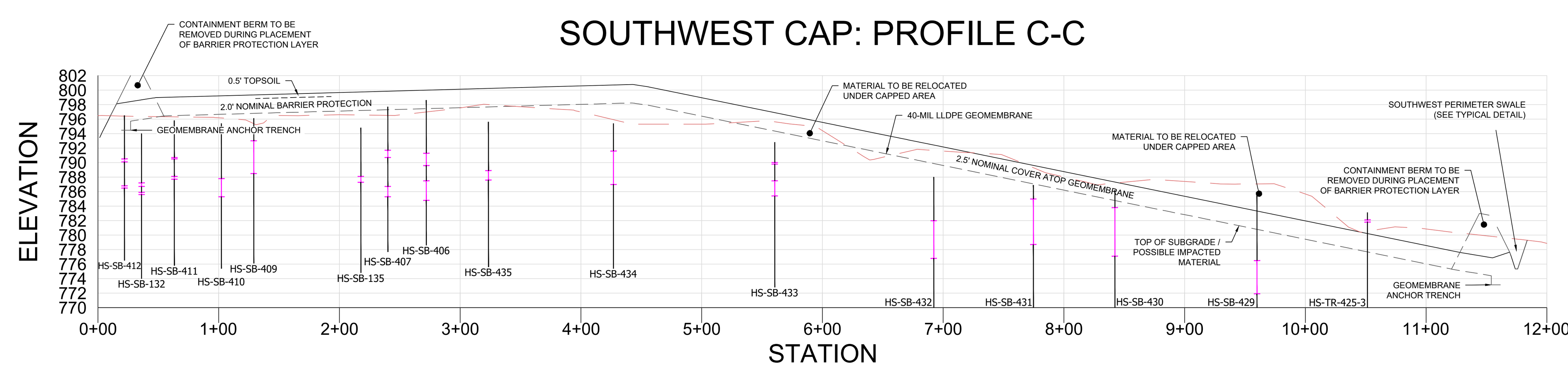
SOUTHWEST CAP: PROFILE A-A



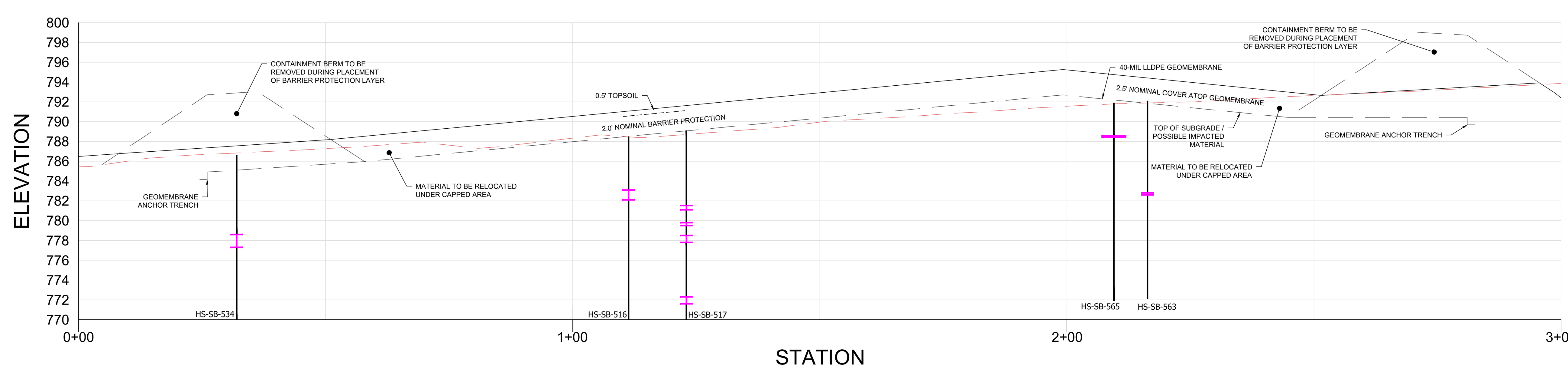
SOUTHWEST CAP: PROFILE B-B



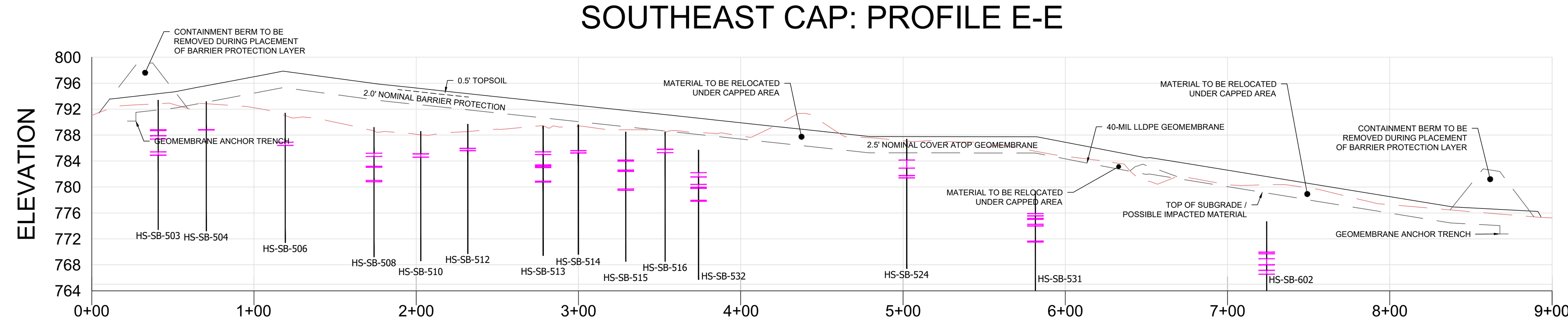
SOUTHWEST CAP: PROFILE C-C



SOUTHEAST CAP: PROFILE D-D



SOUTHEAST CAP: PROFILE E-E



LEGEND

- EXISTING GROUND SURFACE
- TOP OF CONTAINMENT BERM
- TOP OF RE-GRADED IMPACTED MATERIAL
- TOP OF FINISH GRADE
- WASTE (AS SHOWN IN OCTOBER 2021 REVISED FEASIBILITY STUDY REPORT)
- ESTIMATED WASTE BOTTOM
- DEPTH WHERE WASTE ENCOUNTERED IN TEST BORING / PROBE

GENERAL NOTES

1. SUITABLE RELOCATED MATERIAL TO BE INCORPORATED EITHER UNDER THE 40-MIL GEOMEMBRANE AS PART OF SUBGRADE PREPARATION OR INCORPORATED INTO THE PERIMETER CONTAINMENT BERM, AS APPLICABLE, AND IN ACCORDANCE WITH PROJECT SPECIFICATIONS.
2. CONTAINMENT BERM MATERIAL TO BE INCORPORATED INTO BARRIER PROTECTION LAYER AS PART OF CONTAINMENT BERM REMOVAL PROCESS.
3. WASTE ENCOUNTERED TO BE PLACED IN MOUND UNDER 40-MIL GEOMEMBRANE.

NO.	ISSUE/DESCRIPTION	BY	DATE

ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

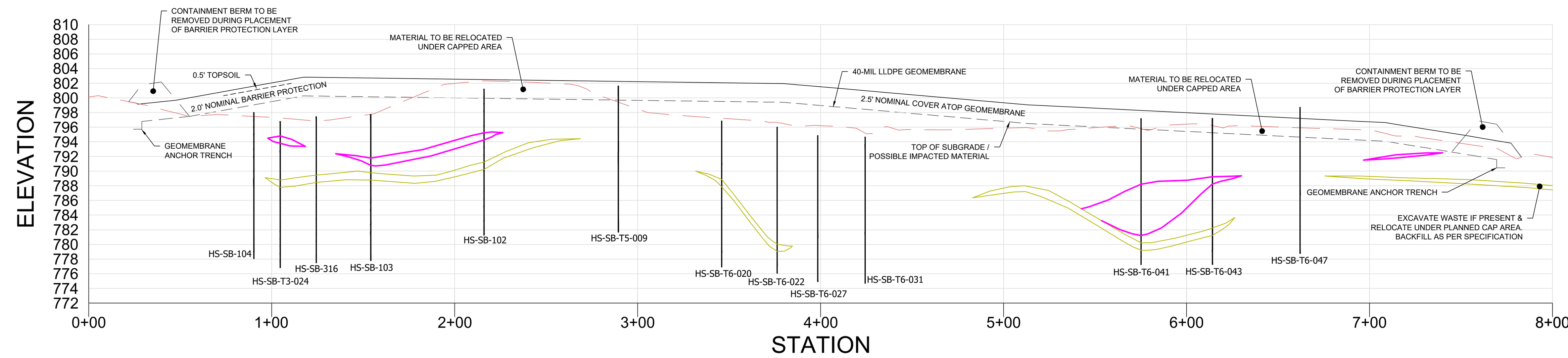
CAPPING SYSTEM TYPICAL PROFILES A-A, B-B, C-C, D-D & E-E

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

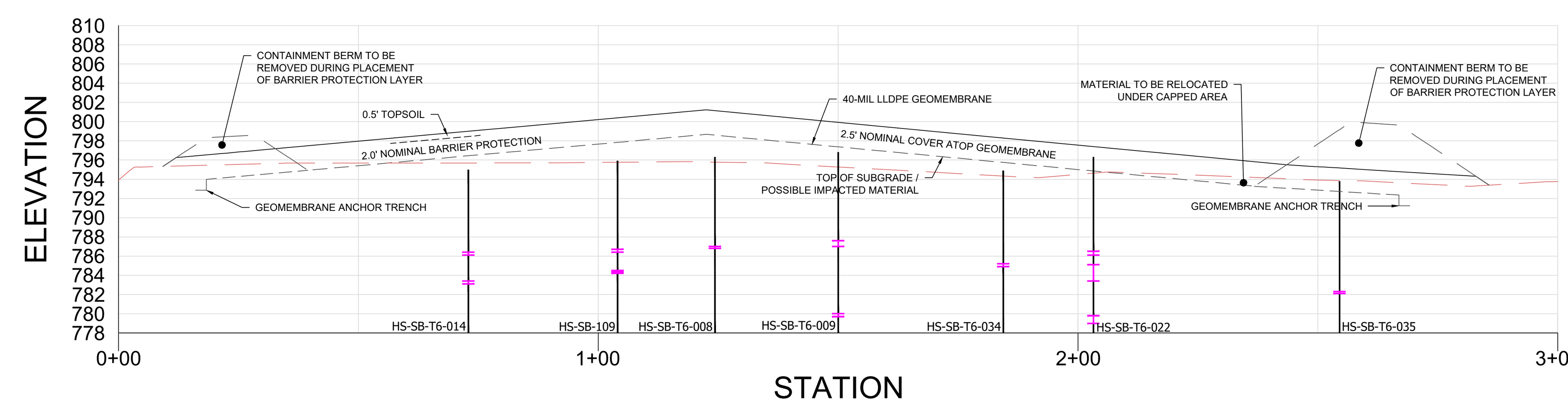
PREPARED FOR: WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: TAK	SCALE: AS SHOWN	PE-012
DATE: DECEMBER 2022	PROJECT NO. 16.0062961.82	REVISION NO.	

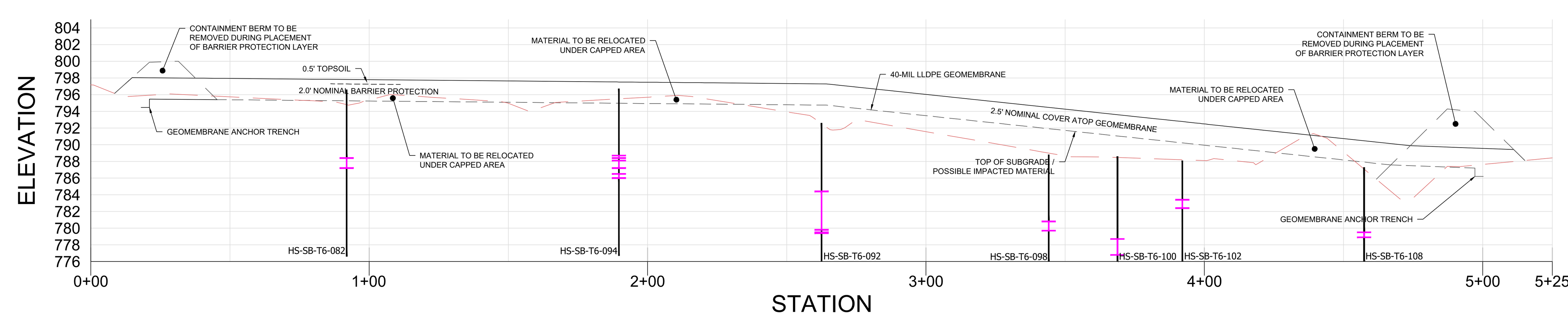
NORTHWEST CAP: PROFILE F-F



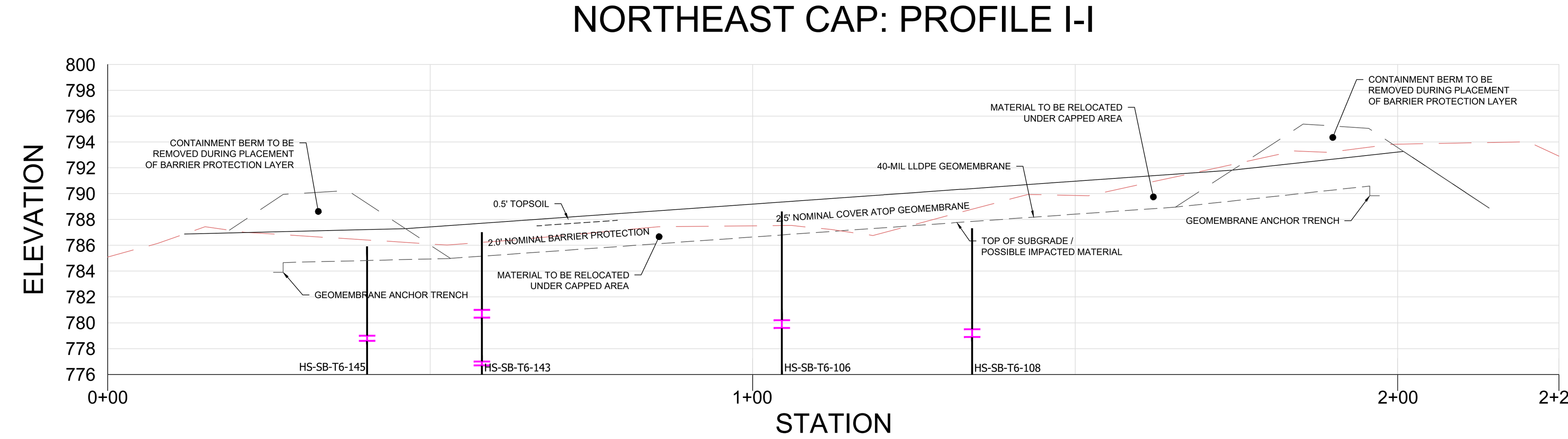
NORTHWEST CAP: PROFILE G-G



NORTHEAST CAP: PROFILE H-H



NORTHEAST CAP: PROFILE I-I



LEGEND

- EXISTING GROUND SURFACE
- TOP OF CONTAINMENT BERM
- TOP OF RE-GRADED IMPACTED MATERIAL
- TOP OF FINISH GRADE
- WASTE (AS SHOWN IN OCTOBER 2021 REVISED FEASIBILITY STUDY REPORT)
- ESTIMATED WASTE BOTTOM
- DEPTH WHERE WASTE ENCOUNTERED IN TEST BORING / PROBE

GENERAL NOTES

1. SUITABLE RELOCATED MATERIAL TO BE INCORPORATED EITHER UNDER THE 40-MIL GEOMEMBRANE AS PART OF SUBGRADE PREPARATION OR INCORPORATED INTO THE PERIMETER CONTAINMENT BERM, AS APPLICABLE, AND IN ACCORDANCE WITH PROJECT SPECIFICATIONS.
2. CONTAINMENT BERM MATERIAL TO BE INCORPORATED INTO BARRIER PROTECTION LAYER AS PART OF CONTAINMENT BERM REMOVAL PROCESS.
3. WASTE ENCOUNTERED TO BE PLACED IN MOUND UNDER 40-MIL GEOMEMBRANE.

NO.	ISSUE/DESCRIPTION	BY	DATE

ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

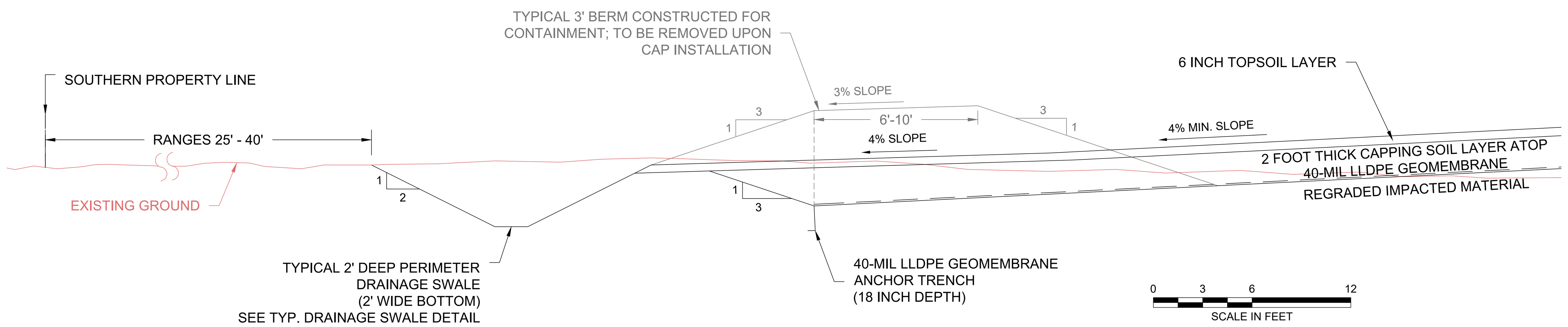
CAPPING SYSTEM TYPICAL PROFILES F-F, G-G, H-H & I-I

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

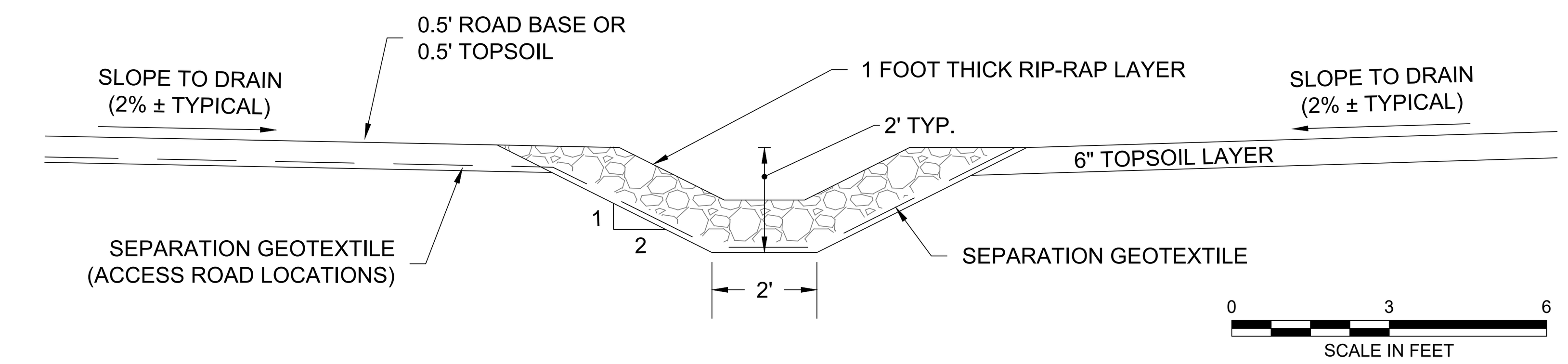
PREPARED FOR: WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: TAK	SCALE: AS SHOWN	PE-013
DATE: DECEMBER 2022	PROJECT NO. 16.0062961.82	REVISION NO.	

TYPICAL SECTION OF SOUTHWEST CAP SOUTH BERM

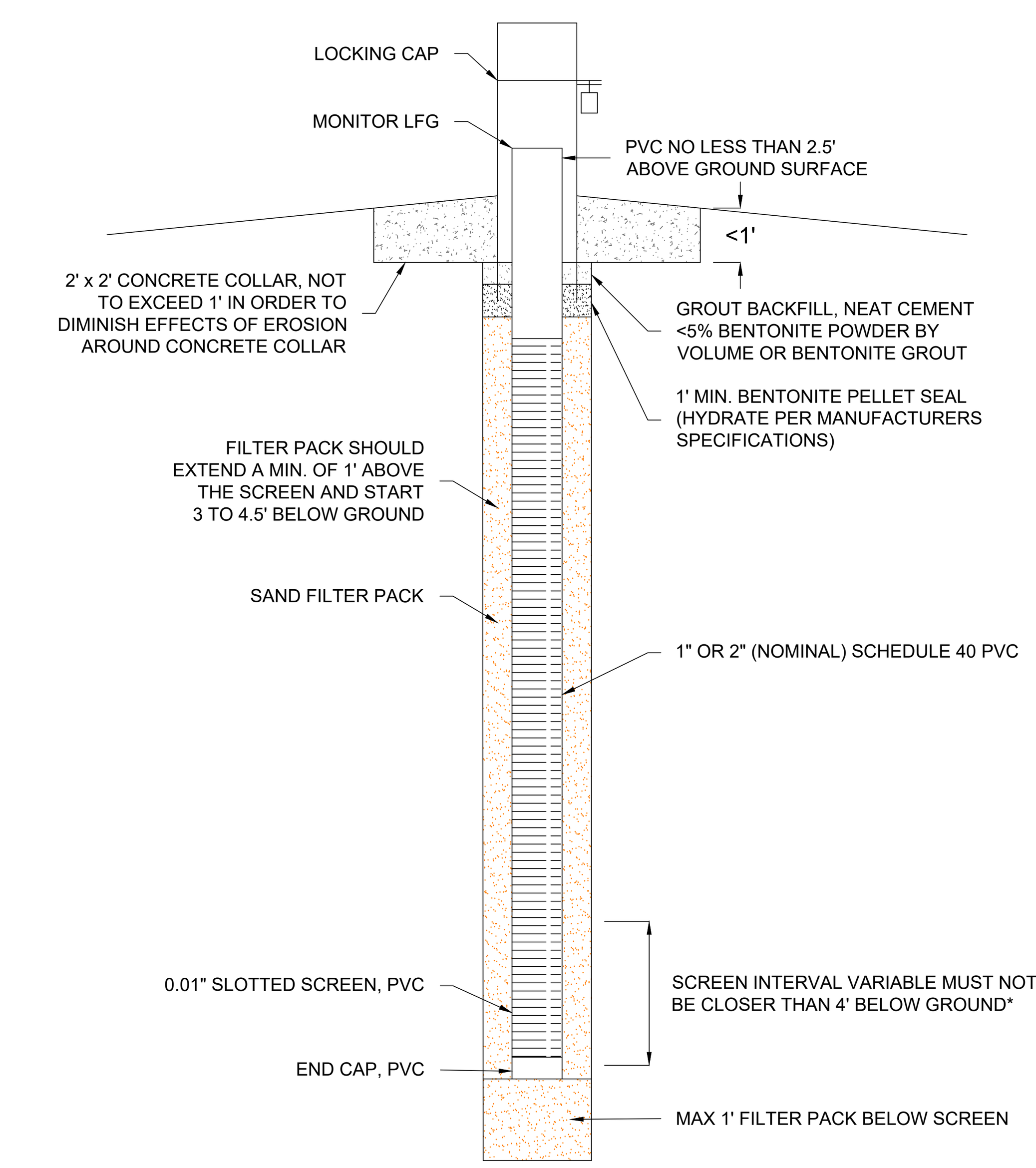


TYPICAL DRAINAGE SWALE



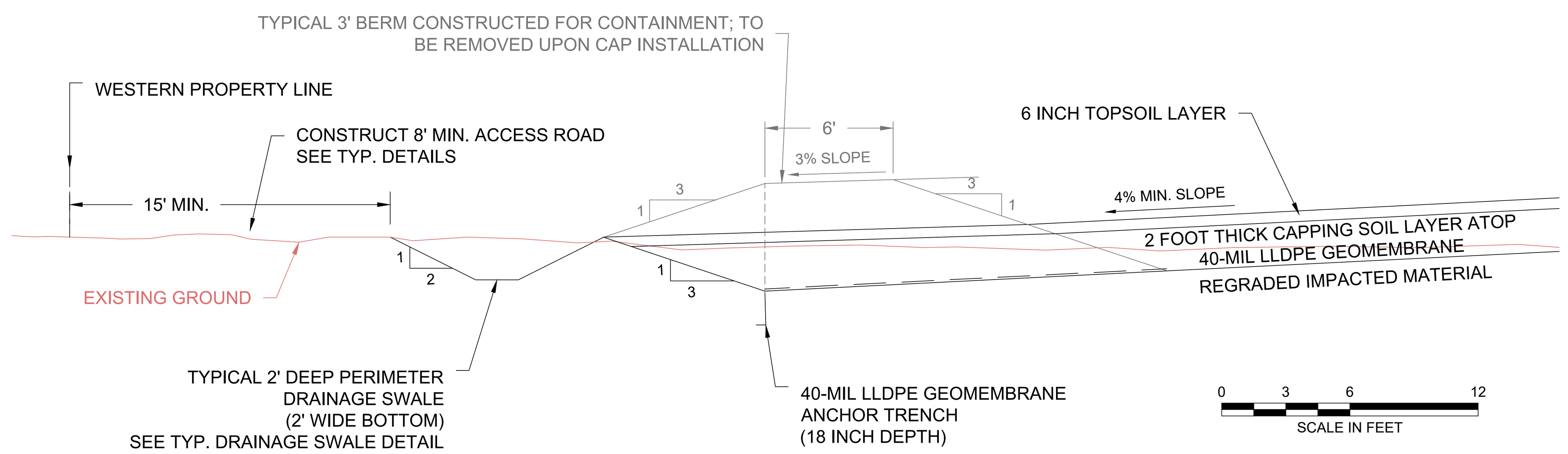
TYPICAL PERIMETER GAS MONITORING PROBE

(NOT TO SCALE)



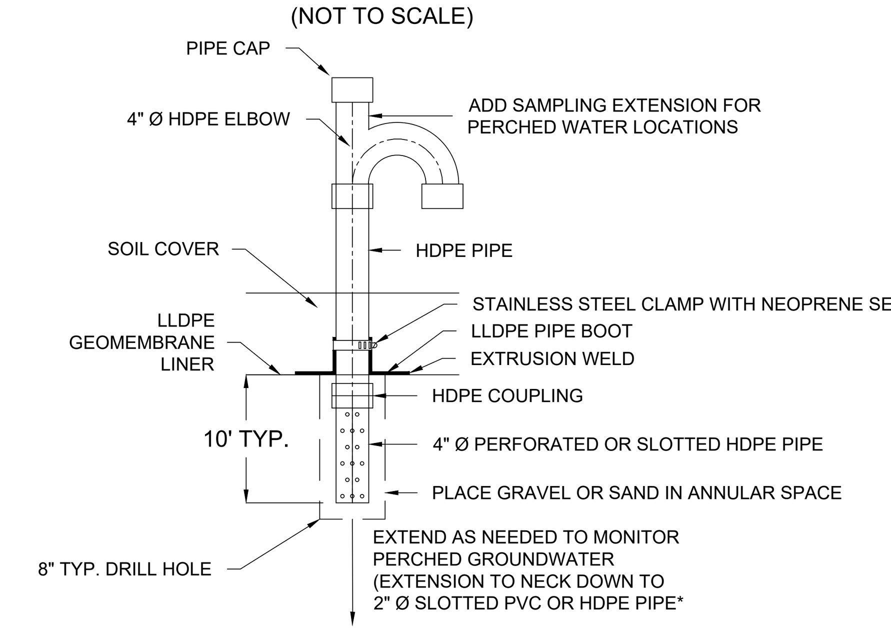
*DEPTH OF PERIMETER GAS MONITORING PROBE TO BE PROVIDED TO EGLE FOR APPROVAL PRIOR TO INSTALLATION. DEPTHS ANTICIPATED TO BE 25-FEET OR LESS.

TYPICAL SECTION OF SOUTHWEST CAP WEST BERM



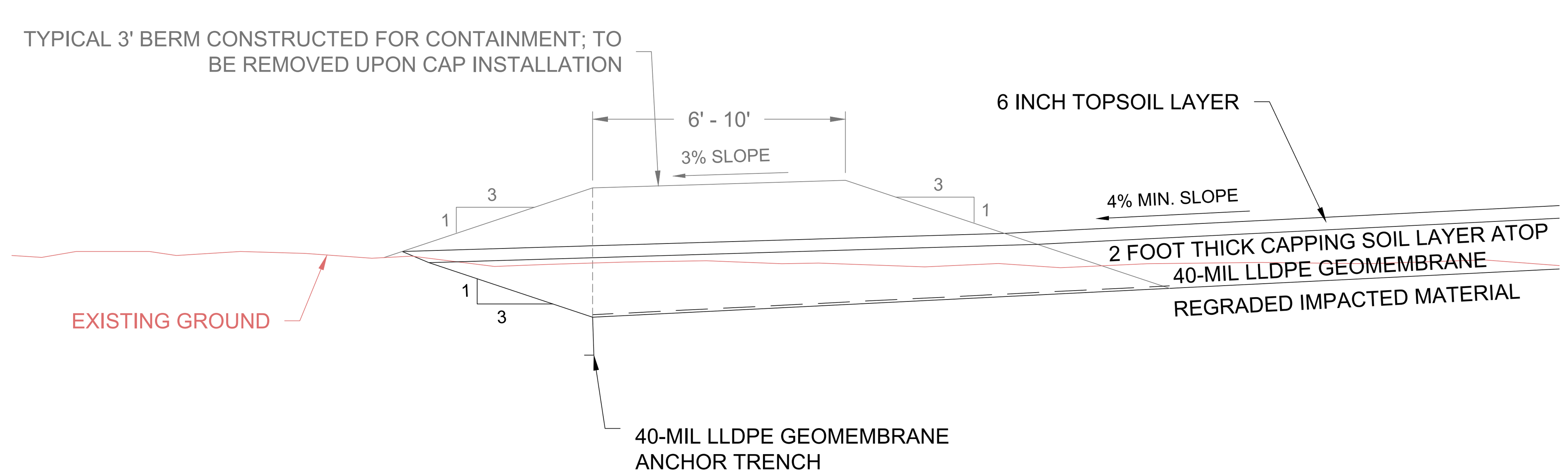
LANDFILL COVER GAS VENT

(NOT TO SCALE)



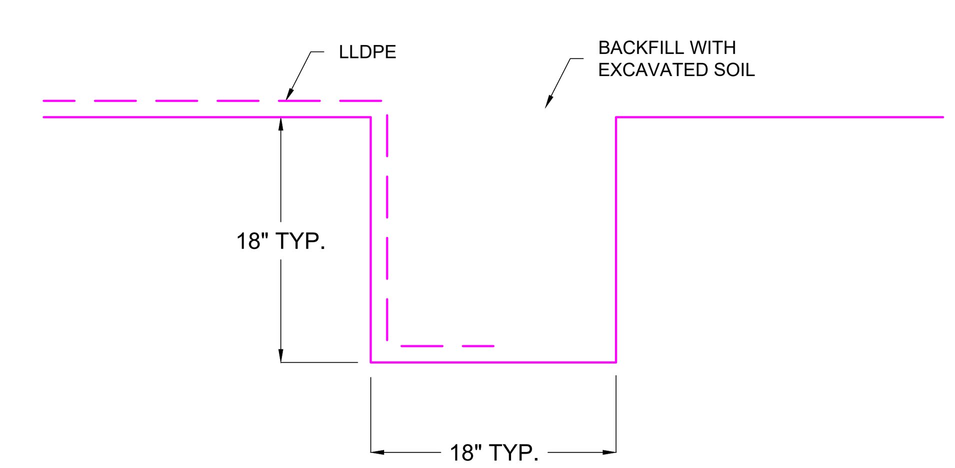
*DEPTH OF MOUND PIEZOMETERS TO BE PROVIDED TO EGLE FOR APPROVAL PRIOR TO INSTALLATION

TYPICAL SECTION OF PERIMETER BERM



TYPICAL LLDPE ANCHOR TRENCH

(NOT TO SCALE)



NO.	ISSUE/DESCRIPTION	BY	DATE

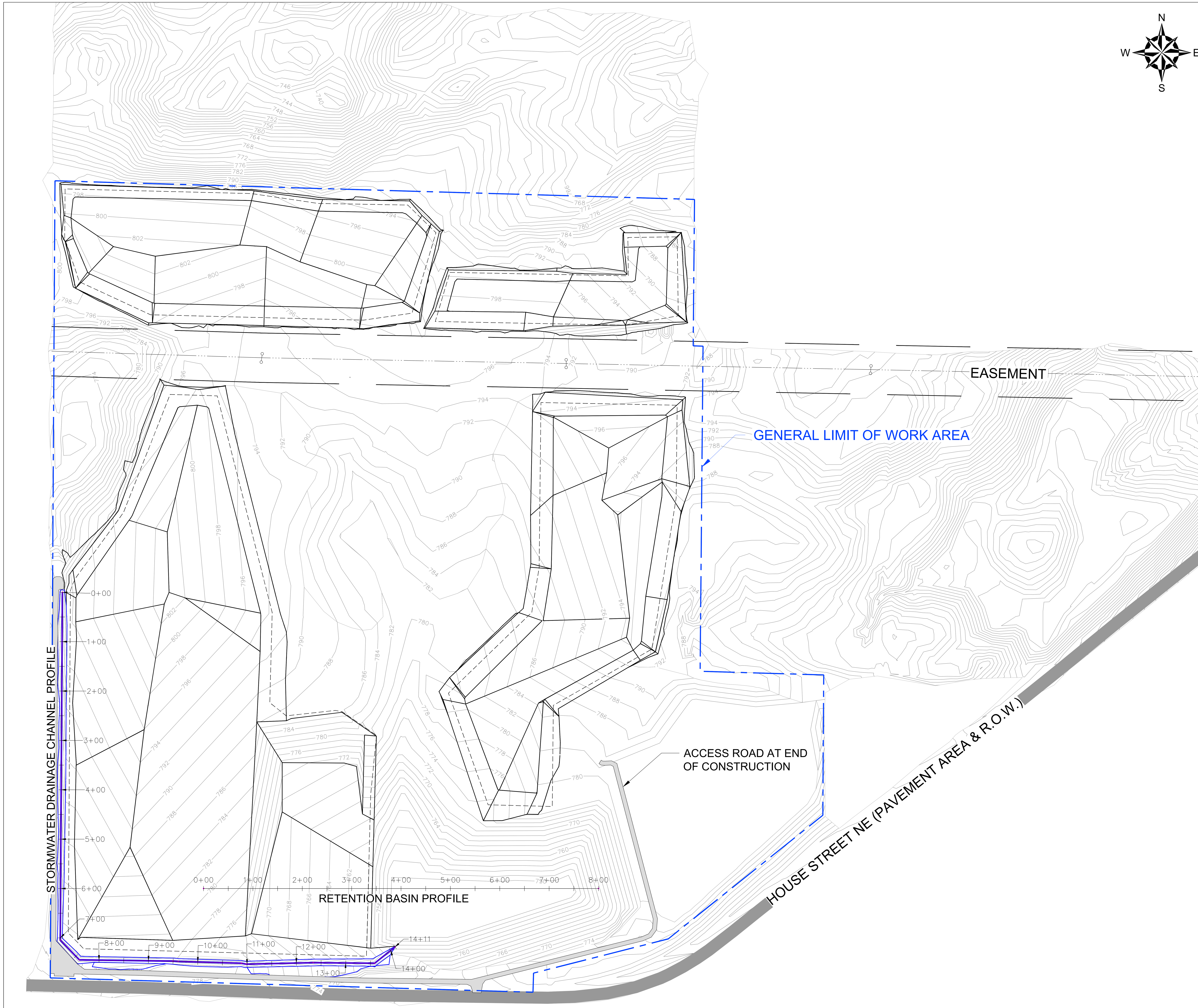
ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

TYPICAL FINAL CAPPING SYSTEM SECTIONS AND DETAILS

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: TAK	SCALE: AS SHOWN	PE-014
DATE: DECEMBER 2022	PROJECT NO. 16.0062961.82	REVISION NO.	



GENERAL NOTES

1. BASE MAP TOPOGRAPHY PROVIDED BY EXXEL ENGINEERING, INC DATED OCTOBER 6, 2020.
2. STATION DATUM IS NAVD88, BASED ON GPS OBSERVATIONS USING MDOT CORS.

LEGEND

- SITE BOUNDARY
- GENERAL LIMIT OF WORK AREA
- EASEMENT
- PROPOSED SITE ACCESS ROAD
- 760 CONTOUR LINES
- PERIMETER SWALE BREAKLINES (SW CORNER)
- TOP OF CAP BREAKLINES
- TOP OF IMPACTED MATERIAL BREAKLINES
- LIMITS OF 40-MIL LLDPE GEOMEMBRANE

0 50 100 200
SCALE IN FEET

NO.	ISSUE/DESCRIPTION	BY	DATE

ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

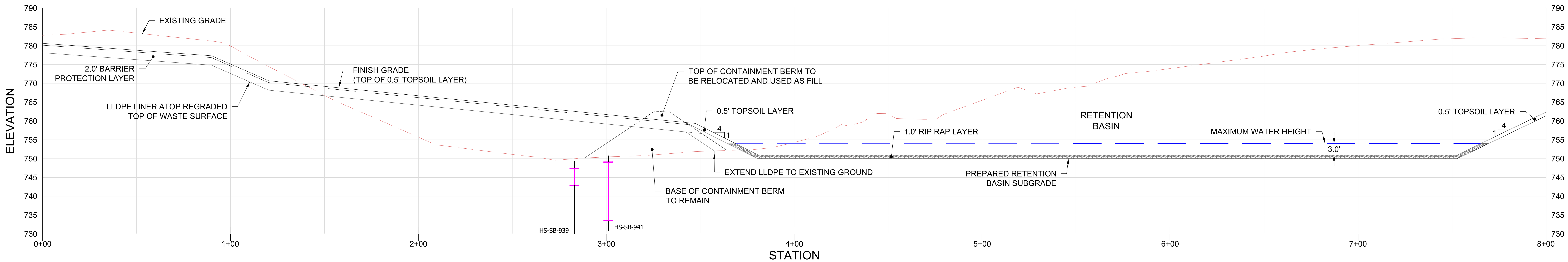
RETENTION BASIN & SOUTHWEST DRAINAGE CHANNEL PLAN

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

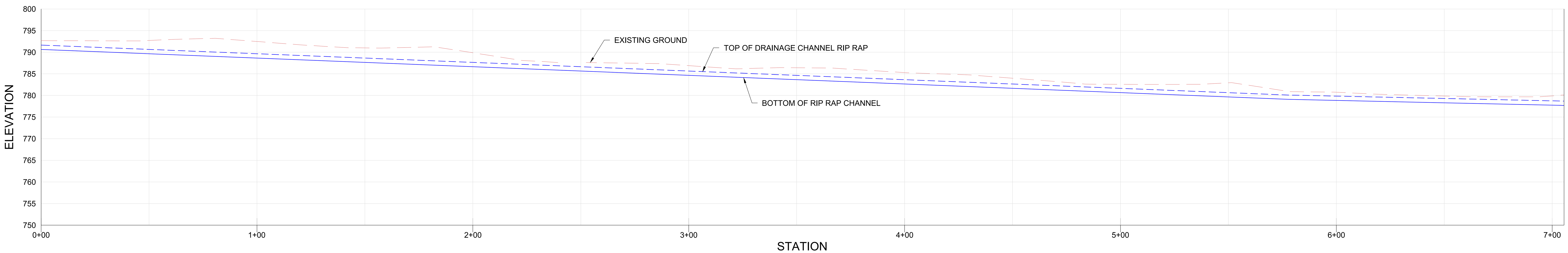
PREPARED FOR: WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: TAK	SCALE: AS SHOWN	PE-015-A
DATE: DECEMBER 2022	PROJECT NO. 16.0062961.82	REVISION NO.	

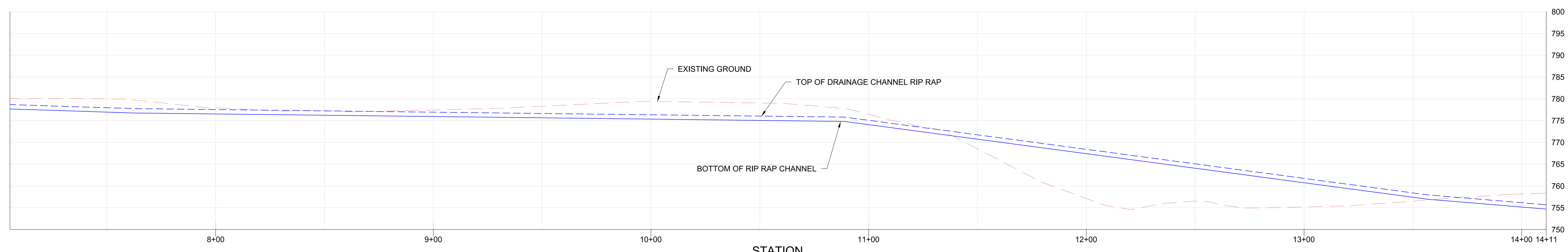
RETENTION BASIN PROFILE



STORMWATER DRAINAGE CHANNEL PROFILE



STORMWATER DRAINAGE CHANNEL PROFILE (CONT.)



GENERAL NOTES

1. APPROXIMATE PROFILES SHOWN FOR CONCEPT, ACUTAL CONSTRUCTION WILL VARY IN THE FIELD BASED ON CONDITIONS ENCOUNTERED.

LEGEND

- EXISTING GROUND SURFACE
- FINISH GRADE SURFACE
- REGRADED WASTE SURFACE
- BOTTOM OF STORMWATER DRAINAGE CHANNEL
- TOP OF STORMWATER DRAINAGE CHANNEL
- DEPTH WHERE WASTE ENCOUNTERED IN TEST BORING / PROBE

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ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

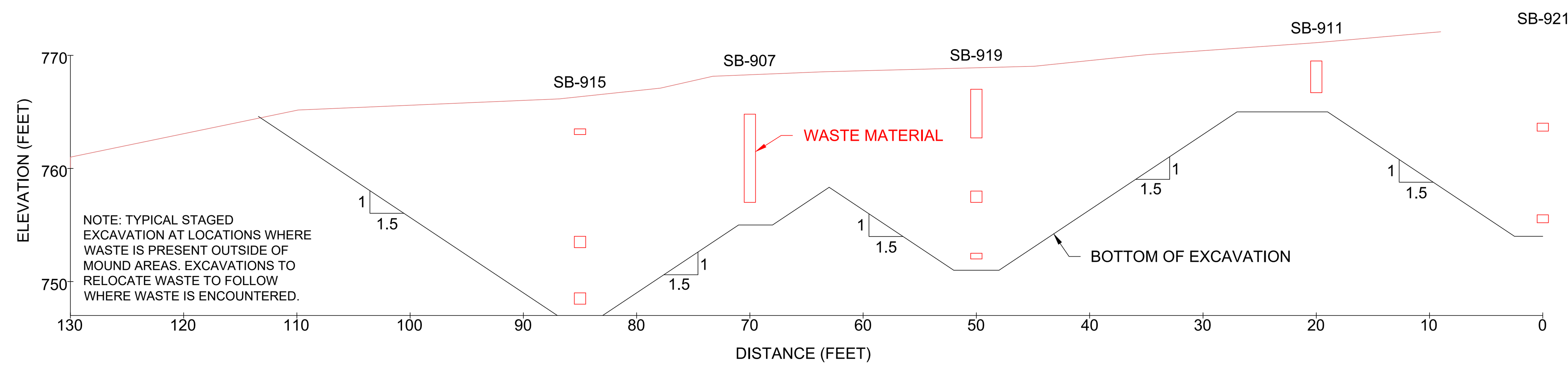
RETENTION BASIN & SOUTHWEST STORMWATER DRAINAGE CHANNEL PROFILES

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: WN&J/WWW

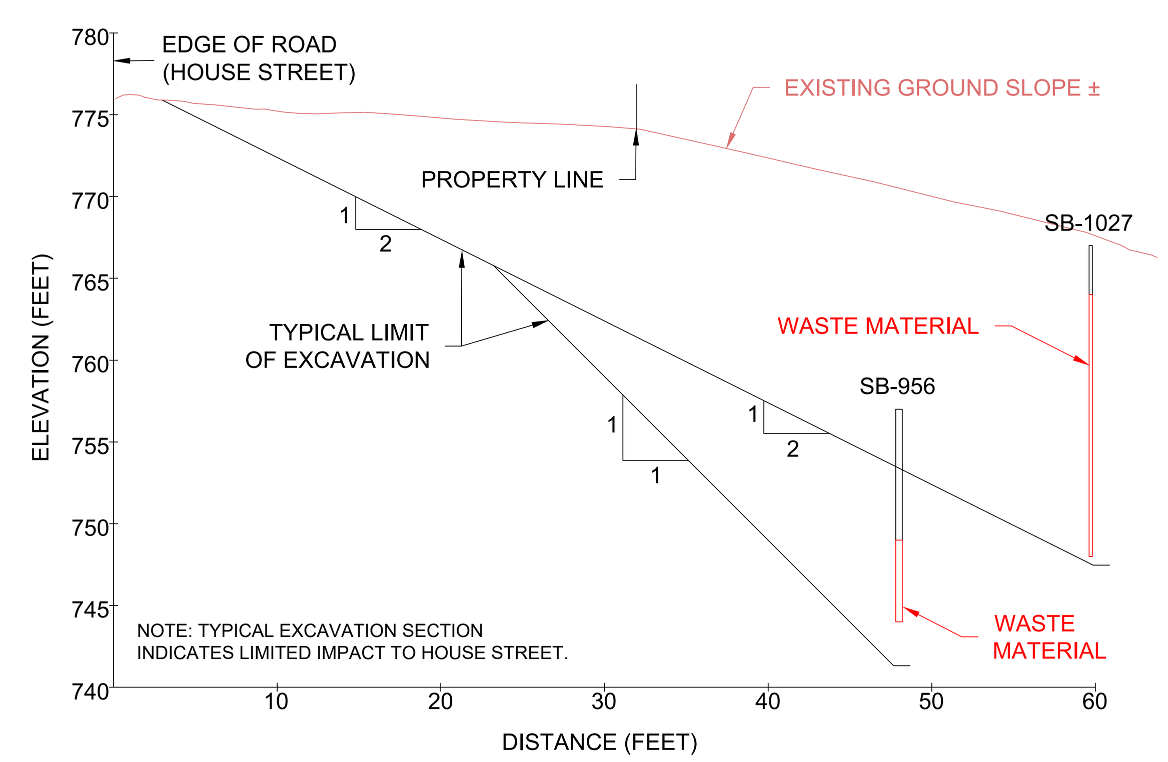
PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: TAK	SCALE: AS SHOWN	PE-015-B
DATE: DECEMBER 2022	PROJECT NO. 16.0062961.82	REVISION NO.	

EXCAVATION OF WASTE WITHIN RETENTION BASIN CONSTRUCTION AREA



TYPICAL SECTION 2

EXCAVATION OF WASTE ALONG SOUTH PROPERTY LINE



TYPICAL SECTION 1

0 5 10 20
SCALE IN FEET

GENERAL NOTES

1. EXCAVATION SIDE SLOPES SHOWN AT 1(H) : 1(V) TO 2(H) : 1(V) FOR PRESENTATION PURPOSES. ACTUAL EXCAVATIONS TO COMPLY WITH OSHA REQUIREMENTS
2. INTENT OF WASTE EXCAVATION IS TO REMOVE ENCOUNTERED WASTE MATERIAL, WHICH MAY DIFFER FROM THAT SHOWN BOTH HORIZONTALLY AND VERTICALLY.
3. APPROXIMATE SECTION LOCATIONS SHOWN ON DRAWING PE-005-A

NO.	ISSUE/DESCRIPTION	BY	DATE

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601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

TYPICAL WASTE EXCAVATION DETAILS

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: TAK	SCALE: AS SHOWN	PE-016
DATE: DECEMBER 2022	PROJECT NO. 16.0062961.82	REVISION NO.	

PLANTING KEY

- ESTABLISH AS LAWN
- PLANT WITH NATIVE CONSERVATION SEED MIX
- RETENTION AREA - PLANT WET MEADOW MIX
- CONCEPTUAL ACCESS ROAD LOCATION

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ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

LANDSCAPING PLAN

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE PE-017
DESIGNED BY: KHM	DRAWN BY: TAK	SCALE: AS SHOWN	
DATE: NOVEMBER 2022	PROJECT NO. 16.0062961.82	REVISION NO.	

GENERAL NOTES

1. BACKGROUND AERIAL IMPORTED WITH AUTOCAD CIVIL 3D 2022.

0 30 60 120
SCALE IN FEET

NO.	ISSUE/DESCRIPTION	BY	DATE

ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

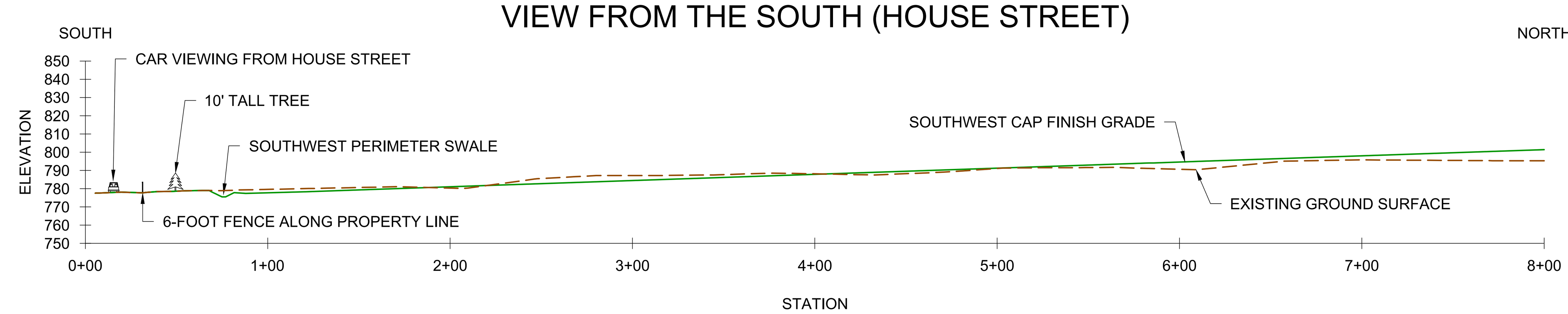
PERIMETER VIEW PLAN

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

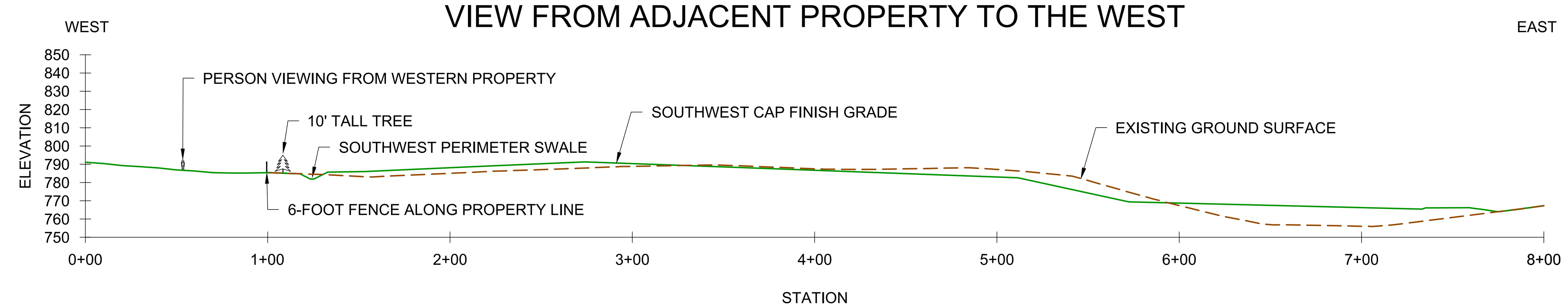
PREPARED FOR:
WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: TAK	SCALE: AS SHOWN	PE-018
DATE: NOVEMBER 2022	PROJECT NO. 16.0062961.82	REVISION NO.	

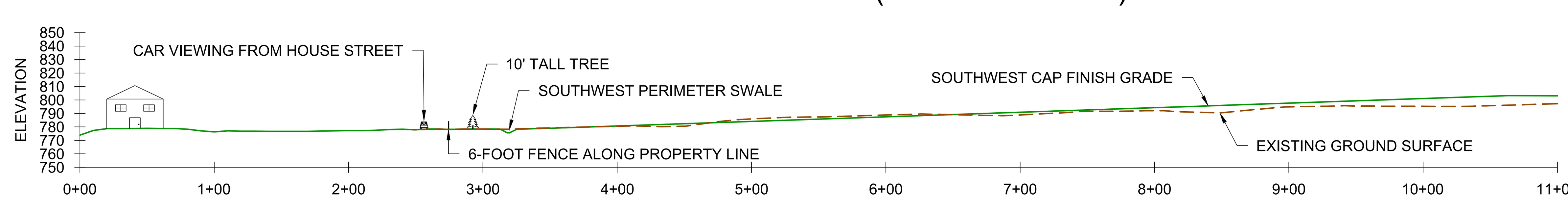
X1-X1
VIEW FROM THE SOUTH (HOUSE STREET)



X2-X2
VIEW FROM ADJACENT PROPERTY TO THE WEST



X3-X3
VIEW FROM THE SOUTH (HOUSE STREET)



NO.	ISSUE/DESCRIPTION	BY	DATE

ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

PERIMETER VIEW PROFILES

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: TAK	SCALE: AS SHOWN	PE-019
DATE: NOVEMBER 2022	PROJECT NO. 16.0062961.82	REVISION NO.	

ATTACHMENT D

SPECIFICATIONS

SECTION 31 05 19

GEOSYNTHETICS for EARTHWORK

PART 1 – GENERAL

1.01. DESCRIPTION

A. This section specifies the material and construction requirements for:

1. Separation Geotextile
2. Geomembrane

B. Related work specified elsewhere:

1. Excavation and Fill: Section 31 23 00

1.02. DEFINITIONS:

A. Separation Geotextile is nominal 6 oz/sy nonwoven filter fabric overlying the drainage swales to separate rip-rap from the underlying soil. It will also be used beneath temporary road base during construction, and maintenance roads that will remain following installation of the cap.

B. Geomembrane is the 40 mil linear low-density polyethylene (LLDPE) liner, to be installed over the proposed top-of-waste or subgrade within each mound area. Smooth surface LLDPE will be used on the top and side slope of mounds with a slope less than 5%; double-rough LLDPE will be used on areas where the slope exceeds 5%.

1.03. JOB CONDITIONS:

A. Retain the services of a geomembrane manufacturer and installer certified by the manufacturer to supply and install the 40 Mil LLDPE liner.

B. Exercise care in placing the geomembrane to allow removal of free particles greater than 3 inches in diameter from the subgrade surface.

1.04. SUBMITTALS:

A. Prior to shipping the product, submit the following to the Owner’s Representative for review and approval:

1. Separation Geotextile

   a. Geotextile supplier/manufacturer

   b. Manufacturer’s product specifications

   c. Manufacturer’s recommendations for installation and anchoring as appropriate for the intended use and application.

   d. Manufacturer's quality control test data, as specified, herein traceable to the lot numbers and roll numbers of geosynthetic material delivered to the project site.

   e. Manufacturer's certificate or statement of compliance in accordance with these specifications.

2. Geomembrane

a. Pre-Construction Submittals

i. LLDPE geomembrane supplier/manufacturer

ii. Manufacturer's product specifications

iii. Manufacturer's recommendations for installation

iv. LLDPE geomembrane installer

v. Installer's qualifications

vi. Installer's quality control plan

vii. Geomembrane Deployment, Panel Layout, and Quality Control Plan

viii. Manufacturer's written certification that the installer is approved by the manufacturer and the manufacturer will warranty the installers work.

ix. Manufacturer's quality control test data, as specified herein, traceable to the lot numbers and roll numbers of geosynthetic material delivered to the project site.

x. Manufacturer's certificate or statement of compliance in accordance with these specifications.

xi. Manufacturer's Warranty

xii. Independent Laboratory Test Results

b. Post-Construction Submittals

i. All field seaming quality control test data including test seam data, and non-destructive seam testing data; and

ii. Destructive seam sample test data.

iii. Submit the post-construction geomembrane documentation identified above, the independent laboratory test results of the destructive seam samples, and the data accepted by the CQA Engineer prior to placement of any material over the geomembrane.

PART 2 - PRODUCTS

2.01 PROVIDE THE FOLLOWING GEOSYNTHETIC MATERIAL THAT SATISFY THE SPECIFIED MINIMUM AVERAGE ROLL VALUES.

2.02 MATERIALS

A. Separation Geotextile:

1. Separation Geotextile - non-woven, needle punched polypropylene or polyester, continuous filament material meeting or exceeding the following minimum requirements:

Property	Test Method	Value
Unit Weight (oz/yd^2)	ASTM D5261	6 (nominal)
Grab Tensile Strength (lbs)	ASTM D4632	160
Elongation (%)	ASTM D4632	50
Trapezoidal Tear Strength (lbs)	ASTM D4533	60
CBR Puncture Strength (lbs)	ASTM D6241	425
Permittivity (sec^{-1})	ASTM D4491	0.02
Apparent Opening Size (U.S. sieve number equivalent)	ASTM D4751	70-100
Ultraviolet Stability (% Ret. @ 500 hrs.) (see Note 2)	ASTM D4355	50%

Notes:

(1) All values are minimum average roll values (MARV) except AOS which is a maximum average roll value (MaxARV), and UV stability which is a minimum value.

(2) Evaluation to be on 2-inch strip tensile specimens after 500 hours exposure.

2. Furnish certificates of compliance from the manufacturer for the geotextile delivered to the site. Test samples of the geotextile for the parameters specified, provide results to the Owner's Representative.

3. Responsibility of the CQA Engineer:

   a. Review the test data and compare them to specifications. Identify rolls not meeting specifications and notify the Contractor that those rolls are not installed); and

   b. Observe the storage of rolls delivered to the Site and the procedures used to shelter them from sunlight, storm water and construction traffic.

B. Geomembrane

1. Provide a smooth and textured Geomembrane cover material fabricated from linear low-density polyethylene (LLDPE), nominal 40 mil continuous thickness that complies with the minimum standards presented below:

Properties	Test Method	Test Values	Test Frequency (min.)
Thickness mils (min. avg.)	ASTM D5199 (smooth) ASTM D 5994 (textured)	nom. (-5%)	per roll
Lowest individual for 8 out of 10 values		-10%	
lowest individual for any of the 10 values		-15%	
Asperity Height mils (minimum average)	ASTM D 7466	16 mil	every 2nd roll *(1)*
Density (max.)	ASTM D 1505	0.939 g/ml	200,000 lbs.

Properties	Test Method	Test Values	Test Frequency (min.)
	ASTM D 792		
Tensile Properties (minimum average) *(2)*	ASTM D 6693 Type IV		
break strength		60 lb/in.	20,000 lbs.
break elongation		250%	
2% Modulus – lb./in. (max.)	ASTM D 5323	2400	per formulation
Tear Resistance (minimum average)	ASTM D 1004	22 lbs.	45,000 lbs.
Puncture Resistance (minimum average)	ASTM D 4833	44 lbs.	45,000 lbs.
Axi-Symmetric Break Resistance Strain - % (min.)	ASTM D 5617	30	per formulation
Carbon Black Content (%)	ASTM D 4218 *(3)*	2.0-3.0%	45,000 lbs.
Carbon Black Dispersion	ASTM D 5596	*Note (4)*	45,000 lbs.
Oxidative Induction Time (OIT) *(5)*			200,000 lbs.
(a) Standard OIT (min. ave.)	ASTM D3895	100	
or —			
(b) High Pressure OIT (min. ave.)	ASTM D5885	400	
Oven Aging at 85°C *(6)* D 5721			
(a) Standard OIT (min. ave.)			
retained after 90 days	ASTM D 3895	35	Per formulation
– or-			
(b)High Pressure OIT (min. ave.) - % retained after 90 days	ASTM D 5885	60	
UV Resistance *(7)*			Per formulation
(a) Standard OIT (min. ave.)	ASTM D 3895	N.R. *(8)*	
-or-			
(b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(9)*	ASTM D 5885	35	

Notes:

(1) Alternate the measurement side for double-sided textured sheet.

(2) Machine direction (MD) and cross-machine direction (XMD) average values should be on the basis of five test specimens each direction. Break elongation is calculated using a gage length of 2 inches at 2 inches/minute.

(3) Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established.

(4) Carbon black dispersion (only near spherical agglomerates) for ten different views: nine Categories 1 or 2 and one in Category 3.

(5) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

(6) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90-day response.

(7) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.

(8) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.
(9) UV resistance is based on percent retained value regardless of the original HP-OIT value.

2. Submit the following information from the geomembrane manufacturer:
   a. The following quality control data on the raw material (resin) for geomembrane shall be provided by the resin manufacturer.

Parameter	Test Rate
Polymer Density	1 per Resin Lot

   b. Documentation demonstrating it has produced at least 50 acres (242,000 square yards) of similar liner material;
   c. Quality control data from the resin producer demonstrating the physical properties of the material by lot number; and
   d. Documentation that shows correlation between the resin lot number and the respective liner rolls.
   e. Provide the manufacturer's sampling procedure and analysis to verify that the LLDPE is "PFAS-Free".
3. Submit a geomembrane deployment plan for review and approval by the Owner's Representative before beginning deployment. Include:
   a. The proposed orientation of seams with respect to cap slopes.
   b. Documented evidence that the field crew foreman of the liner installer has a minimum qualification of successful experience of at least 50 acres of previous landfill or comparable geosynthetic systems on a minimum of five different projects.
4. In addition to the manufacturer's pre-construction testing requirements listed above, employ an Independent Testing Laboratory to conduct conformance testing of the manufactured geomembrane, at a minimum frequency of one sample per 100,000 square feet. Obtain samples at the manufacturing plant, following production of the rolls. Only samples on rolls actually delivered to the site are to be accepted as meeting the above frequency requirement. Obtain samples by cutting at least a minimum 2-foot-wide piece along the entire roll width. Material is not to be taken from the inner or outer wraps of a roll. The sample shall be clearly marked with the roll number, product, manufacturer, and machine direction.
5. Test each sample as follows:

Test	Specification
Thickness	ASTM D5994
Asperity Height (Textured)	ASTM D7466
Density	ASTM D1505/D792
Carbon Black Content	ASTM D4218
Carbon Black Dispersion	ASTM D5596
Tensile Strength at Break	ASTM D6693
Elongation at Break	ASTM D6693

6. Provide copies of all results to the QA/QA Engineer to verify the measured value of the samples tested comply with the value specified. If a conformance sample does not meet the required specifications, collect samples from adjoining roll numbers and test them until the extent of material failing to meet specification is determined. Any rolls from which samples failing to meet the project specifications were obtained are to be rejected for use on the project.

PART 3 - EXECUTION

3.01 SEPARATION GEOTEXTILE

A. Installation Procedures:

1. Geotextile shall be installed as shown on the drawings and in accordance with the manufacturer's recommendations.
2. Separation Geotextile may be joined by either sewing, heat bonding or overlapping a minimum 18 inches; the methods and materials for seaming shall be subject to the approval of the Engineer.
3. Traffic or construction equipment will not be permitted directly on the geotextile.
4. At the time of installation, geotextile shall be rejected if it has defects, rips, holes, flaws, deterioration or damage incurred during manufacture, transportation or storage.
5. Geotextile shall be placed over underlying materials only after survey record information has been obtained by the Owner's surveyor, if applicable.
6. The fabric shall be protected at all times during construction from damage resulting from sunlight, excessive surface water, construction traffic, improper installation procedures, or any other condition which can result in damage to the fabric. Geotextile found to be damaged as a result of improper construction procedures or inadequate protection, shall be replaced by the Contractor at his expense.
7. No grade stakes shall be allowed to penetrate the Geotextile for controlling the lift thickness of the overlying soil.

3.02 GEOMEMBRANE

A. Manufacturer's Conformance Testing

1. Conduct a conformance testing program to document that the specified material requirements are obtained in the manufacturing of the geomembrane. At a minimum include the following:
   a. Test the geomembrane supplied to the project for the parameters and test frequencies listed in Section 2.02(B)(1) in this section.
   b. Submit quality control data from the resin producer demonstrating the physical properties of the material by lot number. Provide

documentation that shows correlation between the resin lot number and the respective liner rolls.

c. Ship the geomembrane in rolls that are properly identified with the following:

i. Manufacturer's Name, Plant and Location

ii. Product Name and Model/Type No.

iii. Lot Number or Designation identifying the date of manufacture and production run

iv. Roll Number

B. Installer Qualifications and Requirements

1. Be approved by the manufacturer as being qualified.

2. Install the geomembrane in accordance with the manufacturer's recommendations, Michigan Environmental, Great Lakes and Energy requirements and these specifications.

3. Verification that the installer's field crew foreman has a documented minimum qualification identified above. Submit resumes for all installer's personnel who will be doing field seaming and field testing that demonstrates they are qualified to do the work specified.

4. Prepare and submit a Quality Control Plan (QC Plan) acceptable to the Owner’s Representative and QA Engineer addressing the installation, seaming and testing requirements specified herein. Adhere to the approved QC Plan, and the requirements specified herein.

5. Submit a liner deployment plan to the Owner’s Representative for review and approval at least ten (10) days before beginning deployment. Include the procedures for deploying and protecting underlying geosynthetic materials.

C. Sequence of Construction

1. Construct the geomembrane to the limits shown on the Drawings and in accordance with these Specifications.

2. Any deviations from the Drawings or Specifications require the prior approval of the Owner’s Representative and must be documented in the Record Drawings .

3. Place and seam the geomembrane to cover the entire area of the underlying waste and soil to the limits identified on the contract Drawings or as directed by the Owner’s Representative. Secure exposed (unwelded) ends of the geomembrane to prevent uplift from wind or movement associated with runoff or precipitation. Deploy only that amount of geomembrane that can be welded to an adjacent section before the day’s end.

4. Deploy and conduct all testing of the geomembrane in the presence of the Owner’s Engineer. Provide documentation of all deployment, seaming,

testing, and observations of the installed geomembrane to the Owner's Engineer for evaluation within 24-hours where it will be evaluated prior to approval.

D. Geomembrane Installation

1. Inspect the geomembrane upon delivery and after deployment for any damage or defects. Remove damaged or defective material from the project site.

2. Refueling of any equipment on the geomembrane is prohibited. Vehicles are not allowed on the geomembrane. Personnel working on the geomembrane are not permitted to smoke or wear damaging shoes or engage in other activities which could damage the geomembrane. At the Owner's discretion, repair or replace any damaged geomembrane by equipment, material handling, trafficking, leakage, or any other means.

3. Install the geomembrane as follows::

   a. Unroll only those sections which are to be seamed together or secured in one day. Panels should be positioned with the overlap recommended by the manufacturer, but not less than 2 inches. The edge of the upslope sheet shall be positioned above the edge of the downslope sheet.

   b. After panels are initially in place, remove as many wrinkles as possible. Unroll panels and allow the liner to "relax" before beginning field seaming. The purpose of this is to make the edges that are to be bonded as smooth and free of wrinkles as possible.

   c. Once panels are in place and smooth, commence field seaming operations.

4. Field seaming is affected by ambient weather conditions which varies depending on the method of field seaming. Establish control parameters prior to the start of field seaming and submit these parameters as well as the method and procedure for seaming to the CQA Engineer for approval.

5. Comply with the following field seaming at a minimum:

   a. Remove all foreign matter (dirt, water, oil etc.) from the edges to be bonded. For extrusion-type welds, thoroughly clean the bonding surface by mechanical abrasion or alternative methods approved by the Owner's Representative to remove surface impurities and prepare the surface for bonding. Use No. 80 grit or finer sandpaper for all abrasive buffing.. Use of solvents to clean the geomembrane if prohibited.

   b. To the extent possible, start field seaming from the top of the slope down. This will keep wrinkles that may occur due to having people working on the side slopes behind the area being seamed. Complete tack welds (if needed using heat only; double-sided tape, glue or other method are not permitted. Completely seam the geomembrane to the ends of all panels to limit the potential of tear propagation along the seam.

c. Repair locations where the completed liner exhibits any "trampolining" during daylight hours to the complete satisfaction of the QA Engineer and the Owner's Representative.

d. Using rope, sandbags or other device approved by the QA Engineer, anchor all unseamed edges at the end of each day or installation segment. Connect sandbags securing the geomembrane on the side slopes by rope fastened at the top of the slope section by a temporary anchor, as necessary. Staples, U-shaped rods or other penetrating anchors used to secure the geomembrane are not permitted.

e. Repair or replace any damage to the geomembrane due to wind, rain, hail, or other weather to the satisfaction of the Owner's Representative and the QA Engineer.

6. Use fusion welding for all field seaming; limit extrusion welding to patchwork. The Owner's Representative reserves the right to reject any proposed seaming method believed to be unacceptable. Additional concepts and requirements of proper field seaming include:

a. Join adjacent sheets by overlapped at least 2 inches or in accordance with the manufacturer's specifications after the necessary aligning and cutting.

b. Orient seams shall be perpendicular to the slope. Minimize the number of field seams in corners and odd-shaped geometric locations.

c. Should the ambient temperature and wind chill be below 32ºF (measured either on site or as reported from the nearest airport), preheating of the geomembrane is required unless it is demonstrated that this is not necessary [i.e., acceptable test (start-up) seams which duplicate, as closely as possible, actual field conditions can be achieved]. Preheating may be achieved by natural and/or artificial means (shelters and heating devices). Measure ambient temperature 18 inches above the geomembrane surface. Document the location of all measurement readings and submit as part of the daily field report.

d. Use of a moveable protective layer of plastic placed directly below each overlap of geomembrane that is to be seamed to limit moisture build-up between the sheets to be welded is acceptable.

e. Seam panels to the outside edge.

f. Use of a firm working surface like a flat board, conveyor belt, or similar hard surface directly under the seam overlap to achieve proper support is acceptable.

g. No excessive grinding prior to welding shall be permitted. Replace overground or improperly ground areas at the Contractor's expense.

h. Complete seams at panel corners of 3 or 4 sheets with a patch having a minimum dimension of 24 inches, extrusion welded to the parent sheet.

E. Testing During Construction

1. Observe the surface of the underlying subgrade to check for perforations, protrusions, or other detrimental effects, before deploying the roll of geomembrane. Document in writing each day that the subgrade surface was checked and that its condition is satisfactory for covering with the liner. Provide a copy of this statement in the Daily Field reports. A satisfactory subgrade shall be relatively smooth and even.

2. The CQA Engineer will also observe the subgrade surface and will inform the installer of areas that, in the CQA Engineer's opinion, are unsatisfactory for covering.

3. The installer will check the condition of each roll for defects and imperfections as it is deployed. The Engineer will observe the condition of each sheet as it is being deployed. Observed defects will be marked on the sheet and will be noted in field reports. Each defect will be patched, and the patch seam will be non-destructively tested, as described below. The date of the successful non-destructive test will be marked on the liner and will be noted in field reports.

4. Provide, maintain and use equipment and personnel at the site to perform testing of test seams. Check seaming equipment daily before beginning seaming (in the morning, after extended breaks, after five hours of seaming, after lunch, after equipment changes, after operator changes, and after significant changes in ambient or geomembrane temperatures) by destructive testing a seam specimen with a tensiometer. Use each seamer to make at least one test seam each day. Requirements for test seams follow:

   a. The test seam sample will be at least 0.9 m (3 ft) long by 0.3 m (1 ft) wide with the seam centered lengthwise. Six adjoining specimens 25 mm (1 in) wide each will be die cut from the test seam sample. These specimens will be tested in the field with a tensiometer for both shear (3 specimens) and peel (3 specimen). Test seams will be tested by the Geomembrane Contractor under observation of the CQA Engineer. Specimens that fail in the weld are failures; seaming and testing a different specimen is required. Supply all necessary knowledgeable personnel and testing equipment. Strain measurements in the field are not required.

   b. A passing machine or hand welded test seam will be achieved when the criteria described below in Section E, (7) are satisfied with the exclusion of any strain requirements. If a test seam fails, the entire operation will be repeated. If the additional test seam fails, the seaming apparatus or seamer will not be used for seaming until the deficiencies are corrected and two consecutive successful full test seams are achieved. Test seam failure is defined as failure of any one of the specimens tested in shear or peel.

c. The CQA Engineer will observe all test seam procedures and log the date, hour, ambient temperature, number of seaming unit, name of seamer, and pass or fail description.

d. A satisfactory test seam will fail the parent material in both peel and shear. The Engineer will observe the destructive testing of test specimens and record the results in field reports.

5. Non-destructive tests will be done on all field seams to measure the integrity of the seam. Seams made by extrusion welding will be tested with a vacuum box (ASTM D4437) and seams made with a double hot wedge will be pressure tested as follows (pressure gauges and equipment will have been calibrated within 180 days of the project initiation and a current calibration certificate shall be provided):

a. Single Weld Seams (extrusion weld) - The Contractor is to maintain and use equipment and personnel at the Site to perform continuous vacuum box testing on all single weld production seams. The system must be capable of applying a vacuum of at least 5 psi and held for a time determined sufficient by the CQA Engineer to observe the vacuum test. Spark test all extrusion welds that are not accessible for vacuum testing, such as those used for welding the LLDPE pipe boot to the gas vent riser pipes.

b. Double Weld Seams (hot wedge) - Maintain and use equipment and personnel to perform air pressure testing of all double weld seams. The system must be capable of applying a pressure of at least 30 psi for not less than 5 minutes. Perform all pressure and vacuum testing under the supervision of the CQA Engineer. Conduct pressure loss tests in accordance with the procedures outlined in ASTM D5820-95.

c. Conduct air pressure tests of fusion-welded seams as follows. Pressure losses over a measurement period of 5 minutes must be less than 2 psi. At no time during the test shall the pressure drop below 30 psi to be considered a passing test. Release air pressure from the end of the test seam opposite the pressure source at end of the test. If air is not released through this point, the seam will be checked to identify any clogging, then repaired and retested.

d. If a pressure loss greater than 2 psi occurs during the test and it is determined that the pressure loss is not due to testing apparatus malfunction, pressurize the seam and apply a soap solution to the seam. The Owner's Representative and the geomembrane installer will check for leaks. The geomembrane installer will repair the leak by placing a cap strip and retesting the seam by pressure test.

e. If a leak is determined to be on the underneath side of the seam, make a progressive search of the seam until that portion of the leaking seam is found. Repair the leaking section of seam with a cap strip. Document the remaining section of seam not capped that passed the air pressure test and repair the sections of the seam damaged by the leak search with cap strips.

f. Record the results of each non-destructive test in daily field reports with the date marked on the liner next to the seam to allow inspection of the liner upon completion.

6. Record the location of each sheet as each is deployed and its respective seam. Collect seam samples for destructive testing at the minimum rate of one sample per every 1,000 feet of seam or at least one sample for each seaming unit/welder combination on each day seaming takes place at locations selected by the Owner's Representative . Survey the location of each sample and plot the location on the sheet deployment plan.

7. Split each sample into three pieces, each 18 inches long (parallel to the seam) and 12 inches wide. One piece will be field-tested by the Contractor, one piece will be tested by the CQA Engineer (or a subcontracted independent laboratory) and one piece will be retained by the Owner's Representative. If the Contractor's field test meets the strength requirements listed below, then submit the CQA Engineer sample piece to the independent lab for testing. If the Contractor's field test does not meet the strength requirements listed below, then investigate and repair the liner seam as described below without independent lab testing of the sample from the failed field test. Cut test samples into ten l-inch wide strips perpendicular to the seam orientation. Test five (5) strips for peel strength and five (5) for shear strength (ASTM D4437). All five strips must satisfy the strength and peel separation and elongation requirements listed below.

Hot Wedge Seams	
Test	**Required Value**
Seam Shear Strength (lbs/in.)	60 min.
Seam Shear Elongation (1) (%)	50 min.
Seam Peel Strength (lbs/in.)	50 min.
Seam Peel Separation (%)	25 max.
Extrusion Fillet Seams	
Test	**Minimum Value**
Seam Shear Strength (lbs/in.)	60 min.
Seam Shear Elongation (1) (%)	50 min.
Seam Peel Strength (lbs/in.)	44 min.
Seam Peel Separation (%)	25 max.

Notes: (1) Elongation measurements omitted for field testing.

8. Remediation is required for any failing destructive test sample. The installer will be required to: (1) patch the seam over the non-conforming destructive test sample location and extending the patch to the nearest

adjacent conforming destructive test sample location; or (2) collect and destructive test an additional sample from each side (a minimum 10 feet from failed seam) of the failing destructive test sample location to identify the limits of the defective seam. These two retest samples must pass both shear and peel testing.

9. If these two samples do not pass, then obtain additional samples until the questionable seam area is defined. Place a patch over the seam between the two passing destructive test locations. Seams will be non-destructively tested as described above.

10. Traffic or construction equipment not associated with field seaming are not permitted directly on the geomembrane. Replace all membrane areas that become torn or damaged by constructing a cap strip. Repairs to seams made by extrusion bead to a seam edge previously fusion welded or extrusion methods are not permitted, cap strips are required. Using non-destructive protocols, test repaired areas.

11. The CQA Engineer is responsible to make field observations, visual examinations, monitor material measurements and the type of installation equipment used to determine if the methods used are in compliance with the specifications for the project.

12. Perform field tests as soon as possible after materials receipt or after completion of a portion of the constructed work in order to provide prompt field test results. The CQA Engineer will observe all production seam field test procedures. The remainder of the successful test seam sample will be assigned a number and marked accordingly by the CQA Engineer, who will also log the date, seam number, approximate location in the seam, and field test pass-or-fail description, if applicable. The CQA Engineer will be responsible to archive the specimen.

13. Provide an installation certificate that states the geomembrane was supplied and installed in accordance with design specifications and manufacturer's requirements and state that all QC testing was done as required by these specifications.

14. Retain all ownership and responsibility for the geomembrane until final acceptance of the project by Owner.

F. Other Requirements

1. Protect the LLDPE geomembrane from exposure to sunlight during transportation and storage. Store the geomembrane off the ground.

2. All seams are subject to the approval of the CQA Engineer. Seaming the LLDPE geomembrane in temperatures less than 32°F or higher than 120°F without prior approval of the CQA Engineer is not permitted. Complete all seams during daylight hours. Do not seam in winds equal to or exceeding 20 miles per hour or during precipitation.

3. Repair or replace and LLDPE geomembrane which becomes torn or damaged. Extend the patch a minimum l.5 feet beyond the perimeter of the tear or damage.

G. Potentially Damaging Activities

1. Personnel working on the geomembrane are not permitted to smoke, wear damaging shoes, or engage in any activity which damages the geomembrane.

2. Upon completion of each section of the geomembrane, the CQA Engineer will observe its condition (both sheets and seams) for defects. Repair any observed defects (nicks, gouges, etc.) to the satisfaction of the Owner's Representative before covering.

H. Protection of Leading Edges on Top Area of Final Cover System

1. Between construction of partial sections of the membrane liner, leading edges of the membrane may be exposed or buried for extended periods of time prior to their joining to adjacent, subsequent membrane sections. The combined action of abrasive soil and equipment impact stresses may "etch" unprotected membrane surfaces sufficiently to affect seam strengths. Therefore, it is necessary to protect leading edges in high activity areas with sacrificial layers of geotextile and LLDPE sheet until they are ready for final seaming.

2. At a minimum, covered by a layer of geotextile overlain by a layer of LLDPE sheet (alternatively, plywood made be used in lieu of geotextile and LLDPE sheet), each leading edge to be seamed that must be buried or which must be exposed for periods of one month or longer..

3. Provide and install non-woven geotextile with a minimum weight of 6 ounces per square yard. The sacrificial LLDPE sheet is to have a minimum thickness equal to that of the membrane liner to be protected and a minimum width of 2 feet. Cover the protective sheets with either soil or weighted with sandbags to prevent displacement by wind. Center the edge of the sheet to be protected beneath the overlying protective layers prior to burial or weighing with sandbags. Burry the leading edges located in areas expected to receive direct traffic from construction equipment under a minimum thickness of one foot of buffer soil.

I. Progress

1. Installation and protection of the geomembrane in areas simultaneous to construction of other underlying/overlying components of the landfill final cover system is permittable.

*****END OF SECTION *****

SECTION 31 22 00

GRADING

PART 1 - GENERAL

1.01. SCOPE:

A. This section specifies the work required by the Contractor to grade the earth materials on the Site.

B. Related work specified elsewhere:

1. Excavation and Fill: Section 31 23 00

1.02. DEFINITIONS:

A. Site grading consists of excavation, backfilling and grading to shape excavated slopes, landfill slopes, embankments and fills, and work areas to remove irregularities and to provide positive drainage during construction and for restoring the site.

1.03. SUBMITTALS:

A. None.

1.04. JOB CONDITIONS:

A. Preserve, protect, and maintain existing structures, channels, roads, drives, drains, sewers, utilities, monitoring wells and all other site features during construction unless otherwise stated and shown.

B. Be thoroughly familiar with the Site, the Site conditions, and all aspects of the Contract Drawings and project specification before commencing any intrusive work.

C. Visually inspect and verify that all soil, erosion, and sedimentation controls are in place and functioning as designed.

PART 2 - PRODUCTS

3.01. MATERIALS:

A. As described in other sections of the specifications and on the Contract Drawings.

PART 3 - EXECUTION

3.01. GENERAL

A. Verify that layout stakes and grades are current, that all runoff controls and temporary storage facilities are in place prior to the start of any earth moving operations.

3.02 EXCAVATION and FILL:

A. Perform earthwork in accordance with Section 31 23 00.

3.03 SITE GRADING DURING CONSTRUCTION:

A. Grade work areas as necessary during construction to divert surface water runoff from excavations and to provide positive drainage of embankments or fills.

3.04 FINISH GRADING:

A. On completion of the work, clean all ditches, channels and drainage pipes and restore them to their pre-construction condition, including removal of temporary haul roads and drainage pipes; restore and finish the site in a neat and presentable condition as approved by both the Owner's Representative and Owner including all haul roads, lay-down areas, parking areas and trailer areas and any other areas disturbed by the construction work.

B. Grade the site to provide positive drainage as shown or as directed and approved by the Owner's Representative.

*****END OF SECTION*****

SECTION 31 23 00

EXCAVATION and FILL

PART 1 - GENERAL

1.01 SCOPE:

A. This section specifies the work required by the Contractor to complete the excavation and backfilling requirements for the various components of this project as shown on the contract drawings and as specified herein.

B. Related Work Specified Elsewhere:

1. Grading: Section 31 22 00.
2. Geosynthetics for Earthwork: Section 31 05 19

1.02 DEFINITIONS:

A. Earth excavation is the removal of in-place, fill soils, waste and natural overburden soils using proper earth moving equipment.

B. Fill placement or backfilling is the placement and compaction of earthen materials to construct the various components of the project to the lines and grades shown.

C. Authorized excavation is excavation of soils, waste and/or soil with waste to the excavation limits shown. It includes excavation of material considered unsuitable by and other excavation as directed by the Owner’s Representative.

D. Unauthorized excavation is excavation of materials beyond the limits shown or not authorized by the Owner’s Representative to be excavated.

1.03 JOB CONDITIONS:

A. Protect Aboveground and Underground Structures, Utilities and Facilities: Where shown, the locations of above ground and below ground facilities are approximate. The contract drawings do not define all above ground or below ground utilities, structures, wells, and other existing facilities at, or adjacent to the project Site and work area. Identify, properly locate, and protect all utilities, underground structures, above ground structures and appurtenances on, or adjacent to the project Site. Contact the Owner’s Representative to obtain further information, requirements, and restrictions, related to work procedures.

B. Health and Safety: At all times safeguard persons and properties in accordance with all provisions of the Health and Safety Plan submitted by the Contractor to the Owner.

C. Dust Control: Control dust in the work area, haul roads, and at the perimeter of the Site by sprinkling with potable water or by other methods approved by the

Owner's Representative and in accordance with the requirements of EGLE. Use of petroleum products to control dust is not permitted.

D. Access Roads, Ramps and Staging Areas:

E. Construct temporary staging areas, access roads and drainage pipes as necessary to provide access to the work areas and cross the existing perimeter drainage channel, as approved by the Owner's Representative.

F. Maintain all temporary staging areas and access roads along with existing Site access roads throughout the duration of the contract as necessary to provide access to the Site for the Contractors operations, the operations of Owner, representatives of Regulatory authorities, the Owner's Representative, and others engaged by Owner at the Site.

G. Remove all temporary roads, ramps, temporary drainage pipes and staging areas, when no longer needed, and restore the Site as presented in the Contract Drawings or as approved by the Owner's Representative.

H. Borrow: Provide all borrow soil, barrier protection material, topsoil and stone products required.

I. Construction Quality Assurance/Quality Control:

J. Implement a construction quality assurance/quality control (QA/QC) program during construction to ensure that the placed soils and materials meet the requirements of these specifications. The CQA Engineer will conduct the quality program.

K. Comply with the requirements of the approved QA/QC Plan and provide all necessary testing and documentation that is specified. Provide documentation to the Owner's Representative that the Contractor's subcontractor at any level complies with the approved QA/QC Plan.

L. Assist the CQA Engineer and others as directed by the Owner's Representative as needed to accommodate sample collection and testing at no additional cost to Owner.

M. SUBMITTALS:

N. Submit dust control procedures, off-Site material sources, earthwork procedures, material handling and stockpiling procedures and locations, material placement procedures and QA/QC control plans for review and approval by the Owner's Representative before initiating any work described by said plan(s).

O. Submit a copy of the Contractor's Health and Safety Plan to the Owner's Representative for project record.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Gas Vent Riser Stone:

1. Provide and place Gas Vent Riser stone that is a washed, crushed stone or crushed gravel free of clays, organics, snow, ice and friable or deleterious particles, and that meets the material requirements of MDOT and the following gradation requirements:

Sieve Size	Percent Finer by Weight
1-1/2 – inch	100
1 - inch	90 - 100
½ - inch	0 - 15

2. In addition, provide on Gas Vent Riser Stone that has a minimum coefficient of permeability of 1 x 10^{-2} cm/sec.

B. Barrier Protection Layer:

1. Provide and place Barrier protection layer material as described below.

2. Us only material that is classified according to the Unified Soil Classification System as SP, SM, ML-CL, CL, or SC, with a maximum plasticity index of 25, having a maximum permeability of 5 x 10^{-6} cm/sec, have a maximum particle size of one (1) inches in its longest dimension.

3. Place only Barrier protection layer material that is free of organic material, construction debris, ice, snow, and deleterious material that is approved by the Owner's Representative.

C. Topsoil:

1. To the extent possible, use topsoil obtained from on-Site. Should an insufficient quantity of topsoil be available on Site, supplement with topsoil from an off-Site source.

2. Provide topsoil that is free of refuse, snow, ice, any material toxic to plant growth, subsoil, woody vegetation and stumps, roots, brush, stones, clay lumps, and objects larger than 2 inches in greatest dimension. Thoroughly break-up and mix sod and herbaceous growth such as grass and weeds with the soil during handling operations.

3. Provide independent documentation and testing that verifies that off-Site Topsoil, if needed, complies with the following minimum requirements:

   a. The pH of the material is between 6.0 and 7.5.

   b. The organic content is not less than 3 percent nor more than 20 percent.

   c. It is well graded with a maximum particle size of 2 inches and with 20 to 90 percent by weight passing a No. 200 sieve.

d. Contains:

i. Arsenic at concentrations no greater than 5,800 micrograms per kilogram (ug/kg)

ii. Perfluorooctane sulfonate (PFOS) at concentrations no greater than 0.22 ug/kg or Perfluorooctanoic acid (PFOA) at concentrations no greater than 350 ug/kg

iii. No pesticides at concentrations greater than the lowest MDEQ Part 201 Residential Soil Clean Up Criteria for each pesticide.

D. Coarse Aggregate:

1. Provide Coarse Aggregate from a MDOT approved source that meets the following criteria:

a. washed, crushed stone or crushed gravel free of clays, organics, snow, ice and friable or deleterious particles, and shall meet the material requirements of MDOT and meet the following gradation requirements:

Sieve Size	**Percent Finer by Weight**
1-1/2 - inch	100
1 - inch	90 - 100
½ - inch	0 - 15

b. Magnesium sulfate, free-thaw, Los Angeles abrasion test, flat and elongated particles and crushed particles in accordance with the requirements of MDOT.

c. Coefficient of permeability of $1x10^{-2}$ cm/sec or greater when compacted to a dense state.

E. Crushed Stone:

1. Provide Crushed Stone from a MDOT approved source.

2. Crushed Stone must be a dolomitic crushed stone or crushed gravel free of dust, clays, organics, snow, ice and friable or deleterious particles and meet the requirements of MDOT and meet the following gradation requirements.

Sieve Size	**Percent Finer by Weight**
2 - inch	100
1/4 - inch	30 - 65
No. 40	5 - 40
No. 200	0 - 10

3. Comply with requirements of MDOT for the concentration of magnesium sulfate, and soundness loss.

F. Riprap:

1. Provide Riprap from a MDOT approved source.

2. Fine Riprap must be a crushed stone or crushed gravel free of dust, clays, organics, snow, ice and friable or deleterious particles and meet the requirements of MDOT (Fine Stone Filling) and additionally with the following gradation requirements.

Stone Size	Percent of Total by Weight
Smaller than 8-inches	90 - 100
Larger than 3-inches	50 - 100
Smaller than No. 10 Sieve	0 - 10

2.02 SOURCE OF MATERIALS:

A. Provide sufficient documentation that demonstrates all soils off-Site sources (except for small amounts from perimeter tie-in soil excavations, and any available on-Site topsoil) that are proposed for use at the Site by the Contractor meets all the specified requirements.

B. In addition, test and provide documentation that the off-Site soils meet all requirements of the QA/QC plan.

C. Evaluate each proposed borrow source as specified and according to the requirements of the QA/QC plan prior to submission of the source to the Owner's Representative for review and approval prior to importing any soil to the Site.

D. Pre-qualification of a source by the Engineer does not relieve the Contractor of its responsibility to supply soil which meets the specified requirements. Soil imported to the Site and placed which does not meet the specified requirements will be removed and replaced by the Contractor at no additional cost to Owner.

PART 3 - EXECUTION

3.01 LAYOUT:

A. Accurately locate and maintain location of all proposed construction components, and existing roads, utilities, monitoring wells, drainage structures and existing landfill components, features, and advise the Owner's Representative of any discrepancies prior to commencing work.

3.02 PROTECTION OF SUBGRADES AND FILL GRADES:

A. The subgrade soils are generally waste fill soils of varying composition and strength properties. They are sensitive to disturbance from construction activity when in the presence of excessive moisture. Prevent water from collecting on earthen subgrade surfaces. Properly drain and protect all excavation and fill grades.

B. Grade the waste (and soil with waste) to the final subgrade elevations including areas requiring tie-in construction of the final cover system to the containment berms and any previously constructed final cover system of an adjacent covered area.

C. Design and construct temporary haul roads with proper materials and thicknesses to protect subgrades, fill grades, underground utilities, constructed components and other work as shown and specified.

D. Failure to properly excavate and protect approved subgrades that results in additional excavation and backfill to attain a suitable subgrade in accordance with these specifications shall be at the sole expense of the Contractor.

E. Maintain both work in progress and completed work until the construction is complete and accepted by the Owner’s Representative. Repair and/or replace any erosion or degradation of the Contractor's work at no additional cost to Owner.

F. Maintain the landfill final cover system and earthen areas until the construction is complete and covered with a uniform dense stand of vegetation at least 2 inches in height. Repair any and all erosion, desiccation, weathering and/or degradation of the final cover system components and earthen areas to the satisfaction of the Owner’s Representative at no additional cost to the Owner.

G. Exercise caution when placing Barrier Protection Material atop the underlying geosynthetics.

3.03 EQUIPMENT:

A. Select, furnish, and properly maintain equipment which will perform the required excavation and compact the fill uniformly to the required density and/or permeability. Submit Contractor's selection of equipment to the Owner’s Representative for review prior to construction.

B. Do not proceed with any intrusive Sitework until the soil erosion and sedimentation controls are properly installed and all submittals relating to soil handing in this and other sections have been reviewed and approved by the Owner’s Representative.

3.04 EARTH AND WASTE EXCAVATION

A. Make all excavation tie-ins to the cover system to existing grades in the presence of the Owner’s Representative. Extend to the lines and grades shown and described on the Contract Drawings and to suitable conditions as determined by the Owners Representative.

B. Fine grade the top of waste/intermediate cover soil surface to eliminate surface irregularities and produce an even surface. Excavate the material down to design grade, within specified tolerances, and place the material in areas below design top-of-waste cover soil grade in areas where an existing cap soil or waste soil is above design grade.

C. Waste that is present and/or encountered outside of the designated design waste mounds shall be relocated within a designated waste mound as directed by the Engineer.

D. All excavation work shall be executed to the lines and grades shown on the drawings, unless directed otherwise by the Engineer. All excavation work shall be performed in such a way to minimize disturbance and maintain stability of subgrade soils and slopes. Special care shall be taken to not disturb the bottom of excavations. Excavation to the final subgrade levels must be done by methods which minimize traffic on the subgrade.

E. The excavation equipment must be of such size and capacity sufficient to excavate the materials encountered and to the specified depths as shown. Excavation in sands, silts and soft clays represent potentially unstable subgrade conditions and proper protection should be implemented.

F. The Contractor shall be responsible at all times for safe and prudent excavation operations so as to protect the workers, the public, utilities and structures, and adjacent property. The Contractor shall perform all excavation in accordance with OSHA standards. The Contractor shall observe all applicable local, state and federal requirements and acquire all necessary permits.

G. Subgrades and slopes which have been damaged or degraded as a result of Contractor's activities, or failure of the Contractor to properly protect them shall be repaired at the Contractor's expense as directed by the Engineer.

H. Subgrades in which soft or unsuitable materials are encountered, which are not a result of Contractor's operations or failure to protect subgrades, shall be undercut and backfilled with appropriate fill as directed by the Engineer.

I. No materials or fill shall be placed by the Contractor until the subgrades are observed and tested by the Engineer and surveys are completed as required.

3.05 STOCKPILING:

A. Do not placed any material adjacent to the sides of sheeted or open excavations within a distance equal to two times the maximum depth of the excavation. Stockpiling material over existing geosynthetic membranes, landfills, utilities, leachate collection and transfer systems, sewers, force mains, water lines may induce settlement and is not permitted.

3.06 FILLING AND BACKFILLING:

A. Preparation: Do not place fill or backfill until underlying subgrades have been observed, tested, and verified by the Owner’s Representative..

B. Materials: Place the following material at the locations depicted on the Contract drawings, and as specified or at other locations as directed by the Owner’s Representative.

1. Gas Vent Riser Stone

a. For sub-surface backfill around the gas vent riser pipes.

2. Barrier Protection Layer:

a. Atop the geomembrane in the capped area.

3. Topsoil:

a. Over the barrier protection layer.

4. Coarse Aggregate:

a. Locations as shown.

5. Crushed Stone:

   a. Locations as shown.

6. Riprap:

   a. For lining the drainage channel on the west and south sides of the Southwest Mound, and as shown on the drawings.

C. Placement and Compaction:

1. Gas Vent Riser Stone

   a. Contractor shall place gas vent riser stone around the gas vent riser pipes as shown and specified.

2. Barrier Protection Layer:

   a. Placed in 2 lifts via low ground-pressure bulldozers in the areas designated to have 2-feet thickness. Push the soil uphill from the toe of slope or sideways across the slope, but not in a downslope direction. Compacted to a minimum of 90 percent of the maximum dry density as determined by the modified Proctor test (ASTM D1557), with a maximum moisture content within 4 percent of its optimum moisture content. Compact using a sheepsfoot or smooth drum roller, as appropriate based on the material type. Equipment used to compact this soil must be compatible with the soil type and the loose lift thickness. Place the material in a manner to prevent sliding and damaging the underlying geomembrane.

   b. Compact each lift of barrier protection soil around each gas vent riser, or any other penetration using a jumping jack tamper. Compacted to form a seal around the pipe to the satisfaction of the Owner's Representative.

   c. Track the surface of the barrier protection layer perpendicular to the slope contour, with bulldozer and moistened to promote bonding immediately before spreading the overlying topsoil layer.

3. Topsoil

   a. Prepare all grades within the areas to be covered by topsoil so that the completed work, after topsoil is spread, conforms to the specified lines and grades.

   b. Scarify the surface of the barrier protection layer and moisten it before topsoil is placed to permit bonding of the topsoil with the subsoil.

   c. Only allow trucks used to transport and place topsoil to travel on haul roads atop the geosynthetics having a minimum of 3 feet of overlying soil (inclusive of the barrier protection layer) to protect the geosynthetics underlying the barrier protection layer.

   d. Do not place topsoil that is in an unworkable condition due to excessive moisture, frost or other conditions until it is suitable for spreading. Place and spread Topsoil on the designated area and graded to 6 inches minimum thickness. Clear and dispose all large stiff clods, rocks, roots or other foreign matter after the topsoil is spread so that the finished surface will be acceptable for subsequent compaction and seeding. Use a bulldozer to track and compact the topsoil. Track the bulldozer perpendicular to the slope contour to limit erosion rills.

4. Coarse Aggregate:

   a. Place Coarse aggregate to the lines and levels shown on the drawings and in a manner that will preclude damage to the final cover system components.

5. Crushed Stone:

   a. Place Crushed Stone in the locations as shown on the drawings.

6. Riprap:

   a. Prior to placement of stone riprap, the underlying materials must be properly placed, compacted, and graded as specified.

   b. Place stone for riprap within the lines, grades and slopes specified and in such a manner as to produce a well graded mass of rock with a minimum percentage of voids.

   c. Place riprap to its full course thickness in one operation and in such a manner as to avoid displacing or damaging the underlying material. On slopes, place starting at the toe of the slope and advance systematically up the slope. Distribute larger stones within the entire mass of stones such that the final position conforms to the grade specified. Verify that the finished layer of stone is free from objectionable pockets of small stones and clusters of larger stones. Placing stone in layers is not permitted.

*****END OF SECTION*****

SECTION 32 91 12

TOP SOIL FOR SEEDING AND PLANTING

PART 1 – GENERAL

1.01 SCOPE

A. The Work of this Section furnishings of all labor, equipment, supplies, and materials to place topsoil on the cap. Work includes the handling, sorting, placement, grading, shaping, conditioning, and fertilizing of topsoil, and plantings. A minimum of six (6) inches of topsoil is required above the backfill and on other disturbed areas of the Site impacted by the construction.

B. Related Work specified elsewhere:

1. Excavation and Fill: Section 31 23 00

2. Grading: Section 31 22 00

1.02 JOB CONDITIONS

A. Protect all existing work; repair and re-grade areas damaged by equipment and materials.

B. Use caution when placing topsoil around gas vents.

1.03 SUBMITTALS

A. At least thirty (30) days in advance of starting any topsoil operations on Site, provide the Owner's Representative with the composition, test data, manufacture's information, and/or source of topsoil material as presented in these specifications for review and approval. Analytical results of topsoil that does not comply with the testing parameters or the characteristics identified below are not acceptable for use at the Site.

PART 2 – PRODUCTS

2.01 TOPSOIL

A. The intent of the work is to utilize, to the extent practical, reclaimed topsoil previously stripped from on-site locations as directed by the Owner's Representative.

B. If sufficient quantity of on-site topsoil is not available, supply acceptable clean, weed-free topsoil from off-site sources. Determine the quantity of off-site topsoil required for each mound and areas that may have been impacted by construction.

C. Provide topsoil free from subsoil, of uniform quality free of hard clods, stiff clay, hardpan, sods, partially disintegrated stone, lime, cement, ashes, debris, trash, slag, concrete, tar residues, tarred paper, boards, chips, sticks, stumps, rocks, weeds, brush, and all other undesirable material and substances toxic to plant growth.

D. Topsoil supplied form an off-site source that is acceptable for use is classified as a sandy loam by the USDA textural classification system determined by sieve and pipette or hydrometer analysis with the following makeup:

1. Contain less than 60 percent sand by weight and less than 35% clay by weight.

2. Fine to medium sand fraction (0.10 to 0.50 mm in diameter) at least 90 percent of the sand fraction. No more than 3 percent of the soil shall be gravel (>1 mm <1-in in diameter).

E. Organic soils, such as peat or muck, are not acceptable as topsoil material. The concentration of soluble salts less than 500 ppm and sodium adsorption ratio is less than 12 are acceptable.

F. New imported topsoil must contain a minimum of 2.5 percent and maximum 12 percent of organic matter as determined by the Loss on Ignition Test, Association of Official Agricultural Chemists, with not more than 50 percent clay and not more than 55 percent sand as determined in accordance with ASTM D 482, "Particle-Size Analysis of Soils" to be considered acceptable. To adjust organic matter content, the soil may be amended, by the addition of composted leaf mold or peat moss. Use of organic amendments is acceptable only if random soil sampling indicates thorough incorporation. Soil shall be capable of supporting and germinating vegetation.

G. The topsoil reaction (pH) shall be between 6.0 and 7.5.

H. Topsoil with arsenic at concentrations greater than 5,800 micrograms per kilogram (ug/kg) is not acceptable.

I. Laboratory analysis of topsoil with per perfluorooctane sulfonate (PFOS) at concentrations greater than 0.22 ug/kg or perfluorooctanoic acid (PFOA) at concentrations greater than 350 ug/kg are not acceptable.

J. Topsoil that does not comply with the lowest MDEQ Part 201 Residential Soil Clean Up Criteria for each pesticide will be rejected for use.

K. Topsoil gradation within the following limits:

Sieve Size	Percent Finer by Weight
1-in	100
1/4-in	97
No. 10	90
No. 100	40 to 60

L. Do not destroy topsoil structure through excessive and unnecessary handling and compaction. Inappropriate handling leading to the compaction or deterioration of soil structure will result in rejection of topsoil for use.

M. Testing Requirement: Submit samples to assure topsoil fulfills specified requirements regarding textural analysis, organic matter content, pH and fertility as follows:

1. Provide one 20lb sample of topsoil to Owner’s Representative from each site that will be used as a topsoil borrow area. Submit samples at least

seven (7) days prior to beginning stripping operations or commencing topsoiling operations on the site.

2. Conduct Standard Soil Test on all soils with Organic Matter that includes reporting of the following parameters: pH, Buffer pH, Extractable Nutrients, Extractable Heavy Metals (e.g., Lead), Cation Exchange Capacity, Percent Base Saturation, Percent Organic Matter, and Total Soil Nitrogen. The laboratory test results shall provide recommendations for nutrient and pH adjustments.

3. Perform a minimum of one test on each distinct on-site topsoil or off-site loam source. Perform a standard soil test for every 500 CY of topsoil or loam used at the site.

4. Soil testing shall be performed at an approved accredited testing laboratory

N. All soils proposed for use on-Site from off-Site sources must be approved by the Owner's Representative for such.

PART 3 - EXECUTION

3.01 TOPSOIL

A. Amend topsoil in accordance with the recommendations of the Testing Laboratory provided in their report and in accordance with these specifications.

B. Clear, grub and bring final sub-grade to the designated elevation prior to spreading topsoil. Spread topsoil so as to form a cover of topsoil in all areas to be seeded, sodded, or otherwise vegetated to a minimum depth of six (6) inches unless otherwise shown on the drawings or directed by the Owner's Representative.

C. Scarified or otherwise roughen disturbed areas outside of the footprint of the caps to a depth of 2 inches, just prior to the placing topsoil.

D. Gather and remove all stiff clods, hard lumps, large stones, trash, stakes, wood, brush, stumps, roots, or other objectionable material from topsoiled area through screening, raking, or similar means after spreading. Use of a lawn roller to provide moderate compaction is acceptable.

E. Dispose of all material removed from topsoil as non-contaminated soil.

F. Promptly fertilize, seed, lightly compact, mulch, or otherwise cover, and stabilize through tracking with suitable equipment.

*****END OF SECTION*****

SECTION 32 92 19

SEEDING

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies the minimum requirements for seeding and mulching.

B. Related work specified elsewhere

1. Topsoil for Seeding and Planting; Section 32 91 12.

1.02 SUBMITTALS

A. At least ten (10) days prior to use, provide the Owner's Representative copies of the manufacturer's information for any soil amendments proposed for use at the Site that verify compliance with the requirements contained in this section.

B. Provide copies of all analysis that verifies compliance with the technical the seed mix for the project records.

C. Submit manufacturer's specifications of all mechanical equipment Contractor intends to use for soil preparation or seeding to the Owner's Representative for review and approval prior to its intended use on Site.

PART 2 - PRODUCTS

2.01 MATERIAL

A. Seed mix specified and one that complies with current state and local rules and regulations. Contractor may propose alternative seed mix for review and approval by the Owner's Representative and is demonstrated to comply with applicable state and local rules and regulations.

B. Verify that mulch conforms to current state and local regulation.

C. Fertilizer that contains 9% nitrogen, 18% available phosphoric acid, and 9% soluble potash.

D. Limestone that conforms to state and local regulations.

PART 3 - EXECUTION:

3.01 APPLICATION

A. After the topsoil is placed to the grades and lines shown and specified, fertilize the seed and mulch with limestone placed at the following rates according to the topsoil pH.

Topsoil pH	**Limestone Rate (lbs/1000 S.F.)**
6.5 or greater	0
6.0	40
5.5	80

B. Prior to seeding, fertilized the area using 12 pounds of 9-18-9 fertilizer per 1,000 square feet (or as specified by the manufacturer) worked lightly into the soil.

C. Apply the following seed mix at a rate of six (6) pounds per 1,000 square feet.

Common Name	**Percent by weight**
Fine Fescue (2 varieties min. must include creeping red)	50-70%
Perennial Ryegrass (2 varieties minimum)	15-40%
Annual Ryegrass	5-15%
Clover (White preferred)	5-10%

D. Immediately after seeding, deploy mulch (hay or straw) be evenly applied to seeded areas at the rate of 100 pounds per 1,000 square feet.

3.02 GROUND PREPARATION AND SEDING

A. Maintain areas to be seeded at the design grades. Eliminate irregularities which form low places which will hold water. Distribute fertilizers, seed, and mulch in the amounts specified evenly on the surfaces to be seeded.

B. Use a harrow, disk, track with a dozer, or otherwise completely pulverized to a state of tillage acceptable to the Owner's Representative. Track the topsoil surface with a dozer traveling up-and-down the slope. Remove all stone or other undesirable material over two inches in greatest dimension for reuse.

C. Incorporate limestone and/or fertilizer as specified shall to a depth of no more than two inches below the finished grades unless otherwise specified. Orient mechanical drills or seeders such that the seed depth does not exceeding one-quarter inch. Cover seeds that have been distributed on the surface to a depth not exceeding one-quarter inch by raking, brush or chain harrowing, or other approved method. Do not broadcast seed during windy weather. After sowing, lightly roll the seeded areas with rollers that have been pre-approved by the Owner's Representative.

D. Alternatively, the Contractor can apply the seed using an approved hydro-seed method provided the procedure is provided to the Owner's Representative at least ten (10) days prior to application.

3.03 MULCHING

A. Clear the surface of areas where mulch is to be applied of stones, stumps, wire or other obstacles which might hinder the subsequent seeding operations, and where required by the plans, harrow or disk the ground to produce a state of suitable tillage. Spread the mulch uniformly in a blanket of sufficient thickness to hide the soil from view.

B. Mulch may be spread by hand or by machinery. When mulching and seeding are specified, the mulch may be spread before or not later than three days after seeding unless otherwise approved. Anchorage will be required unless otherwise specified on the plans. Anchorage to hold the mulch in place may be applied by an approved method during the mulching operation or subsequently if the Contractor so desires.

C. Care and protect mulched areas until final acceptance of the project. Care includes protecting against traffic by approved warning signs or barricades, and repair of areas damaged by erosion, wind, fire or other causes. Expeditiously repair any area that has been damaged to re-establish the condition and grade of the soil prior to mulching; re-mulched as specified under this work.

3.04 CARE DURING CONSTRUCTION

A. Care for the seeded and mulched areas until final acceptance of the project. Care consists of providing protection against traffic by approved warning signs or barricades and repairing of any areas damaged following the seeding or mulching operations due to wind, water, fire, or other causes. Repair and re-establish damaged areas to the condition and grade of the area prior to seeding, then re-fertilize, re-seed and re-mulch as specified herein.

B. Keep seeded areas mowed until acceptance of the contract by cutting to a height of three inches when growth reaches six inches or when the growth tends to smother seedlings or as directed.

3.05 POST CONSTRUCTION CARE

A. Provide post construction care for a period equal to six months or the following spring, from the time of seeding, whichever is greater but not exceeding one year.

B. Final acceptance of the seeded areas will be determined solely by the Owner's Representative and the Contractor. Rework, fertilize, reseed, and mulch any bare or spotty vegetated areas as directed by the Owner's Representative.

*****END OF SECTION *****

SECTION 33 05 31

THERMOPLASTIC UTILITY PIPE

PART 1 - GENERAL

1.01 DESCRIPTION:

A. This section specifies the material and construction requirements associated with pipe components of this project as shown on the Contract Drawings and as specified herein.

B. Related Work Specified Elsewhere:

1. Excavation and Fill: Section 31 23 00

2. Geosynthetics for Earthwork: Section 31 05 19

1.02 DEFINITIONS:

A. Gas vent riser pipes are 4-inch diameter SDR-17 HDPE pipes placed into the cap to allow gases within the mound to vent at locations shown on the drawings. The underground portions are perforated, and the above-ground sections are solid.

B. Perched water monitoring pipes are 2-inch diameter slotted polyvinyl chloride (PVC) pipes attached to the gas vents by a reducer and extend to depth to monitor apparent perched groundwater.

C. Fittings including pipe couplings, ells, caps, and reducers as depicted or inferred on the drawings.

D. HDPE pipe couplings are to be affixed by electro-fusion welding.

E. PVC couplings to PVC pipe are to be connected as defined by the Owner’s Representative.

1.03 SUBMITTALS:

A. Provide the following items to the Owner’s Representative for review and approval prior to ordering the material.

1. Pipe supplier, manufacturer and manufacturer's recommendations for installation, including product specifications, and fabrication drawings and requirements.

PART 2 - PRODUCTS

2.01 MATERIALS:

A. Supply SDR-17, 4-inch nominal diameter, HDPE pipe made of high density, high molecular weight polyethylene pipe material.

B. Four (4) rows of one-half inch (1/2) diameter holes spaced 90 degrees apart with perforations 6-inches on center and staggered from row-to-row are required for gas vent riser.

C. Supply Schedule 40, 2-inch nominal diameter, PVC pipe.

D. PVC pipe screen shall be Schedule 40, 2-inch nominal diameter, 0.010-inch slots.

PART 3 - EXECUTION

3.01 GAS VENT RISER

A. Install all pipe to the lines and grades shown on the drawings or in locations directed by the Owner's Representative. Handle and assemble all pipe in accordance with the manufacturer's instructions, unless otherwise authorized by the Owner's Representative.

B. Provide and install pipe that is homogeneous throughout and free from cracks, holes, foreign inclusions, or other defects.

*****END OF SECTION*****

ATTACHMENT E

BORING LOGS

GZA GeoEnvironmental, Inc.
Engineers and Scientists

Wolverine World Wide, LLC
Cap Design
Rockford, Michigan

Boring No.: HS-GT-1
Page: 1 of 2
File No.: 16.0062961.81
Check: J. Groenleer

Contractor: Stearns Drilling Company
Foreman: J. Gryska
Logged by: C. Melby
Date Start/Finish: 3-2-22 / 3-2-22
Boring Location: 587,511 N; 12,788,485 E
GS Elev.: 774.0' Datum: NAD83/NAVD88

	Auger/ Casing	Sampler
Type:	Hollow Stem Auger	Split Spoon
O.D. / I.D.:	8.0" / 4.25"	2.0" / 1 3/8"
Hammer Wt.:	140lbs	NA
Hammer Fall:	30.0"	NA
TOC Elev.:	NA	NA

GROUNDWATER READINGS

Date	Time	Depth	Casing	Stab

Surveyed By: GZA (Trimble R1) Survey Date: 3/2/2022

Depth	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
	1	24/18	0-2	WOH-2 4-4		Medium stiff, brown, CLAY & SILT, trace fine to medium Sand, moist.	CLAY & SILT		None
							2'		
	2	24/21	2-4	2-5 5-6		Loose to medium dense, brown, fine to medium SAND, little Silt, moist.	SAND		
	3	24/19	4-6	2-3 3-2		Loose, light brown to brown, fine to medium SAND, some Silt, moist.			
	4	24/23	6-8	2-3 3-5		Loose, light brown, fine to medium SAND, little Silt, moist to dry.			
	5	24/20	8-10	2-2 4-4		Loose, light brown, fine to medium SAND, little Silt, dry.			
	6	24/22	15-17	3-3 4-6		Loose, light brown, fine to medium SAND, little Silt, dry.			
	7	24/19	17-19	3-3 5-4		Loose, light brown, fine to medium SAND, little Silt, dry.			
	8	24/24	19-21	2-7 12-15		Medium dense, light brown, fine to medium SAND, little Silt, dry.			
	9	24/22	21-23	6-10 13-13		Medium dense, light brown, fine to medium SAND, little Silt, dry.			
	10	24/20	23-25	4-10 15-22		Medium dense, light brown, fine to medium SAND, little Silt, dry.			
	11	24/16	25-27	11-19 21-25		Dense, light brown, fine to medium SAND, little Silt, wet.		1	
	12	24/20	27-29	6-9 15-15		Medium dense, light brown, fine to medium SAND, little Silt, dry.			
	13	24/22	29-31	4-6 8-11		Medium dense, light brown, fine to medium			

REMARKS

1. Falling head test conducted at approximately 25.0 feet below ground suface. Five gallons of water was added to the augers during the test. Moisture content in the split spoon from approximately 25.0 to 27.0 feet below ground surface was due to water added during the test and is not groundwater.

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.: HS-GT-1

Depth	No.	Pen./Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
						SAND, little Silt, dry.	SAND		
31	14	24/21	31-33	5-7 7-8		Medium dense, light brown, fine to medium SAND, little Silt, dry.			
33	15	24/21	33-35	7-13 19-29		Dense, light brown, fine to medium SAND, little Silt, dry.			
35	16	24/24	35-37	21-21 29-36		Very dense, light brown, fine to medium SAND, little Silt, dry.	37'		
37						Bottom of Borehole at 37.0 Feet		2 3 4	

Depth scale: 31 through 64 ft.

REMARKS

2. Groundwater was not encountered during drilling or upon completion.
3. Borehole was backfilled with bentonite chips upon completion.
4. Approximate ground surface elevation is based on digital raster files of bare Earth digital elevation models (DEMs), generated from LiDAR data with 1-meter horizontal accuracy and 18.5-centimeter vertical accuracy. Digital files of DEMs and LiDAR data were provided by Kent County.

GZA GeoEnvironmental, Inc.
Engineers and Scientists

Wolverine World Wide, LLC
Cap Design
Rockford, Michigan

Boring No.: HS-GT-2
Page: 1 **of** 2
File No.: 16.0062961.81
Check: J. Groenleer

Contractor: Stearns Drilling Company
Foreman: J. Gryska
Logged by: C. Melby
Date Start/Finish: 3-2-22 / 3-2-22
Boring Location: 587,601 N; 12,788,642 E
GS Elev.: 784.0' **Datum:** NAD83/NAVD88

	Auger/ Casing	Sampler
Type:	Hollow Stem Auger	Split Spoon
O.D. / I.D.:	8.0" / 4.25"	2.0" / 1 3/8"
Hammer Wt.:	140lbs	NA
Hammer Fall:	30.0"	NA
TOC Elev.:	NA	NA

GROUNDWATER READINGS

Date	Time	Depth	Casing	Stab

Surveyed By: GZA (Trimble R1) **Survey Date:** 3/2/2022

Depth	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
1	1	24/14	0-2	2-2 3-4		Medium stiff, brown, SILT & CLAY, some fine to medium Sand, moist.	SILT & CLAY		None
2–3	2	24/24	2-4	3-3 3-4		Medium stiff, brown, SILT & CLAY, some fine to medium SAnd, moist.			
4–5	3	24/12	4-6	3-6 8-9		Stiff, brown, CLAY & SILT, little fine to medium Sand, moist.	4' CLAY & SILT		
6–7	4	24/12	6-8	4-9 14-18		Very stiff, brown, Silty CLAY, trace fine to medium Sand embedded, dry.	6' Silty CLAY		
8–13	5	24/24	8-10	5-11 16-18		Very stiff, brown, Silty CLAY, trace fine Sand embedded, dry.			
14–18	6	24/16	14-16	2-2 4-5		Loose, light brown, fine to medium SAND, little Silt, dry.	14' SAND		
19–20	7	24/17	19-21	2-6 8-12		Medium dense, light brown, fine to medium SAND, little Silt, dry.			
21–22	8	24/19	21-23	5-10 20-27		Dense, light brown, fine to medium SAND, little Silt, dry.			
23–24	9	24/18	23-25	9-18 23-27		Dense, light brown, fine to medium SAND, little Silt, dry.			
25–26	10	24/24	25-27	4-11 13-18		Medium dense, light brown, fine to medium SAND, little Silt, dry.			
27–28	11	24/16	27-29	5-7 8-11		Medium dense, light brown, fine to medium SAND, little Silt, dry.			
29	12	24/17	29-31	3-8 15-14		Medium dense, light brown, fine to medium			

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.

Depth	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
						SAND, little Silt, dry.	SAND		
31	13	24/18	31-33	3-5 9-11		Medium dense, light brown, fine to medium SAND, little Silt, dry.			
33	14	24/13	33-35	6-10 12-13		Medium dense, light brown, fine to medium SAND, little Silt, wet.		1	
35	15	24/21	35-37	4-6 8-13		Medium dense, light brown, fine to medium SAND, little Silt, dry.			
37	16	24/21	37-39	7-11 16-19		Medium dense, light brown, fine to medium SAND, trace Silt, dry.			
39	17	24/19	39-41	8-15 22-27		Dense, light brown, fine to medium SAND, little Silt, dry.			
41	18	24/18	41-43	10-19 26-25		Dense, light brown, fine to medium SAND, little Silt, dry.			
43	19	24/19	43-45	9-17 29-44		Dense, light brown, fine to medium SAND, little Silt, dry.	45'		
45						Bottom of Borehole at 45.0 Feet		2 3 4	

Depth scale: 31–64

REMARKS

1. Falling head test conducted at approximately 33.0 feet below ground surface. Five gallons of water was added to the augers during the test. Moisture content in the split spoon from approximately 33.0 to 35.0 feet below ground surface was due to water added during the test and was not groundwater.
2. Groundwater was not encountered during drilling or upon completion.
3. Borehole was backfilled with bentonite chips upon completion.
4. Approximate ground surface elevation is based on digital raster files of bare Earth digital elevation models (DEMs), generated from LiDAR data with 1-meter horizontal accuracy and 18.5-centimeter vertical accuracy. Digital files of DEMs and LiDAR data were provided by Kent County.

GZA GeoEnvironmental, Inc.
Engineers and Scientists

Wolverine World Wide, LLC
Cap Design
Rockford, Michigan

Boring No.: HS-GT-3
Page: 1 of 2
File No.: 16.0062961.81
Check: J. Groenleer

Contractor: Stearns Drilling Company
Foreman: J. Gryska
Logged by: C. Melby
Date Start/Finish: 3-1-22 / 3-1-22
Boring Location: 588,140 N; 12,788,498 E
GS Elev.: 785.0' Datum: NAD83/NAVD88

	Auger/ Casing	Sampler
Type:	Hollow Stem Auger	Split Spoon
O.D. / I.D.:	8.0" / 4.25"	2.0" / 1 3/8"
Hammer Wt.:	140lbs	NA
Hammer Fall:	30.0"	NA
TOC Elev.:	NA	NA

GROUNDWATER READINGS

Date	Time	Depth	Casing	Stab

Surveyed By: GZA (Trimble R1) Survey Date: 3/1/2022

Depth	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
0-1	1	24/24	0-2	2-2 4-6		Medium stiff, brown, CLAY & SILT, some fine to coarse Sand, moist.	CLAY & SILT		None
2	2	24/13	2-4	5-4 5-5		Stiff, brown, CLAY & SILT, little fine to medium Sand, moist.			
4	3	24/17	4-6	2-2 2-3		Soft, brown, Silty CLAY, little fine to medium Sand, moist.	4' Silty CLAY		
6	4	24/18	6-8	4-50 17-12		Hard, brown, Silty CLAY, little fine to medium Sand, moist. Changing at 6.6 feet to: Gray and brown, GRAVEL and fine to coarse Sand, dry (likely Cobble).	6.6' GRAVEL		
8	5	24/18	8-10	4-10 11-13		Medium dense, brown, fine to medium SAND, little Silt, dry with 2 inch Silty Clay seam at 9.5 feet.	8' SAND		
14	6	9/9	14-14.8	3-60/3"		Brown, Silty CLAY, trace fine to medium Sand, dry with 1.0" Gravel/Cobble (rock) at bottom.	14' Silty CLAY		
19	7	24/17	19-21	5-8 10-14		Medium dense, light brown, fine to medium SAND, little Silt, moist to dry.	19' SAND		
24	8	24/19	24-26	3-7 11-13		Medium dense, light brown, fine to medium SAND, little Silt, dry.			
29	9	24/16	29-31	3-7 10-12		Medium dense, light brown, fine to medium			

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.: HS-GT-3

Depth	No.	Pen./Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
31–33						SAND, little Silt, dry.	SAND		
34	10	24/19	34-36	6-8 10-11		Medium dense, light brown, fine to medium SAND, little Silt, dry.			
36	11	24/17	36-38	10-9 12-16		Medium dense, light brown, fine to medium SAND, little Silt, dry.	38'		
38						Bottom of Borehole at 38.0 Feet		1 2 3	

REMARKS

1. Groundwater was not encountered during drilling or upon completion.
2. Borehole was backfilled with bentonite chips upon completion.
3. Approximate ground surface elevation is based on digital raster files of bare Earth digital elevation models (DEMs), generated from LiDAR data with 1-meter horizontal accuracy and 18.5-centimeter vertical accuracy. Digital files of DEMs and LiDAR data were provided by Kent County.

GZA GeoEnvironmental, Inc.
Engineers and Scientists

Wolverine World Wide, LLC
Cap Design
Rockford, Michigan

Boring No.:	HS-GT-4
Page:	1 of 2
File No.:	16.0062961.81
Check:	J. Groenleer

Contractor:	Stearns Drilling Company
Foreman:	J. Gryska
Logged by:	C. Melby
Date Start/Finish:	3-1-22 / 3-1-22
Boring Location:	588,494 N; 12,788,488 E
GS Elev.:	797.0'
Datum:	NAD83/NAVD88

	Auger/ Casing	Sampler
Type:	Hollow Stem Auger	Split Spoon
O.D. / I.D.:	8.0" / 4.25"	2.0" / 1 3/8"
Hammer Wt.:	140lbs	NA
Hammer Fall:	30.0"	NA
TOC Elev.:	NA	NA

GROUNDWATER READINGS

Date	Time	Depth	Casing	Stab

Surveyed By: GZA (Trimble R1) Survey Date: 3/1/2022

Depth	Sample No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
0-2	1	24/24	0-2	3-1 4-3		Medium stiff, brown, SILT & CLAY, some fine to medium Sand, moist.	SILT & CLAY		None
2-4	2	24/16	2-4	4-4 6-7		Stiff, brown, SILT & CLAY, some fine to medium Sand, moist.			
4-6	3	24/19	4-6	3-3 4-6		Stiff, brown, SILT & CLAY, some fine to medium Sand, moist.			
6-8	4	24/24	6-8	5-11 16-20		Very stiff, brown, CLAY & SILT, little fine to medium Sand, dry. Changing at 7.5 feet to: Brown and gray, fine to coarse SAND, trace Silt, dry.	6' CLAY & SILT; 7.5' SAND		
8-10	5	24/14	8-10	5-10 8-6		Medium dense, gray and brown, GRAVEL and fine to coarse Sand, little Silt, dry.	8' GRAVEL		
14-16	6	24/14	14-16	2-3 3-4		Loose, brown and gray, fine to coarse SAND and Gravel, little Silt, dry.	14' SAND		
19-21	7	24/19	19-21	2-3 3-4		Loose, brown, fine to medium SAND, little Silt, dry to moist.			
24-26	8	24/17	24-26	7-11 13-12		Medium dense, light brown, fine to coarse SAND, little fine Sand, dry. Changing at 25.5 feet to: Medium dense, light brown, fine to coarse Silty SAND, dry.			
29-31	9	24/16	29-31	4-5 7-10		Medium dense, light brown, fine to medium			

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

Wolverine World Wide, LLC
Cap Design
Rockford, Michigan

Boring No.: HS-GT-4
Page: 2 of 2
File No.: 16.0062961.81
Check: J. Groenleer

Depth	Sample Information: No.	Pen./Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
30–34						SAND, little Silt, dry.	SAND		
34	10	24/18	34-36	5-8 9-11		Medium dense, light brown, fine to medium SAND, little Silt, dry.			
36	11	24/17	36-38	6-3 3-5		Loose, light brown, fine to medium SAND, little Silt, dry. Changing at 36.8 feet to: Brown, SILT, little fine Sand, wet. Changing at 37.1 feet to: Loose, light brown, fine to medium SAND, little Silt, dry.	36.8' 37.1' SILT SAND 38'	1	
38						Bottom of Borehole at 38.0 Feet		2 3 4	

Depth scale: 31–64

REMARKS

1. Perched water encountered at approximately 36.8 feet below ground surface.
2. Groundwater was not encountered during drilling or upon completion.
3. Borehole was backfilled with bentonite chips upon completion.
4. Approximate ground surface elevation is based on digital raster files of bare Earth digital elevation models (DEMs), generated from LiDAR data with 1-meter horizontal accuracy and 18.5-centimeter vertical accuracy. Digital files of DEMs and LiDAR data were provided by Kent County.

GZA GeoEnvironmental, Inc.
Engineers and Scientists

Wolverine World Wide, LLC
Cap Design
Rockford, Michigan

Boring No.: HS-GT-5
Page: 1 of 2
File No.: 16.0062961.81
Check: J. Groenleer

Contractor: Stearns Drilling Company
Foreman: J. Gryska
Logged by: C. Melby
Date Start/Finish: 2-28-22 / 2-28-22
Boring Location: 587,376 N; 12,787,878 E
GS Elev.: 780.0' Datum: NAD83/NAVD88

	Auger/ Casing	Sampler
Type:	Hollow Stem Auger	Split Spoon
O.D. / I.D.:	8.0" / 4.25"	2.0" / 1 3/8"
Hammer Wt.:	140lbs	NA
Hammer Fall:	30.0"	NA
TOC Elev.:	NA	NA

GROUNDWATER READINGS

Date	Time	Depth	Casing	Stab

Surveyed By: GZA (Trimble R1) Survey Date: 2/28/2022

Depth	Sample No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
0-2	1	24/22	0-2	2-4 5-5		Loose, brown, fine to medium SAND, little Silt, dry.	SAND		None
2-4	2	24/17	2-4	2-3 3-4		Loose, brown, fine to medium SAND, little Silt, dry.			
4-6	3	24/22	4-6	2-4 5-6		Loose, brown, fine to medium SAND, little Silt, dry.			
6-8	4	24/18	6-8	3-3 3-4		Loose, brown, fine to medium SAND, trace Silt, wet. Changing at 6.8 feet to: Brown and gray, Silty CLAY, moist.	6.8' Silty CLAY	1	
8-10	5	24/17	8-10	2-4 5-6		Stiff, brown and gray, Silty CLAY, moist. Changing at 8.8 feet to: Brown, fine to medium SAND, little Silt, dry.	8.8' SAND		
14-16	6	24/18	14-16	2-4 8-8		Medium dense, light brown, fine to medium SAND, little Silt, dry.			
19-21	7	24/19	19-21	2-1 2-4		Very loose, light brown, fine to medium SAND, trace Silt, dry. Changing at 19.8 feet to: Brown, Silty CLAY, moist. Changing at 20.3 feet to: Very loose, light brown, fine to medium SAND, trace Silt, moist to dry.	19.8' Silty CLAY; 20.3' SAND; 22' Silty CLAY	2	
24-26	8	24/24	24-26	3-4 6-9		Stiff, gray, Silty CLAY, trace medium Sand embedded, moist to dry.	28' SAND	3	
29-	9	24/17	29-31	5-8 13-21		Medium dense, light brown, fine to medium			

REMARKS

1. Perched water encountered at approximtely 6.0 feet below ground surface.
2. Driller noticed change in auger speed (harder to advance) at 22.0 feet below ground surface. Likely a strata change.
3. Driller noticed change in auger speed (easier) at 28.0 feet below ground surface. Likely a strata change.

Depth	No.	Pen./ Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
31–33						SAND, little Silt, dry.	SAND		
34	10	24/24	34-36	6-11 19-20		Medium dense, light brown, fine to medium SAND, little Silt, dry.			
39	11	24/24	39-41	5-9 11-21		Medium dense, light brown, fine to medium SAND, little Silt, dry.			
41	12	24/24	41-43	17-23 23-23		Dense, light brown, fine to medium SAND, little Silt, dry.	43'		
43						Bottom of Borehole at 43.0 Feet		4 5 6	
44–64									

REMARKS

4. Groundwater was not encountered during drilling or upon completion.
5. Borehole was backfilled with bentonite chips upon completion.
6. Approximate ground surface elevation is based on digital raster files of bare Earth digital elevation models (DEMs), generated from LiDAR data with 1-meter horizontal accuracy and 18.5-centimeter vertical accuracy. Digital files of DEMs and LiDAR data were provided by Kent County.

GZA GeoEnvironmental, Inc.
Engineers and Scientists

Wolverine World Wide, LLC
Cap Design
Rockford, Michigan

Boring No.: HS-GT-6
Page: 1 of 2
File No.: 16.0062961.81
Check: J. Groenleer

Contractor: Stearns Drilling Company
Foreman: J. Gryska
Logged by: C. Melby
Date Start/Finish: 2-28-22 / 2-28-22
Boring Location: 588,460 N; 12,787,895 E
GS Elev.: 797.0' Datum: NAD83/NAVD88

	Auger/Casing	Sampler
Type:	Hollow Stem Auger	Split Spoon
O.D. / I.D.:	8.0" / 4.25"	2.0" / 1 3/8"
Hammer Wt.:	140lbs	NA
Hammer Fall:	30.0"	NA
TOC Elev.:	NA	NA

GROUNDWATER READINGS

Date	Time	Depth	Casing	Stab

Surveyed By: GZA (Trimble R1) Survey Date: 3/1/2022

Depth	Sample Information: No.	Pen./Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
0-2	1	24/24	0-2	2-3 4-4		Medium stiff, brown, SILT & CLAY, little fine to medium Sand embedded, dry.	SILT & CLAY		None
2-4	2	24/20	2-4	3-4 4-6		Medium stiff to stiff, brown, CLAY & SILT, little fine to medium Sand embedded, dry.	2' CLAY & SILT		
4-6	3	24/24	4-6	2-2 2-3		Soft to medium stiff, brown, CLAY & SILT, trace fine to medium Sand embedded, moist.			
6-8	4	24/24	6-8	1-3 3-6		Medium stiff, brown, Silty CLAY, trace fine to medium Sand embedded, moist.	6' Silty CLAY		
8-10	5	24/24	8-10	2-4 8-8		Medium stiff, brown, Silty CLAY, trace fine to medium Sand embedded, moist.			
14-16	6	24/24	14-16	3-16 24-26		Hard, brown, Silty CLAY, some fine to coarse Sand embedded, moist. Changing at 15.2 feet to: Dense, gray and brown, GRAVEL and fine to coarse Sand, moist.			
19-21	7	24/24	19-21	3-8 9-8		Medium dense, brown, fine to coarse SAND, trace Silt, wet. Changing at 19.2 feet to: Stiff, brown, Silty CLAY, trace fine to medium Sand embedded, moist. Changing at 20.1 feet to: Medium dense, brown, fine to medium SAND, little Silt, wet. Changing at 20.8 feet to: Stiff, brown, Silty CLAY, moist.	19' SAND; 19.2' Silty CLAY; 20.1' SAND; 20.8' Silty CLAY	1	
24-26	8	24/24	24-26	3-8 12-14		Very stiff, brown, Silty CLAY, moist. Changing at 25.2 feet to: Medium dense, light brown, fine to medium SAND, little Silt, dry.	25.2' SAND		
29-31	9	24/16	29-31	8-9 16-21		Medium dense, brown, fine to medium			

REMARKS

1. Perched water encountered at approximately 19.0 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.

GZA GeoEnvironmental, Inc.
Engineers and Scientists

Wolverine World Wide, LLC
Cap Design
Rockford, Michigan

Boring No.: HS-GT-6
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File No.: 16.0062961.81
Check: J. Groenleer

Depth	No.	Pen./Rec. (in.)	Depth (Ft.)	Blows (/6")	Test Data	Sample Description & Classification	Stratum Desc.	Remarks	Equipment Installed
31–33						SAND, little Silt, dry.	SAND		
34–35	10	24/18	34-36	5-12 18-22		Medium dense to dense, brown, fine to medium SAND, little Silt, dry.			
36–37	11	24/16	36-38	26-17 14-12		Dense, brown, fine to coarse SAND, little Silt, dry.	38'		
38						Bottom of Borehole at 38.0 Feet		2 3 4	
39–64									

REMARKS

2. Groundwater was not encountered during drilling or upon completion.
3. Borehole was backfilled with bentonite chips upon completion.
4. Approximate ground surface elevation is based on digital raster files of bare Earth digital elevation models (DEMs), generated from LiDAR data with 1-meter horizontal accuracy and 18.5-centimeter vertical accuracy. Digital files of DEMs and LiDAR data were provided by Kent County.

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 E

MONITORING PLAN

Rose & Westra
A Division of GZA

GEOTECHNICAL
ENVIRONMENTAL
ECOLOGICAL
WATER
CONSTRUCTION MANAGEMENT

HOUSE STREET FINAL REMEDY MONITORING PLAN

1855 HOUSE STREET NE
Plainfield Township, Kent County, Michigan

The Widdicomb Building
601 Fifth Street NW
Suite 102
Grand Rapids, MI 49504
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F: 616.288.3327
www.rosewestra.com
www.gza.com

December 2022
File No. 16.0062961.81

PREPARED FOR:
Wolverine World Wide, Inc.
Rockford, Michigan

Rose & Westra, a Division of GZA GeoEnvironmental, Inc.
601 Fifth Street NW | Suite 102 | Grand Rapids, MI 49504
616-956-6123

30 Offices Nationwide
www.GZA.com

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ACRONYMS

CD	Consent Decree, effective February 19, 2020 (No. 1:18-cv-0039-JTN-ESC)
EGLE	Michigan Department of Environment, Great Lakes and Energy
HSP	House Street Property, also referred to as
PIC	Principal-in-Charge
PM	Project Manager
PFAS Compounds	Poly- and Perfluorinated Alkyl Substances as defined in Appendix G of the CD
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
R&W/GZA	Rose & Westra, a Division of GZA GeoEnvironmental, Inc.
SOPs	Standard Operating Procedures
Wolverine	Wolverine World Wide, Inc.

1.0 INTRODUCTION

This monitoring plan has been prepared for monitoring to follow the House Street Property (HSP) Cap Final Remedy construction. The plan presents the proposed Monitoring Program, which has been developed and will be implemented under the most recent revision of the existing *Quality Assurance Project Plan (QAPP) for the Former Wolverine Tannery, House Street Property, and Wolven/Jewell Area, Per- and Polyfluoroalkyl Substances Investigation Program* (R&W/GZA, 2021 as amended).

2.0 MONITORING PROGRAM ORGANIZATION

The Monitoring Program organization will follow the organizational chart provided in the QAPP. In general, field activities are overseen by a Field Team Lead who is experienced in the proposed monitoring activities. Field personnel work under the direction of the Field Team Lead as appropriate. The field team is overseen by the Project Manager (PM), Principal-in-Charge (PIC), and Quality Assurance Officer (QAO). Refer to the QAPP for additional details on project organization.

The selected analytical laboratory for poly- and perfluorinated alkyl substances (PFAS) samples is specified in the QAPP. The QAO is responsible for verifying the laboratory performs analyses in accordance with the QAPP and documenting any material deviations. Per the QAPP, a percentage of laboratory data are validated by an independent third party.

3.0 PROPOSED MONITORING APPROACH

The following summarizes the components of the post-construction Monitoring for the HSP Final Remedy:

- Monitoring cap areas and retention basin side slopes for evidence of erosion;
- Gas vent and perimeter gas probe installation;
- Monitoring for methane gas in the gas vents and perimeter gas probes will be completed quarterly for two years following construction completion;
- Piezometer installation in historical perched water areas;
- Piezometer water level measurements to be completed quarterly for two years following construction completion;
- Baseline groundwater sampling from nine existing monitoring well clusters (installed as part of other investigations related to the HSP) to be completed within six months of construction completion;
- One follow-up groundwater sampling event from the nine existing monitoring well clusters sampled during the baseline event to be completed one year following the baseline event; and,
- Data evaluation and consultation with the Michigan Department of Environment, Great Lakes, and Energy (EGLE) to develop a long-term monitoring plan.

These components are detailed in the following subsections.

3.1 CAP SYSTEM MAINTENANCE AND MONITORING

The waste mound caps will be mowed at least once per year in accordance with the project Specifications. The waste mound caps and the retention basin side slopes will be observed quarterly for evidence of erosion, surficial damage, and sufficient vegetative cover growth. If there is evidence of erosion, damage, or lack of vegetative cover then repairs or reseeding will be completed.

3.2 GAS VENT AND PERIMETER GAS PROBE MONITORING

Gas vents and perimeter gas probes are proposed in and adjoining the three capped areas (refer to Appendix D, Attachment C, Drawing PE-011). Up to 20 gas vents and 12 gas probes are proposed to be installed as part of the cap installation and in accordance with the design plans (refer to **Figure 1** for approximate locations).

Following installation, GZA will develop a post-closure gas monitoring plan that will include the following[1]:

- Quarterly monitoring to confirm that methane gas, if generated, is not more than 100% of the lower explosive limit (LEL) at the perimeter gas probes, and gases generated, if any, do not create a nuisance odor at the HSP boundary; and,
- Mitigation and remedial measures if methane gas levels exceed the limits specified in the gas monitoring plan and post-closure plan.

3.3 PIEZOMETER INSTALLATION AND WATER LEVEL MEASUREMENTS

Piezometers are proposed in capped areas where perched water was observed (refer to Figure 11M of the *Implementation of the 2018 Work Plan Summary Report*, dated May 21, 2019 (R&W/GZA 2019). Up to six piezometers will be installed in conjunction with the landfill gas venting system and in accordance with the design plans (refer to **Figure 1** for approximate locations). The bottom elevation of the piezometers will be situated at the approximate elevation of the base of the temporary monitoring well screens installed in 2018-2019 (See **Table 1**).

Following installation, the location and elevation of the piezometers will be surveyed by a Michigan-licensed surveyor. GZA will complete two years of quarterly water level measurements from the piezometers and transmit the tabulated data to EGLE as part of quarterly reporting under the Consent Decree (CD). Each year one of the quarterly measurements will be completed in conjunction with the groundwater sampling (refer to **Sections 3.2** and **3.3**). The purpose of the piezometer installation and water level measurements is to evaluate the effect the cap has on the perched water thickness within the waste material.

3.4 BASELINE GROUNDWATER SAMPLING

Within six months of Final Remedy construction completion, groundwater samples will be collected from nine monitoring well clusters (refer to **Figure 2**) and analyzed for PFAS Compounds. Samples will be collected using standard low-flow sampling methodology in accordance with Standard Operating Procedures (SOPs) in the EGLE-approved QAPP. GZA will transmit the tabulated data to EGLE as part of existing data transmittal and reporting mechanisms under the CD.

[1] Gas management plan and landfill gas migration monitoring plan components identified by EGLE in their October 18, 2022 Notice of Approval with Conditions and clarified via email communication with Karen Vorce dated November 14, 2022.

3.5 FOLLOW-UP GROUNDWATER SAMPLING

An additional set of groundwater samples will be collected one year following the baseline groundwater sampling event. The samples will be collected from the baseline groundwater sampling wells and will be analyzed for PFAS Compounds in accordance with the QAPP. GZA will transmit the tabulated data to EGLE as part of existing data transmittal and reporting mechanisms under the CD.

3.6 DATA EVALUATION

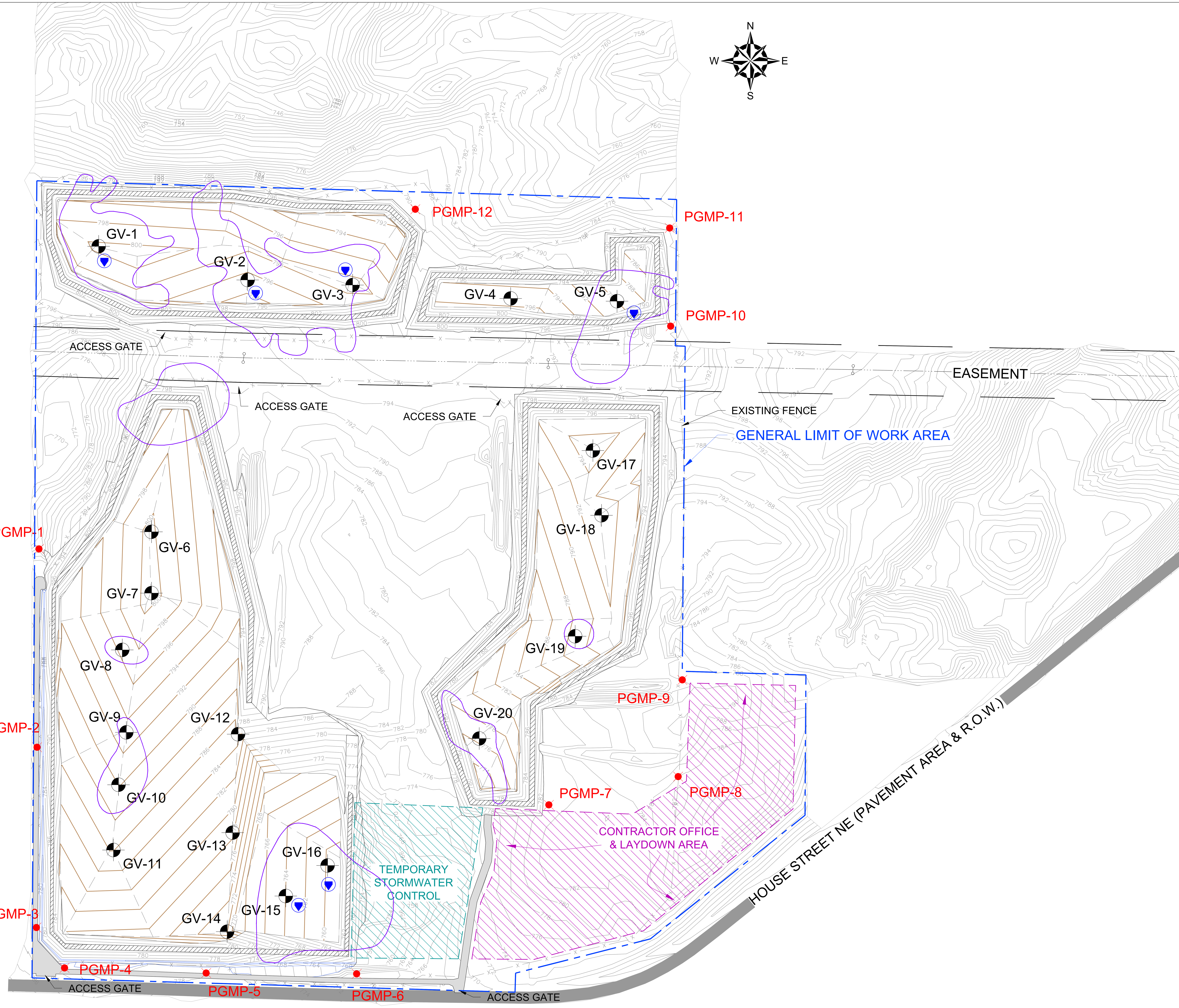
Following completion of the eight quarters of water level measurements and two groundwater sampling events, GZA will compile the post-construction monitoring data into a summary memorandum and recommend a long-term monitoring plan for the Final Remedy.

TABLE

TABLE 1
PROPOSED PIEZOMETERS
HSP FINAL REMEDY

Proposed Piezometer	Piezometer Location	Corresponding Temporary Wells	Temp Well Bottom Elevation	Proposed Piezometer Screen Length	Proposed Piezometer Bottom Elevation
HS-PZ-01	NW Cap Area	HS-SB-T2-030	772	5	772
HS-PZ-02	N Central Cap Area	HS-SB-T6-024	776	5	776
HS-PZ-03	NE Cap Area	HS-SB-T6-038	776	5	776
HS-PZ-04	NE Cap Area	HS-SB-T6-104	769	5	769
HS-PZ-05	SW Cap Area	HS-SB-937	730	5	730
HS-PZ-06	SW Cap Area	HS-SB-949	731	5	731

FIGURES



GENERAL NOTES

1. BASE MAP TOPOGRAPHY PROVIDED BY EXXEL ENGINEERING, INC DATED OCTOBER 6, 2020.
2. STATION DATUM IS NAVD88, BASED ON GPS OBSERVATIONS USING MDOT CORS.
3. PROPOSED GAS VENT AND PIEZOMETER SHALL BE CO-LOCATED, SHOWN HERE AS SEPARATE FOR CLARITY.

LEGEND

- SITE BOUNDARY
- GENERAL LIMIT OF WORK AREA
- EASEMENT
- PROPOSED ACCESS ROAD
- 760 EXISTING GROUND CONTOURS
- PERIMETER SWALE BREAKLINES (SW CORNER)
- BERM DESIGN BREAKLINES
- TOP OF IMPACTED MATERIAL BREAKLINES
- PROPOSED GAS VENT LOCATION. SEE DRAWING PE-008 FOR COORDINATES.
- PROPOSED PIEZOMETER IN HOUSE ST. CAP
- ESTIMATED EXTENT OF PERCHED GROUNDWATER OBSERVED IN 2018-2019. PERCHED GROUNDWATER AT DEPTHS GREATER THAN 10 FEET BELOW GROUND SURFACE (BGS).
- PERIMETER GAS MONITORING PROBE (PGMP)

0 50 100 200
SCALE IN FEET

NO.	ISSUE/DESCRIPTION	BY	DATE

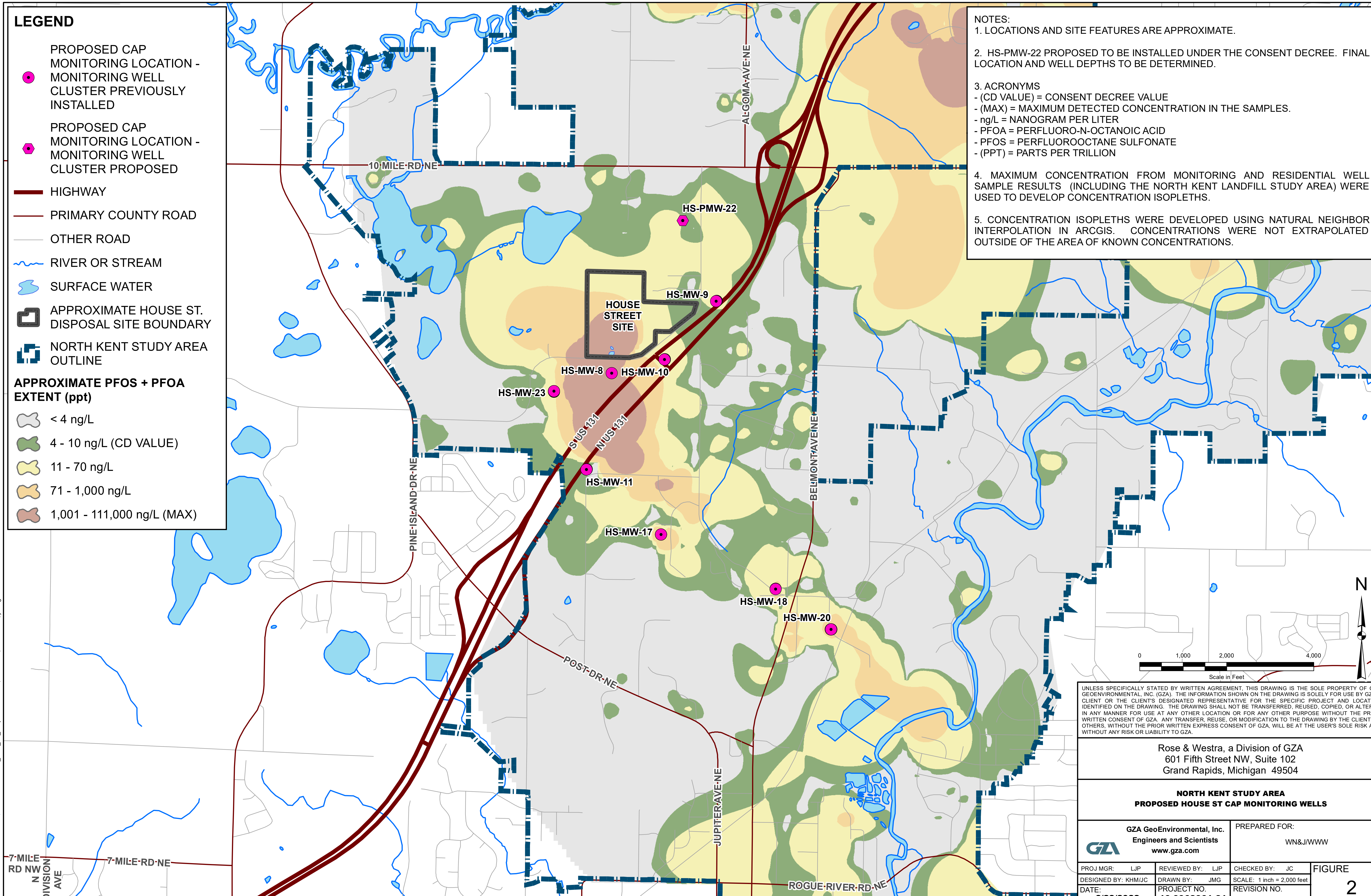
ROSE & WESTRA, A DIVISION OF GZA
601 FIFTH STREET NW, SUITE 102
GRAND RAPIDS, MICHIGAN 49504

PROPOSED PIEZOMETERS IN CAPPED AREAS

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM	DRAWN BY: TAK	SCALE: AS SHOWN	1
DATE: NOVEMBER 2022	PROJECT NO. 16.0062961.81	REVISION NO.	



LEGEND

- PROPOSED CAP MONITORING LOCATION - MONITORING WELL CLUSTER PREVIOUSLY INSTALLED
- PROPOSED CAP MONITORING LOCATION - MONITORING WELL CLUSTER PROPOSED
- HIGHWAY
- PRIMARY COUNTY ROAD
- OTHER ROAD
- RIVER OR STREAM
- SURFACE WATER
- APPROXIMATE HOUSE ST. DISPOSAL SITE BOUNDARY
- NORTH KENT STUDY AREA OUTLINE

APPROXIMATE PFOS + PFOA EXTENT (ppt)

- < 4 ng/L
- 4 - 10 ng/L (CD VALUE)
- 11 - 70 ng/L
- 71 - 1,000 ng/L
- 1,001 - 111,000 ng/L (MAX)

NOTES:

1. LOCATIONS AND SITE FEATURES ARE APPROXIMATE.
2. HS-PMW-22 PROPOSED TO BE INSTALLED UNDER THE CONSENT DECREE. FINAL LOCATION AND WELL DEPTHS TO BE DETERMINED.
3. ACRONYMS
   - (CD VALUE) = CONSENT DECREE VALUE
   - (MAX) = MAXIMUM DETECTED CONCENTRATION IN THE SAMPLES.
   - ng/L = NANOGRAM PER LITER
   - PFOA = PERFLUORO-N-OCTANOIC ACID
   - PFOS = PERFLUOROOCTANE SULFONATE
   - (PPT) = PARTS PER TRILLION
4. MAXIMUM CONCENTRATION FROM MONITORING AND RESIDENTIAL WELL SAMPLE RESULTS (INCLUDING THE NORTH KENT LANDFILL STUDY AREA) WERE USED TO DEVELOP CONCENTRATION ISOPLETHS.
5. CONCENTRATION ISOPLETHS WERE DEVELOPED USING NATURAL NEIGHBOR INTERPOLATION IN ARCGIS. CONCENTRATIONS WERE NOT EXTRAPOLATED OUTSIDE OF THE AREA OF KNOWN CONCENTRATIONS.

Rose & Westra, a Division of GZA
601 Fifth Street NW, Suite 102
Grand Rapids, Michigan 49504

NORTH KENT STUDY AREA
PROPOSED HOUSE ST CAP MONITORING WELLS

GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR: WN&J/WWW

PROJ MGR: LJP	REVIEWED BY: LJP	CHECKED BY: JC	FIGURE
DESIGNED BY: KHM/JC	DRAWN BY: JMG	SCALE: 1 inch = 2,000 feet	2
DATE: 3/28/2022	PROJECT NO. 16.0062961.81	REVISION NO.	