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Reference No. 11230149

Mr. Kevin Willis
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Mr. Benjamin J. McPherson
Alternate S-Area Coordinator
NYS Department of Environmental Conservation
270 Michigan Avenue
Buffalo, NY 14203-2999

Dear Messrs. Willis and McPherson:

Re: Revised Work Plan for Additional Shallow Bedrock NAPL Recovery System Investigation, S-Area Landfill Niagara Falls, New York

1.0 Introduction

Glenn Springs Holdings, Inc. (GSH) received comments from the United States Environmental Protection Agency (USEPA) via email dated June 8, 2021 regarding the report entitled "Revised Effectiveness Evaluation – Shallow Bedrock NAPL Recovery System" prepared by GHD and dated December 1, 2020 (Effectiveness Evaluation); and the letter "Results from Additional Field Investigation" dated October 6, 2020 (Additional Investigations).

GSH reviewed the comments and replied to USEPA/NYSDEC in a letter dated July 21, 2021 entitled "Response to Comments, NAPL Recovery Well Pump Test Report, S-Area Landfill". GSH's response indicated that many of the USEPA/NYSDEC comments would require additional field investigations to collect the required data. GSH agreed to submit a work plan for the additional investigations. This letter provides the requested work plan; and provides additional details regarding the work plan components. The work plan is subdivided into two main sections; additional investigations and related activities, and data evaluation and reporting, which will further address comments contained in the USEPA letter dated May 20, 2021.

This revised work plan incorporates responses to comments provided by USEPA/NYSDEC in letters dated March 31, 2022 and June 10, 2022 as applicable. GSH provided the responses to these comments in letters dated May 12, 2022 and July 11, 2022.

2.0 Additional Investigations and Related Activities

The additional investigations and related activities included in this work plan include conversion of the existing Shallow Bedrock Aquifer monitoring well OW806 into a Shallow Bedrock Aquifer NAPL Recovery Well; and additional investigations related to NAPL characteristics and NAPL presence in the Shallow Bedrock. Figure 1 presents the location of the S Area landfill site and surrounding facilities, and the location of the Shallow Bedrock RRT System, NAPL recovery wells, and monitoring wells.

The additional investigations related to NAPL characteristics and NAPL presence in Shallow Bedrock presented in this work plan will be obtained through a three-stage approach that will provide additional information and details to the lines of evidence approach being used to evaluate the Shallow Bedrock Aquifer NAPL Recovery System. The three stages of the investigation include:

- NAPL Characterization – overburden soil characterization, NAPL location evaluation, and overburden and shallow bedrock NAPL characterization
- Installation of Additional Shallow Bedrock Monitoring Wells – installation of additional shallow bedrock boreholes, documentation of fractures, borehole geophysics, and potential presence of NAPL
- Shallow Bedrock Aquifer NAPL Recovery System Pumping Tests - combined Shallow Bedrock Aquifer NAPL Recovery System pumping test

These individual activities are described in the following sections.

2.1 Conversion of NAPL Monitoring Well OW806 into Shallow Bedrock NAPL Recovery Well

GSH has completed the engineering design for conversion of monitoring well OW806 into a shallow bedrock NAPL recovery well, and previously completed test excavations to confirm the location of underground utilities in the immediate vicinity of OW806. The main construction activities to be completed for the conversion of OW806 into a Shallow Bedrock NAPL Recovery Well include:

- Over-drilling the well to a larger diameter
- Installing a concrete vault over the well
- Installing a pump, piping, and well vault controls
- Connecting the well to the immediately adjacent forcemain
- Installing underground electrical cable from the well vault to the motor control center located approximately 350 feet west of the well

This work will be performed in the immediate vicinity of a public bike/walking path along the Niagara River that is highly utilized in the warmer months of the year. As monitoring well OW806 is located in close proximity to the public bike/walking path, the work will require closure of the area to restrict access to potentially contaminated media and potentially dangerous equipment and activities. The underground electrical cable will cross the public bike/walking path, requiring excavation of the path, underground cable installation, and path restoration.

2.2 NAPL Characterization

The NAPL characterization activities include reviewing the overburden NAPL and waste disposal areas, the historical limits of overburden and shallow bedrock NAPL presence, determining the current limits of NAPL presence in overburden and shallow bedrock, characterizing the overburden soils relative to NAPL transmissibility, and characterizing NAPL in the overburden and shallow bedrock. The NAPL characterization will follow the applicable principles outlined in the USEPA (2009) publication “Assessment and Delineation of DNAPL Source Zones at Hazardous Waste Sites”[1].

[1] Kueper, B.H., and K.L. Davies, 2009. Assessment and Delineation of DNAPL Source Zones at Hazardous Waste Sites, USEPA/600/R-09/119, September 2009.

2.2.1 Overburden Waste Disposal Locations

This component of the investigation relies primarily on available historical data and records. Historical figures and related information will be assembled into a map and associated documentation depicting waste disposal locations and general waste categories.

It is intended that this review will provide a summary of S-Area source areas to aid in understanding historic and current NAPL distributions.

2.2.2 Historical Overburden and Shallow Bedrock NAPL Presence

This component of the investigation relies both on available historical data and information collected during ongoing routine monitoring. The historical NAPL presence was determined through the original investigations at the S-Area site during the late 1980s to early 1990s. The historical presence of NAPL in the overburden and shallow bedrock have been presented on figures in reports and letters, with occasional revisions to these figures based on the presence/absence of NAPL at monitoring wells.

It is intended that this review will provide a summary of historic S-Area NAPL presence and distribution to aid in understanding NAPL transport pathways and current NAPL distributions.

2.2.3 Current Overburden and Shallow Bedrock NAPL Presence

The review of recent historical and current overburden NAPL presence and thickness will provide a summary of the current distribution of NAPL in S-Area overburden as it relates to potential on-going source area(s). Recent historical refers to the previous minimum 5 years of data. However, available data will be compiled for the period of regular NAPL presence monitoring. It will also allow for a revised evaluation of NAPL thickness and potential recoverability in the overburden, should additional NAPL recovery be implemented. In many overburden monitoring wells, NAPL thicknesses have declined markedly (to nearly asymptotic conditions) or NAPL is no longer present in significantly measurable thicknesses, indicating that the overburden in the vicinity of that monitoring well may no longer contain significant amounts of mobile NAPL.

The review of recent historical and current shallow bedrock NAPL presence and thickness will provide a summary of the current distribution of residual and pooled NAPL in S-Area shallow bedrock as it relates to possible shallow bedrock transport pathways and to overburden source area(s). It will also allow for a revised evaluation of NAPL thickness and potential recoverability in the shallow bedrock. In many shallow bedrock monitoring wells, NAPL thicknesses have declined markedly, indicating that the shallow bedrock in the vicinity of that monitoring well may no longer contain significant amounts of mobile NAPL. It is recognized that some shallow bedrock monitoring wells consistently contain recoverable quantities on NAPL on a routine (e.g., quarterly, monthly) basis, and that in some shallow bedrock monitoring wells, NAPL presence and thickness can be strongly affected by operation of the Shallow Bedrock NAPL Recovery System.

The wells that will be used to determine the current overburden and shallow bedrock NAPL distribution are shown on Figures 2 and 3, respectively.

2.2.4 Overburden Soil Material Characterization

The overburden soil material will be characterized in general terms through a review of available historical documents. The data sources may include stratigraphic logs, grain size analysis, geotechnical test results, vertical hydraulic conductivity testing, etc. Relative soil vertical hydraulic conductivity (between soil types) will consider soil material type, general grain size ranges of components, layering, continuity of overburden stratigraphic horizons, and presence/absence of NAPL during the historical investigations. This soil material characterization will then provide a relative NAPL transmissivity estimation based on relative soil vertical hydraulic conductivity. This relative NAPL transmissivity estimation will be used to compare the overburden areas identified as potential vertical overburden NAPL transport to the overburden areas identified as probable limited vertical overburden NAPL transport (e.g., underlain by clay or glacial till).

The available overburden stratigraphic logs will be assembled into an appendix and the characterization will be presented through historical and/or newly created cross-sections depicting the main overburden characteristics related to NAPL transmissibility and soil vertical hydraulic conductivity.

2.2.5 Overburden and Shallow Bedrock NAPL Characterization

This component of the investigation relies both on available historical data and records, and newly collected information, and is intended to provide a summary of S-Area historic NAPL characteristics and compare those historic characteristics to current NAPL characteristics.

2.2.5.1 Historical Overburden and Shallow Bedrock NAPL Characterization

The available historical information regarding overburden and shallow bedrock NAPL characteristics will be compiled and tabulated to provide a summary of the known NAPL characteristics. Available NAPL characteristics may include NAPL density, viscosity, and chemical composition. Where available, NAPL characteristics from individual locations will be used to provide information related to potential spatial variations in NAPL characteristics. Much of the available NAPL data consists of routine bulk NAPL characterization, used for disposal purposes.

2.2.5.2 Current Overburden and Shallow Bedrock NAPL Characterization

NAPL Physical and Chemical Characterization

Current NAPL characteristics will be obtained by sampling selected overburden and shallow bedrock monitoring wells in the source area and southerly toward the Niagara River. The current NAPL characterization will include the following physical properties and chemical analysis:

- NAPL density (specific gravity)
- NAPL dynamic and kinematic viscosity at standard, and at estimated aquifer temperatures
- NAPL/water interfacial tension (using groundwater collected from site)
- NAPL chemical constituent analysis to identify the main constituents (volatile and semi-volatile organic compounds including tentatively identified compounds)

NAPL Characterization Locations

The current overburden NAPL characterization will focus on selected deeper overburden monitoring wells in the vicinity of the source area(s). These locations will represent the more mobile NAPL in/near the source area(s) that may still have the potential to flow from the deep overburden to the shallow bedrock. The overburden locations selected for NAPL sampling are presented on Figure 4 and are as follows:

- Monitoring wells OW525 and OW526
- Wet Well A (WWA), which collects APL/NAPL from the area beneath and immediately around the landfill via the overburden Site Containment System

The current shallow bedrock NAPL characterization will focus on shallow bedrock monitoring wells between the S-Area landfill and the Niagara River. These locations will represent the more mobile NAPL in the shallow bedrock. The current shallow bedrock characterization will also include sampling Shallow Bedrock NAPL Recovery Wells, where NAPL is accessible, such as at sample ports, well bottoms when pumps are removed, and during well rehabilitation. These locations will represent the less mobile NAPL where the more soluble NAPL constituents have been stripped from the NAPL, and the lower solubility NAPL constituents remain in and near the recovery well. This is consistent with the findings from similar NAPL characterization at the Hyde Park Landfill site[2], where the NAPL recovery wells contained highly viscous NAPL, with less viscous NAPL in the monitoring wells. The shallow bedrock locations selected for NAPL sampling are presented on Figure 4 and are as follows:

- Monitoring well OW806
- Monitoring wells OW244/OW245 (combined into one sample)
- Monitoring well OW670
- Shallow Bedrock recovery well BPW238R

The current overburden and shallow bedrock NAPL characterization will be compared to available historical NAPL characterization to determine if changes in NAPL characteristics have occurred, and whether these changes affect the potential for NAPL migration.

These data will be useful for constraining NAPL transport calculations and/or descriptions related to NAPL transport from the overburden to shallow bedrock and from the S-Area landfill towards the Niagara River in the shallow bedrock.

2.2.6 NAPL Location and Characterization Summary

It is intended that through a combination of historical data review and current NAPL presence and characterization, a more complete understanding of the potential NAPL source area(s) in the overburden, potential interconnection between overburden and shallow bedrock and the related potential NAPL overburden hydraulic pressure, and shallow bedrock NAPL presence is provided. This understanding will potentially allow for the general assessment of whether overburden NAPL is expected to be weakly to strongly hydraulically connected to the shallow bedrock (NAPL pressure head). This will allow for more accurate determinations of potential NAPL transport in the shallow bedrock aquifer. A macroscopic (at a scale greater than the pore scale) approach for NAPL entry pressures will be utilized.

For both overburden and bedrock, measured DNAPL properties (density and DNAPL/water interfacial tension) will be employed to assess DNAPL connection from overburden to bedrock fractures.

2.3 Installation of Additional Shallow Bedrock Monitoring Wells

The additional shallow bedrock monitoring wells are designed to provide spatial information regarding the hydrogeologic characteristics of and the presence of NAPL in the shallow bedrock. These additional shallow bedrock monitoring wells will also be used for hydraulic monitoring during the Shallow Bedrock NAPL Recovery System pumping tests to further evaluate hydrogeologic connections and groundwater/NAPL capture by the Shallow Bedrock NAPL Recovery System.

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[2] Conestoga-Rovers & Associates, Sayko Environmental Data Analysis, and S.S. Papadopulos & Associates, Inc., 2000. Site Characterization Report – Revised Geologic and Hydrogeologic Characterization, Hyde Park Landfill Site, Town of Niagara, New York, Prepared for Miller Spring Remediation Management, Inc., and Glenn Springs Holdings, Inc., August 2000, CRA Ref. No. 12553(5) and 1069(299).

2.3.1 Proposed Locations and Rationale

The attached Figure 4 presents 8 proposed monitoring shallow bedrock monitoring well locations along with the existing Shallow Bedrock NAPL recovery and monitoring wells. Figure 4 also presents the strike (N69°E) and dip direction (N159°E) and magnitude of dip (39 feet/mile, 0.42°) using labelled dashed lines. The direction of dip line was drawn through monitoring well OW806 and northwest through the S-Area landfill.

The rationale for each proposed monitoring well is presented below. These proposed locations would be incorporated into the existing hydraulic and NAPL monitoring programs and be used for monitoring during aquifer testing.

As part of the selection of these proposed locations, an expanded line of wells along the shallow bedrock NAPL recovery system (proposed shallow bedrock monitoring wells 1 through 5), and a line of wells parallel to the Niagara River (proposed shallow bedrock monitoring wells 6 through 8) were selected. The location of these wells also provides north to south transect lines of wells from the Site to the river for evaluation purposes.

Location 1: Located adjacent to and slightly north of the western end of the shallow bedrock NAPL recovery system south of Robert Moses Parkway (north of shallow bedrock NAPL recovery well BPW239). This location would be used for groundwater level, NAPL thickness, and additional hydraulic monitoring to evaluate groundwater capture at the western end of the shallow bedrock NAPL recovery system.

Location 2: Located near and slightly north of the western end of the shallow bedrock NAPL recovery system south of Robert Moses Parkway (north of shallow bedrock NAPL recovery wells BPW609 and BPW238R). This location would be used for groundwater level, NAPL thickness, and additional hydraulic monitoring to evaluate groundwater capture by the western portion of the shallow bedrock NAPL recovery system.

Locations 3 and 4: Located along the shallow bedrock NAPL recovery system between recovery wells BPW610R and BPW237. In this area, USEPA/NYSDEC have commented on the lack of monitoring and recovery wells, specifically related to NAPL presence in shallow bedrock monitoring well OW806. GSH has indicated that OW806 would be converted to a shallow bedrock NAPL recovery well, and these additional monitoring locations would be used for groundwater level, NAPL thickness, and additional hydraulic monitoring to evaluate groundwater capture by the eastern portion of the shallow bedrock NAPL recovery system.

Location 5: Located adjacent to and slightly north of the eastern end of the shallow bedrock NAPL recovery system on the east side of 53rd Street, approximately north of shallow bedrock recovery well BPW671. This location would be used for groundwater level, NAPL thickness, and additional hydraulic monitoring to evaluate groundwater capture by the eastern portion of the shallow bedrock NAPL recovery system.

Location 6: Located south of the western portion of the shallow bedrock NAPL recovery system (south of shallow bedrock NAPL recovery wells BPW609 and BPW238R). This location would be used for groundwater level, NAPL thickness, and additional hydraulic monitoring to evaluate groundwater capture by the western portion of the shallow bedrock NAPL recovery system. This location may also show the influence of the Niagara River on hydraulic head in the shallow bedrock groundwater system south of the western portion of the shallow bedrock NAPL recovery system.

Location 7: Located within the Dock area south of the eastern portion of the shallow bedrock NAPL recovery system. This location would be used for groundwater level, NAPL thickness, and additional hydraulic monitoring to evaluate groundwater capture by the eastern portion of the shallow bedrock NAPL recovery system. This location may also show the influence of the Niagara River on hydraulic head in the shallow bedrock groundwater system south of the eastern portion of the shallow bedrock NAPL recovery system.

Location 8: Located within the Dock area south of the eastern portion of the shallow bedrock NAPL recovery system. This location would be used for groundwater level, NAPL thickness, and additional hydraulic monitoring to evaluate groundwater capture by the eastern portion of the shallow bedrock NAPL recovery system. This location may also better show the influence of the Niagara River on hydraulic head in the shallow bedrock groundwater system south of the eastern portion of the shallow bedrock NAPL recovery system.

It is known that the area from about Robert Moses Parkway to the Niagara River was formerly riverbed and has been reclaimed by fill materials, particularly shot rock from the construction of the hydroelectric canals. This has resulted in difficult drilling where auger refusal was encountered during previous investigations due to the cobble and boulder-sized materials. If shot rock is encountered and prevents advancement at a borehole location, the borehole will be abandoned, the drill rig and equipment will be moved several feet and the borehole will be re-advanced. Multiple borehole attempts could be required to advance the borehole through shot rock material.

In order to focus on the NAPL migration in a north to south orientation, the lines of wells form the following transects:

- Transect 1 - Proposed wells 1 and BPW239
- Transect 2 - OW244/OW245, proposed well 2, BPW609/BPW238R, and proposed well 6
- Transect 3 - Proposed wells 3 and 4, OW806 (to be converted into a shallow bedrock NAPL recovery well), and proposed well 7

2.3.2 Utility Locates

Utility locates will be performed due to the known presence of the two buried forcemains, electrical conduits, and pump controls for overburden and shallow bedrock pumping wells south of Robert Moses Parkway in the vicinity of proposed shallow bedrock wells 1, 2, 3, 4, and 5. These utility locates may require excavations to determine the locations of buried utilities, and/or hydrovac/air knife to expose soils to a depth below the installation depth of buried utilities in this area.

It is known that other utilities such as underground electrical conduits are likely present in this area are due to the presence of solar pathway lights (with possible historical electrical connections) along the public bike/walking path in the vicinity of the Dock, and the presence of the overhead electrical tower. In addition, the Dock contains buildings that house the controls for the overburden and shallow bedrock pumping systems.

2.3.3 Overburden Borehole Advancement and Installation of Surface Casing

The majority of the existing shallow bedrock monitoring wells and NAPL recovery wells were constructed with a 6-inch open hole. These wells were typically installed in a 12-inch to 13-inch overburden borehole (to a depth of approximately 30 ft bgs), with nominal 6-inch steel surface casing set in cement-bentonite grout. The bedrock boreholes were usually advanced using HQ core drilling methods. Many of the NAPL recovery wells were HQ monitoring well coreholes (3.8-inch diameter) that were later drilled out to larger diameter monitoring or recovery wells. It is known that overburden drilling was difficult, with refusal at many drilling locations.

The overburden boreholes would be advanced with 6.25-inch inside diameter hollow-stem augers. Soil samples will be collected at regular intervals from split-spoons or auger cuttings returns (depending on the level of difficulty in drilling) and visually screened for the presence of NAPL consistent with “Appendix ‘B’ – Plans, Specifications & Protocols, S-Area/Water Treatment Plant, Subsurface Investigation, S-Area Remedial Program”, dated April 1996 and amended July 1997. Hydrophobic dye testing will also be employed for soil cores to confirm NAPL presence. A HW-size (4-inch diameter) surface casing will be set into the upper surface of the shallow bedrock using cement-bentonite grout emplaced by tremie pipe and positive displacement methods. Any water returned to surface during grouting will be contained. The grout will be allowed to cure a minimum of 24 hours. The shallow bedrock monitoring wells would be advanced using standard HQ core drilling methods producing a 3.8-inch corehole.

2.3.4 Bedrock Core Drilling

The bedrock portion of the boreholes will be advanced using HQ core drilling techniques which provides a 2.5-inch drill core in a 3.8-inch diameter borehole. Each bedrock borehole will be core drilled a maximum of approximately 30 ft below the overburden/bedrock interface. Core drilling will use potable water as a drilling fluid and will be recirculated during drilling until evidence of NAPL is present in the return drilling water. The remainder of the corehole will be drilled with once-through drilling water to reduce the potential for contamination of the drilling equipment.

All recovered drill core will be placed into wooden core boxes, labelled, and described in detail paying attention for geologic and hydrogeologic indications of water-bearing fractures, including orientation, weathering, presence of NAPL, etc., consistent with “Appendix ‘B’ – Plans, Specifications & Protocols, S Area/Water Treatment Plant, Subsurface Investigation, S-Area Remedial Program”, dated April 1996 and amended July 1997. Hydrophobic dye testing will also be employed for soil cores to confirm NAPL presence. Measurements of the length of core recovered for each core run will be recorded, and the Rock Quality Designation (RQD) will be calculated. The depth of each water-bearing fracture will be recorded, and indications of bedrock and fracture weathering will be noted. In addition, the depths of NAPL staining of fractures or rock matrix (including later staining of the corebox or leaking from the bedrock core) will be noted.

The shallow bedrock fracture apertures are spatially variable in location, presence, relation to natural bedding, continuity, and fracture aperture. Asperities in the bedrock fracture plane indicate the potential for variations in the fracture aperture width and fracture hydraulic conductivity.

2.3.5 Borehole Geophysics

At the GSH Hyde Park Landfill Site, extensive borehole geophysics and recharacterization of the bedrock was conducted during 2001. These investigations were conducted to improve bedrock groundwater flow characterization in order to demonstrate groundwater capture by the remedial pumping system in an area of variable bedrock thickness, where bedrock groundwater flow was known to occur in at least 9 discrete flow zones in the Lockport Group. These flow zones make up the shallow, intermediate, and deep bedrock zones at the S-Area Site.

The principal objective of the Hyde Park borehole geophysical logging program was to locate water-bearing fractures in the bedrock. Century Geophysics (now Century Wireline Services) was subcontracted to perform the borehole geophysical logging. The following geophysical tools were utilized during this program in one multi-parameter tool (excluding the acoustic televiewer, which is a separate logging tool):

- Caliper
- Natural Gamma
- Spontaneous Potential
- Fluid Resistivity
- 16-N and 64-N resistivity
- Single Point Resistivity
- Fluid Temperature and Delta Temperature
- Acoustic Televiewer

The key geophysical logs that showed the presence of water-bearing fractures were the acoustic televiewer and the fluid temperature/delta temperature. Fluid resistivity also aided in the interpretation of flow. The gamma log was used to better constrain bedrock stratigraphy where drill cores were unavailable. The individual geophysical methods are described below.

Acoustic Televiewer

The acoustic televiewer borehole geophysical tool takes a north-oriented acoustic picture of the borehole wall using sound waves. This information is interpreted to provide an unwrapped image of the borehole wall, and the location of bedding planes, fractures, and borehole anomalies. The orientation and dip of bedding planes and fractures can be determined through analysis of the borehole image.

Caliper

The three-arm caliper tool measures the borehole diameter, which can indicate the presence of horizontal and near-horizontal fractures, and washouts at fractures or at the bottom of the surface casing. It does not readily provide evidence of dipping fractures.

Fluid Temperature and Delta Temperature

Fluid temperature is the temperature of the borehole fluid, ideally under undisturbed conditions. The delta temperature is the change from the previous measurement and emphasizes areas with changing fluid temperatures. The temperature of the fluid changes where fluid flows into or out of a borehole and can indicated hydraulically active fractures and zones that are hydraulically inactive.

Fluid Resistivity

Similar to fluid temperature, fluid resistivity is the resistivity of the borehole fluid, ideally under undisturbed conditions. Fluid resistivity can also indicate the presence of hydraulically active fractures, where the resistivity of the fluid changes either due to a fluid of differing electrical conductivity entering or leaving the borehole, or in the case of zones above or below hydraulically active fractures, an equilibration of the borehole fluid with the soluble salts in the bedrock. For example, high fluid resistivity is often seen in the bottom of the borehole, where there are no hydraulically active fractures.

Natural Gamma

The natural gamma log provides a count of the gamma emissions emanating from the near-borehole zone. The gamma emissions are from radioactive elements, primarily potassium, uranium, and thorium. The natural gamma is an indirect indicator of the presence of fine-grained sediments, essentially, the shaliness of the bedrock. There are typically relatively unique signatures in the stratigraphic sequence, that are related to stratigraphic contacts, and water-bearing fractures are often found at consistent separations from these gamma signatures.

Resistivity

The various resistivity tools (16-N, 64-N, SPR) all provide a rock resistivity that is related in part to the shaliness of the bedrock, the bedrock material (shale versus dolostone), and to porosity, especially high porosity bedrock filled with conductive fluids.

The borehole geophysics would be used to determine the location of water-bearing fractures in new wells. Borehole geophysics would not be conducted in existing wells due to the likely presence of NAPL in the bottom of the wells and NAPL smeared on the sides of the wells, that may prove difficult to remove from the geophysical tooling, and may result in muted geophysical responses due to NAPL on the borehole wall.

2.3.6 Well Completions

Each monitoring well would be completed as a flushmount well with a traffic-rated road box or well vault set in a concrete surface seal, consistent with other wells at the Site.

2.3.7 Single-Well Response Tests

The purpose of single-well response (slug) testing of monitoring wells is to determine an estimated hydraulic conductivity for the soil or bedrock in the vicinity of the monitoring well. The slug test involves a rapid change or displacement of the water column in the monitoring well, followed by monitoring the recovery of the water level back to the static water level conditions.

Single-well response (slug) tests will be conducted on all newly installed monitoring wells using the following steps:

1. Measure depth to water (for flushmount wells allow time for the well to equilibrate to static water level conditions) and depth to bottom of the well and compare to well installation records.
2. Program a pressure transducer to record height of water and ensure that it is recording properly prior to installation, using a recording frequency of a tenth of a second or faster.
3. Check depth to water again to ensure that the water level is at static conditions.
4. Rapidly insert a solid slug to displace the water column upward and initiate the falling head test, measure initial depth to water, and record start time and water depth.
5. Monitor depth to water periodically to determine the approximate duration of the first slug test.
6. After at least 90 percent recovery, rapidly remove the slug from the well to displace the water column downward and initiate the rising head test, measure initial depth to water, and record start time and water depth.
7. For slug tests completed in less than 5 minutes, complete at least two additional falling head and rising head tests.
8. For slug tests completed in less than 15 minutes, complete at least one additional falling head and rising head test.
9. Once the water column has recovered to static conditions, remove the pressure transducer and decontaminate the equipment.

The slug test data for each monitoring well will be graphed to review data quality. The data will be reduced to elapsed time and displacement for data analysis. These data, along with well installation details, will be used to analyze the data using the aquifer test analysis software program AQTESOLV (v.4.51).

Based on NAPL collection activities previously conducted at the Site, DNAPL is relatively slow to recharge into wells. If NAPL is observed in the proposed monitoring wells, preliminary bailing of NAPL will be conducted to determine an approximate recovery rate. If the NAPL is observed to recover within three days, a NAPL bail-down test will be performed.

2.3.8 Monitoring Well Elevation Survey

The top of casing (TOC) and ground elevation at each new monitoring well will be surveyed upon installation completion.

2.3.9 Waste Management and Characterization

All wastes generated during well installation will be containerized and managed in accordance with applicable regulations.

2.4 Shallow Bedrock Aquifer NAPL Recovery System Pumping Test

The shallow bedrock aquifer NAPL recovery system pumping test will be a combined shallow bedrock aquifer NAPL recovery well system start-up test. This pumping test would be conducted once the proposed additional shallow bedrock monitoring wells have been installed and OW806 has been retrofitted. This will be similar to the start-up test completed during April 2020 but will include the newly converted OW806 as a shallow bedrock NAPL recovery well, and the new shallow bedrock monitoring wells. The shallow bedrock aquifer NAPL recovery well test will consist of starting each shallow bedrock aquifer NAPL recovery well at staggered intervals and allowing for groundwater elevations to approximately stabilize prior to starting the next recovery well. Each of the shallow bedrock NAPL recovery wells will be started using a staggered approach. Each shallow bedrock NAPL recovery well will be started at 1 to 1.5-hour intervals on a single day. Pumping rates will be similar to operational pumping rates; however, lack of backpressure in the shallow bedrock NAPL forcemain may allow some wells to operate at higher pumping rates for a period of time. Pumping rates will be recorded periodically during the startup of the shallow bedrock NAPL recovery wells. Once the entire recovery system is running, monitoring will continue until drawdown in the shallow bedrock aquifer has stabilized, a minimum of 24 hours.

Pressure transducers would be installed in shallow bedrock monitoring and NAPL recovery wells, and in the Niagara River, and programmed to record at one-minute intervals. Manual depth to water measurements will be taken regularly during start-up at the recovery and monitoring wells. The pressure transducers would be installed in the following locations:

Background Monitoring Wells/Locations	Monitoring Wells		NAPL Recovery Wells
OW228	OW616	Proposed well 1	BPW239
OW240R	OW648	Proposed well 2	BPW609
OW612		Proposed well 3	BPW238R
OW690		Proposed well 4	BPW610R
		Proposed well 5	Retrofitted OW806

Background Monitoring Wells/Locations	Monitoring Wells		NAPL Recovery Wells
Niagara River		Proposed well 6	BPW237
		Proposed well 7	BPW611
		Proposed well 8	BPW671

It is anticipated that these pumping tests will show significant drawdown is occurring at each shallow bedrock NAPL recovery well, causing significant additional drawdown in nearby shallow bedrock aquifer NAPL recovery wells and shallow bedrock monitoring wells. This is consistent with previous observations of significant drawdown at each shallow bedrock NAPL recovery well caused by the operation of nearby shallow bedrock NAPL recovery wells.

3.0 Data Evaluation and Reporting

GSH will continue the multiple lines of evidence approach presented in the "Revised Effectiveness Evaluation Report", including a macroscopic approach to NAPL entry pressures. The additional information produced from our three-phase work plan will add detail to the lines of evidence evaluation of the Shallow Bedrock Aquifer NAPL Recovery System. The additional data collected will be evaluated in conjunction the previous Effectiveness Evaluations already conducted, conditions already known from assessment reports submitted in the late 1980s, specifically "Assessment of the Extent of APL/NAPL Migration from the S-Area in the Lockport Bedrock" (June 1988) and "NAPL in Bedrock Beneath the Niagara River, Assessment of Human Endangerment" (May 1989). The data evaluation will focus on further demonstrating that the goal (as stated in the RRT Stipulation) to demonstrate that control of further NAPL migration toward the Niagara River has been achieved.

The data evaluation and reporting component of this work plan encompasses the review of historical waste placement, historical and current NAPL extents, historical and current NAPL characteristics, evaluation of the hydraulic capture of groundwater, and by further calculations, NAPL capture. The assessment of hydraulic capture will include hydrographs of the groundwater elevation data, drawdown and recovery versus time, and a discussion of the results including the influence of the pumping wells on adjacent wells. The report will be updated to reflect groundwater pumping rates, NAPL removal volume, and related information through to the end of calendar year 2021The comments, and GSH responses to the comments, will be incorporated, as appropriate into the revised report. More detail regarding calculations will be provided, including reasonable assumptions, and sensitivity analysis.

In addition, the report will contain an updated conceptual site model (CSM) as appropriate. All overburden stratigraphic logs and all shallow bedrock stratigraphic logs for the S-Area Landfill and immediately adjoining areas related to the S-Area Landfill south of the shallow bedrock NAPL extent will be compiled and included in the revised CSM. The revised CSM will use cross-sections depicting the overburden stratigraphy and where known, shallow bedrock fractures at each shallow bedrock well. The cross-sections will also show the intervals of documented presence of NAPL based on the stratigraphic logs. The revised CSM will describe the operation of the shallow bedrock NAPL recovery system, the NAPL characteristics, the presence of NAPL, and NAPL thickness in wells. Where warranted by sufficient data, NAPL recovery charts will be prepared.

4.0 Schedule

NAPL sampling for physical and chemical characterization will be completed in July 2022. The analytical results as well as the historic and current overburden and shallow bedrock NAPL characterization will be submitted as a technical memorandum by October 31, 2022.

Monitoring well installation will commence in October/November 2022 and be completed in February 2023, with overdrilling of OW806 and installation of the monitoring wells closest to the bike path being completed first. Conversion of OW806 to a recovery well (mechanical and electrical) will be completed Maybe the end of February 2023. Pumping tests will be completed during the spring of 2023. The report presenting the results of the work plan activities will be submitted by July 31, 2023.

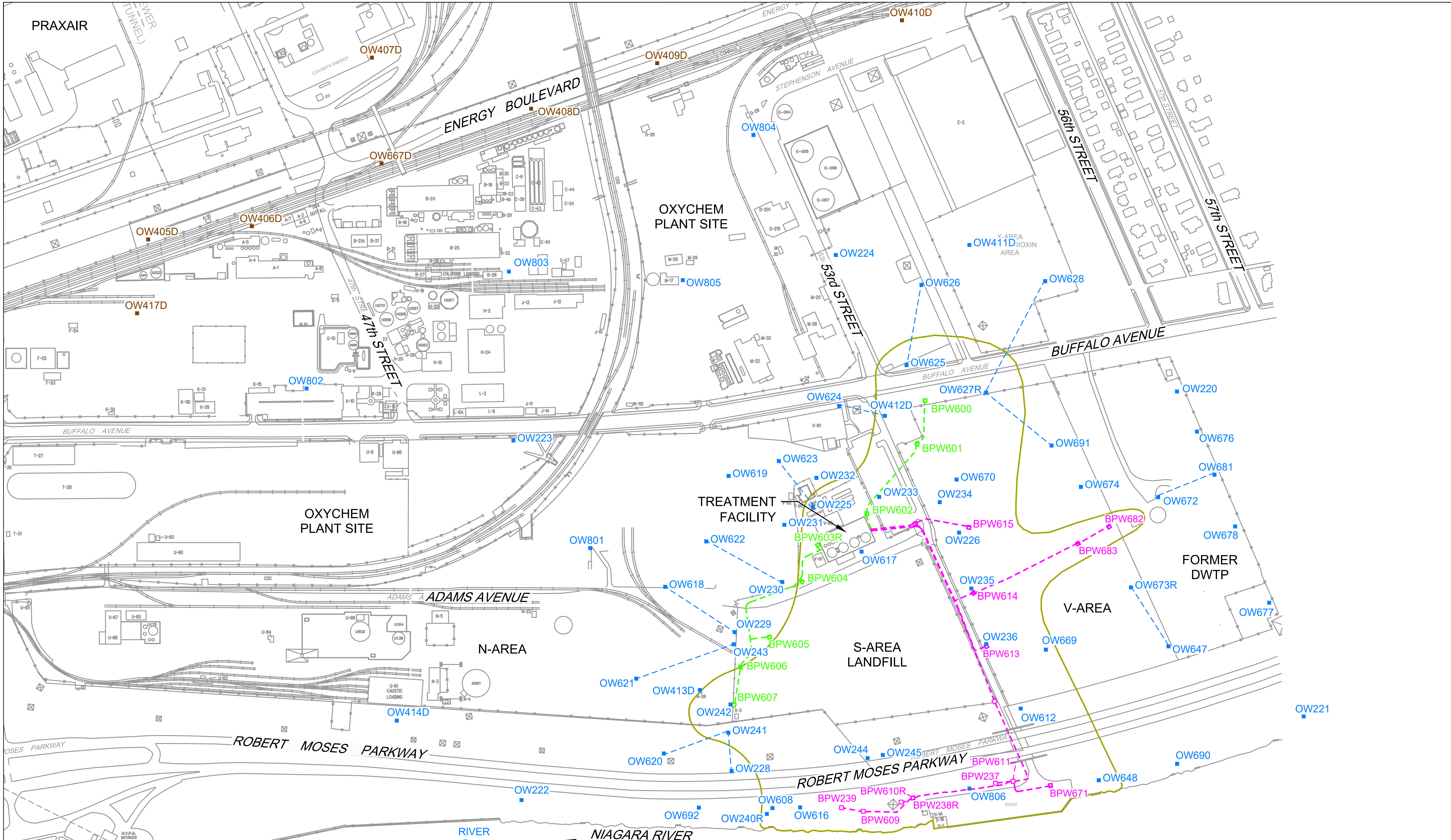
Should you have any questions on the above, please do not hesitate to contact me at 231-670-6809 or email at joseph_branch@oxy.com.

Very truly yours,

Joseph Branch
Project Manager
Glenn Springs Holdings, Inc.

JP/kf/7/11230149

cc: Maeve Wurtz (USEPA)
Frank Parigi (Oxy)
Bernie Kueper (B. Kueper & Associates, Ltd.)
John Pentilchuk (GHD)



LEGEND

OW691	SBHP MONITORING WELL
OW410D	EMP MONITORING WELL
	SHALLOW BEDROCK NAPL PLUME
BPW605	SHALLOW BEDROCK APL PURGE WELL
BPW609	SHALLOW BEDROCK NAPL RECOVERY WELL
	SHALLOW BEDROCK APL FORCEMAIN
	SHALLOW BEDROCK NAPL FORCEMAIN
	PERFORMANCE WELL PAIRS
OW526	OVERBURDEN VERTICAL GRADIENT MONITORING WELL
WWA	WET WELL LOCATION

0 150 300 ft

1" = 300 ft

Coordinate System:
NAD 83 NEW YORK STATE PLANES, WEST ZONE, US FOOT

GHD

GLENN SPRINGS HOLDINGS, INC.
S-AREA LANDFILL SITE
NIAGARA FALLS, NEW YORK

Project No. 11230149
Date July 2022

SHALLOW BEDROCK RRT SYSTEM

FIGURE 1

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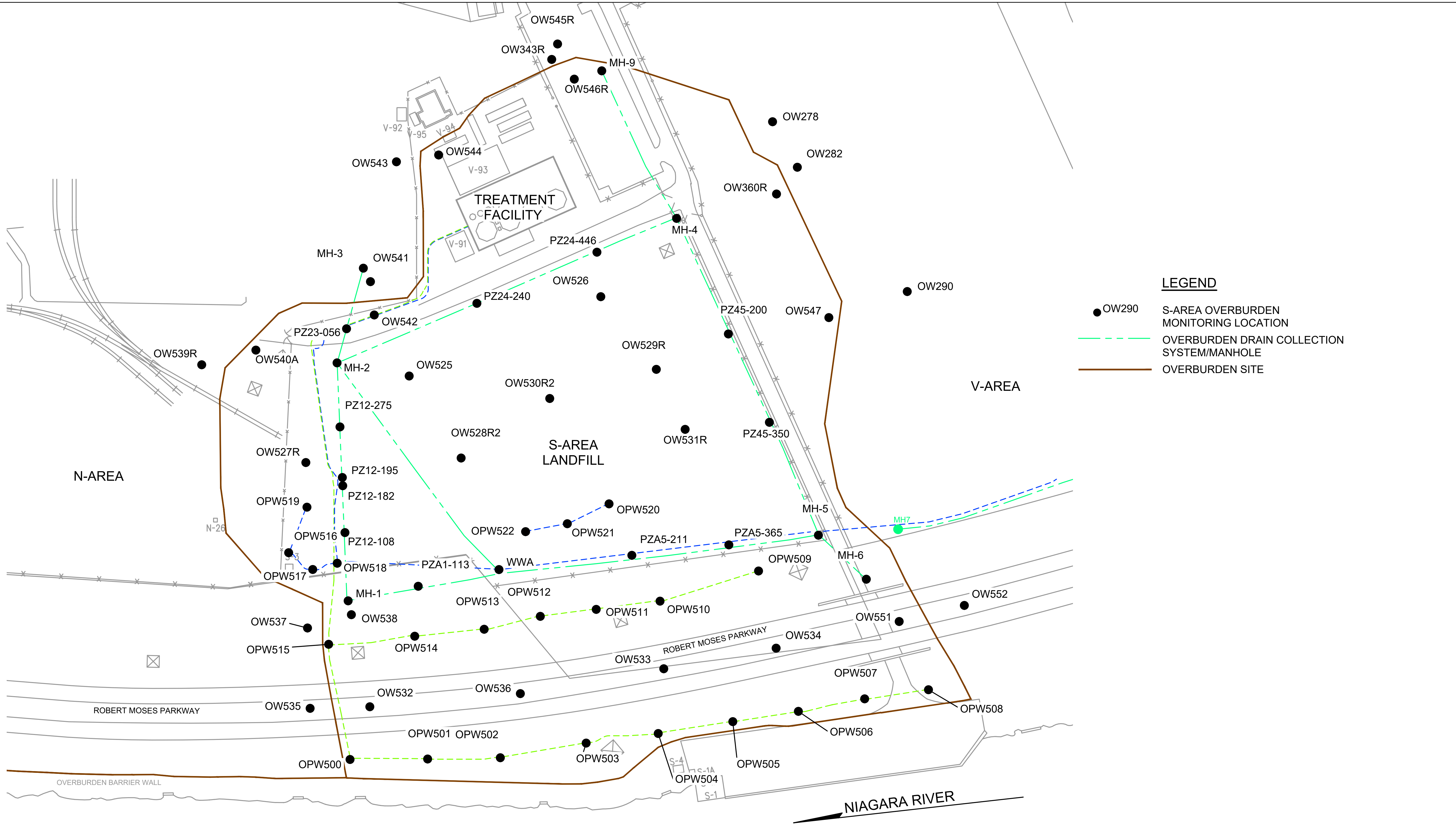

GLENN SPRINGS HOLDINGS, INC.
S-AREA LANDFILL SITE
NIAGARA FALLS, NEW YORK

Project No. 11230149
Date July 2022

GHD

OVERBURDEN MONITORING WELL LOCATIONS

FIGURE 2

Filename: \\ghdnet\ghd\CA\Waterloo\Projects\662\11230149\Digital_Design\ACAD\Figures\LTR007\11230149-GHD-00-00-LTR-EN-D102_WA-007.dwg
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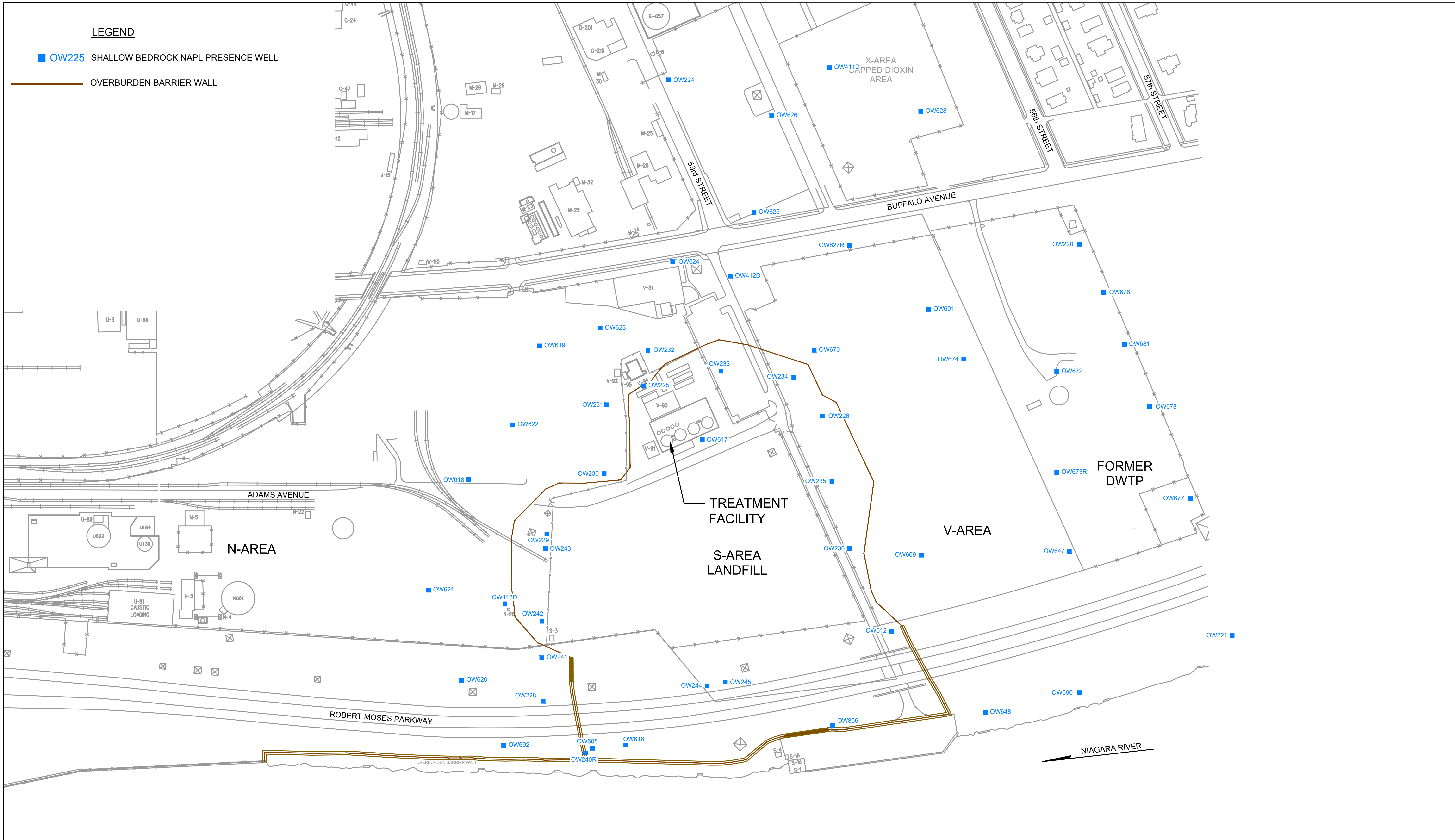

0 125 250 ft
1" = 250 ft

N

GHD

GLENN SPRINGS HOLDINGS, INC.
S-AREA LANDFILL SITE
NIAGARA FALLS, NEW YORK

SHALLOW BEDROCK
MONITORING WELL LOCATIONS

Project No. 11230149
Date July 2022

FIGURE 3

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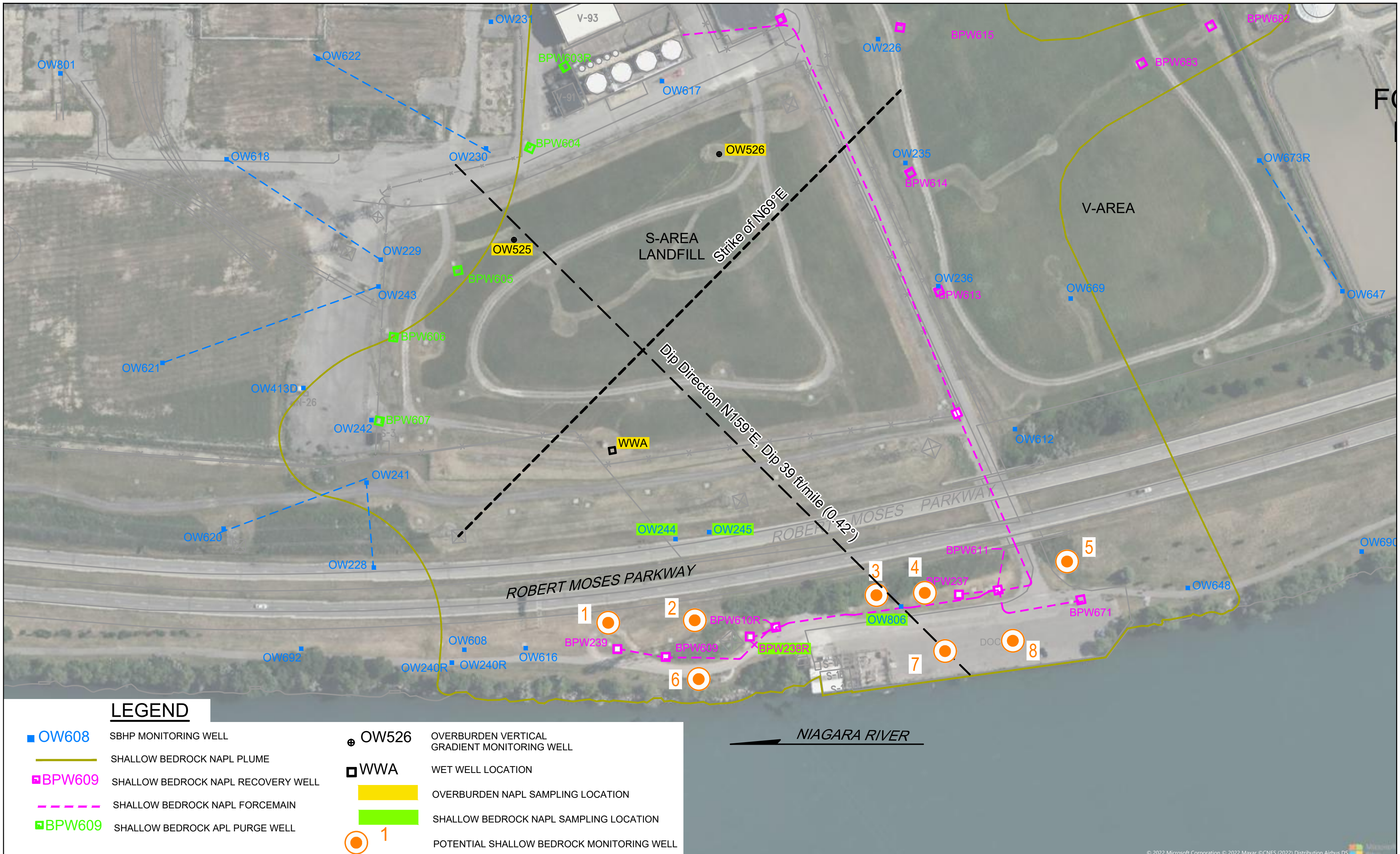

0 100 200 ft

1" = 200 ft

Coordinate System:
NAD 83 NEW YORK STATE PLANES, WEST ZONE,
US FOOT

N

GHD

GLENN SPRINGS HOLDINGS, INC.
S-AREA LANDFILL SITE
NIAGARA FALLS, NEW YORK

PROPOSED SHALLOW BEDROCK MONITORING WELLS

Project No. **11230149**
Date **July 2022**

FIGURE 4

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