Division of Environmental Remediation

# Hydrogeologic Evaluation Report

## Niagara Sanitation Landfill
## Wheatfield, Niagara County, New York
## Site Number 932054

December 2024

New York State Department of Environmental Conservation
Region 9
700 Delaware Avenue
Buffalo, New York 14209

# Special Report

## Hydrogeologic Evaluation of the Niagara Sanitation Landfill in the Town of Wheatfield, Niagara County, New York


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# 1.0 INTRODUCTION

The Niagara Sanitation Landfill is an inactive landfill located on Nash Road in the Town of Wheatfield, Niagara County, New York (Figure 1-1). During implementation of a State Superfund Remedial Investigation at the site in 2017, groundwater flow in the shallow fill/upper sand unit underlying the site was to the south toward Forbes Street. This flow pattern, however, was opposite to that identified in studies completed in 2013 & 2014. As a result, in 2022 the New York State Department of Environmental Conservation (NYSDEC) began a detailed evaluation of the geology, hydrogeology, and groundwater geochemistry of the Niagara Sanitation Landfill to evaluate groundwater in the various water-bearing zones underlying the site. A primary objective was to further evaluate groundwater flow patterns in the water-bearing zones underlying the site. A complete understanding of the groundwater flow patterns, especially in the fill/upper sand water-bearing zone, is critical for evaluating the potential for contaminants in groundwater to migrate from the site. The remaining sections of this report are organized as follows:

- **Section 2.0, Site History and Background:** This section describes the site and various site features, and discusses the history and previous investigations completed at the site;

- **Section 3.0, Surface Water Hydrology:** This section describes the surface water hydrology of the site, which includes precipitation, evapotranspiration, drainage, and infiltration characteristics.

- **Section 4.0, Geology:** This section describes regional and site geology. The characteristics and areal extent of the geologic strata are discussed;

- **Section 5.0, Hydrogeology:** This section describes regional and site hydrogeology. Groundwater flow patterns and the hydrogeologic properties of the various water-bearing zones are discussed;

- **Section 6.0, Groundwater Geochemistry:** This section describes the general geochemistry data from the various hydrogeologic zones underlying the site, and evaluates the results against a conceptual geochemical model for the Niagara Sanitation Landfill;

- **Section 7.0, Summary:** This section summarizes the findings of Sections 4.0 through 6.0;

and

- **Section 8.0, References:** This section contains a list of references utilized or cited in this report.

# 2.0 SITE HISTORY AND BACKGROUND

## *2.1 Site Description*

The Niagara Sanitation Company Site, also known as the Nash Road or Niagara Sanitation Landfill, is an inactive landfill located on Nash Road in the Town of Wheatfield, Niagara County, New York (Figure 1-1). The property is owned by the Town of Wheatfield and is adjacent to the municipal boundary that separates the Town of Wheatfield from the City of North Tonawanda (Figure 2-1). The landfill is located approximately 1,400 feet east of Nash Road (Figures 1-1 and 2-1). The majority of historic landfilling operations took place on the portion of the property that is rectangular in shape, which consists of approximately 18.7 acres of the 20.8-acre parcel (Figure 2-2). The property is zoned for Public Service use.

The site is bordered by the Society of Catholic Apostolate property to the north; a property that contains a former motel and livery service to the east; a utility right-of-way (both overhead electric and underground natural gas and brine lines) and residential properties to the south; and Nash Road and residential properties to the west (Figures 1-1 and 2-1).

## *2.2 Site Features*

The Niagara Sanitation property is vacant and overgrown with mature trees, dense brush, and marsh vegetation (e.g., phragmites). The site is poorly drained and contains delineated wetlands in the western, northern, and eastern portions of the property (Figure 2-2). These wetlands, however, are dry during the summer and early fall months. In December 2017, the Town of Wheatfield installed a 6-foot-tall perimeter fence with locking gates that encompasses most of the landfill. Prior to that time access to the site was not restricted.

Historic landfilling activities have resulted in an irregular ground surface topography at the site, with relief being less than 10 feet (Figure 2-3). Numerous soil/debris mounds predominate in the western two-thirds of the site but can be observed throughout the site, with general municipal (i.e., non-hazardous) waste protruding at most mounded locations. During a site reconnaissance completed for the 2013 NYSDEC Site Characterization Study and during the 2017 Remedial Investigation, evidence of residential/municipal waste, either partially buried or lying directly on the ground surface was observed in discrete areas across the site. Identifiable municipal wastes found at the surface typically include used/discarded clothing, shoes, children's toys, sports equipment, household appliances, containers for residential cleaning supplies, food containers, dishes, glassware, silverware, tires, and battery casings along with generally unidentifiable metal, glass, rubber, plastic debris, and in a few locations, whole vehicles. There is also evidence of industrial wastes at the site (e.g., empty steel drums and 4-inch diameter carbon core samples) mixed within the predominately residential/municipal waste.

## *2.3 Site History*

Available records indicate that the site was operated as a landfill by the Niagara Sanitation Company from approximately 1955 to 1968. The landfill accepted both municipal and industrial solid wastes, including caustic materials, plating tank sludge, fly ash, salt solids, graphite, carbon, scrap adhesives, and miscellaneous laboratory chemicals. Records from the NYSDEC indicate that Bell Aerospace, Carborundum, and Graphite Specialties disposed of waste at the site.

In June 1968, shortly before the site's formal disposal operations were discontinued, the New York State Department of Transportation (NYSDOT) discovered waste while constructing the LaSalle Expressway in Niagara Falls. This material was excavated from the area that later became known as Love Canal. Niagara Sanitation Landfill records indicate that approximately 1,600 cubic yards of excavated materials were placed into a 30-foot wide by 100-foot long by 27-foot-deep trench at the eastern end of the landfill. The waste was reportedly placed from the bottom of the trench to 15 feet below ground surface and covered with 12 feet of excavated native soil.

The NYSDEC completed a Phase I Investigation (historical records review and site walk over) of the site in 1983, a Phase II Investigation (on-site data collection) in 1985, and a Supplemental Phase II Investigation in 1989. In association with these investigations, the New York State Department of Health (NYSDOH) completed surface soil sampling in 1991 to evaluate potential exposure risks. At that time, it was determined that the site did not pose a significant threat to public health or the environment because the exposure was limited; the wastes were buried, contained, or sufficiently covered to avoid significant exposure. Groundwater as a potential exposure pathway was also limited because the area was served by public water and the closest private well was approximately one mile away. As a result, the site was designated as Class 3 (action can be deferred) in the NYSDEC Registry of Inactive Hazardous Waste Disposal Sites. These reports can be found online at https://www.dec.ny.gov/data/DecDocs/932054/.

NYSDEC continuously monitors and evaluates sites on the Registry of Inactive Hazardous Waste Disposal Sites. In 2013, as part of these efforts, the NYSDEC completed a Site Characterization Study to re-evaluate the Class 3 NYSDEC Registry designation for the site, to confirm the location of the wastes from the LaSalle Expressway project, and to re-evaluate the potential for direct contact exposures. The Site Characterization was heavily focused on the eastern portion of the site where the wastes associated with the construction of the LaSalle Expressway were placed (Figure 2-4). This report can be found online at https://www.dec.ny.gov/data/DecDocs/932054/.

Later in 2013, Glenn Spring Holdings, an affiliate of the Occidental Chemical Corporation, began an Interim Remedial Measure (IRM) to characterize and remove the LaSalle Expressway wastes. These wastes were excavated from the site during the Fall/Winter of 2014 and the Winter/Spring of 2015 and transported out of state for incineration. The IRM Closure Report can be found online at https://www.dec.ny.gov/data/DecDocs/932054/.

In 2014, the NYSDEC conducted a Supplemental Site Characterization Study to characterize the municipal and industrial waste in the remainder of the landfill. While most of the site contained contaminant concentrations typical of non-hazardous municipal/industrial waste, three locations were identified that contained hazardous concentrations of lead or PCBs. Several surface soil samples exceeded residential soil cleanup objectives (SCOs) for polycyclic aromatic hydrocarbons (PAHs) and metals. Groundwater within the footprint of the landfill contained elevated concentrations of volatile organic compounds, semi-volatile organic compounds, pesticides, and metals that exceeded the NYSDEC groundwater standards or guidance values. These results are described in more detail in the Supplemental Site Characterization Study Report (GES, 2014), which can be found online at https://www.dec.ny.gov/data/DecDocs/932054/.

Based upon the results of the Site Characterization and Supplemental Site Characterization Studies, the NYSDEC reclassified the site to Class 2 (represents a significant threat to public health and/or the environment) and completed a comprehensive, state funded Remedial Investigation of the site in 2017. A more detailed history of the Niagara Sanitation Landfill, along with the analytical results of the samples collected, are presented in the Remedial Investigation Report (LiRo, 2019). This report can be found online at https://www.dec.ny.gov/data/DecDocs/932054/.

Between October 22, 2019 and January 9, 2020, the NYSDEC completed additional groundwater and surface water sampling activities at the site to evaluate current groundwater and surface water conditions, and to supplement the results contained in the Remedial Investigation

Report (LiRo, 2019). The 2019/20 results are discussed in the Groundwater & Surface Water Monitoring Report (NYSDEC, 2022), which can be found online at https://www.dec.ny.gov/data/DecDocs/932054/.

In an ongoing effort by the NYSDEC to investigate the Niagara Sanitation Landfill, groundwater samples were collected from the site between October 29, 2021 and November 8, 2021. These sampling activities were completed to evaluate current groundwater conditions at the site, and to supplement the results contained in the Remedial Investigation Report (LiRo, 2019) and the 2019/20 Groundwater & Surface Water Monitoring Report (NYSDEC, 2022). The 2021 results are discussed in the 2021 Groundwater Monitoring Report (NYSDEC, 2023), which can be found online at https://www.dec.ny.gov/data/DecDocs/932054/.

In its continued effort to investigate the Niagara Sanitation Landfill, the NYSDEC completed additional groundwater and surface water sampling activities at the site between October 15 and 23, 2023. These sampling activities were completed to evaluate current groundwater and surface water conditions at the site, and to supplement the results contained in the Remedial Investigation Report (LiRo, 2019), the 2019/20 Groundwater & Surface Water Monitoring Report (NYSDEC, 2022), and the 2021 Groundwater Monitoring Report (NYSDEC, 2023). The report describing the 2023 sampling event is currently being drafted.

# 3.0 SURFACE WATER HYDROLOGY

Surface water runoff is a potential pathway for the migration of contaminants from the Niagara Sanitation Landfill. In addition, infiltration of surface water and precipitation recharges shallow groundwater, and in the process, can leach contaminants from the waste material through which it passes. Surface water hydrology, therefore, is an important aspect of this study. This section describes the surface water hydrology of the Niagara Sanitation Landfill, which includes precipitation, evapotranspiration, and site drainage characteristics.

## *3.1 Precipitation*

Infiltration, and hence groundwater recharge, depends upon the amount of precipitation falling on an area and the amount of water lost through evapotranspiration (discussed below) and runoff. Precipitation data for the Niagara Sanitation Landfill is not available so the precipitation measured at the National Weather Service Station at the Buffalo Niagara International Airport are used as a proxy for on-site precipitation amounts. The National Weather Service Station is located approximately 11 miles southeast of the Niagara Sanitation Landfill in the Town of Cheektowaga, New York.

The average annual precipitation between 1985 and 2015 as measured at the National Weather Service Station at the Buffalo Niagara International Airport is 40.62 inches (Table 3-1), which equates to an average monthly precipitation of 3.39 inches. This precipitation is fairly evenly distributed throughout the year (Table 3-1; Figure 3-1), although slightly larger amounts fall in September and October, and slightly lower amounts fall in February and March. Severe droughts are rare, but periods of low precipitation and relatively high temperatures are common, sometimes causing at least temporary concern over declining water levels and moisture stress in crops and other vegetation. Precipitation generally falls as rain from April through November, and as snow from December through March. The mean annual snowfall between 1985 and 2015 as measured at the National Weather Service Station is 94.61 inches, with ¾ of this total falling between December and February. The snowpack generally reaches its maximum depth in February, and decreases in March and early April (Dethier, 1966). During this snowmelt period, there is a significant increase in both surface water runoff and groundwater recharge via infiltration.

The average annual precipitation at the National Weather Service Station between 2016 and

2022 was 41.81 inches (Table 3-1), which is slightly above the long-term annual average. In contrast to these totals, the annual precipitation for 2017 and 2019 was 48.48 inches and 47.82 inches, respectively (Table 3-1). This represents a 19.4% increase over the long-term average for 2017 and a 17.7% increase for 2019.

The largest increases in 2017 occurred during April and May, which exhibited increases in precipitation of 3.18 inches and 2.92 inches, respectively, over the long-term averages for those months. March, July, October, and November were also substantially wetter than normal (i.e., >1.0 inch above the long-term average for those months), while June was substantially drier (1.43 inches below the long-term average for that month). Graphs showing daily precipitation between August 2 and October 27, 2017 are presented in Appendix E.

In contrast, the largest increases in 2019 occurred during January and September, which exhibited increases in precipitation of 2.57 inches and 2.34 inches, respectively, over the long-term averages for those months. October and December were also substantially wetter than normal (i.e., >1.0 inch above the long-term average for those months), while July and November were substantially drier (1.39 inches and 1.73 inches, respectively, below the long-term average for those months).

The annual precipitation for 2020 (39.67 inches) and 2021 (40.33 inches) were close to the long-term annual average (Table 3-1).

## *3.2 Evapotranspiration*

Evapotranspiration is defined as the sum of the water loss attributable to evaporation from soil and surface water bodies (e.g., lakes, rivers, wetlands) and to transpiration by plants (Staubitz and Miller, 1987). Since quantifying the contribution to water loss by each mechanism is generally not possible, potential evapotranspiration is generally used, which is defined as the maximum evapotranspiration that would occur if the quantity of water available in soil was unlimited (Freeze and Cherry, 1979). Under actual field conditions where soil moisture is limited, evapotranspiration will always be less than the potential evapotranspiration.

Specific estimates of potential evapotranspiration rates are generally not completed during environmental investigations. A literature search, however, found that annual evapotranspiration rates have been estimated for the Ashland 1 and 2 sites in nearby Tonawanda, New York. In addition, Staubitz and Miller (1987) report monthly potential evapotranspiration rates for the Clarence-Newstead area of northeastern Erie County (Table 3-1). The annual evapotranspiration rates for the Ashland 1 and 2 sites were estimated at 29.4 inches, 28.2 inches and 29.2 inches for the years 1987, 1988 and 1989, respectively (Bechtel, 1993). These rates are slightly higher than the 25.74-inch annual estimate for the Clarence-Newstead area (Staubitz and Miller, 1987). In the current study, the monthly potential evapotranspiration rates reported by Staubitz and Miller (1987) are used as a proxy for on-site potential evapotranspiration rates at the Niagara Sanitation Landfill.

The data in Table 3-1 shows that the potential evapotranspiration rates for June, July, and August are higher than the long-term precipitation for those months. This suggests that shallow groundwater underlying the Niagara Sanitation Landfill would decrease during those months. This relationship is described in more detail in Section 5.0 of this report.

## *3.3 Site Drainage Characteristics*

Before landfilling activities began, the property was believed to be a low-lying swampy area with natural on-site ponds. At the present time, most surface water bodies occur in small, enclosed depressions less than 3 feet deep. In contrast to the small ponds, a large, shallow pond is located at the northeast portion of the site (Figure 2-3). Most of these swampy areas and ponds contain marsh vegetation (e.g., phragmites).

The occurrence and location of surface water bodies on the Niagara Sanitation property is variable and seasonal. They are formed by either snow meltwater or rainfall, and generally disappear during the summer months due to lower amounts of precipitation and elevated rates of potential evapotranspiration. During 2021 and 2023, surface water bodies at the site were still dry in mid-October of those years. In the spring, however, approximately one-third of the site may be under water (Figure 2-2).

On-site overland flow in the eastern portion of the site is generally into the large, shallow pond at the northeast portion of the site (Figure 2-3). When surface water elevations in this pond are relatively high it will discharge to the north via a small swale into the Northern Boundary Ditch (Figure 2-3). At the northeast corner of the site, the Northern Boundary Ditch makes a "dogleg" turn and continues to the south (Figure 2-3). The Northern Boundary Ditch also extends to the west along the northern boundary of the site, shallows in the center of the site (the area where wetlands are not shown on Figure 2-3), then deepens slightly as it continues to the west.

During a significant rain event (i.e., >1.0 inches of precipitation within 24 hours) during the Remedial Investigation field activities, LiRo directly observed and recorded surface overland flow and channel flow in the eastern portion of the site, which terminated at the Northern Boundary Ditch (Figure 2-3). Surface water runoff from the neighboring property to the north was channeled southward into shallow drainage swales and small (i.e., <4”) buried drain lines that discharged directly into the Northern Boundary Ditch. Flow from a pond on the neighboring property to the east (Figure 1-1) was carried by a buried 8-inch diameter pipe directly into the Northern Boundary Ditch (Figure 2-3). Surface water runoff from the south followed a shallow off-site ditch east of the site property boundary. This ditch initially flowed to the east and then north to feed directly into the Northern Boundary Ditch.

The 1989 Supplemental Phase II Investigation Report suggested that the Northern Boundary Ditch drained into Sawyer Creek, which is less than one-quarter mile northeast of the site along Niagara Falls Boulevard. During the GES and LiRo site visits, however, no surface water outlets were observed for the Northern Boundary Ditch, and it is believed that all impounded water is lost by a combination of evapotranspiration during the hot, drier months and infiltration into subsurface soils throughout the year.

# 4.0 GEOLOGY

One objective of this study was to establish the characteristics, areal extent and hydrogeologic properties of strata underlying the Niagara Sanitation Landfill. This is important as these attributes govern the occurrence and flow of groundwater at the site. These attributes also govern the potential for contaminant migration and determine the rate and extent of this migration. As a result, a detailed evaluation of the geology of the Niagara Sanitation Landfill is essential. Before completing such a detailed evaluation, however, it is important to first describe the regional geologic history of the western New York area as a general knowledge of this history is critical to a complete understanding of the complex interrelationships between the various geologic strata and their hydrogeologic properties. This section, therefore, describes regional and site geology, along with the characteristics and areal extent of the strata underlying the Niagara Sanitation Landfill.

## *4.1 Regional Geology*

The Niagara Sanitation Landfill is located in the Erie-Ontario Lowland physiographic province of New York State, which can be characterized as the areas of low relief that border Lakes Erie and Ontario (Muller, 1965). The lowland region extends from the Onondaga escarpment located about eight miles south of the site to Lake Ontario.

### 4.1.1 Overburden Geology

Geologic evidence suggests that at least four major glacial episodes covered parts of North America during the Pleistocene Epoch (Buehler and Tesmer, 1963). In western New York, however, there is evidence of only two such episodes. The last glacial event in the area, the Wisconsin, eroded and modified the earlier glacial deposits to such an extent that little evidence of their existence remains. These glacial events widened the preexisting valleys and basins and led to the development of the present-day drainage system in western New York (La Sala, 1968).

During the final retreat of the Wisconsin ice sheet from the region, meltwater formed a complex sequence of proglacial lakes in front of the ice margin. These lakes inundated an extensive area of western New York. This succession originated in the Erie-Huron Basin prior to 14,000 years ago as the ice sheet retreated from the basin and ended approximately 9,800 years ago with the formation of Lake Tonawanda (Calkins and Brett, 1978). This lake sequence was responsible for the deposition of the stratified lacustrine clays, silts, sands, and gravels that now cover much of western

New York.

Lake Tonawanda was one of the largest of these lakes. It was an elongated lake that occupied an east-west trending basin between the Onondaga and Niagara escarpments and drained to the north into Lake Iroquois. Sediments deposited in this lake consist of blanket sands and beach ridges that are occasionally interlayered with lacustrine silts and clays. Parts of this sequence are "...very regularly bedded with cyclic alternation of clay and silt laminae; moderately permeable along bedding surfaces..." (Muller, 1977). The Niagara Sanitation Landfill is located on property that was inundated by this lake.

The Pleistocene Epoch presented a variety of environments that resulted in the deposition of unconsolidated deposits. In southwestern Niagara County these deposits include the following (GTC, 1983; Engineering Science, 1989; URS, 1991; Ecology and Environment, 1992):

- Glacial till consisting of a non-sorted, non-stratified mixture of sand, silt, clay, gravel, and rock fragments deposited directly from glacial ice;

- Glaciolacustrine deposits consisting primarily of silt, sand and clay deposited in lakes that formed during melting and retreat of the ice sheets;

- Glaciofluvial deposits consisting of sand and gravel deposited either by glacial meltwater streams or by the reworking of till and other glacial deposits along the shore of former glacial lakes; and

- Alluvial deposits consisting of silt, sand and gravel deposited by streams during comparatively recent geologic time.

La Sala (1968) reports that glacial till is the most widespread deposit in the Erie-Niagara Basin, ranging in thickness from 2 to 200 feet. Glaciolacustrine clay is also widespread, reaching thicknesses of 300 feet in some valleys within the basin (La Sala, 1968).

### 4.1.2 Bedrock Geology

The bedrock underlying western New York is characterized as a thick sequence of shales, sandstones, limestones and dolostones deposited in ancient seas during the Silurian and Devonian Periods (Buehler and Tesmer, 1963). This stratigraphic sequence is summarized in Table 4-1. Bedrock bedding generally strikes in an east-west direction, approximately paralleling the Niagara and Onondaga escarpments, and dips to the south at approximately 30 to 40 feet per mile (Johnson, 1964; La Sala, 1968; Yager and Kappel, 1987). Erosion and weathering, however, have produced local differences in the bedrock surface configuration (Snyder Engineering, 1987).

The uppermost bedrock unit underlying the Niagara Sanitation Landfill is unknown. The 1985 Phase II investigation (Engineering Science, 1985) identified bedrock as "dolostone" of the Lockport Group. A published geologic map of the western New York area, however, suggests that bedrock beneath the site is the Salina Group (Rickard and Fisher, 1970). In addition, an EPA report (EPA, 1985) stated that bedrock at the site is the Camillus Shale, a member of the Salina Group. None of the borings completed at the Niagara Sanitation Landfill have cored into bedrock for positive identification. As a result, both the Camillus Shale and Lockport Group are briefly discussed below.

The Camillus Shale Formation of the Salina Group was deposited in a shallow sea environment during the Late Silurian Period (Rickard and Fisher, 1970). This formation extends across northern Erie County/southern Niagara County in an east-west trending belt approximately 6 to 8 miles wide (Conestoga-Rovers & Associates, 1998). Exposures of this formation are rare because of the low relief of the outcrop area and the mantle of glacial deposits. Buehler and Tesmer (1963, page 30) describe the Camillus Shale as a "thin bedded shale to massive mudstone. Color is gray or brownish gray with some beds showing a red or green tinge. Gypsum and anhydrite are present throughout the formation in Erie County," and occur in beds and lenses up to 5 feet thick (La Sala, 1968). Subsurface data indicate, however, that a considerable quantity of gray limestone and dolostone is interbedded within the shale (Stanley Consultants, 1981; GZA, 1983; URS, 1992; Woodward-Clyde, 1993; Parsons Engineering Science, 1995). The upper 10 to 25 feet of this formation can be heavily weathered and often contains abundant bedding planes and vertical fractures enlarged by dissolution and glacial scour (La Sala, 1968). Buehler and Tesmer (1963) report that the maximum thickness of the Camillus Shale is 400 feet. Within the Erie-Niagara Basin, however, the thickness of this formation ranges from approximately 80 to 100 feet (Rickard, 1966).

The Lockport Group varies in thickness from 20 to 175 feet (Johnson, 1964; Brett et al., 1995), and is described by Brett et al (1995, page 45) as a “massive- to medium-bedded, argillaceous dolomite with minor amounts of dolomite and shale.” The uppermost bedrock formation of the Lockport Group is the Guelph Dolostone (Table 4-1), which was deposited in a shallow sea environment during the Middle Silurian Period (Brett et al., 1995). In Ontario, Canada the Guelph Dolostone is between 200 and 300 feet thick; however, only a thin wedge of the formation extends into Niagara County where it is only 33 to 36 feet thick (Brett et al., 1995). Brett et al (1995, page 59) describe the Guelph Dolostone as a "medium-gray to dark-gray, light-gray to tan weathering, laminated, fine-grained, commonly oolitic dolomite." The upper 10 to 25 feet of the Lockport Group contains abundant bedding planes and vertical fractures enlarged by dissolution and glacial scour (Miller and Kappel, 1987).

## *4.2 Site Geology*

The stratigraphy of the Niagara Sanitation Landfill has been evaluated by examining seventy-seven (77) stratigraphic logs obtained from soil borings completed at the site. The locations of the soil borings evaluated during this study are shown on Figure 4-1. The stratigraphic logs for these soil borings are given in Appendix A, while a stratigraphic summary of these logs is provided as Table 4-2.

These stratigraphic logs indicate that most investigation activities have been confined to the fill material and the upper glaciolacustrine deposits underlying the site. Several borings, however, have completely penetrated the native deposits, with 5 borings having encountered the underlying bedrock (Table 4-2).

An evaluation of the stratigraphic logs compiled for this study (Table 4-2) reveals that there are eight (8) distinct stratigraphic units underlying the Niagara Sanitation Landfill, which are summarized as follows:

- Fill: General refuse (e.g., glass, plastic, cloth, etc.) mixed with native fine sand and clay that ranges in thickness from 0.5 to >12.0 feet;
- Silt and Clay: An upper brown silt & clay deposit that ranges in thickness from 0.5 to 4.0 feet;
- Upper Sand: An upper yellow-brown sand deposit that ranges in thickness from 0.4 to 11.0 feet;
- Silty Clay: A gray-brown lacustrine silty clay deposit that ranges in thickness from 2.0 to 8.0 feet;
- Layered Clay: A red-gray layered lacustrine clay deposit containing thin sand seams. This

deposit ranges in thickness from 18.5 to 33.0 feet;

- Lower Sand: A lower red-brown sand deposit that ranges in thickness from 0.2 to 5.0 feet;
- Glacial Till: A dense reddish brown to gray till that ranges in thickness from 22.0 to 42.2 feet; and
- Bedrock: Dolostone bedrock encountered at depths ranging from 66.0 to 70.3 feet below ground surface.

The gray-brown silty clay deposit and underlying red-gray layered clay act as a groundwater aquitard that prevents the downward migration of groundwater and contaminants from the upper sand and fill water bearing unit to the lower water-bearing zones.

The stratigraphic relationship between these units can be seen on the various cross-sections prepared from the stratigraphic logs (Figures 4-4 through 4-9). The cross-sections shown in Figures 4-4 and 4-5 are from the 1985 Phase II Report, while the cross-sections shown in Figures 4-6 through 4-9 are from the 2019 Remedial Investigation Report. The locations of the Phase II cross-sections are shown on Figure 4-2, while the locations of the RI cross-sections are shown on Figure 4-3. These cross-sections are referenced in the following discussion where appropriate.

### 4.2.1 Surface Soils

The following discussion regarding surface soils at the Niagara Sanitation Landfill was included in the 1989 Supplemental Phase II Report completed by Engineering-Science for the NYSDEC. This discussion is based on soil borings completed at the site and information from the Niagara County Soil Survey (USDA, 1972). The soils mapped for the site include the Raynham silt loam and the Canandaigua silt loam. The Raynham soils are somewhat poorly drained, medium textured silt loam occurring on slopes ranging from 0% to 6%. These soils formed from calcareous silty sediments deposited by glacial Lake Tonawanda. The permeability of the Raynham silt loam is estimated at $1 \times 10^{-3}$ to $4 \times 10^{-4}$ cm/sec (USDA, 1972).

The Canandaigua silt loam is a very poorly drained, medium to moderately fine textured soil. These soils are level or depressional and occupy areas where water remains ponded or runs off very slowly. These soils formed in lacustrine deposits of silt, very fine sand, and clay. The permeability of Canandaigua silt loam is estimated at $4 \times 10^{-3}$ to $4 \times 10^{-4}$ cm/sec (USDA, 1972).

### 4.2.2 Fill Material

Fill material overlies the native deposits throughout most of the Niagara Sanitation Landfill but is discontinuous across the site (Table 4-2; Figures 4-4 through 4-9). Where fill material is absent, native deposits are generally encountered at ground surface (Table 4-2). The fill material encountered contains varying degrees of re-worked native soils (i.e., silt, clay, and sand) and municipal landfill waste, the latter consisting primarily of glass, plastic, wood, cloth/canvas, and metal. Rubber, ash, cinders, slag, tile, and bricks were also observed at some locations. Photos of typical fill material found at the site are provided in Appendix I. It is believed that these materials were typically disposed in natural low-lying areas or within shallow pits and trenches excavated into the native deposits for disposal purposes.

Grain size analyses were completed on 3 different types of reworked soil encountered at the site (Table 4-3). These soils are quite variable, ranging from 0.1% to 26.9% gravel, 20.8% to 66.9% sand, 25.3% to 66.8% silt, and 4.6% to 21.2% clay (Table 4-3).

Fill material was encountered in 44 borings completed at the site (Table 4-2). Where encountered, fill material was observed at the ground surface and extended to depths typically ranging from 2.0 to 6.0 feet below ground surface. Thicker fill (i.e., > 6.0 feet) was observed at borings completed in the disposal pit that was excavated for the Lasalle Expressway wastes (Table 4-2). Where completely penetrated, the thickness of the fill material ranges from 0.5 to 10.0 feet (Table 4-2). The average thickness of the fill material is 4.1 feet.

While shallow soil observed at boring SB-B was not initially classified as fill material by GES, based upon previous site investigations, observed solvent odors, the softness of the material relative to other shallow native silty clay, and a review of historical documents, the clay is believed to be re-worked native soil that was used to backfill the LaSalle Expressway disposal pit. This material was also observed at boring SB-M. These reworked soils are included with the fill material in Table 4-2.

Boring SB-AA was advanced from the top of a prominent mound west of the landfill and traversed by the gravel access road. The mound was estimated to be 8 to 10 feet high relative to the surrounding land surface. The samples collected from this boring consisted entirely of clay with no fill material observed. It is likely that this mound is man-made and may have been part of the landfill operations in the 1960s.

### 4.2.3 Glaciolacustrine Deposit

The native soils underlying the Niagara Sanitation Landfill include a glaciolacustrine deposit and glacial till. With increasing depth, the glaciolacustrine deposit consists of a brown silt and clay unit, an upper sand unit, a gray-brown silty clay unit, a red-gray layered clay unit, and a lower sand unit (Figures 4-4 through 4-9). These units were deposited in glacial lakes that covered the area during the Wisconsin Glacial Stage.

The full thickness of the glaciolacustrine deposit was only penetrated at 7 borings completed at the site (Table 4-2). The total thickness of this deposit was quite variable, ranging from 21.5 to 45.0 feet. It should be noted, however, that at 6 of the 7 locations the thickness of the glaciolacustrine deposit was 36.0 feet or greater.

#### *4.2.3.1 Brown Silt and Clay*

The 1985 Phase II Report states that "in the eastern part of the site, the upper sand is overlain by a layered silt" (Engineering Science, 1985). This deposit was only encountered in one boring completed during the Supplemental Phase II Investigation (Table 4-2) so was not included in the stratigraphic column generated for the site nor discussed in the report (Engineering Science, 1989). This deposit was also encountered during the GES and LiRo investigations (Table 4-2) but again was not discussed in their respective reports (GES, 2013; GES, 2014, LiRo, 2019).

When adding this unit to the site's stratigraphic discussion, it was necessary to determine if this unit was a reworked soil related to landfilling operations or native soils of the glaciolacustrine deposit. An evaluation of Table 4-2 reveals that the brown silt and clay deposit either underlies the fill material or is encountered at the ground surface. In addition, this deposit directly overlies the upper sand deposit where the upper sand is present. This suggests that the brown silt and clay deposit is native, and it has been included with the glaciolacustrine deposit. The occurrence of this fine-grained deposit may suggest a deepening of glacial Lake Tonawanda.

The brown silt and clay deposit is described as a light brown silt and clay, a light brown stiff silt, or a gray silt and clay with a trace of fine sand (Engineering Science, 1985). Engineering Science (1989) describes this deposit as a brown clay with some silt. In contrast, LiRo (2019) describes this deposit as a dark brown silt and sand and include it with the fill/topsoil layer on their geologic cross-sections (Figures 4-4 through 4-9).

A grain size analysis of the brown silt and clay deposit shows that it contains 18% sand, 59%

silt and 23% clay (Table 4-3). During testing, a suspension of the silt was extremely frothy and had a soapy odor.

The brown silt and clay deposit was encountered in 30 borings completed at the site (Table 4-2). Depth to this deposit ranged from 0.0 to 4.0 feet below ground surface, with its thickness ranging from 0.5 to 4.0 feet (Table 4-2). The average thickness of brown silt and clay deposit is 2.0 feet.

#### *4.2.3.2 Upper Sand Deposit*

The first encountered native deposit that is areally extensive across the Niagara Sanitation Landfill is the upper sand deposit (Figures 4-4 through 4-9). This deposit is described as a medium to coarse grained, well sorted, orange-brown sand (Engineering Science, 1989). GES (2013), however, described this sand as fine to coarse grained, gray to black in some borings, and tan to brown in others. LiRo (2019) described the sand as light brown-yellowish brown to light gray. This deposit likely originated as a late deposit of Lake Tonawanda. Photos of the upper sand deposit underlying the site are provided in Appendix I.

Grain size analyses of the upper sand deposit show that it contains 74.4% to 87.6% sand with the remaining percentage being silt and clay (Table 4-3).

The upper sand deposit was encountered in 61 borings completed at the site (Table 4-2). Depth to this deposit was quite variable, ranging from 0.0 to 10.0 feet below ground surface. Where completely penetrated, the thickness of the upper sand deposit was also quite variable, ranging from 0.4 to 11.0 feet (Table 4-2). The average thickness of this deposit is 4.4 feet.

The upper sand deposit is thickest in the southwest portion of the site and thins to the north and east (Figure 4-11). There also appears to be a thick "ridge" of sand that trends northwest-southeast in the northeastern portion of the site that is roughly centered on borings OW-14A, OW-14BR, and SB-J (Figure 4-11). A surface elevation contour map of the upper sand deposit (Figure 4-10) shows a series of ridges and circular to ovoid depressions. This topography may be related to the excavation of disposal pits and trenches during landfill operations.

#### *4.2.3.3 Gray-Brown Silty Clay Deposit*

Underlying the upper sand deposit is a stiff, gray-brown silty clay deposit (Figures 4-4 and 4-

5). Photos of this deposit underlying the site are provided in Appendix I. Very fine sand beds about one inch thick are present in this deposit. This silty clay deposit was often less saturated than the overlying upper sand deposit, suggesting that it is an aquitard as discussed in previous site investigations. This deposit may be the regularly bedded cyclic laminae of clay and silt described by Muller (1977) as being typical of the lacustrine sediments deposited in Lake Tonawanda. The lower portion of this lacustrine unit is slightly higher in clay content (86%), but in general, this deposit contains 93% to 100% silt and clay (Table 4-3).

The gray-brown silty clay deposit was encountered in 63 borings completed at the Niagara Sanitation Landfill (Table 4-2). Depth to this deposit was quite variable, ranging from 3.0 to 15.0 feet below ground surface. This deposit was only completely penetrated at 11 locations, with the thickness ranging from 2.0 to 8.0 feet (Table 4-2). The average thickness of the gray-brown silty clay deposit is 4.8 feet.

Figure 4-12 is a contour map showing the depth to the gray-brown silty clay deposit. This contour shows a deep (≈6 feet) north-south trending trough in the southwestern portion of the site that shallows to the west, north and east. A heart-shaped depression is located in the west-central portion of the site and is defined by borings OW-32, OW-33, SB-U, SB-V, SB-X, and SB-JJ. A circular depression centered roughly on the disposal pit is located in the eastern portion of the site, with depths becoming shallower to the north, south, and west.

### *4.2.3.4 Red-Gray Layered Clay Deposit*

Underlying the gray-brown silty clay deposit and blanketing the site is a layered "fat" clay deposit (Figures 4-4 and 4-5). This deposit is described as a red-gray layered clay containing thin sand seams that is moist and highly plastic.

Grain size analyses of the red-gray layered clay deposit show that it contains 13.7% to 24.0% silt and 76.0% to 86.0% clay (Table 4-3). This deposit is a classic example of the Lake Tonawanda deposits as mapped by Muller (1977).

The red-gray layered clay deposit was encountered in 11 borings completed at the site (Table 4-2). Depth to this deposit was quite variable, ranging from 8.0 to 16.0 feet below ground surface. Where completely penetrated (8 borings), the thickness of the red-gray layered clay deposit was extremely variable, ranging from 18.5 to 33.0 feet (Table 4-2). The average thickness of this deposit is 25.6 feet. Neither the depth to this deposit, nor its thickness, have been contoured.

#### *4.2.3.5 Lower Sand Deposit*

A relatively thin, red-brown sand deposit underlies the red-gray layered clay deposit and mantles the glacial till (Figures 4-4 through 4-9). Grain size analyses of this deposit show that it is predominantly a sand (30.4% to 65.0%) that also contains 0.0% to 18.3% gravel and 35.0% to 57.3% silt and clay (Table 4-3). Based on its lithology and stratigraphic position, this sand deposit is interpreted to be an early deposit of Lake Tonawanda.

The lower sand deposit was only encountered in 6 borings completed at the site (Table 4-2). Depth to this deposit was quite variable, ranging from 26.3 to 42.0 feet below ground surface. Where completely penetrated (5 borings), the thickness of this deposit was somewhat variable, ranging from 0.2 to 5.0 feet (Table 4-2). In 4 of these borings, however, the thickness of this deposit ranged from 3.0 to 5.0 feet (Table 4-2).

Figure 4-13 is a contour map showing the thickness of the lower sand deposit. This contour shows that this deposit is thickest in the north-central portion of the site and thins to the south and east. The lower sand deposit was absent in the easternmost (OW-1B) and westernmost (OW-6) borings that encountered the underlying glacial till deposit. These borings are shown on Figure 4-1. It should be noted, however, that it is possible that this deposit was missed due to the large sampling interval (i.e., 5 feet) utilized at depths greater than 20 feet below ground surface during the 1985 Phase II Investigation.

### 4.2.4 Glacial Till Deposit

A relatively thick, continuous layer of glacial till underlies the lower sand deposit and mantles the underlying bedrock (Figures 4-4 through 4-9). The term "till" is used for a variety of non-sorted, non-stratified glacial deposits; however, because a till is so variable, caution must be exercised when describing its character and hydrogeologic properties. The till underlying the Niagara Sanitation Landfill consists predominantly of a dense, brown silt with fine to coarse sand and fine gravel.

Grain size analyses of the glacial till deposit show that it contains 50.5% to 66.0% silt and clay, 10.0% to 15.3% gravel, and 19.0% to 34.7% sand (Table 4-3).

The glacial till deposit was only encountered in 7 borings completed at the site. Depth to till was quite variable, ranging from 26.5 to 45.0 feet below ground surface. Where completely penetrated (5 borings), the thickness of this deposit ranged from 22.0 to 42.2 feet (Table 4-2). The average thickness of the glacial till deposit is 29.0 feet.

Figure 4-14 is a contour map showing the depth to the glacial till deposit. This contour shows that the glacial till is shallowest in the southeast portion of the landfill and gradually deepens to the northwest to form a trough under the western portion of the landfill. The maximum relief of the till surface across the Niagara Sanitation Landfill is 18.5 feet (Figure 4-14).

### 4.2.5 Bedrock

As stated in Section 4.1.2, the uppermost bedrock unit underlying the Niagara Sanitation Landfill is unknown. Available information suggests that it could be dolostone of the Lockport Group or the Camillus Shale of the Salina Group. None of the borings completed at the Niagara Sanitation Landfill cored into bedrock for positive identification.

Bedrock was only encountered in 5 borings completed at the site (Table 4-2). The boring logs, however, do not describe this bedrock, only stating that it is dolostone (see boring logs in Appendix A). Depth to bedrock beneath the Niagara Sanitation Landfill was relatively consistent, ranging from 66.0 to 70.3 feet below ground surface (Table 4-2).

Figure 4-15 is a contour map showing the depth to bedrock. This contour shows that bedrock is deepest in the central portion of the landfill and shallows to the east and west. The maximum relief of the bedrock surface across the Niagara Sanitation Landfill is 4.3 feet (Figure 4-15).

Figure 4-16 is a contour map showing the surface elevation of the bedrock underlying the site. This contour shows a bedrock trough in the central portion of the site that shallows slightly to the east and more substantially to the west.

# 5.0 HYDROGEOLOGY

In Section 4.0 the geology of the Niagara Sanitation Landfill was described in detail. In this section the hydrogeologic properties of these strata are evaluated. As part of this evaluation, a series of hydrographs and groundwater contour maps were produced and are examined. Before completing such a detailed evaluation, however, it is important to first describe the regional hydrogeologic setting of southwestern Niagara County.

## *5.1 Regional Hydrogeology*

Many site investigations and hydrogeologic studies have been completed in southwestern Niagara County. These studies indicate that there are four principal hydrogeologic zones in the area described as follows:

- Shallow alluvium, glaciofluvial, and glaciolacustrine sand deposits, which can be characterized as either unconfined (water table) or perched aquifers;
- The glaciolacustrine silty clay deposit, which can be characterized as an aquitard, confining groundwater from the underlying Lockport Dolostone or Camillus Shale;
- The glacial till deposit, which can also be characterized as an aquitard; and
- The Lockport Dolostone or Camillus Shale bedrock, which can be characterized as confined aquifers.

Of these zones, the principal aquifers include the sands of the recent alluvium, glaciofluvial, and glaciolacustrine deposits, and the upper bedrock of the Lockport Dolostone or Camillus Shale. In southwestern Niagara County, unconfined groundwater is encountered largely within the alluvium, glaciofluvial, and glaciolacustrine sand deposits. Where these deposits overlie glaciolacustrine silty clay, perched groundwater conditions occur. Well yields from these deposits in southwestern Niagara County are generally unknown, although wells installed in highly permeable outwash deposits in the Tonawanda Creek valley have yields ranging from 1,000 to 1,400 gallons per minute (gpm) (La Sala, 1968).

The glaciolacustrine silty clay and glacial till deposits separate the unconfined and/or perched aquifers from the confined upper bedrock aquifer. The hydraulic conductivities of these deposits are generally low, typically ranging from $10^{-6}$ to $10^{-8}$ cm/sec. The glaciolacustrine silty clay and glacial till deposits, therefore, can be considered aquitards, preventing the vertical movement of shallow groundwater to the underlying Lockport Dolostone or Camillus Shale. Some vertical movement, however, can occur through desiccation cracks in the upper glaciolacustrine silty clay, although such cracks have not been documented at the Niagara Sanitation Landfill. Horizontal groundwater flow within this deposit is severely limited. In fact, the glaciolacustrine deposit is generally not water bearing, yielding only small quantities of water, which is primarily interstitial pore water that is tightly bound to the soil particles. This deposit, however, frequently contains horizontal laminations and sand seams. These internal features facilitate localized horizontal groundwater flow through otherwise low permeability materials.

La Sala (1968) reports that the Camillus Shale is "by far the most productive bedrock aquifer" in the Erie-Niagara Basin, with individual well yields ranging from 300 to 1,200 gpm. The production well at the Dunlop Tire Corporation in the Town of Tonawanda yields 600 to 900 gpm (Pyanowski, 1990), although yields of 1,800 gpm were observed during a 1995 Hydrogeologic Evaluation Study (May, 2007).

Groundwater within the Camillus Shale occurs primarily in the following types of openings: (1) weathered surface fractures, (2) horizontal beds widened by dissolution, (3) vertical joints, and (4) small cavities and vugs. The availability of groundwater within the Camillus Shale results largely from the dissolution of thin (up to 5 feet in thickness; La Sala, 1968) gypsum seams and layers interbedded throughout the formation. Since the solubility of gypsum is high compared to the shales, limestones and dolostones that constitute the Camillus Shale, circulating groundwater will more readily dissolve the gypsum, producing migration pathways that can transmit large quantities of groundwater. The most prolific water-bearing zones, therefore, are generally horizontal because gypsum typically occurs in horizontal beds and thin zones of gypsiferous shale and dolostone (La Sala, 1968). These water bearing zones have been encountered at varying depths and stratigraphic horizons within the Camillus Shale, with individual dissolution zones ranging up to several miles in lateral extent (La Sala, 1968). The larger solution openings most likely occur in discharge areas near Tonawanda Creek and the Niagara River, where groundwater flow is greatest. Some horizontal groundwater flow, however, may also occur through small cavities and vugs.

Vertical movement of groundwater also occurs within the Camillus Shale, especially in the upper several feet of bedrock where vertical fractures, created by stress relief from tectonic events and glacial rebound (Gross and Engelder, 1991), have been enlarged by glacial scour, dissolution, and other weathering processes. In general, however, vertical movement of groundwater within the Camillus Shale is limited. La Sala (1968) reports that this weathered and fractured zone is in hydraulic communication with the overlying glacial till throughout the area. Collectively, these zones can yield small quantities of water to wells but are generally not used for domestic or industrial purposes.

Although the hydraulic conductivity of the Camillus Shale is typically very low, the dissolution of gypsum produces zones of high transmissivity within the formation. Reported transmissivity values for the Camillus Shale based upon specific-capacity tests range from 7,000 to 70,000 gallons per day per feet (gpd/ft) (La Sala, 1968). Because of these yields, groundwater from the Camillus Shale is commonly utilized for industrial purposes (i.e., non-contact cooling). This water, however, is not utilized as a source of drinking water because of naturally occurring high mineral content and the close proximity of the Niagara River, an important and easily accessed source of municipal drinking water throughout the Western New York area.

Groundwater within the Lockport Dolostone occurs primarily in the following types of openings: (1) weathered surface fractures, (2) bedding joints, (3) vertical joints, and (4) small cavities and vugs. Although the Lockport Dolostone consists predominantly of dolostone, thin beds of limestone and shaly dolostone, and small irregularly shaped masses of gypsum are common. These thin beds and masses are subject to dissolution by groundwater, resulting in the enlargement of fractures and the formation of migration pathways that transmit large quantities of groundwater. The principal control on groundwater flow, however, is the vertical and horizontal bedding plane fractures. The latter are the primary groundwater flow pathways in the Lockport Dolostone and are areally extensive over several miles (Johnson, 1964; Yager and Kappel, 1987). Johnson (1964) identified seven such zones in the Niagara Falls area. Some horizontal groundwater flow, however, also occurs through small cavities and vugs (Woodward-Clyde and Conestoga-Rovers & Associates, 1992).

Vertical movement of groundwater also occurs, especially in the upper 10 to 25 feet of rock where vertical fractures, created by stress relief from tectonic events and glacial rebound (Gross and Engelder, 1991) have been enlarged by dissolution and/or glacial scour. Vertical movement of groundwater within the Lockport Group is quite prevalent, with both upward and downward gradients observed (Woodward-Clyde and Conestoga-Rovers & Associates, 1992). Where horizontal and vertical fractures intersect, the water bearing capacity of the bedrock is substantially increased. Such areas have been identified in the Niagara Falls area.

Groundwater wells completed in the Lockport Group have yields commonly ranging from 10 to 100 gpm (Miller and Kappel, 1987), with yields up to 950 gpm reported (Yager and Kappel, 1987). Reported transmissivity values range from 330 to 68,000 gpd/ft (Johnson, 1964). Groundwater in the Lockport Group is very hard and highly mineralized (Johnson, 1964; La Sala, 1968; NYSDEC, 1997). As a result, this groundwater is not extensively utilized as a source of drinking water. Because of significant well yields, however, Lockport Dolostone groundwater is commonly utilized for industrial purposes (i.e., non-contact cooling; quarry washing operations).

Most recharge to the Lockport Dolostone and Camillus Shale results from infiltration of rainfall, snowmelt, and surface water through the overburden deposits (Johnson, 1964; La Sala, 1968). The low permeability of the glacial deposits within southwestern Niagara County, however, only permit limited recharge to the upper bedrock aquifer. Subsurface flow of groundwater from areas of higher elevation (e.g., the Niagara Escarpment) also recharges the upper bedrock aquifer (Johnson, 1964; La Sala, 1968). Recharge of deeper unconsolidated deposits and the upper bedrock aquifer may also result from infiltration of Niagara River and Tonawanda Creek water through the recent alluvium and glaciofluvial deposits. In general, however, these water bodies are typically discharge zones, so recharge in these areas would be restricted to the small stagnant zone underlying these water bodies.

### 5.1.1 Regional Groundwater Flow

Information regarding regional groundwater flow in the upper bedrock near the Niagara Sanitation Landfill is not available. Investigations completed at sites west of the landfill, however, indicate that upper bedrock groundwater flow is toward the Niagara River, the principal discharge zone in southwestern Niagara County (GTC, 1983; Golder Associates, 1991).

## *5.2 Site Hydrogeology*

As discussed in Section 4.2, eight distinct stratigraphic units underlie the Niagara Sanitation Landfill. The hydrogeologic data compiled and generated during this study, however, indicate that five hydrogeologic zones underlie the site. These hydrogeologic zones are summarized as follows:

- Fill/Upper Sand Water-Bearing Zone: The fill/upper sand water-bearing zone includes the following stratigraphic units, which act as a single water-bearing unit across the site:

  - Fill: General refuse (glass, plastic, cloth, etc.) mixed with native fine sand and clay that ranges in thickness from 0.5 to >12 feet;

  - Upper Sand: The upper yellow-brown sand deposit that ranges in thickness from 0.4 to 11.0 feet;

- Upper Clay Aquitard: The upper clay aquitard includes the following stratigraphic units:

  - Silty Clay: The gray-brown lacustrine silty clay that ranges in thickness from 2.0 to 8.0 feet;

  - Layered Clay: The red-gray layered lacustrine clay that ranges in thickness from 18.5 to 33.0 feet;

- Lower Sand Water-Bearing Zone: The lower red-brown sand deposit that ranges in thickness from 0.2 to 5.0 feet;

- Glacial Till Aquitard: The dense reddish brown to gray till that ranges in thickness from 22.0 to 42.2 feet; and

- Upper Bedrock Water-Bearing Zone: Dolostone bedrock encountered at depths ranging from 66.0 to 70.3 feet below ground surface.

The gray-brown silty clay and underlying red-gray layered clay units of the glaciolacustrine deposit are characterized as an aquitard, restricting the downward movement of groundwater from the shallow to the deeper hydrogeologic zones. In addition, the designation of the glacial till aquitard as a separate hydrogeologic unit is highly generalized as the lower portion of this deposit is hydraulically connected to the upper bedrock hydrogeologic zone (La Sala, 1968).

There are forty (40) existing monitoring wells and two (2) staff gauges installed at the Niagara Sanitation Landfill that have been utilized to monitor groundwater and surface water elevations (Figure 5-1). The surface completions and well casings at two historic monitoring wells (OW-13 and OW-14B) were found to be heaved/damaged due to frost action and were no longer considered accurate for groundwater and hydrogeologic data collection. During the 2017 Remedial Investigation field activities, monitoring well OW-13 was replaced by well LPZ-08S and monitoring well OW-14B was replaced by well OW- 14BR.

A monitoring well construction summary table for the existing wells at the Niagara Sanitation Landfill is given in Table 5-1, while the well construction diagrams are given in Appendix B. Historic and recent groundwater and surface water elevation data are summarized in Table 5-2.

### 5.2.1 Fill/Upper Sand Water-Bearing Zone

Thirty-two (32) monitoring wells installed at the Niagara Sanitation Landfill screen either fill material or the upper sand deposit underlying the site (Figure 5-1; Table 5-1). These wells include 14 previously installed wells (OW-01, OW-13, OW-14B, OW-16, OW-21, OW-22, OW-23, and OW-31 through OW-37), 14 wells installed during the 2017 Remedial Investigation (LPZ-01S through LPZ-13S and OW-14BR), and 4 hand-drilled wells installed during the 2017 Remedial Investigation (LDP-01 through LDP-04). Hand-drilled wells LDP-01 through LDP-03 are located within the south gas-line and brine-line right-of-way, while LDP-04 is located at the northwest corner of the landfill (Figure 5-1). Well LDP-02 was subsequently destroyed and not replaced.

Water level measurements in pre-RI wells have been collected on numerous occasions: four times during the Supplemental Phase II Investigation, once during the Site Characterization Study, and once during the Supplemental Site Characterization Study (Table 5-2A). During the Remedial Investigation, water levels in the fill/upper sand wells were measured on thirteen occasions (Tables 5-2B through 5-2J). Water level measurements were also completed in 2019 (Table 5-2K), 2020 (Table 5-2L), and 2021 (Table 5-2M). The water level measurements taken during the Supplemental Phase II Investigation suggested that water levels in the upper sand deposit were highest in the vicinity of the ponds over the reported disposal pit in the northeastern portion of the site. There was insufficient data, however, to construct a groundwater contour map or to determine the relationship between shallow groundwater and the ponds.

The water level data compiled during this study were utilized to construct hydrographs for the fill/upper sand wells (Figures 5-2 through 5-4). These hydrographs reveal that water levels fluctuated between August and November 2017, the period in which the water level measurements were taken. Water levels steadily decreased between August 22nd and September 25th, a period that was characterized by lower-than-normal rainfall (Figure 3-1; Table 3-1). In contrast, October and November 2017 were characterized by higher-than-normal rainfall (Figure 3-1; Table 3-1), and as a result, water levels increased substantially in all fill/upper sand wells (Figures 5-2 through 5-4) at the Niagara Sanitation Landfill. The response in all fill/upper sand wells was similar, the difference being that water levels in some wells decreased more than in others, with these same wells generally showing a greater increase in water levels during October and November 2017 (Figures 5-2 through 5-4).

To further evaluate the relationship between the fill/upper sand wells and precipitation, Figure 5-5 is a hydrograph of the two staff gauges installed at the site along with the upper sand wells closest to those gauges. This hydrograph shows a strong correlation between surface water elevations at the Niagara Sanitation Landfill with those in the upper sand deposit.

The water level data compiled during this study were also utilized to construct a series of groundwater contour maps for the fill/upper sand wells (Figures 5-6 through 5-22). At the time of the 2013 GES Site Characterization Study, groundwater flow in the fill/upper sand water-bearing zone (hereinafter called the shallow zone) was to the north and northwest (Figure 5-6). It was suspected that groundwater flow was influenced by surface water hydrology, including the large pond in the northeastern portion of the site, as groundwater flow mimicked the surface drainage pattern. During the Remedial Investigation, these wells were resurveyed. The groundwater contour map generated from the recalculated water level elevations of 2013 is illustrated in Figure 5-7. This figure indicates that groundwater is mounded at well OW-13 and flows from this mound to the northeast, north, and northwest. This example shows that at sites with very shallow gradients (note that the contour interval is 0.10 feet for Figure 5-6 and 0.20 feet for Figure 5-7), survey and water level measurement errors can drastically impact groundwater flow patterns.

It was stated in the Supplemental Site Characterization Study (GES, 2014) that groundwater flow in the shallow zone was generally to the north. It is important to note, however, that due to seasonal overgrowth the top of riser (TOR) elevations could not be surveyed at wells OW-33 through OW-36. As a result, LiRo generated a groundwater contour map using the 2014 water level measurements and the 2017 survey elevations. This contour is provided as Figure 5-8 and shows that groundwater flows radially at a very shallow gradient into a depression centered on well OW-33.

Four groundwater contour maps were generated using water level data from August 2017. The RI wells were being installed during this time, so these contours use between 8 and 25 water level measurements each. Groundwater contour maps generated from these water level data are provided as Figures 5-9 through 5-12. These figures show that groundwater in the fill/upper sand water-bearing zone generally flows to the south at gradients ranging from 0.003 to 0.005 foot per foot (ft/ft). Note that the contour interval for these figures is only 0.25 feet.

Figure 5-13 is a groundwater contour map generated from the water level data collected on September 12, 2017. This contour shows that groundwater is mounded in the north-east portion of the landfill and flows outward from this mound toward the south and east. By September 25, 2017, the groundwater mound was more defined with a smaller mound now present at the northwest corner of the landfill (Figure 5-14).

During the Remedial Investigation, groundwater elevations in the shallow zone were observed to fluctuate in direct response to significant (i.e., >1.0-inch within 24-hours) precipitation events. The September 25, 2017 elevation measurements were recorded at the end of an approximate 2-week long dry period with little to no precipitation (see charts in Appendix E). In fact, the hydrographs of Figures 5-2 through 5-4 show that the lowest groundwater elevations documented for 2017 were recorded on that date.

Subsequent water level measurements were collected on October 17, 2017 following a significant precipitation event (see charts in Appendix E). Figure 5-15 is a groundwater contour map generated from that data, which shows that the groundwater flow direction was generally inward toward the central portion of the landfill. As a result, groundwater flow in the southern portion of the landfill reversed and was now to the north. Groundwater flow to the east, however, was still observed at the eastern portion of the site.

Figure 5-16 is a map showing the difference in elevation between September 25, 2017, and October 17, 2017. The greatest elevation changes were generally observed along the southern and northern boundaries of the site. All fill/upper sand monitoring wells reported a positive net change in groundwater elevation (Figures 5-2 through 5-4), which ranged between 0.24 feet (LPZ-09S) and 3.05 feet (LDP-02). The duration of this inward flow condition is unknown but can still be observed in the west half of the landfill on the October 20, 2017 (Figure 5-17) and October 27, 2017 (Figure 5-18) contours. In the eastern portion of the landfill groundwater flow was generally to the east on October 20, 2017 (Figure 5-17) and October 27, 2017 (Figure 5-18) with a northeast flow component observed on October 20, 2017 (Figure 5-17). A small groundwater depression is observed around well LPZ-07S for both dates (Figures 5-17 and 5-18).

Figure 5-19 is a groundwater contour map generated from the water level data collected on

November 7, 2017 when groundwater elevations were high (compare to Figures 5-2 through 5-4). This contour shows that groundwater from the southern portion of the landfill was flowing to the north toward two groundwater sinks. The largest sink, located in the western portion of the landfill, is centered on wells OW-16, OW-32, OW-35, OW-37, LPZ-04S, and LPZ-09S. The smaller sink is located in the eastern portion of the landfill.

Water levels measurements were also collected on November 21, 2019, April 3, 2020, and November 23, 2021. Groundwater contour maps generated from these data are provided as Figures 5-20 through 5-22, respectively. Figure 5-20 is very similar to Figure 5-15 and shows that groundwater flow was inward toward a well-defined groundwater sink in the central portion of the landfill and centered on wells OW-32, OW-33, LPZ-09S, and LPZ-13S. Smaller sinks were observed in the western (e.g., well OW-16) and eastern (e.g., wells OW-21 and OW-22) portions of the landfill. As a result, groundwater flow in the southern portion of the landfill was to the north toward these sinks.

Figure 5-21 is a groundwater contour map generated from the water level data collected on April 3, 2020. This contour shows that groundwater flow was to the north with a northwest flow component at the eastern portion of the landfill.

Figure 5-22 is a groundwater contour map generated from the water level data collected on November 23, 2021. This contour is similar to Figure 5-21 and shows that groundwater flow was to the north with a northwest flow component at the eastern portion of the landfill.

An in-situ permeability test (slug test) was conducted on well OW-1 during the Phase II Investigation (Engineering Science, 1985). The hydraulic conductivity of this well was determined to be $4.37 \times 10^{-4}$ cm/sec (Table 5-3), which is consistent with the rapid water level fluctuations observed in this well (Figure 5-2). Hydraulic conductivity tests have not been conducted on any other well that screens the fill/upper sand water-bearing zone.

### 5.2.2 Upper Clay Aquitard

Only one (1) monitoring well (OW-2) installed at the Niagara Sanitation Landfill screens the upper clay aquitard underlying the site (Figure 5-1; Table 5-1). This well is shallow and screens the gray-brown silty clay deposit and upper 2 feet of the underlying red-gray layered clay (Figure 4-4). Historically, water level measurements from this well have been collected on numerous occasions: once during the Supplemental Phase II Investigation, once during the Site Characterization Study, and eleven times during the Remedial Investigation (Tables 5-2A through 5-2J).

The water level data compiled for this well were utilized to construct a hydrograph for the upper clay aquitard (Figure 5-23). This hydrograph reveals that water levels fluctuated between August and November 2017 in a pattern similar to that documented for the fill/upper sand wells (compare with Figures 5-2 through 5-4), with water levels ranging from 573.74 to 575.44 feet above mean sea level (Figure 5-22; Tables 5-2B through 5-2J).

To further evaluate the relationship between the upper clay aquitard well and the fill/upper sand wells, Figure 5-24 is the same hydrograph as Figure 5-5 (see Section 5.2.1 for details) with the hydrograph for well OW-2 added to it. This hydrograph shows that the response of well OW-2 is nearly identical to the response in the two upper sand wells and the staff gauges, indicating that well OW-2 is hydraulically connected to the upper sand deposit. It is important to note that the top of the filter pack for this well was at the upper sand/gray-brown silty clay interface, which supports the idea of a hydraulic connection.

Due to the presence of only one well in the upper clay aquitard, a groundwater contour map could not be generated.

An in-situ permeability test (slug test) was conducted on well OW-2 during the Phase II Investigation (Engineering Science, 1985). The hydraulic conductivity of this well was determined to be $6.75 \times 10^{-4}$ cm/sec (Table 5-3). This value, however, is two to four orders of magnitude higher than typical hydraulic conductivities of the glaciolacustrine deposit, which usually range from $10^{-6}$ to $10^{-8}$ cm/sec (see Section 5-1). It is likely that the slug test was influenced by groundwater inflow from the upper sand deposit, so this hydraulic conductivity would not be representative of the upper clay aquitard underlying the Niagara Sanitation Landfill.

### 5.2.3 Lower Sand Water-Bearing Zone

Only two (2) monitoring wells (OW-14A and OW-15) installed at the Niagara Sanitation Landfill screen the lower sand deposit underlying the site (Figure 5-1; Table 5-1). Historically, water level measurements from these wells have been collected on numerous occasions: four times during the Supplemental Phase II Investigation and ten times during the Remedial Investigation (Table 5-2).

The water level data compiled during this study were utilized to construct hydrographs for the lower sand wells (Figure 5-25). The hydrograph for well OW-15 reveals that there was very little seasonal fluctuation in this well, with water levels ranging from 567.58 to 568.11 feet above mean sea level (Figure 5-25; Table 5-2). The hydrograph for well OW-14A, however, is completely different, having lower water levels and greater fluctuations prior to October 17, 2017. The lower groundwater elevations in early August 2017 (August 2nd and 8th) likely result from the screened interval (3 feet) having completely silted up since this well was last sampled in 1988. Re-development, which took place on 6 separate days between August 16 and September 12, 2017, likely accounts for the lower groundwater elevations between August 22 and September 25, 2017, the day the well was sampled (i.e., water levels in the well didn't fully recover between re-development events). Following well re-development, the response in well OW-14A mirrors that of well OW-15 (Figure 5-25).

Due to the presence of only two wells in the lower sand deposit, a groundwater contour map could not be generated, and the direction of groundwater flow through this deposit is unknown.

In-situ permeability tests (slug tests) have not been conducted on either well that screens the lower sand deposit.

### 5.2.4 Glacial Till Aquitard

Five (5) monitoring wells installed at the Niagara Sanitation Landfill screen the glacial till deposit underlying the site (Figure 5-1; Table 5-1). Four of these wells screen the bottom of the glacial till deposit, while the remaining well screens the approximate midpoint of this deposit (Figures 4-4 and 4-5). Historically, water level measurements from these wells have been collected on numerous occasions: twice during the Supplemental Phase II Investigation and thirteen times during the Remedial Investigation (Table 5-2).

The water level data compiled during this study were utilized to construct hydrographs for the glacial till wells (Figure 5-26). These hydrographs reveal that there was very little seasonal fluctuation in the wells, with water levels ranging from 564.95 to 565.75 feet above mean sea level (Figure 5-26; Table 5-2). The lower groundwater elevations observed for well OW-1B in August 2017 are likely related to well re-development.

Figure 5-27 is a groundwater contour map for the glacial till deposit generated from the water level data collected during the Phase II Investigation (date not specified in the report). This contour shows that groundwater is mounded in the north-central portion of the landfill and flows outward from this mound toward the east, south, and west. This mound may be attributable to the overlying lower sand deposit that acts as a source of recharge to the glacial till deposit.

Figure 5-28 is a groundwater contour map for the glacial till deposit generated from the water level data collected on October 20, 2017. This contour shows that groundwater in the glacial till flows across the site from east to west at a very shallow gradient. Note that the contour interval is only 0.05 feet.

In-situ permeability tests (slug tests) were conducted on all five glacial till wells during the Phase II Investigation (Engineering Science, 1985). The results of these tests are summarized in Table 5-3, and indicate that the hydraulic conductivity of the glacial till deposit is extremely variable, ranging from $7.50 \times 10^{-4}$ to $7.88 \times 10^{-7}$ cm/sec. Because of this extreme variability, the hydraulic conductivities for the glacial till deposit were separated into two groups (e.g., wells OW-1B, OW-03, and OW-04, and wells OW-05 and OW-06) based upon similar conductivities (Table 5-3). The arithmetic and geometric means for these groups are $1.02 \times 10^{-6}$ and $9.83 \times 10^{-7}$ cm/sec, and $7.15 \times 10^{-4}$ and $7.14 \times 10^{-4}$ cm/sec, respectively.

These results suggest that the tests for monitoring wells OW-05 and OW-06 may have been influenced by the degree of fracturing in the upper bedrock. Independent evidence of this comes from recharge and field parameter observations recorded during monitoring well re-development (Appendix C) during the 2017 Remedial Investigation, which suggest that monitoring wells OW-05 and OW-06 are hydraulically connected to the upper bedrock water-bearing zone. The well purging and sampling logs from the 2017 Remedial Investigation are included as Appendix D as they were not included in the 2019 Remedial Investigation Report.

The OW-05 well development logs from August 10, 2017 reported the extraction of 47 gallons of groundwater over a period of 62 minutes at an approximate rate of 0.75 gallons per minute (gpm). During re-development, the maximum drawdown in groundwater elevation was 9.46 feet, out of an available 56.48 feet of water column prior to pumping. The 47-gallons removed was greater than 4.5 times the calculated well volume. Additionally, the water was noted to have a sulfur odor, which is a typical characteristic of groundwater pumped from local bedrock due to the presence and dissolution of sulfur containing minerals (e.g., gypsum [calcium sulfate: $CaSO_4$], pyrite [iron sulfide: FeS], and sphalerite [iron/zinc sulfide: Fe/ZnS]) in the bedrock.

Similarly, monitoring well OW-06 produced 50 gallons of water (i.e., 5.70 times the initial well volume) over 93 minutes at an approximate rate of 0.53 gpm with minimal drawdown noted.

Well development observations indicate that monitoring wells OW-1B, OW-03, and OW-04 are not hydraulically connected to the upper bedrock water-bearing zone. These wells went dry repeatedly during re-development, typically after the removal of only one well volume. At each of these locations, it was necessary to conduct re-development over several days due to poor recharge and to achieve acceptable field parameter results. The turbidity at OW-04, however, did not sustain readings below 800 Nephelometric Turbidity Units (NTUs) even after the removal of 67.5 gallons of water over six separate days of purging. The slow recharge of these wells is consistent with the lower hydraulic conductivities determined for them (Table 5-3).

### 5.2.5 Upper Bedrock Water-Bearing Zone

Upper bedrock monitoring wells have not been installed at the Niagara Sanitation Landfill, so the upper bedrock water-bearing zone was not evaluated.

# 6.0 GROUNDWATER GEOCHEMISTRY

## *6.1 General*

In Section 5.0 the hydrogeology of the Niagara Sanitation Landfill was described in detail. In this section the general geochemistry data from the various hydrogeologic zones are evaluated. Geochemical evaluation methods are based upon the principle that dissolved constituents in groundwater occur in predictable proportions, which are based upon the minerals present in the aquifer. In addition, the way in which dissolved constituents behave is known and predictable. As a result, if the minerals present are known, it is possible to predict the water quality resulting from the dissolution of these minerals. Geochemical evaluation methods, therefore, can be utilized to fingerprint different water types by the proportions of dissolved constituents present in the water.

## *6.2 Water Quality Database*

During the 2017 Remedial Investigation thirty-eight (38) samples were collected for geochemical analyses from the four overburden hydrogeologic zones identified at the site along with one (1) surface water sample from the northern drainage ditch. These data are summarized in Appendix H. All samples were analyzed by TestAmerica, Inc. in Amherst, New York for calcium, magnesium, sodium, potassium, sulfate, chloride, and alkalinity. In addition, historic water quality data for wells that screen the Camillus Shale in Tonawanda, Erie County, New York (Table H-7), and the upper Lockport Dolostone in Niagara Falls, Niagara County, New York (Table H-8) were also compiled.

Prior to conducting geochemical evaluations, the general reliability of the data set must first be determined by completing charge balance calculations. These calculations consider the major dissolved species that account for most of the charge contribution to the solution. These species are divided into cations (i.e., calcium, magnesium, sodium, and potassium) and anions (i.e., alkalinity (or bicarbonate), chloride, and sulfate). Because most natural waters are electrically neutral, the sum of the positive cation charges should be approximately equal to the sum of the negative anion charges, with respect to the above seven ions. If there is a significant departure from neutrality (greater than 20 percent), there might be a problem with the analytical results and hence data reliability.

To calculate charge balance error, the concentration of each of the above seven ions is converted to their respective charge contributions. Each of the ions has a positive or negative charge, as follows:

| CATIONS (POSITIVE CHARGE) | ANIONS (NEGATIVE CHARGE) |
|---|---|
| Calcium (+2) or $Ca^{+2}$ | Alkalinity/Bicarbonate (-1) or $HCO_3^{-1}$ |
| Magnesium (+2) or $Mg^{+2}$ | |
| Sodium (+1) or $Na^{+1}$ | Sulfate (-2) or $SO_4^{-2}$ |
| Potassium (+1) or $K^{+1}$ | Chloride (-1) or $Cl^{-1}$ |

The amount of charge contributed by each ion is determined by taking the reported concentration of each ion (in parts per million [ppm]), dividing by its molecular weight, and multiplying by the ionic charge. For example, the amount of charge due to 100 ppm calcium is:

$$\underset{\text{(concentration)}}{100\text{ ppm}} \div \underset{\text{(molecular weight)}}{40\text{ mg/mmol}} \times \underset{\text{(ionic charge)}}{2} = \underset{\text{(total charge)}}{5\text{ meq/L.}}$$

The total charge is expressed in milliequivalents per liter (meq/L). This value is calculated for each of the seven ions, with the calculated meq/L values added separately for the positive and negative ions as follows:

Σmeg/L cations = meq/L calcium + meq/L magnesium + meq/L sodium + meq/L potassium;

Σmeq/L anions = meq/L bicarbonate + meq/L sulfate + meq/L chloride.

The percent error is then calculated as follows:

(Σmeq/L cations - Σmeq/L anions) ÷ (Σmeq/L cations + Σmeq/L anions) x 100 = % error.

There may be circumstances that will produce excessive charge balance errors even with good analytical data. For example, if there is a significant concentration of trace constituents in the water sample, the result will be an apparent imbalance. For typical natural water samples, however, trace constituents are rarely concentrated enough to result in an error exceeding 20 percent.

The error of the water quality database utilized in this study is less than 20 percent (Tables H-1 through H-8 in Appendix H), indicating that the data are reliable for evaluation with geochemical evaluation methods.

## 6.3 *Geochemical Evaluation Methods*

The geochemical evaluation method utilized in this study relied extensively on ion ratios, rather than comparisons of reported concentrations of natural occurring geochemical constituents typically observed in groundwater. This technique minimizes the effects of variability in reported concentrations between sampling locations. The graphical method utilized was the Piper plot. These plots were interpreted within the context of the known hydrogeology of the Niagara Sanitation Landfill.

### 6.3.1 Piper Plots

A water's chemical character is determined by seven major ions (calcium, magnesium, sodium, potassium, chloride, sulfate, and bicarbonate); therefore, evaluating the relative abundance of these ions can be utilized to identify mineral or waste sources for these ions. As a result, Piper plots are an effective means of evaluating a large quantity of water quality data as numerous samples can be included on a single plot. Major ion groupings and mixing trends are clearly differentiated, while water quality changes for a given well over time can also be determined.

Piper plots are prepared by first calculating the relative proportion of each cation (calcium, magnesium, sodium, potassium) to the total cation concentration, and the relative proportion of each anion (chloride, sulfate, bicarbonate) to the total anion concentration. The cation chemistry for each sample is plotted on the lower left triangle of the Piper plot, while the anion chemistry is plotted on the lower right triangle (Figure 6-1). The corresponding data points in each triangle are then extrapolated up into the central diamond and plotted at the intersection of the extrapolations (Figure 6-1). Waters originating from different geologic materials will plot within distinct hydrogeochemical regions that will be characteristic of the associated aquifer (Figure 6-2). Waters that are mixtures will plot between these distinct facies. Thus, the origin of a given aquifer's water chemistry can be determined, along with mixing reactions between different aquifers or water types.

## 6.4 *Conceptual Geochemical Model for the Niagara Sanitation Landfill*

As groundwater flows through the subsurface environment, it evolves geochemically based upon the minerals present in the aquifer and the solubility of those minerals. As a general rule, the concentration of total dissolved solids (TDS) and most of the major ions will increase naturally with increased depth and/or residence time. This generalization suggests that shallow groundwater in recharge areas (i.e., areas with low depth and/or short residence time) will be lower in TDS and major ion concentrations than shallow groundwater in discharge areas, and further, will also be lower in TDS and major ion concentrations than groundwater deeper in the flow system (Freeze and Cherry, 1979). Combining this general principle with the known hydrogeology of the Niagara Sanitation Landfill, a conceptual geochemical model for the site was developed. The Piper plots generated during this study are then interpreted within the framework of this model.

As discussed in Section 5.0, the general stratigraphy of the site, with increasing depth, consists of miscellaneous fill, an upper sand deposit, glaciolacustrine silty clays, a lower sand deposit, glacial till, and Camillus Shale or Lockport Dolostone bedrock. For wells screened within the fill materials, groundwater quality would likely exhibit a wide range of characteristics relating to the chemistry of the fill. The presence of native soil intermixed with the fill material will also result in variable geochemistry.

Since limestone (predominantly $CaCO_3$), dolostone (predominantly $CaMg[CO_3]_2$), and shale are the dominant rock types in western New York, the native overburden soils will be composed predominantly of the minerals present in these rocks. The exception to this may be the upper and lower sand deposits, as the source rock for these deposits is unknown. Since the upper sand deposit is encountered at such shallow depths, however, it is anticipated that groundwater in this deposit will be dominated by bicarbonate resulting from the interaction of atmospheric and soil $CO_2$ with carbonate present in local soils intermixed with the sand.

While the hydraulic conductivity of the underlying glaciolacustrine silty clay deposit is generally extremely low, the presence of vertical desiccation cracks increases the potential for precipitation to infiltrate into this deposit. Concentrations of calcium and magnesium would remain the dominant cations, but the concentrations of bicarbonate will decrease as the presence of atmospheric $CO_2$ becomes less available to the system.

Groundwater in the underlying lower sand and glacial till deposit will continue to evolve but under closed-system conditions as atmospheric $CO_2$ is no longer available to the system. The carbonate minerals are less soluble under closed-system conditions, giving rise to increased dissolution of other minerals in the soils. Since it is believed that Camillus Shale bedrock underlies the site, the presence of shale minerals would begin to play a significant role in the evolution of the deeper zone groundwater. Since sodium and sulfate are common ions in shale, groundwater in the lower sand and glacial till deposits should exhibit increasing concentrations of these ions.

Groundwater within the upper bedrock hydrogeologic zone evolves differently than groundwater within the overburden deposits; upper bedrock groundwater evolves as it flows through the saturated media over greater distances and generally lower velocities. Groundwater in the bedrock recharge zone, which is believed to be located miles away from the Niagara Sanitation Landfill, would have characteristics similar to those in the shallow hydrogeologic zone; active flushing during recharge would be dominated by bicarbonate resulting from the interaction of atmospheric and soil $CO_2$ with carbonate derived from the dissolution of limestone, dolostone, and shale in the recharge zone. As groundwater flows through the upper bedrock, the concentrations of the major ions will continue to increase, as will the concentration of TDS. Since the Camillus Shale contains abundant quantities of gypsum ($CaSO_4 \cdot H_2O$), groundwater within this formation will become concentrated in calcium and sulfate, while bicarbonate concentrations will decrease as limestone ($CaCO_3$), which is also found in abundant quantities within the Camillus Shale, is less soluble under close-system (saturated) conditions. As a result, groundwater in the Camillus Shale is classified as a calcium-sulfate water.

It is also possible that the Lockport Dolostone underlies the Niagara Sanitation Landfill. Johnson (1964) reports that groundwater in the Lockport Dolostone contains significant concentrations of calcium (10.0 to 194.0 mg/l), magnesium (54.8 to 142.0 mg/l), sulfate (62.0 to 1,320 mg/l), and bicarbonate (119.0 to 429.0 mg/l), which are derived from the dissolution of dolostone ($CaMg(C0_3)_2$) and gypsum ($CaS0_4 \cdot 2H_20$) by percolating groundwater. As a result, groundwater in the Lockport Dolostone is typically either a calcium-sulfate or calcium-bicarbonate water, is very hard, and highly mineralized (Johnson, 1964; La Sala, 1968).

## *6.5 Geochemical Results*

### 6.5.1 Surface Water

Only one surface water sample was collected from the Niagara Sanitation Landfill and analyzed for the major cations and anions (Table H-1 in Appendix H). These results indicate that surface water at the site contains higher concentrations of calcium (35.5 mg/l) and bicarbonate (146.3 mg/l) compared to the other major anions and cations (Table H-1). The percentage of calcium and bicarbonate in surface water compared to the total cations and anions, respectively, are shown on Figure 6-3.

The other major cations and anions are detected at much lower concentrations (Table H-1):

magnesium (8.9 mg/l), potassium (4.2 mg/l), sodium (2.3 mg/l), chloride (1.9 mg/l) and sulfate (6.7 mg/l). The percentages of these constituents are also shown on Figure 6-3. The Piper plot for these data (Figure 6-4) confirm that surface water at the Niagara Sanitation Landfill is classified as a calcium-bicarbonate water (compare Figure 6-4 with the diamond plot of Figure 6-2).

### 6.5.2 Fill Wells

As stated in Section 6.4, groundwater from wells that screen the fill materials likely exhibit a wide range of characteristics relating to the chemistry of the fill. As a result, these wells are described separately from wells that screen the upper sand deposit. During the Remedial Investigation, seven (7) groundwater samples from wells that screen the fill materials were collected and analyzed for the major cations and anions (Table H-2 in Appendix H). These results indicate that groundwater in fill at the site contains higher concentrations of calcium (124.0 to 373.0 mg/l) and bicarbonate (815.7 to 1,499.6 mg/l) compared to the other major anions and cations (Table H-2). The arithmetic means for calcium and bicarbonate are 216.86 mg/l and 1,091.73 mg/l, respectively (Table H-2). The percentage of calcium and bicarbonate in fill groundwater compared to the total cations and anions, respectively, are shown on Figure 6-3.

Concentrations of the other major cations and anions range as follows (Table H-2): magnesium (30.5 to 163.0 mg/l), potassium (9.2 to 42.0 mg/l), sodium (10.3 to 153.0 mg/l), chloride (6.9 to 127.0 mg/l) and sulfate (non-detect to 1,150 mg/l). The arithmetic and geometric means for these constituents are given in Table H-2. The percentages of these constituents are shown on Figure 6-3.

The Piper plot for the fill material wells (Figure 6-5) shows variability in the results but also shows that 5 of the 7 samples plot relatively close together in the calcium-bicarbonate section of the diamond (compare Figure 6-5 with the diamond plot of Figure 6-2). Only the sample from well OW-33 does not plot as calcium-bicarbonate water. This well plots as calcium-sulfate water (compare Figure 6-5 with the diamond plot of Figure 6-2).

### 6.5.3 Upper Sand Water-Bearing Zone

During the Remedial Investigation, twenty-three (23) groundwater samples from wells that screen the upper sand deposit were collected and analyzed for the major cations and anions (Table H-3 in Appendix H). These results indicate that groundwater from the upper sand deposit is highly variable, most likely affected by precipitation, seasonal fluctuations in water levels and the fill materials found throughout the Niagara Sanitation Landfill. In general, water in this zone contains higher concentrations of calcium (148.0 to 780.0 mg/l) and bicarbonate (508.4 to 1,402.1 mg/l) compared to the other major anions and cations (Table H-3). The arithmetic means for calcium and bicarbonate are 338.00 mg/l and 895.02 mg/l, respectively (Table H-3). The percentage of calcium and bicarbonate in upper sand groundwater compared to the total cations and anions, respectively, are shown on Figure 6-3.

Concentrations of the other major cations and anions range as follows (Table H-3): magnesium (34.8 to 293.0 mg/l), sodium (13.8 to 500.0 mg/l), potassium (0.99 to 33.2 mg/l), chloride (11.3 to 664.0 mg/l) and sulfate (8.0 to 1,540.0 mg/l). The arithmetic and geometric means for these constituents are given in Table H-3. The percentages of these constituents are shown on Figure 6-3.

The Piper plot for the upper sand wells (Figure 6-6) shows variability in the results but indicates that groundwater in the upper sand deposit is best classified as a calcium-bicarbonate water (compare Figure 6-6 with the diamond plot of Figure 6-2). Several wells, however, plot as calcium-sulfate water (compare Figure 6-6 with the diamond plot of Figure 6-2). Three (3) specific wells are denoted in Figure 6-6. Well OW-31 is located along the eastern boundary of the landfill (Figure 5-1) but plots in a similar location to three (3) wells located within the landfill. This well plots as calcium-sulfate water. Well OW-21 (Figure 5-1) has the lowest sulfate concentration (8.0 mg/l) of all the upper sand deposit wells, the next lowest sulfate concentration being 84.3 mg/l (Table H-3). The low sulfate concentration in this well, however, is similar to the sulfate concentrations in 5 of the 7 fill wells (compare Tables H-2 and H-3). Well LPZ-04S is located along the southern boundary of the Niagara Sanitation Landfill (Figure 5-1). This well has a higher percentage of sodium and chloride than the other upper sand wells (Figure 6-6). It is interesting to note that this well is located close to the brine pipelines that border the site and may reflect leakage from one of the pipelines.

### 6.5.4 Upper Clay Aquitard

As discussed in Section 5.2.2, only one (1) well screens the upper clay aquitard underlying the Niagara Sanitation Landfill, and that this well appears to be in hydraulic connection with the overlying upper sand deposit. To evaluate this connectivity further, Figure 6-7 is a Piper plot of well OW-2 along with two (2) nearby upper sand wells. The locations of these wells are shown on Figure 5-1. The Piper plot indicates that well OW-2 has a slightly higher percentage of magnesium than the

2 upper sand wells and a slightly lower percentage of bicarbonate. In general, however, groundwater from this well plots close to groundwater in the nearby upper sand wells and appears to confirm that this well is in hydraulic connection with the upper sand deposit. The major cation and anion results for this well are provided in Table H-4 in Appendix H. The percentages of the major cations and anions are shown on Figure 6-3.

### 6.5.5 Lower Sand Water-Bearing Zone

As discussed in Section 5.2.3, only two (2) wells screen the lower sand deposit underlying the Niagara Sanitation Landfill. During the Remedial Investigation, both wells were sampled and analyzed for the major cations and anions (Table H-5 in Appendix H). These results indicate that groundwater in the lower sand deposit contains higher concentrations of sodium (50.8 and 64.5 mg/l) and sulfate (112.0 and 125.0 mg/l) compared to the other major anions and cations (Table H-5). The arithmetic means for sodium and sulfate are 57.65 mg/l and 118.50 mg/l, respectively (Table H-5). The percentage of sodium and sulfate in lower sand groundwater compared to the total cations and anions, respectively, are shown on Figure 6-3.

Concentrations of the other major cations and anions range as follows (Table H-5): calcium (16.8 and 18.2 mg/l), magnesium (3.2 and 8.3 mg/l), potassium (1.4 and 1.9 mg/l), bicarbonate (64.0 and 82.5 mg/l), and chloride (3.0 and 15.8 mg/l). The arithmetic and geometric means for these constituents are given in Table H-5. The percentages of these constituents are shown on Figure 6-3.

The Piper plot for the lower sand deposit is given as Figure 6-8, which shows that groundwater in this deposit is best classified as a sodium-chloride water (compare Figure 6-8 with the diamond plot of Figure 6-2). Figure 6-8 also shows that groundwater in the lower sand deposit is significantly different than groundwater encountered in the fill material, the upper sand deposit, and the upper clay aquitard. This indicates that the upper clay aquitard has prevented the downward migration of shallow groundwater to the lower sand deposit.

### 6.5.6 Glacial Till Aquitard

As discussed in Section 5.2.4, five (5) wells screen the glacial till deposit underlying the Niagara Sanitation Landfill, and that wells OW-05 and OW-06 are hydraulically connected to the underlying upper bedrock. During the Remedial Investigation, all five (5) wells were sampled and analyzed for the major cations and anions (Table H-6A in Appendix H). A review of Table H-6A reveals that the concentrations of calcium, magnesium, and sulfate are significantly higher in well

OW-6 than in the other glacial till wells. As a result, the geochemistry of this well will be discussed separately from the other glacial till wells.

The major cation and anion results indicate that groundwater in glacial till wells OW-1B, OW-3, OW-4, and OW-5 contains higher concentrations of sodium (54.3 to 107.0 mg/l) and sulfate (261.0 to 491.0 mg/l) compared to the other major anions and cations (Table H-6B). The arithmetic means for sodium and sulfate are 84.85 mg/l and 348.50 mg/l, respectively (Table H-6B). The percentage of sodium and sulfate in glacial till groundwater compared to the total cations and anions, respectively, are shown on Figure 6-3.

Concentrations of the other major cations and anions range as follows (Table H-6B): calcium (36.8 to 88.7 mg/l), magnesium (25.1 to 46.7 mg/l), potassium (1.9 to 2.7 mg/l), bicarbonate (66.4 to 256.0 mg/l), and chloride (5.0 to 34.8 mg/l). The arithmetic and geometric means for these constituents are given in Table H-6B. The percentages of these constituents are shown on Figure 6-3.

The Piper plot for the glacial till is given as Figure 6-9, which shows that groundwater in this deposit is best classified as a calcium-sulfate water (compare Figure 6-9 with the diamond plot of Figure 6-2). Figure 6-9 also shows that groundwater in the glacial till deposit is quite variable, with only wells OW-1B, OW-4, and OW-5 plotting in a loose cluster. Well OW-3, which is located southeast of the IRM excavation area, contains groundwater that plots between the upper sand deposit wells and the glacial till wells (compare Figures 6-6 and 6-9) and could reflect migration of upper sand groundwater to the glacial till through the former disposal pit. The cross-section provided as Figure 4-7 shows that the reported depth of the disposal pit would have extended into the glacial till deposit, and that the top of the screen of well OW-3 is only about 5 feet lower. The concentration of bicarbonate in this well is also substantially higher than the other glacial till wells (Table H-6A), which is indicative of shallow groundwater.

Although the lower sand deposit wells did not show evidence of leakage from the shallow water-bearing zones (see Figure 6-8), the lower sand wells may not be located downgradient of the disposal pit and thus may not be impacted by leakage if it is in fact occurring.

Table H-6A shows that well OW-6 contains much higher concentrations of calcium, magnesium, and sulfate than the other glacial till wells. The geochemical difference of the groundwater in this well is clearly observed on the bar graph of Figure 6-3 (labelled as Bedrock?)

and the Piper plot of Figure 6-9. Well OW-6 will be further discussed in Section 6.5.7 below.

### 6.5.7 Upper Bedrock Water-Bearing Zone

**Camillus Shale**: Upper bedrock wells have not been installed at the Niagara Sanitation Landfill, and there is some question as to whether bedrock that underlies the site is the Camillus Shale or the Lockport Dolostone. To evaluate the Camillus Shale, water quality data from upper Camillus Shale bedrock wells in the Tonawanda area were compiled during this study (Table H-7 in Appendix H). These results indicate that groundwater in the upper Camillus Shale contains higher concentrations of calcium (389.0 to 612.0 mg/l) and sulfate (1,370 to 2,970 mg/l) compared to the other major anions and cations (Table H-7). The arithmetic means for calcium and sulfate are 472.13 mg/l and 2,242.12 mg/l, respectively (Table H-7). The percentage of calcium and sulfate in upper Camillus Shale groundwater compared to the total cations and anions, respectively, are shown on Figure 6-3.

Concentrations of the other major anions and cations range as follows (Table H-7): magnesium (35.7 to 232.0 mg/l), sodium (29.9 to 476.0 mg/l), potassium (2.8 to 64.7 mg/l), bicarbonate (21.7 to 474.3 mg/l), and chloride (3.6 to 420.0 mg/l). The arithmetic and geometric means for these constituents are given in Table H-7. The percentages of these constituents are shown on Figure 6-3.

The Piper plot for the upper Camillus Shale bedrock is given as Figure 6-10, which shows that groundwater in this formation is best classified as a calcium-sulfate water (compare Figure 6-10 with the diamond plot of Figure 6-2). The Piper plot, however, shows two distinct groups within the calcium-sulfate quadrant. The first group contains proportions of calcium and magnesium above 75%, while the second group contains proportions of these cations below 75% (Figure 6-10). The first group also contains slightly higher proportions of chloride and sulfate than the second group (Figure 6-10).

**Lockport Dolostone**: Since upper bedrock underlying the Niagara Sanitation Landfill could be the Lockport Dolostone, water quality data from upper Lockport Dolostone bedrock wells in the Niagara Falls area were compiled during this study (Table H-8 in Appendix H). These results indicate that groundwater in the upper Lockport Dolostone contains higher concentrations of calcium (72.0 to 620.0 mg/l), bicarbonate (231.7 to 607.2 mg/l), and sulfate (78.0 to 1,628 mg/l) compared to the other major anions and cations (Table H-8). The arithmetic means for calcium, bicarbonate, and sulfate are 265.43 mg/l, 369.82 mg/l, and 679.14 mg/l, respectively (Table H-8). The percentage of calcium, bicarbonate, and sulfate in upper Lockport Dolostone groundwater compared to the total cations and anions, respectively, are shown on Figure 6-3.

Concentrations of the other major anions and cations range as follows (Table H-8): magnesium (34.0 to 178.0 mg/l), sodium (3.9 to 161.0 mg/l), potassium (non-detect to 11.0 mg/l), and chloride (10.0 to 290.0 mg/l). The arithmetic and geometric means for these constituents are given in Table H-8. The percentages of these constituents are shown on Figure 6-3.

The Piper plot for the upper Lockport Dolostone bedrock is given as Figure 6-11, which shows that groundwater in this formation plots as two distinct clusters. Upper Lockport Dolostone groundwater is either a calcium-sulfate or calcium-bicarbonate water (compare Figure 6-11 with the diamond plot of Figure 6-2).

**Niagara Sanitation Landfill**: A comparison of the Piper plots for glacial till wells at the Niagara Sanitation Landfill (Figure 6-9), upper Camillus Shale bedrock wells in the Tonawanda area (Figure 6-10), and upper Lockport Dolostone bedrock wells in the Niagara Falls area (Figure 6-11) reveals that glacial till well OW-6 plots squarely within the first group of Camillus Shale wells. The concentrations of the major cations and anions in this well are also squarely within the ranges documented for the upper Camillus Shale wells (compare Tables H-6 and H-7). These results suggest that well OW-06 is hydraulically connected to the upper bedrock, and that the bedrock underlying the Niagara Sanitation Landfill is the Camillus Shale.

Although the results discussed in Section 5.2.4 suggest that glacial till well OW-5 is also hydraulically connected to upper bedrock underlying the Niagara Sanitation Landfill, the groundwater geochemistry does not support this (compare Figure 6-9 to Figures 6-10 and 6-11).

# 7.0 SUMMARY

During implementation of a State Funded Remedial Investigation at the Niagara Sanitation Landfill in 2017, groundwater flow in the fill/upper sand water-bearing zone was to the south toward Forbes Street. This flow pattern, however, was opposite to that identified in studies completed in 2013 & 2014. To further evaluate groundwater flow patterns at the site, a detailed study of the geology and hydrogeology of the Niagara Sanitation Landfill was completed, with the information utilized to develop a conceptual geochemical model for the site. Geochemical data obtained during the Remedial Investigation from the various water-bearing zones underlying the site were then evaluated within this framework.

## *7.1 Geology*

The stratigraphy of the Niagara Sanitation Landfill was evaluated by examining seventy-seven (77) stratigraphic logs obtained from soil borings completed at the site. These data suggest that eight (8) distinct stratigraphic units underlie the site: (1) fill material, (2) an upper brown silt and clay deposit, (3) an upper yellow-brown sand deposit, (4) a gray-brown lacustrine silty clay deposit, (5) a red-gray layered lacustrine clay deposit, (6) a relatively thin, lower red-brown sand deposit, (7) a relatively thick, reddish brown to gray glacial till deposit, and (8) bedrock. Most investigations completed at the site have been confined to the fill material, the upper sand deposit, and the upper brown silt and clay deposit.

Fill material overlies the native deposits throughout most of the Niagara Sanitation Landfill but is discontinuous across the site. Where fill material is absent, native deposits are generally encountered at ground surface. The thickness of the fill material typically ranges from 2.0 to 6.0 feet, although thicker areas of fill are associated with the former disposal pit. The average thickness of the fill material is 4.1 feet.

The native soils underlying the Niagara Sanitation Landfill include a glaciolacustrine deposit and glacial till. With increasing depth, the glaciolacustrine deposit consists of a brown silt and clay unit, an upper sand unit, a gray-brown silty clay unit, a red-gray layered clay unit, and a lower sand unit. These units were deposited in glacial lakes that covered the area during the last ice age.

The full thickness of the glaciolacustrine deposit was only penetrated at 7 borings completed at the site. The total thickness of this deposit was quite variable, ranging from 21.5 to 45.0 feet. At 6 of the 7 boring locations, however, the thickness of the glaciolacustrine deposit was 36.0 feet or greater.

The brown silt and clay deposit was encountered in 30 borings completed at the site. The depth to this deposit ranged from 0.0 to 4.0 feet below ground surface, while the thickness ranged from 0.5 to 4.0 feet. The average thickness of brown silt and clay deposit is 2.0 feet.

The upper sand deposit was encountered in 61 borings completed at the site. The depth to this deposit ranged from 0.0 to 10.0 feet below ground surface. Where completely penetrated, the thickness of the upper sand deposit was quite variable, ranging from 0.4 to 11.0 feet. The average thickness of this deposit is 4.4 feet.

The gray-brown silty clay deposit was encountered in 63 borings completed at the Niagara Sanitation Landfill. The depth to this deposit was quite variable, ranging from 3.0 to 15.0 feet below ground surface. This deposit was only completely penetrated at 11 locations, with the thickness ranging from 2.0 to 8.0 feet. The average thickness of the gray-brown silty clay deposit is 4.8 feet.

The red-gray layered clay deposit was encountered in 11 borings completed at the site. The depth to this deposit was quite variable, ranging from 8.0 to 16.0 feet below ground surface. Where completely penetrated, the thickness of the red-gray layered clay deposit was extremely variable, ranging from 18.5 to 33.0 feet. The average thickness of this deposit is 25.6 feet.

A relatively thin, red-brown sand deposit underlies the red-gray layered clay deposit and mantles the glacial till. Based on its lithology and stratigraphic position, this sand deposit is interpreted to be an early deposit of Lake Tonawanda. The lower sand deposit was only encountered in 6 borings completed at the site. The depth to this deposit was quite variable, ranging from 26.3 to 42.0 feet below ground surface, while the thickness was somewhat variable, ranging from 0.2 to 5.0 feet. In 4 borings, however, the thickness of this deposit ranged from 3.0 to 5.0 feet.

A relatively thick, continuous layer of glacial till underlies the lower sand deposit and mantles the underlying bedrock. The till underlying the Niagara Sanitation Landfill consists predominantly of a dense, brown silt with fine to coarse sand and fine gravel. The glacial till deposit was only encountered in 7 borings completed at the site. The depth to till was quite variable, ranging from 26.5 to 45.0 feet below ground surface. Where completely penetrated, the thickness of this deposit ranged from 22.0 to 42.2 feet. The average thickness of the glacial till deposit is 29.0 feet.

The uppermost bedrock unit underlying the Niagara Sanitation Landfill is unknown. Available information suggests that it could be dolostone of the Lockport Group or the Camillus Shale of the Salina Group. None of the borings completed at the Niagara Sanitation Landfill cored into bedrock for positive identification. Bedrock was only encountered in 5 borings completed at the site. Depth to bedrock beneath the Niagara Sanitation Landfill was relatively consistent, ranging from 66.0 to 70.3 feet below ground surface.

## *7.2 Hydrogeology*

A primary objective of this study was to further evaluate groundwater flow patterns in the water-bearing zones underlying the site. This was completed by generating a series of groundwater contour maps. A complete understanding of the groundwater flow patterns, especially in the fill/upper sand water-bearing zone, is critical for evaluating the potential for contaminants in groundwater to migrate from the site.

The hydrogeology of the Niagara Sanitation Landfill was evaluated by examining hydrogeologic data obtained during this study. These data suggest that five (5) hydrogeologic zones underlie the site: (1) the fill/upper sand water-bearing zone consisting of miscellaneous fill and the upper sand deposit, (2) the upper clay aquitard consisting of the gray-brown lacustrine silty clay and red-gray layered lacustrine clay deposits, (3) the lower sand water-bearing zone, (4) the glacial till deposit that acts an aquitard, and (5) the upper bedrock water bearing zone. Upper bedrock monitoring wells have not been installed at the Niagara Sanitation Landfill, so the upper bedrock water-bearing zone was not evaluated.

In Sections 5.2.1 through 5.2.4, hydrographs and groundwater contour maps for the various hydrogeologic zones underlying the Niagara Sanitation Landfill were presented and discussed. In this section, those hydrographs and groundwater contours are evaluated collectively to form a comprehensive picture of the hydrogeology at the site.

Figure 7-1 is a hydrograph showing representative wells from all hydrogeologic zones at the site. As discussed in Section 5.2.1, water levels in the fill/upper sand wells fluctuated throughout the year in response to precipitation. Water levels steadily decreased between August 22nd and September 25th, a period that was characterized by lower-than-normal rainfall. Water levels then increased substantially in all fill/upper sand wells during October and November 2017, a period that was characterized by higher-than-normal rainfall. These fluctuations are clearly seen on Figure 7-1.

There is only one (1) monitoring well (OW-2) at the Niagara Sanitation Landfill that screens the upper clay aquitard that underlies either fill material or the upper sand deposit. As discussed in Section 5.2.2, the hydrogeologic data compiled for this study indicates that well OW-2 is hydraulically connected to the fill/upper sand water-bearing zone. The hydrograph for this well shows that water level fluctuations mirrored those in the fill/upper sand wells. This relationship is clearly seen on Figure 7-1.

There are only two monitoring wells (OW-14A and OW-15) at the Niagara Sanitation Landfill that screen the lower sand deposit that underlies the upper clay aquitard. As discussed in Section 5.2.3, the hydrograph for well OW-15 shows very little seasonal fluctuation, with water levels ranging from 567.58 to 568.11 feet above mean sea level. The relatively small fluctuations in this well are clearly seen on Figure 7-1.

Figure 7-1 indicates that water levels in the lower sand deposit are approximately 6 feet lower than water levels in the overlying hydrogeologic zones. This indicates the potential for vertical downward movement of groundwater from the fill/upper sand water-bearing zone to the lower sand deposit. This potential, however, is thought to be very limited due to the low permeability of the glaciolacustrine silty clay and clay deposits, which typically range from $10^{-6}$ to $10^{-8}$ cm/sec. In addition, the layered nature of the sediments on-site suggest that the vertical hydraulic conductivity could be orders of magnitude lower than the horizontal hydraulic conductivity.

There are five monitoring wells at the Niagara Sanitation Landfill that screen the glacial till deposit that underlies the lower sand deposit. As discussed in Section 5.2.4, the hydrographs for these wells reveal that there was very little seasonal fluctuation, with water levels ranging from 564.95 to 565.75 feet above mean sea level. The relatively small fluctuations in these wells are clearly seen on Figure 7-1.

Figure 7-1 indicates that water levels in the glacial till deposit are approximately 3 feet lower than water levels in the overlying upper sand deposit. This indicates the potential for vertical downward movement of groundwater from the lower sand deposit to deeper water-bearing zones. This potential, however, is again thought to be very limited due to the low permeability of the glacial till deposit. The hydraulic conductivity of the glacial till wells not influenced by the underlying bedrock ranged from $1.43 \times 10^{-6}$ to $7.88 \times 10^{-7}$ cm/sec (Table 5-3).

Numerous groundwater contour maps have been generated for the fill/upper sand water-bearing zone (Figures 5-6 through 5-22). These contours, however, do not show a consistent pattern of groundwater flow across the Niagara Sanitation Landfill. Groundwater flow has been documented to the north (Figures 5-6, 5-7, 5-21 and 5-22), south (Figures 5-9, 5-10, 5-11, 5-12, 5-13, and 5-14), and inward (Figures 5-8, 5-15, 5-17, 5-18, 5-19, and 5-20). In the eastern portion of the site, an eastward component to groundwater flow was observed on August 2, 2013 (Figure 5-7), August 2, 2017 (Figure 5-9), August 22, 2017 (Figure 5-11), August 30, 2017 (Figure 5-12), September 12, 2017 (Figure 5-13), September 25, 2017 (Figure 5-14), October 17, 2017 (Figure 5-15), October 20, 2017 (Figure 5-17), and October 27, 2017 (Figure 5-18), while flow to the west or northwest in the eastern portion of the site was observed on November 7, 2017 (Figure 5-19), April 3, 2020 (Figure 5-21), and November 23, 2021 (Figure 5-22).

It is important to note that flow gradients are low, typically ranging from 0.003 to 0.005 ft/ft. Groundwater contour intervals are also low, ranging from 0.05 feet (0.6 inches) to 0.25 feet (3 inches). This suggests that an error in measurement, recording, or a slightly heaved well can drastically impact the contour. An example of the latter is documented by Figures 5-9 and 7-2. As stated in Section 5.2, well OW-14B was found to be heaved/damaged due to frost action and was no longer considered accurate for groundwater and hydrogeologic data collection. These figures show the groundwater contour for August 2, 2017 with (Figure 7-2) and without (Figure 5-9) the water level from this well. The groundwater flow patterns for these two contours are drastically different.

For sites with low flow gradients, the number of wells utilized to generate a groundwater contour can also have a huge influence. An example of this is documented by Figures 5-6 and 5-7. During the 2013 GES Site Characterization Study, water levels were measured in ten (10) monitoring wells. The contour generated from these data (Figure 5-6) showed that groundwater in the fill/upper sand water-bearing zone flowed to the north and northwest.

During the Remedial Investigation, these wells were resurveyed. The groundwater contour map generated from the new survey data is illustrated in Figure 5-7. It is important to note, however, that several wells had been removed during the Interim Remedial Measure completed by the Occidental Chemical Corporation, so this contour only includes water levels from five (5) wells. This contour indicates that groundwater is mounded at well OW-13 and flows from this mound to the northeast, north, and northwest. Once again, the groundwater flow patterns for these two contours are drastically different.

Due to the limited number of wells in the upper clay aquitard (1 well) and the lower sand deposit (2 wells), groundwater contour maps for these hydrogeologic zones could not be generated.

Two (2) groundwater contour maps have been generated for the glacial till deposit (Figures 5-27 and 5-28). Figure 5-27 is a groundwater contour map for the glacial till deposit generated from the water level data collected during the Phase II Investigation (date not specified in the report). This contour shows that groundwater is mounded in the north-central portion of the landfill and flows outward from this mound toward the east, south, and west. Figure 5-28 is a groundwater contour map for the glacial till deposit generated from the water level data collected on October 20, 2017. This contour shows that groundwater in the glacial till flows across the site from east to west at a very low gradient.

## *7.3 Geochemistry*

A conceptual geochemical model based upon the hydrogeology of the Niagara Sanitation Landfill was developed to provide a framework in which to further evaluate the five (5) hydrogeologic zones that underlie the site. During the 2017 Remedial Investigation thirty-eight (38) samples were collected for geochemical analyses from the four overburden hydrogeologic zones identified at the site. One (1) surface water sample from the northern drainage ditch was also collected and analyzed. These data were evaluated by using Piper plots.

The Piper plots presented in Section 6.5 reveal that distinct water types are present at the Niagara Sanitation Landfill. For example, surface water is best classified as a calcium-bicarbonate water (Figure 6-4), while water in the Camillus Shale bedrock is best classified as a calcium-sulfate water (Figure 6-10). In this section, the water types identified during this evaluation will be discussed in relation to the conceptual geochemical model described in Section 6.4.

Surface water at the Niagara Sanitation Landfill is best classified as a calcium-bicarbonate water (Figure 6-4). This type of water results from the dissolution of calcium that occurs naturally in soils of southwestern Niagara County and the interaction of atmospheric and soil $CO_2$ with carbonate present in on-site soils. The presence of calcium-bicarbonate surface water at the site is consistent with the conceptual geochemical model.

Groundwater in the fill material at the Niagara Sanitation Landfill is best classified as a calcium-bicarbonate water (Figure 6-5). This groundwater generally contains low sulfate (5 of 7 samples), which is likely caused by the interaction of groundwater and fill material. Calcium is the dominant cation in this groundwater, resulting from the dissolution of calcium carbonate from the native soils intermixed with the fill material. Bicarbonate is the dominant anion in this groundwater, resulting from the interaction of atmospheric and soil $CO_2$ with carbonate present in on-site soils. The presence of calcium-bicarbonate groundwater in the fill material at the site is consistent with the conceptual geochemical model.

Groundwater in the upper sand deposit is highly variable, most likely affected by precipitation, seasonal fluctuations in water levels and the fill materials found throughout the Niagara Sanitation Landfill. The Piper plot for the upper sand deposit (Figure 6-6) shows that groundwater in this deposit is best classified as a calcium-bicarbonate water, although several wells plot as calcium-sulfate water. Once again, the presence of calcium-bicarbonate groundwater in the upper sand deposit is consistent with the conceptual geochemical model.

There is only one well at the Niagara Sanitation Landfill that screens the upper clay aquitard. As previously stated, this well appears to be in hydraulic connection with the overlying upper sand deposit. As a result, groundwater in this well plots close to groundwater from nearby upper sand wells (Figure 6-7). Additional wells would need to be installed in this deposit to further evaluate the groundwater type in this zone.

Groundwater in the lower sand deposit at the Niagara Sanitation Landfill is best classified as a sodium-chloride water (Figure 6-8). Figure 6-8 also shows that groundwater in the lower sand deposit is significantly different than groundwater encountered in the overlying fill material, the upper sand deposit, the upper clay aquitard, and the underlying glacial till deposit (compare Figure 6-8 with Figures 6-5, 6-6, and 6-9). This suggests that the upper clay aquitard has prevented the downward migration of shallow groundwater to the lower sand deposit, while the glacial till deposit has prevented upward migration of upper bedrock groundwater into this zone. Since the areal extent of the lower sand deposit is unknown, the source of the groundwater in this deposit is also unknown.

Groundwater in the glacial till deposit at the Niagara Sanitation Landfill is best classified as a calcium-sulfate water (Figure 6-9). Figure 6-9 also shows that groundwater in the glacial till deposit is quite variable, with only wells OW-1B, OW-4, and OW-5 plotting in a loose cluster. The presence of calcium-sulfate groundwater in this deposit is consistent with the conceptual geochemical model; the carbonate minerals in the glacial till are less soluble under closed-system conditions, concentrations of bicarbonate decrease as the presence of atmospheric $CO_2$ becomes less available to the system, and there is increased dissolution of other minerals in the soils.

Upper bedrock wells have not been installed at the Niagara Sanitation Landfill. Glacial till well OW-6, however, which appears to be in hydraulic connection with the upper bedrock, plots squarely within a group of Camillus Shale wells located in nearby Tonawanda, New York (Figure 6-10), but does plot within either of the Lockport Dolostone clusters (Figure 6-11). This highly suggests that bedrock underlying the Niagara Sanitation Landfill is the Camillus Shale. The higher concentrations of sodium and sulfate in the Camillus Shale wells are consistent with the conceptual geochemical model, i.e., as groundwater flows through the upper bedrock, the concentrations of the major ions will continue to increase. Since the Camillus Shale contains abundant quantities of gypsum ($CaSO_4 \cdot H_2O$), groundwater within this formation will become concentrated in calcium and sulfate, while bicarbonate concentrations will decrease as limestone ($CaCO_3$), which is also found in abundant quantities within the Camillus Shale, is less soluble under close-system (saturated) conditions.

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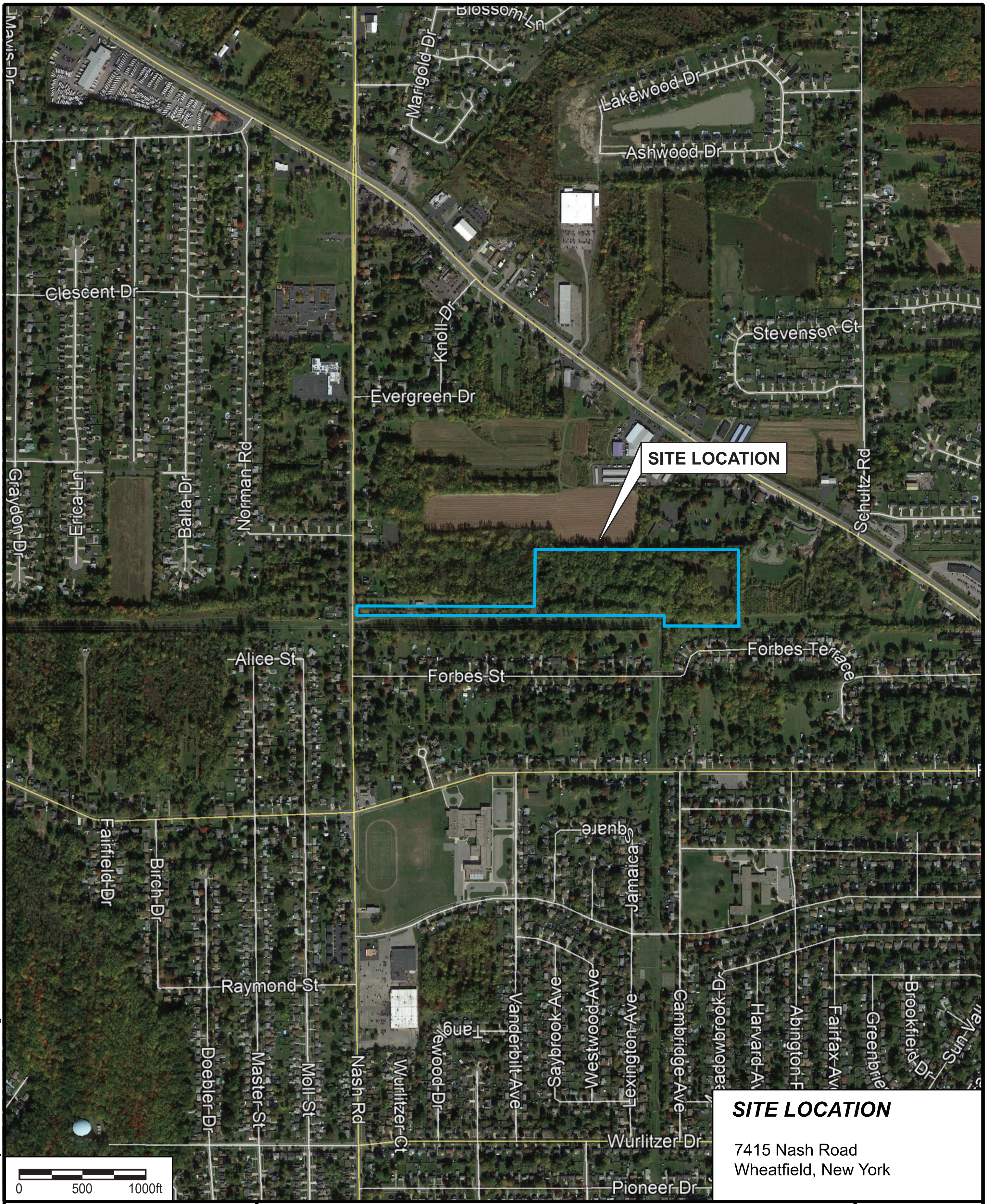
# FIGURES




**SITE LOCATION**

7415 Nash Road
Wheatfield, New York

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LiRo-Engineers, Inc.
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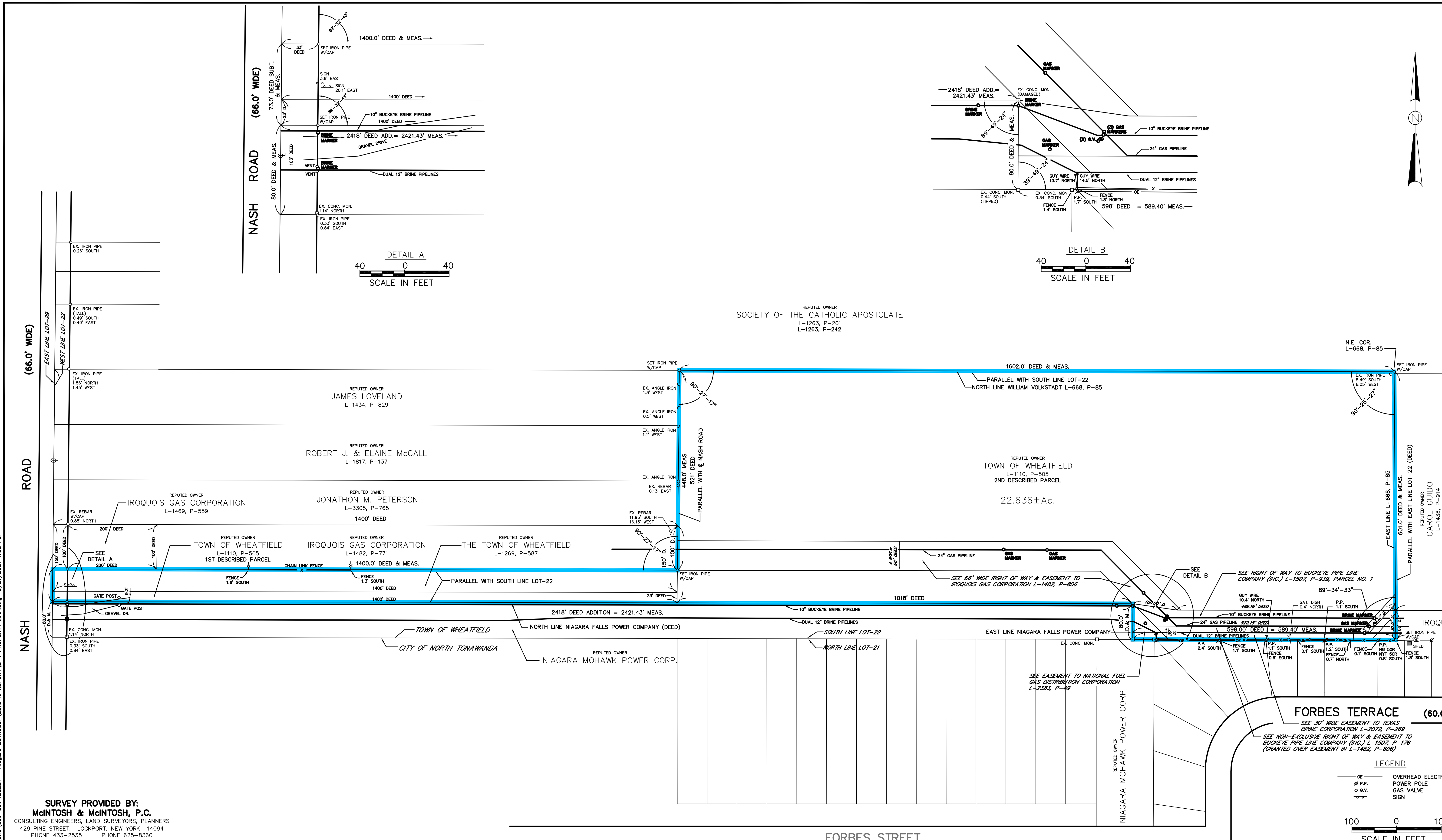
**NIAGARA SANITATION LANDFILL**
**SITE LOCATION MAP**

FIGURE NO.

1-1

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CLIENT:
NEW YORK STATE OF OPPORTUNITY
Department of Environmental Conservation

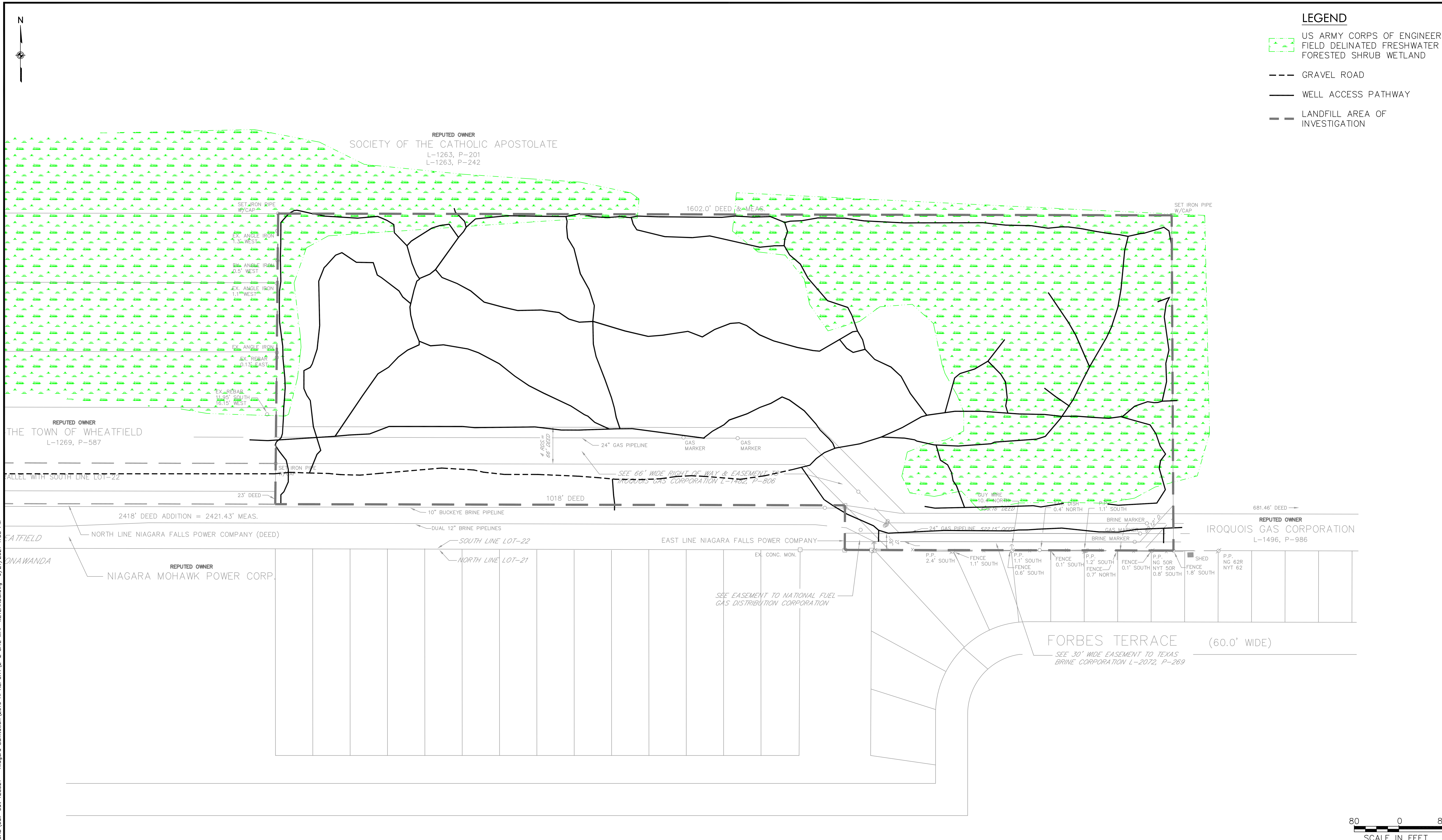
DATE: SEPTEMBER 2021
SCALE: AS SHOWN

JOB TITLE AND LOCATION:
NIAGARA SANITATION / NASH ROAD LANDFILL SITE
7415 NASH ROAD
TOWN OF WHEATFIELD, NIAGARA COUNTY, NEW YORK
NYSDEC SITE NUMBER 932054

DRAWING TITLE:
NIAGARA SANITATION LANDFILL PROPERTY MAP

LIRO JOB NO.: 17-013-0289
SHEET OF
FIGURE NO. 2-1

J:\17-013-0289 NYSDEC Standby\CAD\Call-Out 128321 - Niagara Sanitation\2019 RI REPORT\2-1 PROPERTY MAP.dwg 9/21/2021 1:38 PM




J:\17-013-0289 NYSDEC Standby\CAD\Call-Out 128321 – Niagara Sanitation\2019 RI REPORT\2-2 SITE MAP WETLANDS.dwg 9/21/2021 1:38 PM

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DATE: SEPTEMBER 2021

SCALE: AS SHOWN

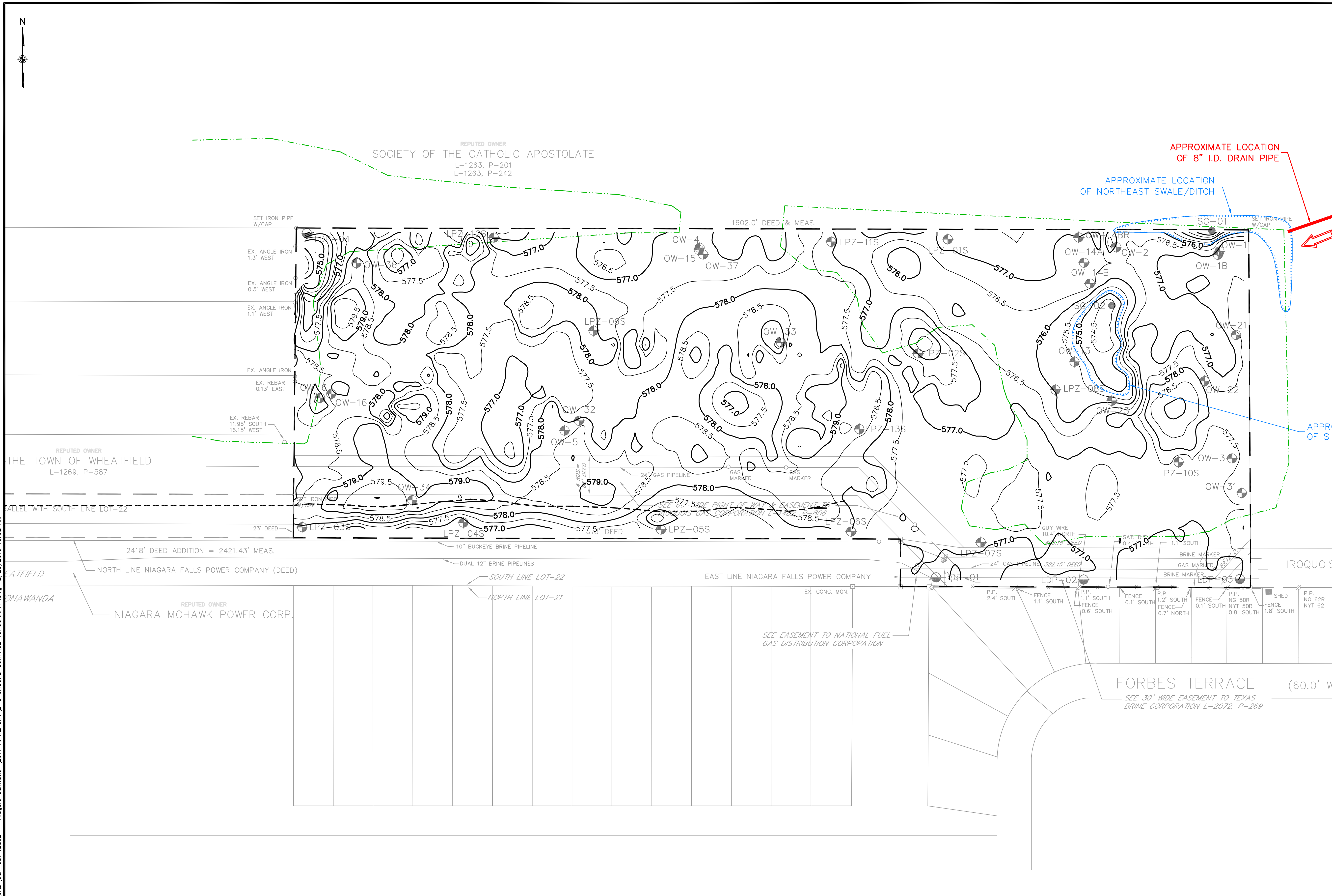
JOB TITLE AND LOCATION:
NIAGARA SANITATION / NASH ROAD LANDFILL SITE
7415 NASH ROAD
TOWN OF WHEATFIELD, NIAGARA COUNTY, NEW YORK
NYSDEC SITE NUMBER 932054

DRAWING TITLE: SITE BOUNDARY MAP SHOWING WETLANDS

LIRO JOB NO.: 17-013-0289

SHEET OF

FIGURE NO. 2-2




## LEGEND

- FRESHWATER FORESTED/SHRUB WETLAND
- GRAVEL ROAD
- AREA OF INVESTIGATION
- 576.0 GROUND SURFACE CONTOUR NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88) FEET ABOVE MEAN SEA LEVEL (AMSL)
- MONITORING WELL AND PIEZOMETER LOCATIONS
- 2017 HAND DRILLED 1-INCH ID PIEZOMETER LOCATION
- 2017 STAFF GAUGE LOCATION
- NORTH SWALE/DITCH
- DIRECTION OF DRAIN PIPE FLOW

ELEVATION DATA FROM SITE SURVEY COMPLETED ON OCTOBER 18, 2017.

80 0 80
SCALE IN FEET

J:\17-013-0289 NYSDEC Standby\CAD\Call-Out 128321 - Niagara Sanitation\2017 RI REPORT\2-3 GROUND SURFACE TOPOGRAPHY.dwg 2/25/2019 10:02 AM

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| CLIENT: | NEW YORK STATE OF OPPORTUNITY — Department of Environmental Conservation |
| DATE: | FEBRUARY 2019 |
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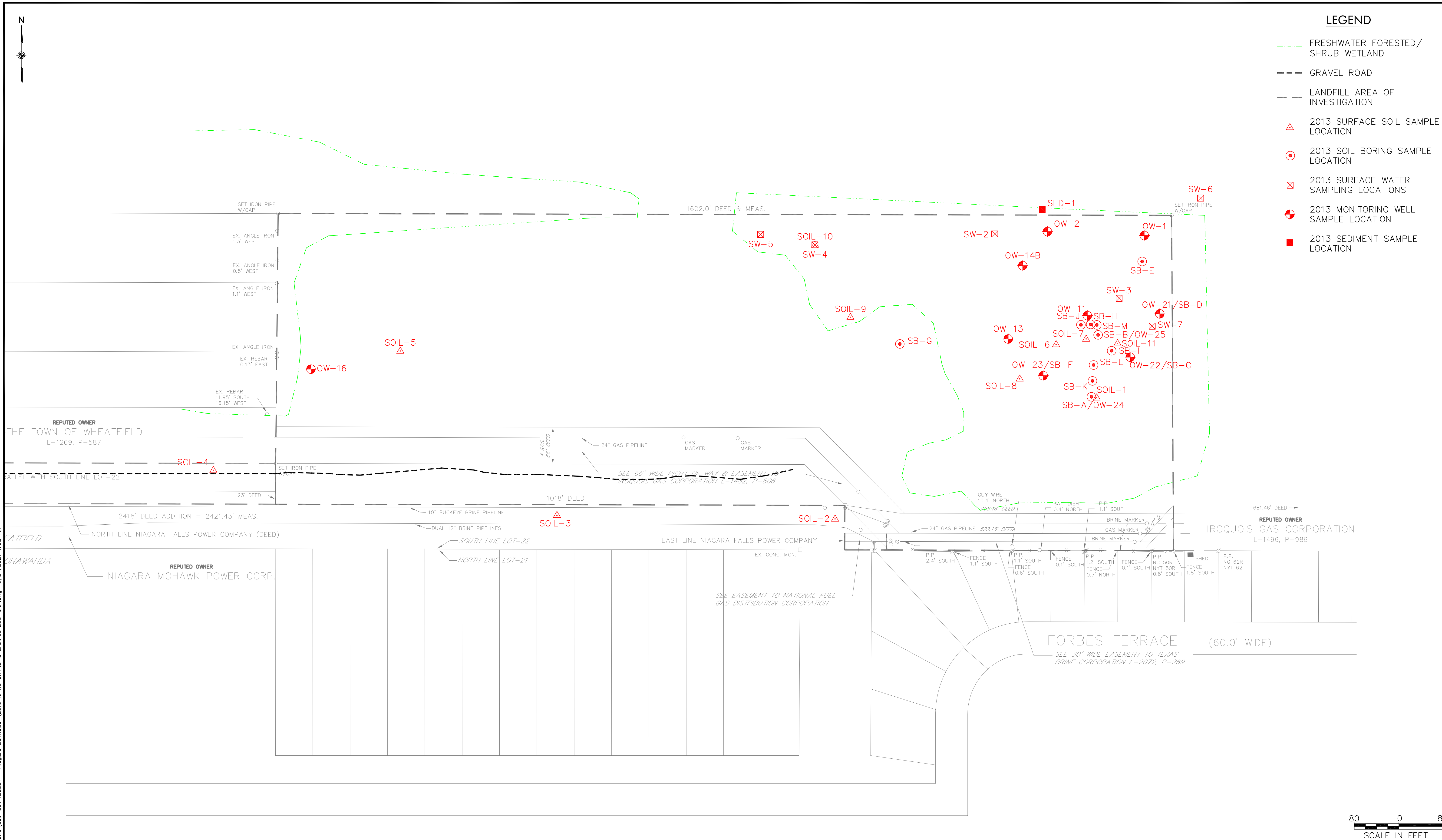
| DRAWING TITLE: | GROUND SURFACE TOPOGRAPHY |
| LIRO JOB NO.: | 17-013-0289 |
| SHEET OF | |
| FIGURE NO. | 2-3 |




J:\17-013-0289 NYSDEC Standby\CAD\Call-Out 128321 - Niagara Sanitation\2019 RI REPORT\2-3 SAMPLE LOC MAP.dwg 9/21/2021 1:38 PM

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7415 NASH ROAD
TOWN OF WHEATFIELD, NIAGARA COUNTY, NEW YORK
NYSDEC SITE NUMBER 932054

DRAWING TITLE:
2013 SITE CHARACTERIZATION SAMPLE LOCATION MAP

LIRO JOB NO.: 17-013-0289
SHEET OF
FIGURE NO. 2-4

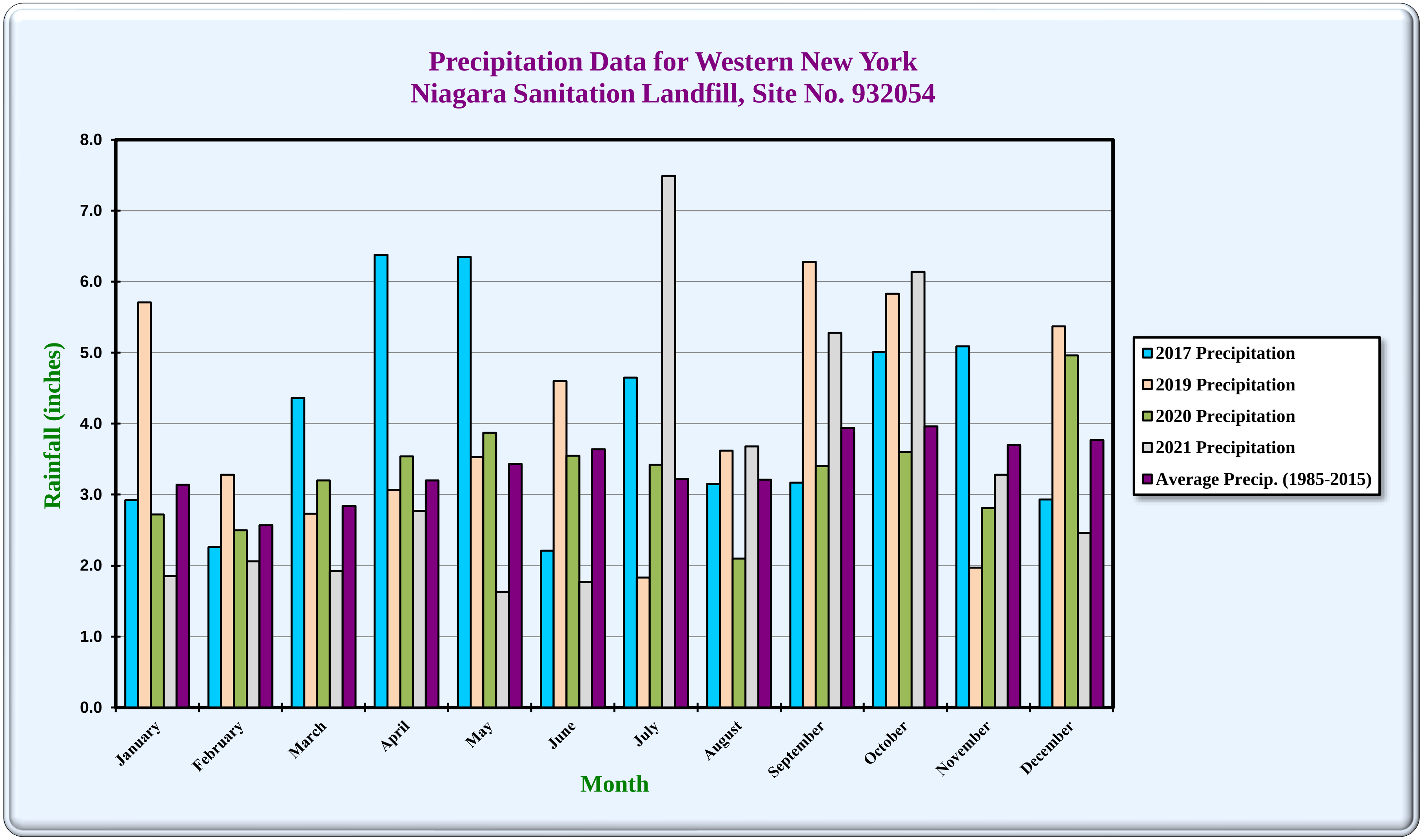
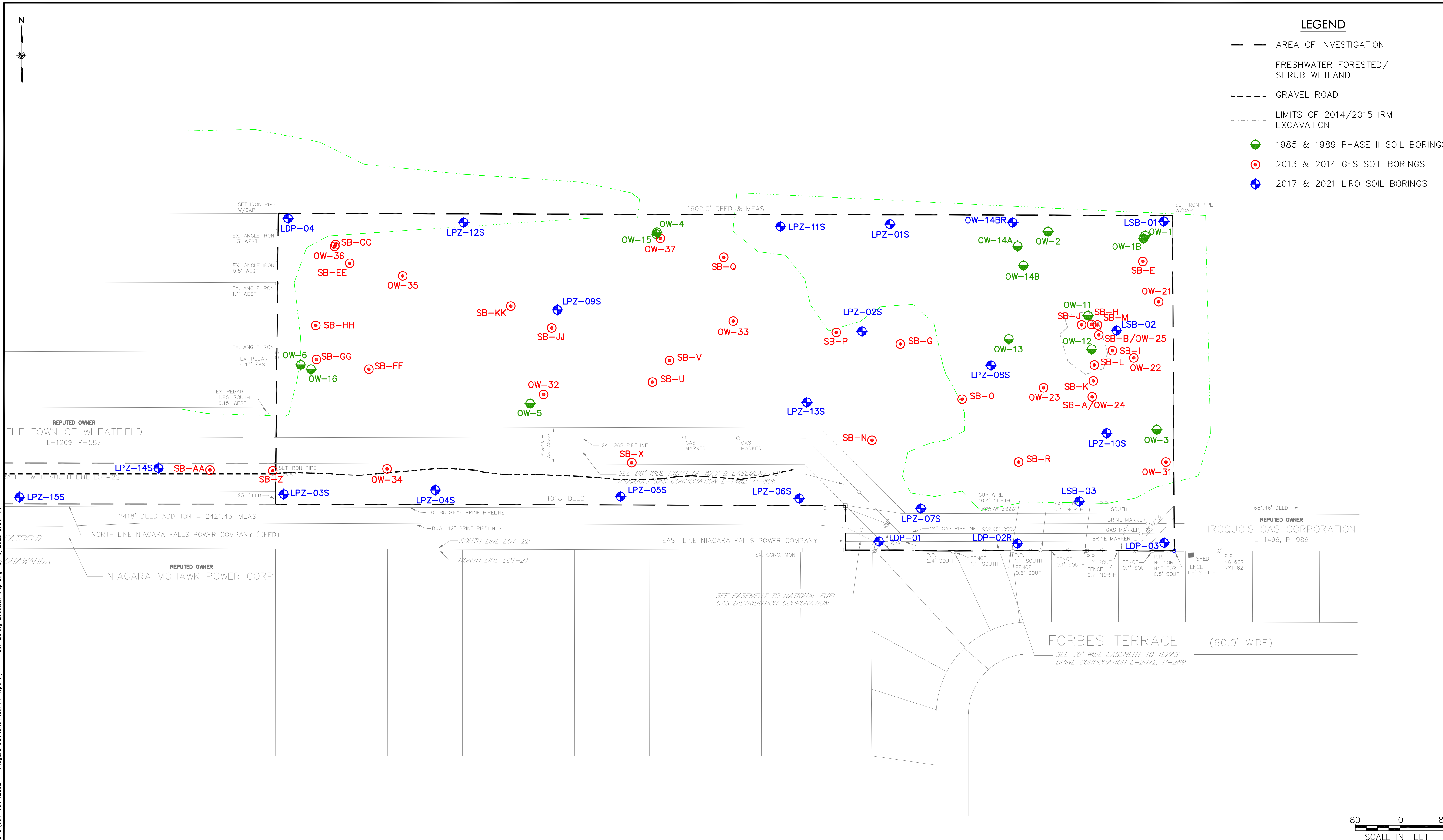



**Figure 3-1. Precipitation Data for Western New York.**




J:\17-013-0289 NYSDEC Standby\CAD\Call-Out 128321 - Niagara Sanitation\GM RI Report\4-1 - Soil Boring Location Map.dwg 8/10/2023 9:30 AM

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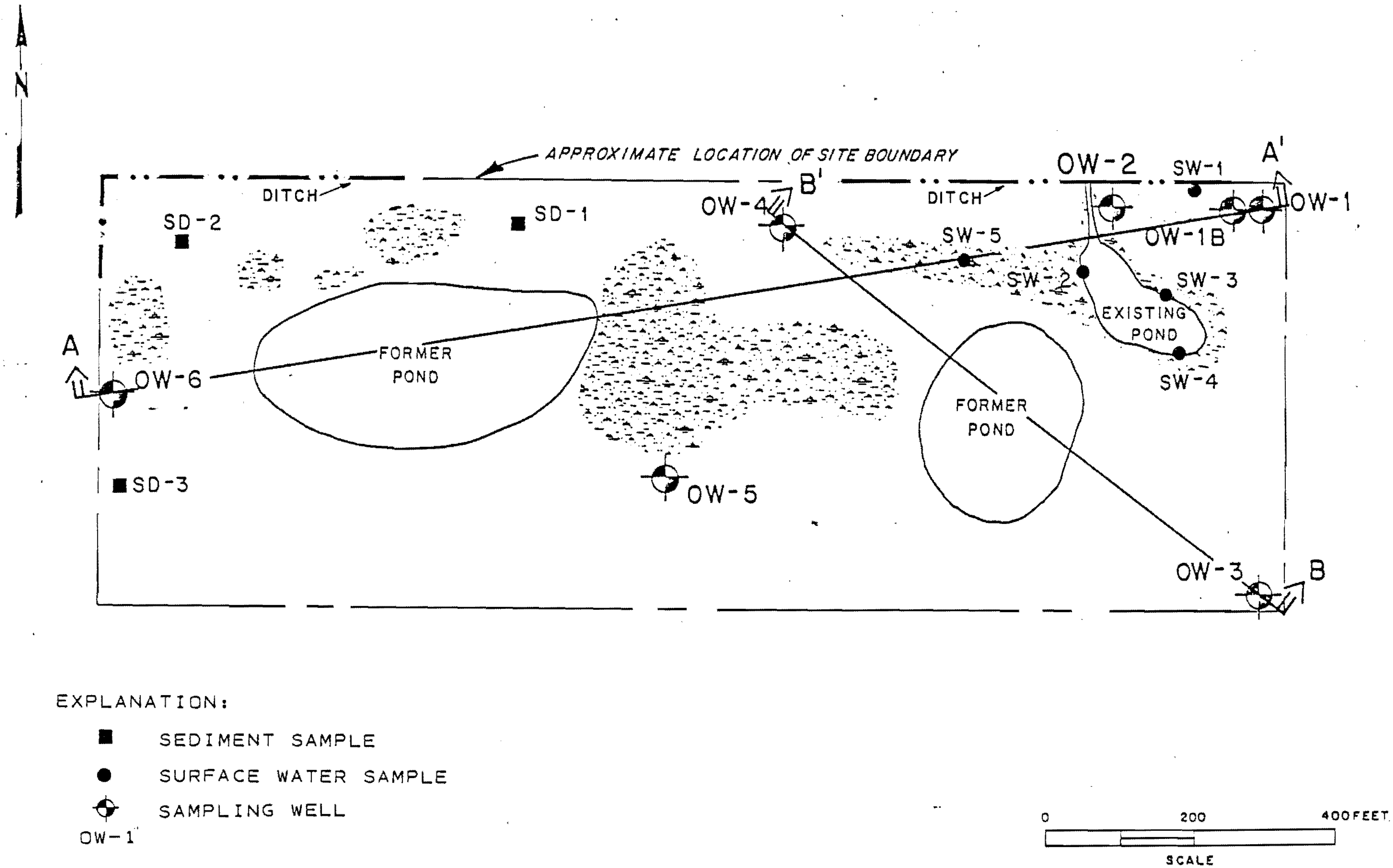
7415 NASH ROAD
TOWN OF WHEATFIELD, NIAGARA COUNTY, NEW YORK
NYSDEC SITE NUMBER 932054

DRAWING TITLE:
SOIL BORING LOCATION MAP

LIRO JOB NO.: 17-013-0289
SHEET OF
FIGURE NO. 4-1

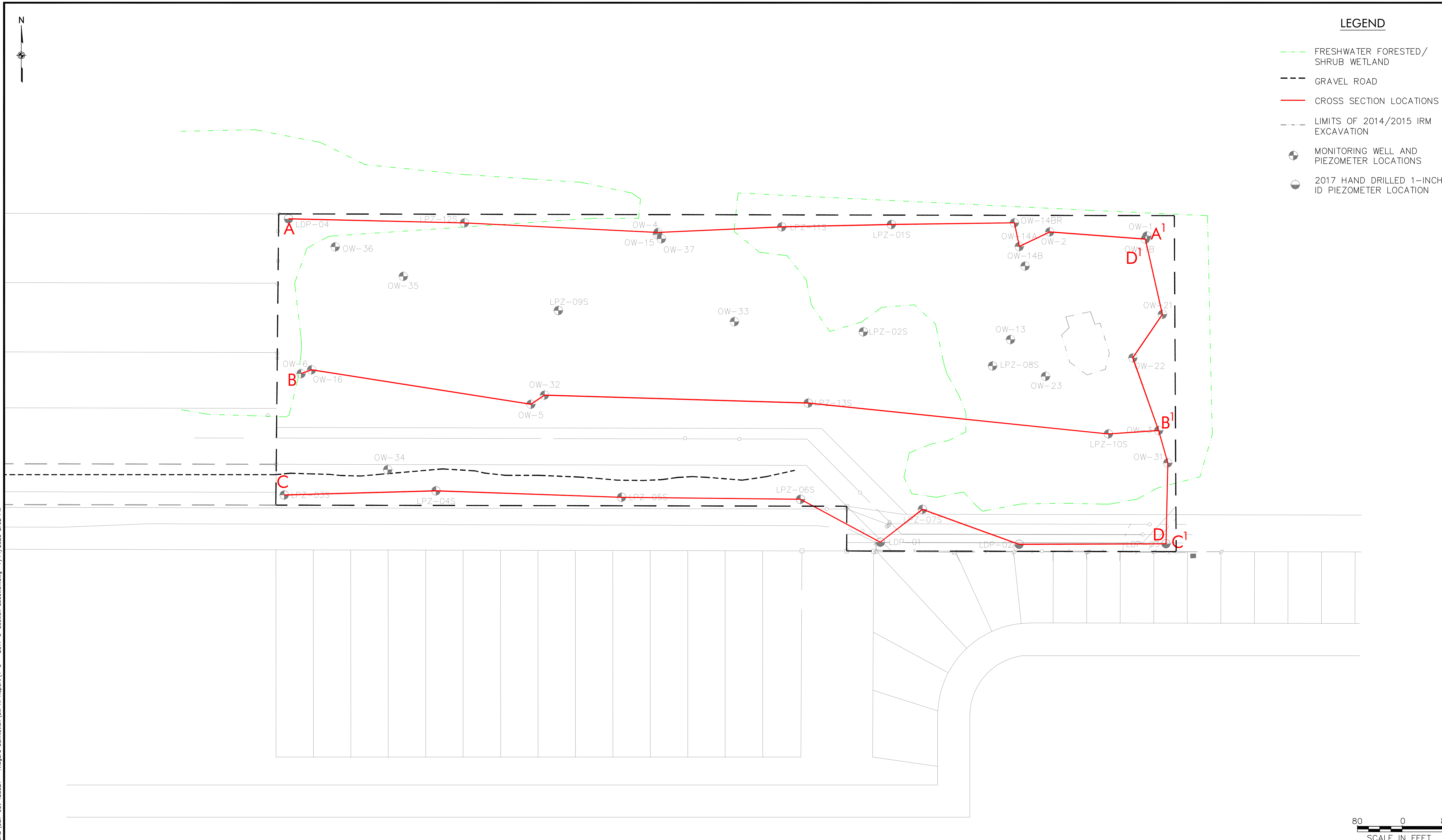
BY D. Tomas DATE 8/3/84




NOTE : OSTERMAN WELL IS LOCATED APPROXIMATELY 1000 FEET WEST OF SITE.

FIGURE 4-2
PLOT PLAN
SHOWING CROSS SECTION LOCATIONS
NASH ROAD SITE

DAMES & MOORE

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TOWN OF WHEATFIELD, NIAGARA COUNTY, NEW YORK
NYSDEC SITE NUMBER 932054

DRAWING TITLE:
CROSS-SECTION LOCATION MAP
2017 REMEDIAL INVESTIGATION

LIRO JOB NO.: 17-013-0289

SHEET OF

FIGURE NO. 4-3

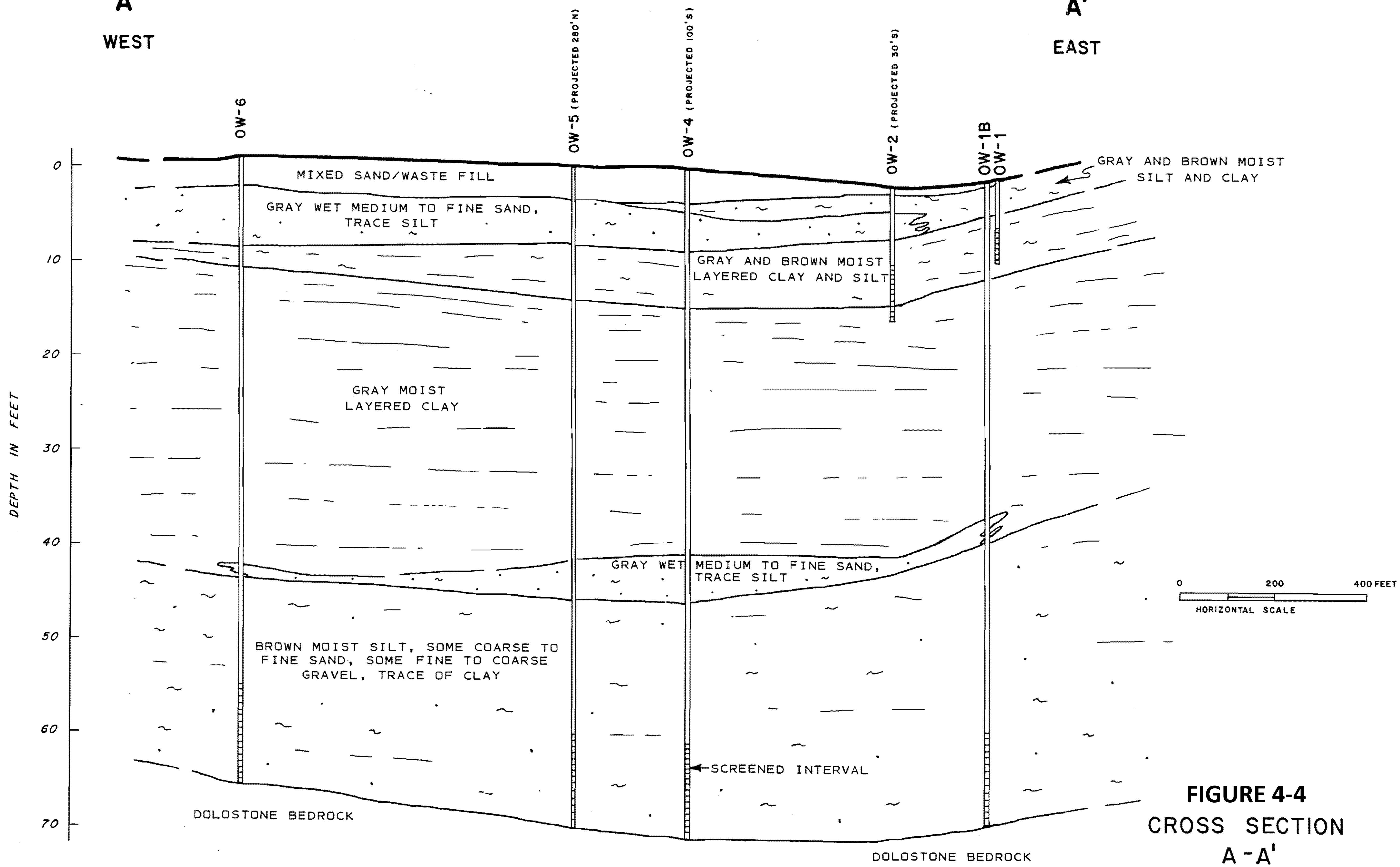



**FIGURE 4-4**
CROSS SECTION
A - A'
NASH ROAD SITE
DAMES & MOORE

F. 133 -60 .7
BY D. Tomsa DATE 8/6/84

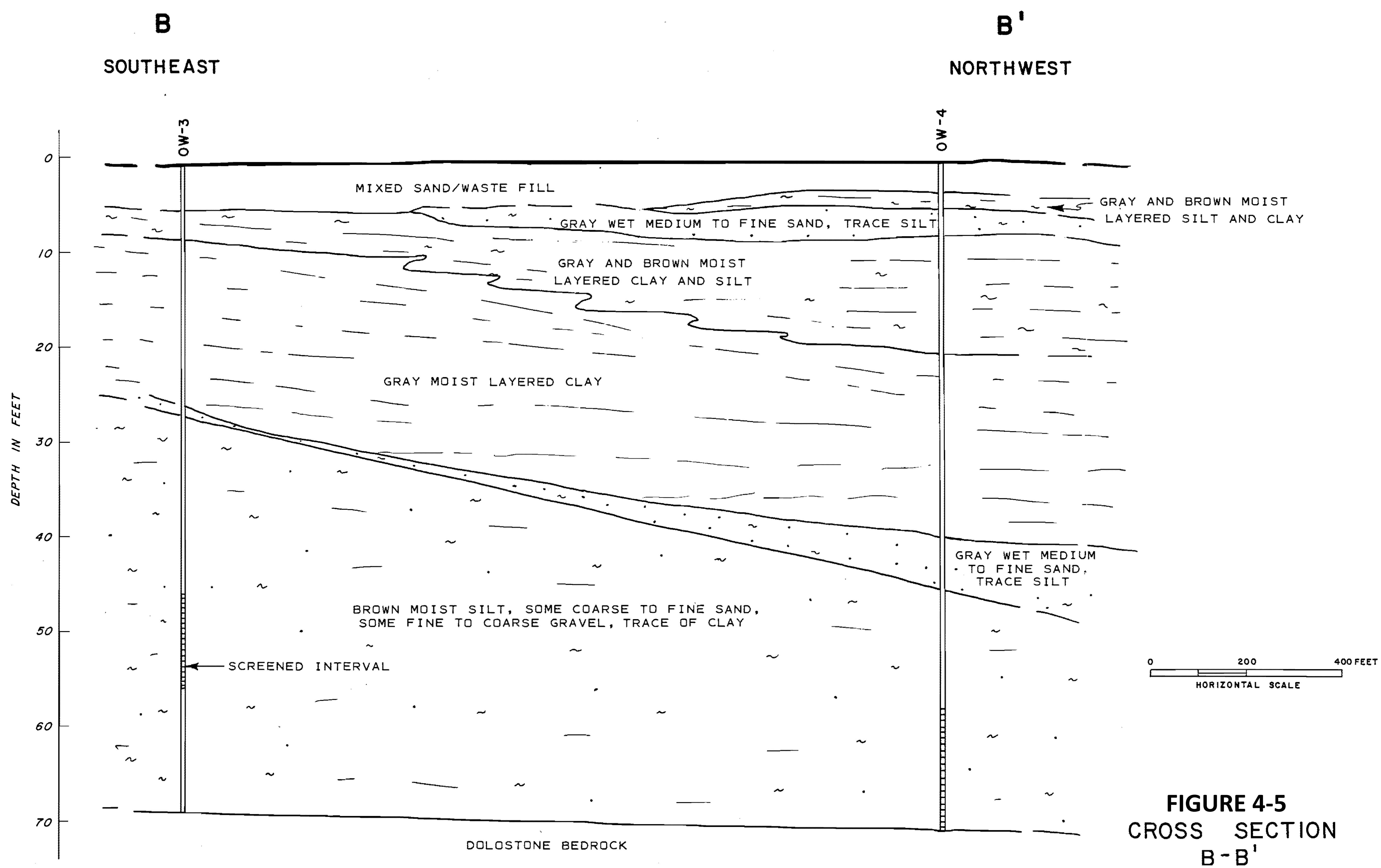
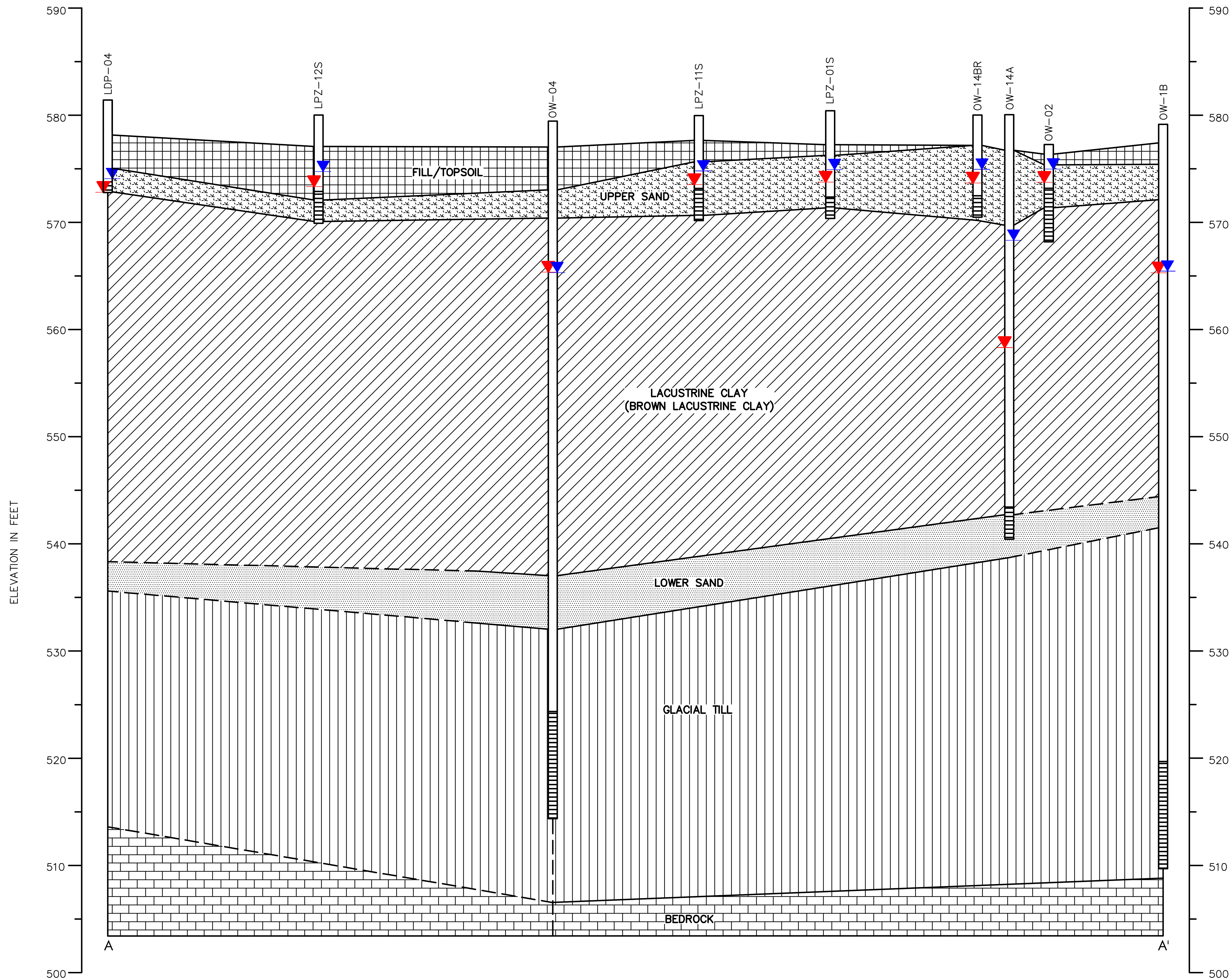



**FIGURE 4-5**
CROSS SECTION
B - B'
NASH ROAD SITE

DAMES & MOORE

BY DATE 8/6/84




NOTES:

1. ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL.
2. WATER LEVELS MEASURED ON SEPTEMBER 25, 2017 AND OCTOBER 17, 2017.
3. REFER TO TEXT FOR DESCRIPTION OF UNITS.

LEGEND

- WATER LEVEL RECORDED SEPTEMBER 25, 2017
- WATER LEVEL RECORDED OCTOBER 10, 2017
- SCREENED INTERVAL
- INFERRED GEOLOGICAL BOUNDARY (DATA NOT AVAILABLE)

80 0 80
HORIZONTAL SCALE IN FEET

5 0 5
VERTICAL SCALE IN FEET

J:\17-013-0289 NYSDEC Standby\CAD\Call-Out 128321 - Niagara Sanitation\GM RI Report\4-6 - Geo Cross Section A-A.dwg 7/14/2023 2:02 PM



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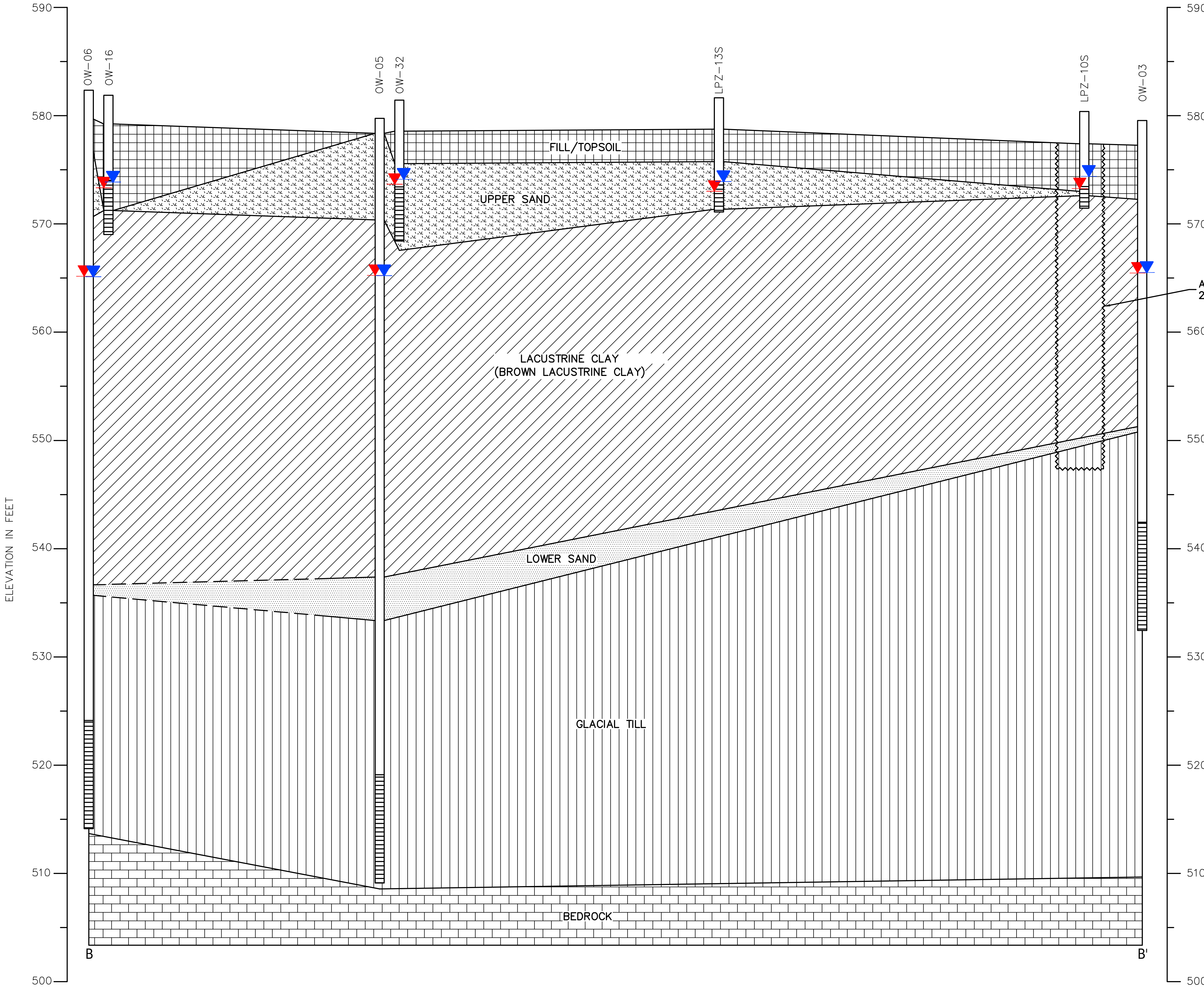
7415 NASH ROAD
TOWN OF WHEATFIELD, NIAGARA COUNTY, NEW YORK
NYSDEC SITE NUMBER 932054

DRAWING TITLE:
GEOLOGIC CROSS-SECTION A-A'
2017 REMEDIAL INVESTIGATION

LIRO JOB NO.: 17-013-0289

SHEET OF

FIGURE NO. 4-6




NOTES:

1. ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL.
2. WATER LEVELS MEASURED ON SEPTEMBER 25, 2017 AND OCTOBER 17, 2017.
3. REFER TO TEXT FOR DESCRIPTION OF UNITS.
4. DISTANCE BETWEEN WELLS OW-06 AND OW-16 OF 9.18 FEET IS SHOWN EXAGGERATED FOR CLARITY.

LEGEND

WATER LEVEL RECORDED SEPTEMBER 25, 2017

WATER LEVEL RECORDED OCTOBER 10, 2017

SCREENED INTERVAL

INFERRED GEOLOGICAL BOUNDARY (DATA NOT AVAILABLE)

80 0 80
HORIZONTAL SCALE IN FEET

5 0 5
VERTICAL SCALE IN FEET

J:\17-013-0289 NYSDEC Standby\CAD\Call-Out 128321 - Niagara Sanitation\GM RI Report\4-7 - Geo Cross Section B-B.dwg 7/14/2023 2:02 PM



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JOB TITLE AND LOCATION:
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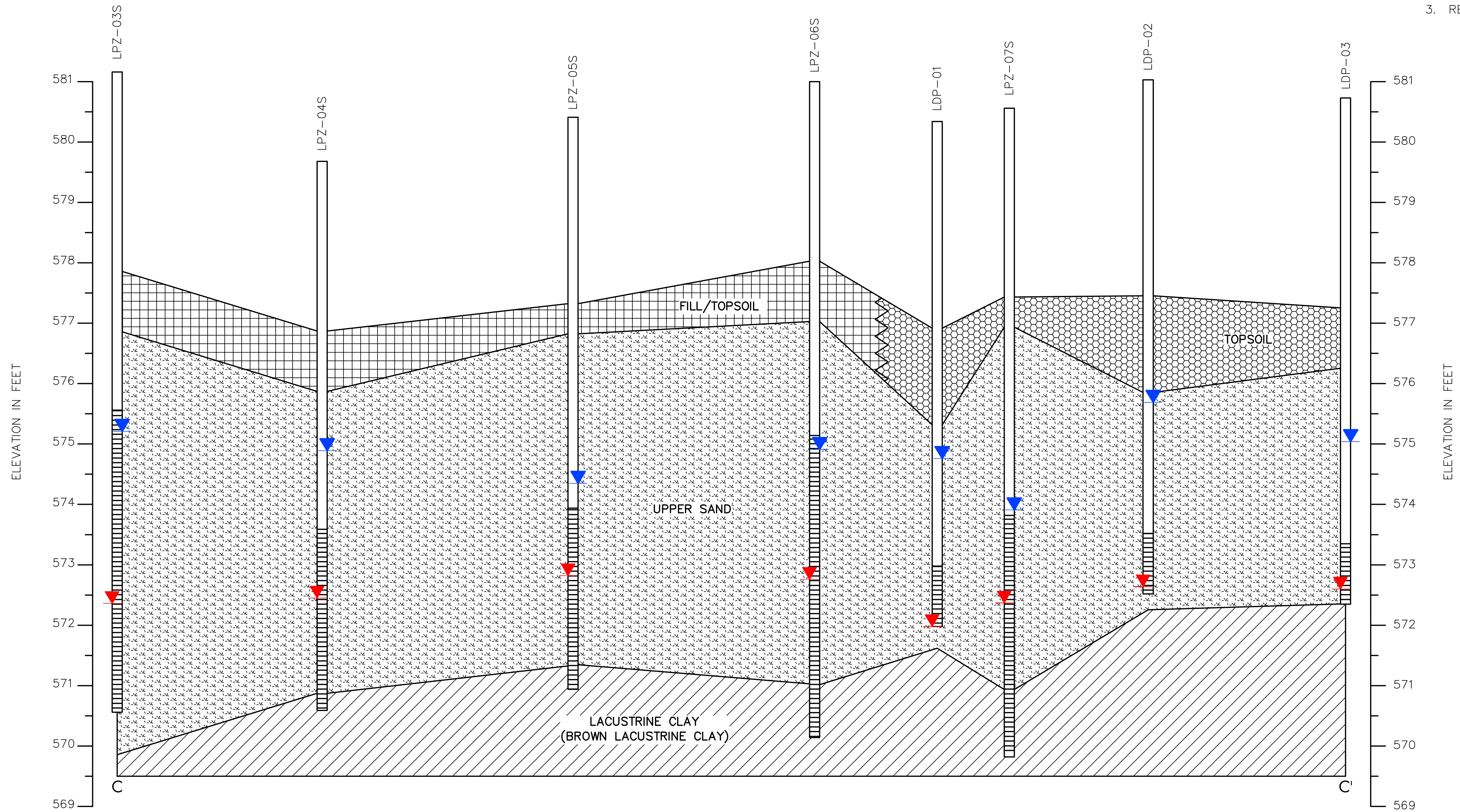
7415 NASH ROAD
TOWN OF WHEATFIELD, NIAGARA COUNTY, NEW YORK
NYSDEC SITE NUMBER 932054

DRAWING TITLE:
GEOLOGIC CROSS-SECTION B-B'
2017 REMEDIAL INVESTIGATION

LIRO JOB NO.: 17-013-0289
SHEET OF
FIGURE NO. 4-7

NOTES:

1. ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL.
2. WATER LEVELS MEASURED ON SEPTEMBER 25, 2017 AND OCTOBER 17, 2017.
3. REFER TO TEXT FOR DESCRIPTION OF UNITS.




LEGEND

WATER LEVEL RECORDED SEPTEMBER 25, 2017

WATER LEVEL RECORDED OCTOBER 10, 2017

SCREENED INTERVAL

80 0 80

HORIZONTAL SCALE IN FEET

1 0 1

VERTICAL SCALE IN FEET



| NO. | DATE | DESCRIPTION |
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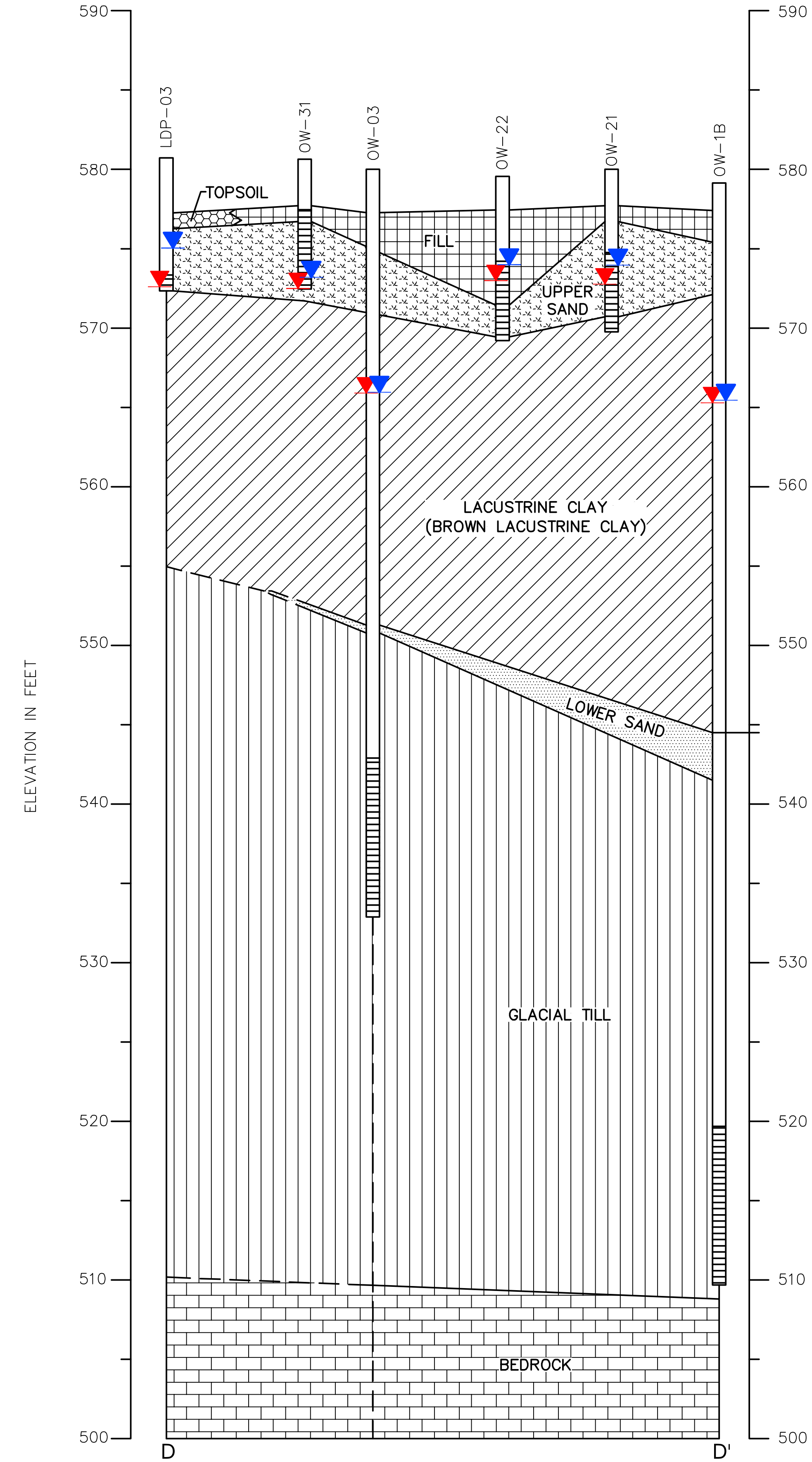
|---|---|---|---|---|
| DESIGNED BY: | | | | SHEET OF |
| CHECKED BY: | | | DRAWING TITLE: GEOLOGIC CROSS-SECTION C-C'<br>2017 REMEDIAL INVESTIGATION | FIGURE NO. 4-8 |
| DRAWN BY: | DATE: JULY 2023 | SCALE: AS SHOWN | | |

J:\17-013-0289 NYSDEC Standby\CAD\Call-Out 128321 - Niagara Sanitation\GM RI Report\4-8 - Geo Cross Section C-C.dwg 7/14/2023 2:02 PM

NOTES:

1. ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL.
2. WATER LEVELS MEASURED ON SEPTEMBER 25, 2017 AND OCTOBER 17, 2017.
3. REFER TO TEXT FOR DESCRIPTION OF UNITS.




LEGEND

- WATER LEVEL RECORDED SEPTEMBER 25, 2017
- WATER LEVEL RECORDED OCTOBER 10, 2017
- SCREENED INTERVAL
- INFERRED GEOLOGICAL BOUNDARY (DATA NOT AVAILABLE)

80 0 80
HORIZONTAL SCALE IN FEET

5 0 5
VERTICAL SCALE IN FEET

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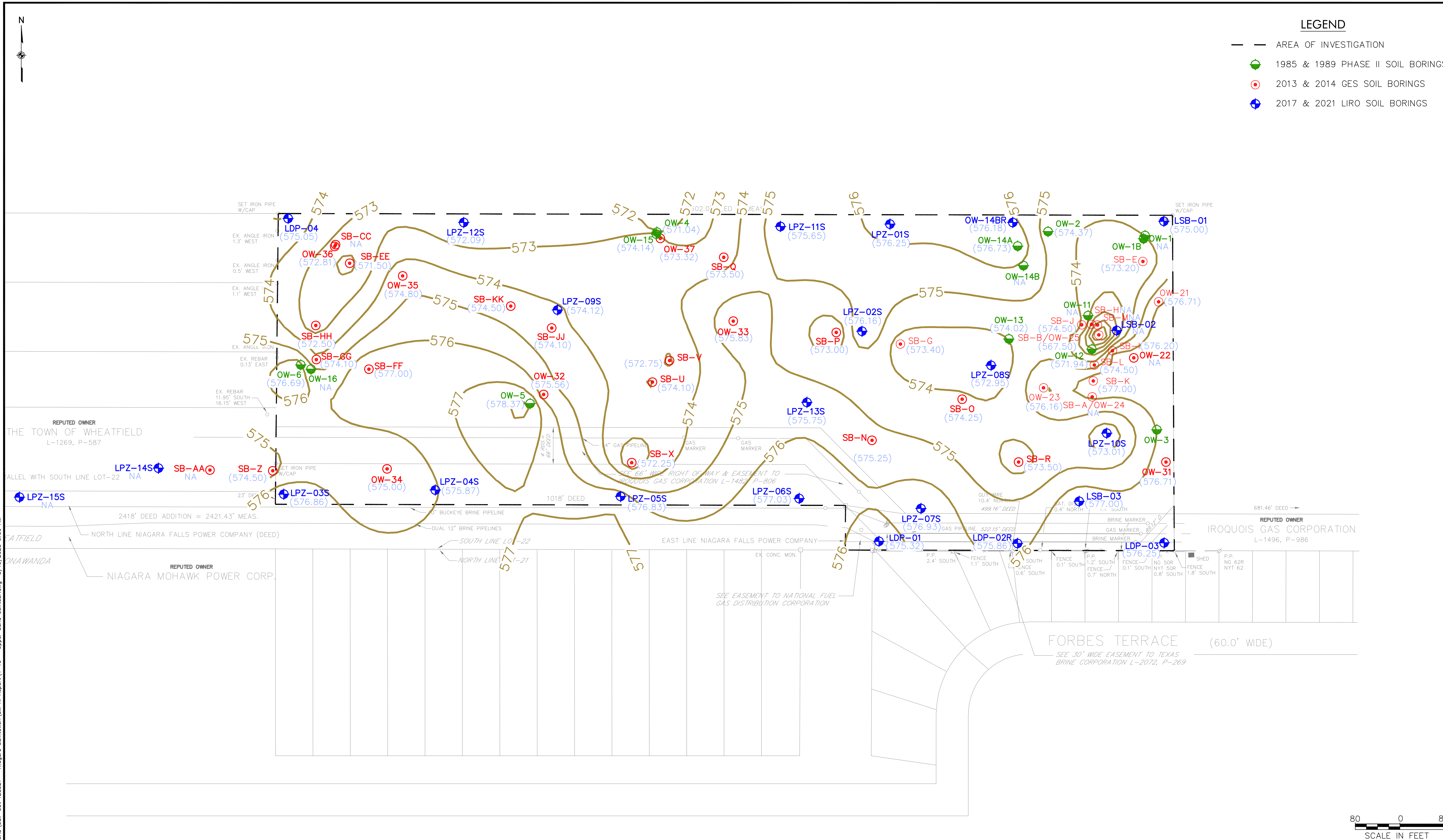
TOWN OF WHEATFIELD, NIAGARA COUNTY, NEW YORK
NYSDEC SITE NUMBER 932054

DRAWING TITLE:
GEOLOGIC CROSS-SECTION D-D'
2017 REMEDIAL INVESTIGATION

LIRO JOB NO.: 17-013-0289
SHEET OF
FIGURE NO. 4-9



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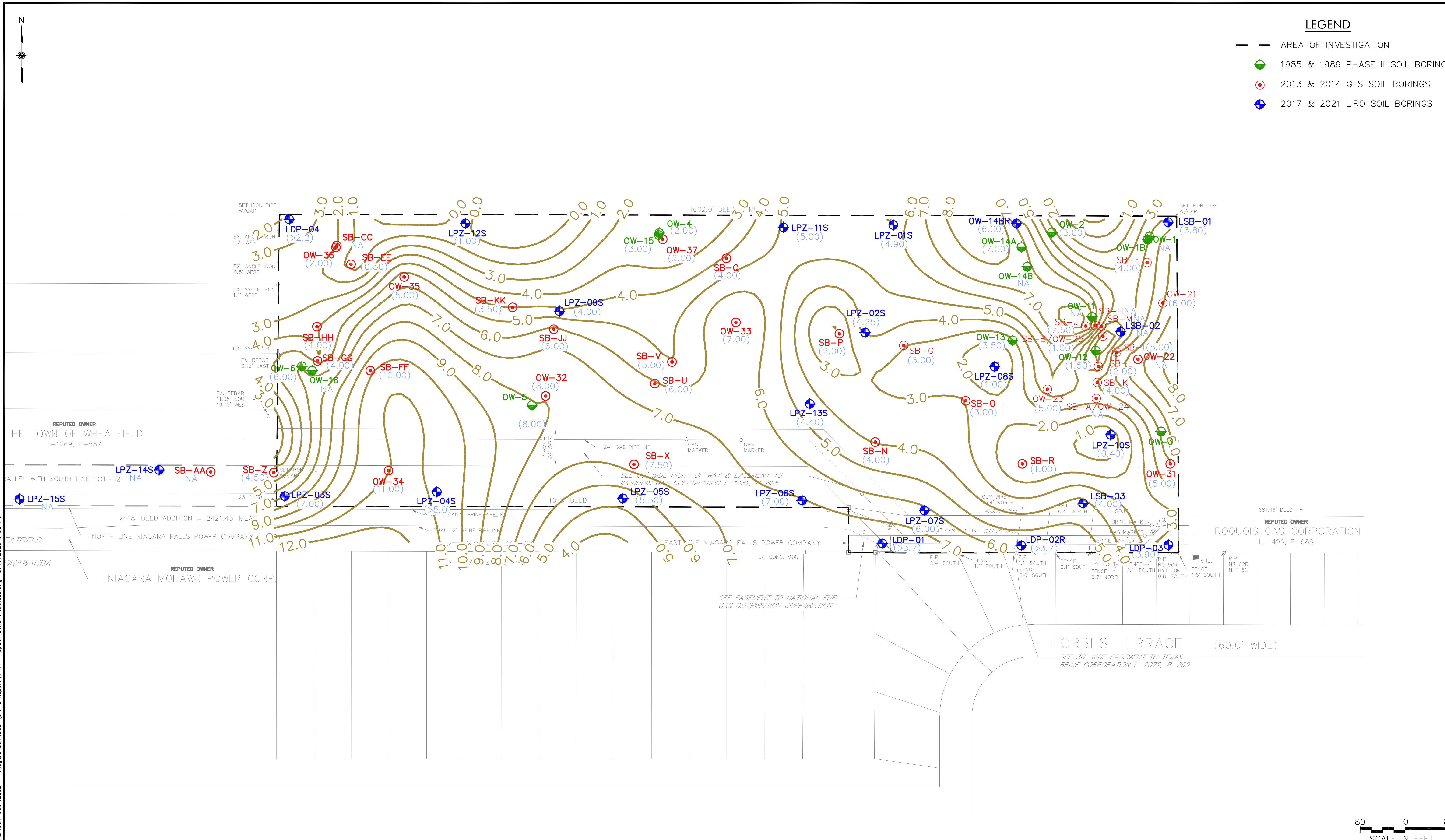
7415 NASH ROAD
TOWN OF WHEATFIELD, NIAGARA COUNTY, NEW YORK
NYSDEC SITE NUMBER 932054

DRAWING TITLE:
UPPER SAND
SURFACE CONTOUR MAP

LIRO JOB NO.: 17-013-0289

SHEET OF

FIGURE NO. 4-10

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NYSDEC SITE NUMBER 932054

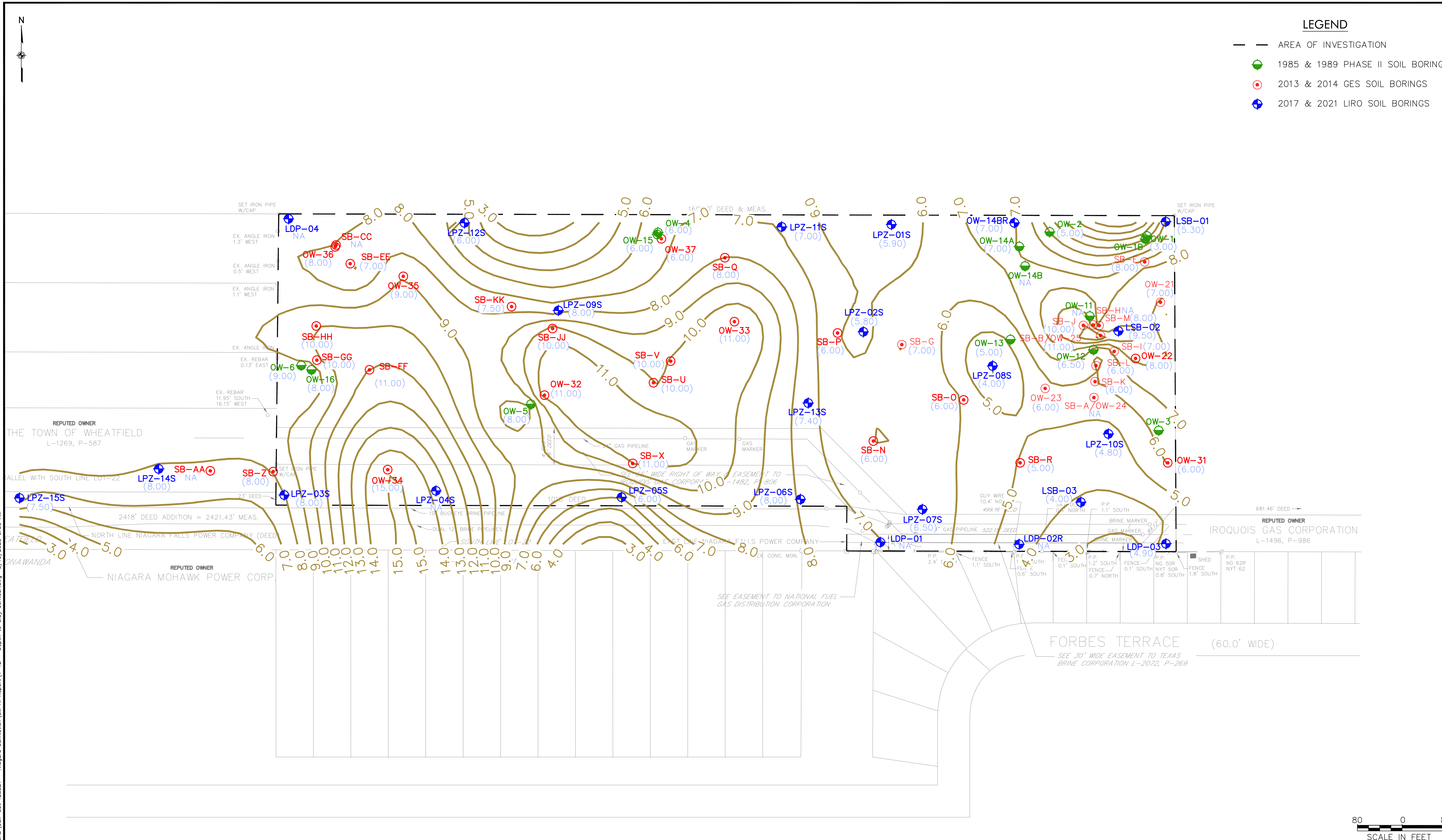
DRAWING TITLE:
UPPER SAND
THICKNESS CONTOUR MAP

LIRO JOB NO.: 17-013-0289

SHEET OF

FIGURE NO. 4-11

J:\17-013-0289 NYSDEC Standby\CAD\Call-Out 128321 - Niagara Sanitation\GM RI Report\4-11 - Upper Sand Thickness.dwg 8/10/2023 9:30 AM



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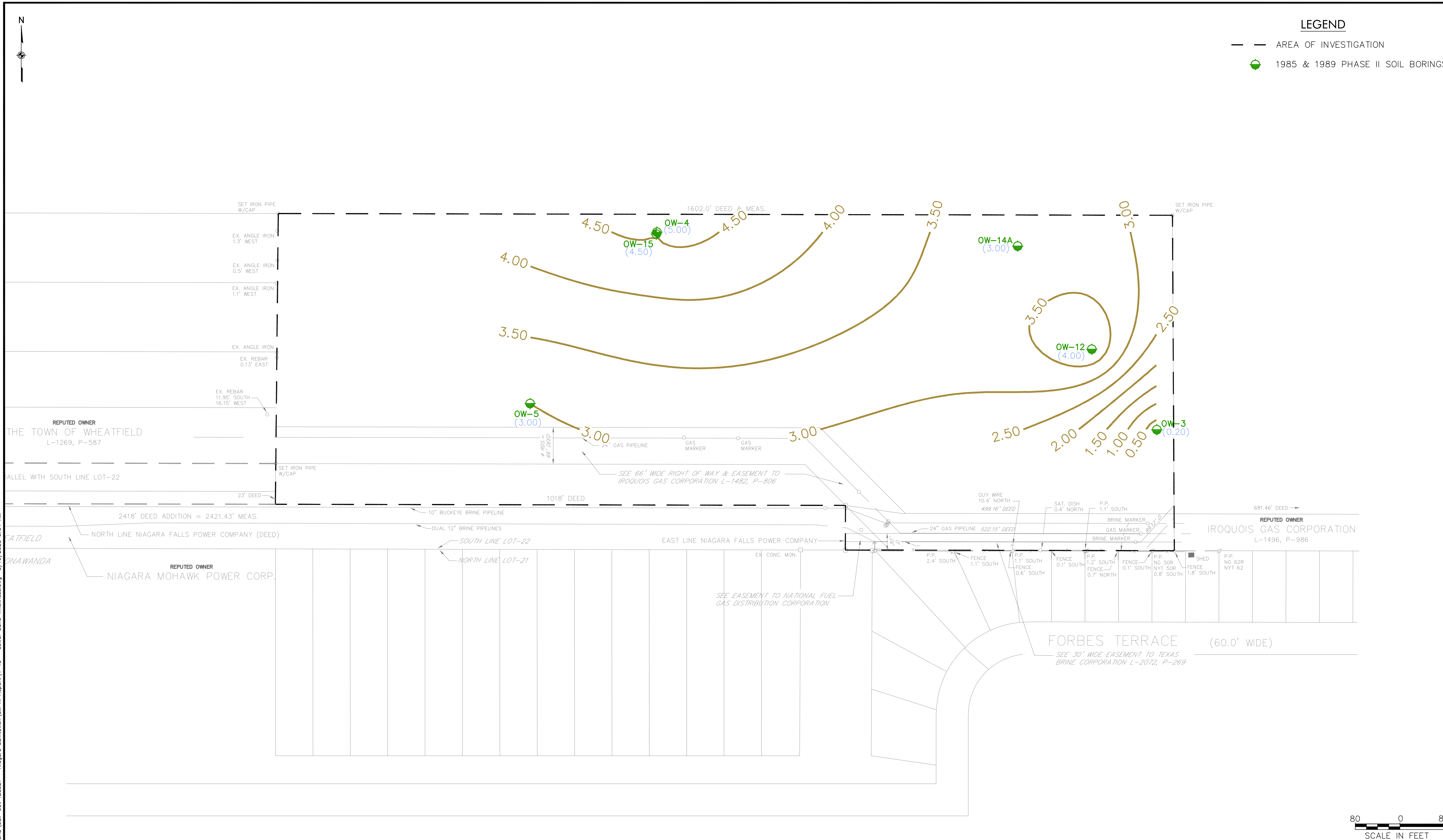
7415 NASH ROAD
TOWN OF WHEATFIELD, NIAGARA COUNTY, NEW YORK
NYSDEC SITE NUMBER 932054

DRAWING TITLE:
DEPTH TO GRAY-BROWN SILTY CLAY CONTOUR MAP

LIRO JOB NO.: 17-013-0289
SHEET OF
FIGURE NO. 4-12

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TOWN OF WHEATFIELD, NIAGARA COUNTY, NEW YORK
NYSDEC SITE NUMBER 932054

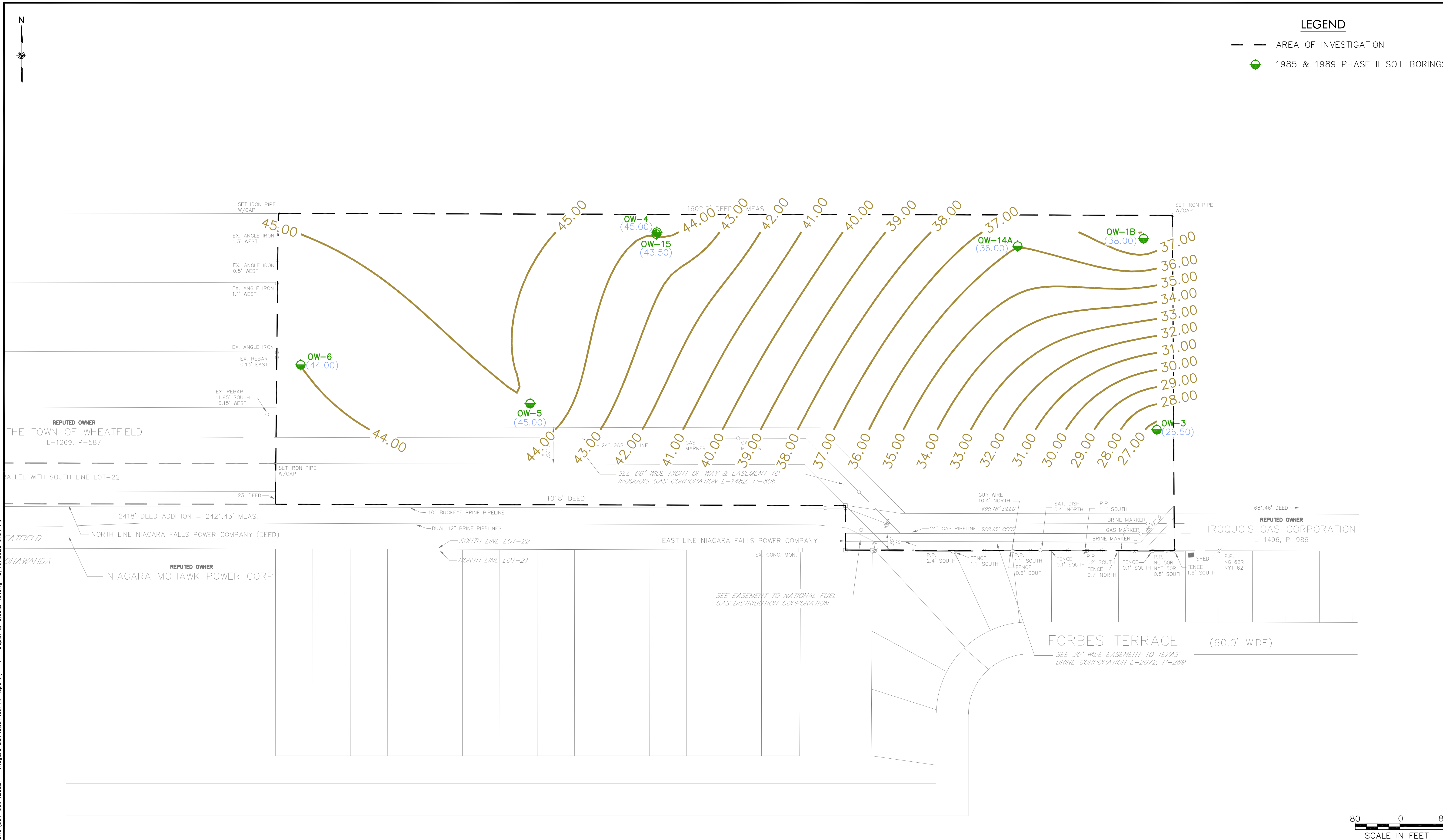
DRAWING TITLE:
LOWER SAND THICKNESS MAP

LIRO JOB NO.: 17-013-0289

SHEET OF

FIGURE NO. 4-13

J:\17-013-0289 NYSDEC Standby\CAD\Call-Out 128321 - Niagara Sanitation\GM RI Report\4-13 - Lower Sand Thickness.dwg 8/10/2023 9:54 AM

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LiRo Engineers, Inc.
690 Delaware Avenue
Buffalo, New York

PROJ. ENG.:
DESIGNED BY:
CHECKED BY:
DRAWN BY:

CLIENT: NEW YORK STATE OF OPPORTUNITY — Department of Environmental Conservation

DATE: JULY 2023

SCALE: AS SHOWN

JOB TITLE AND LOCATION:
NIAGARA SANITATION / NASH ROAD LANDFILL SITE
7415 NASH ROAD
TOWN OF WHEATFIELD, NIAGARA COUNTY, NEW YORK
NYSDEC SITE NUMBER 932054

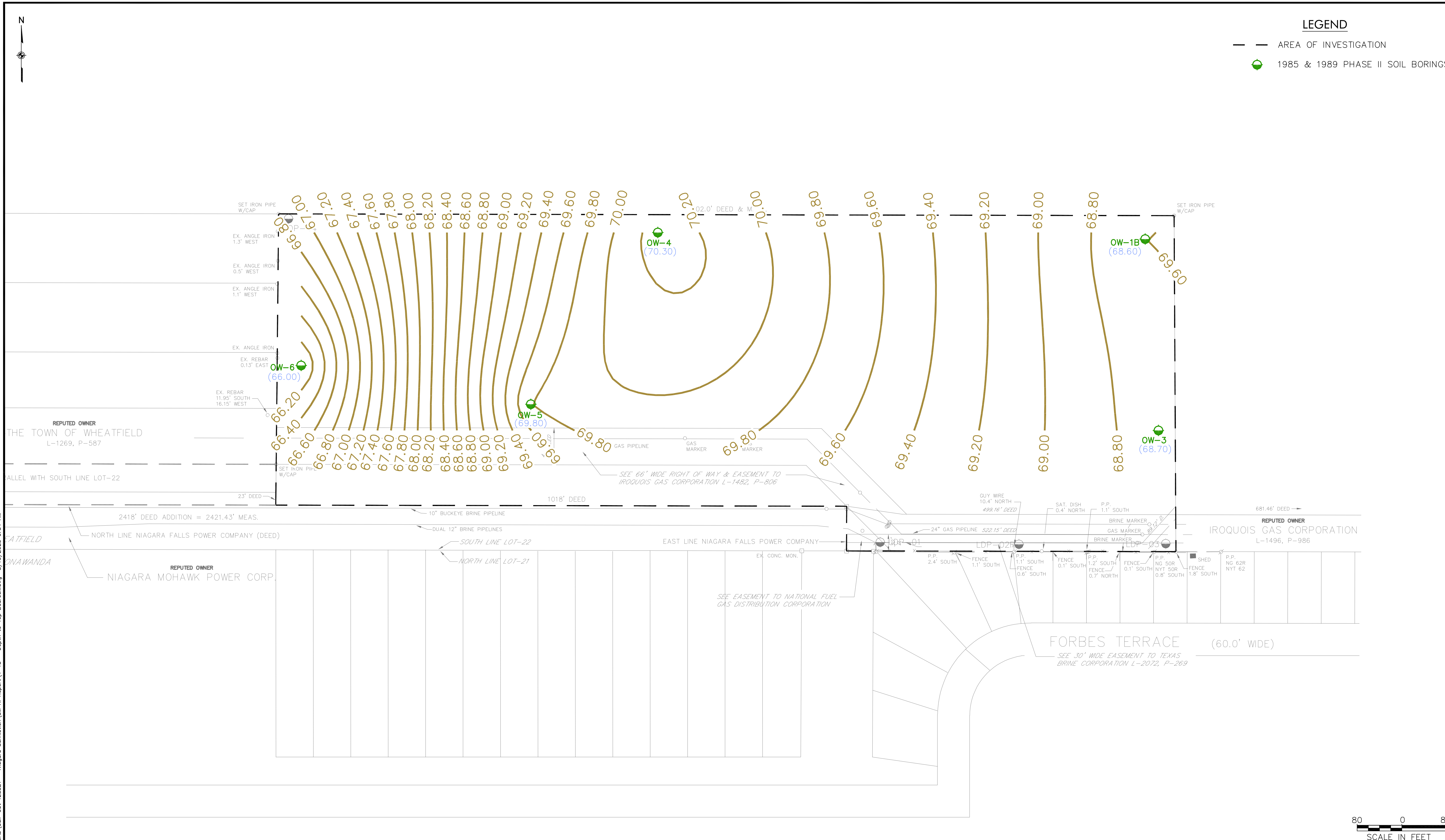
DRAWING TITLE:
DEPTH TO THE GLACIAL TILL CONTOUR MAP

LIRO JOB NO.: 17-013-0289

SHEET OF

FIGURE NO. 4-14

J:\17-013-0289 NYSDEC Standby\CAD\Call-Out 128321 - Niagara Sanitation\GM RI Report\4-14 - Depth to Glacial Till.dwg 8/10/2023 9:54 AM




J:\17-013-0289 NYSDEC Standby\CAD\Cell-Out 128321 – Niagara Sanitation\GM RI Report\4-15 – Depth to Top Bedrock.dwg 8/10/2023 9:54 AM

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DRAWN BY:

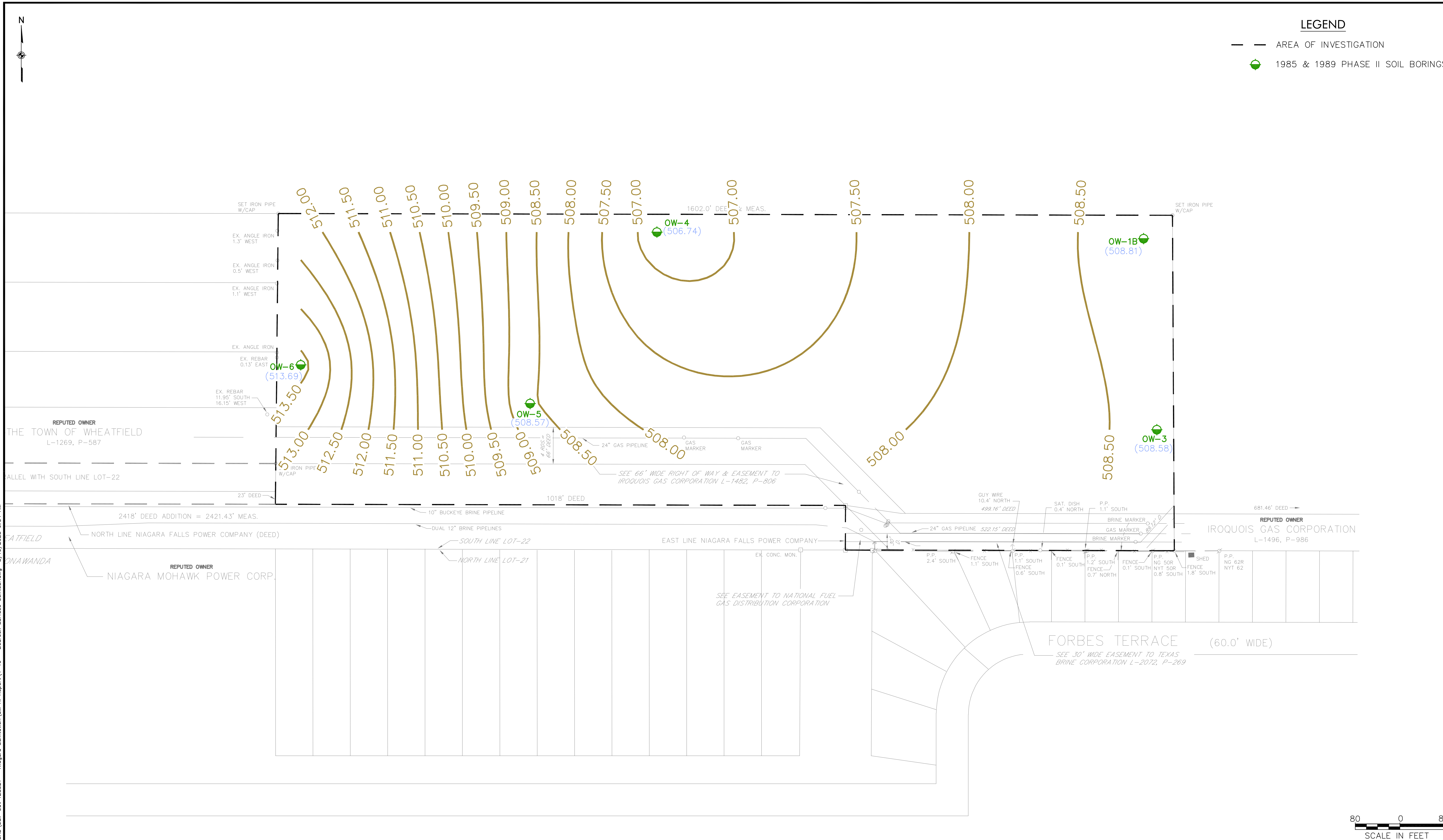
CLIENT: NEW YORK STATE OF OPPORTUNITY — Department of Environmental Conservation

DATE: JULY 2023
SCALE: AS SHOWN

JOB TITLE AND LOCATION:
NIAGARA SANITATION / NASH ROAD LANDFILL SITE
7415 NASH ROAD
TOWN OF WHEATFIELD, NIAGARA COUNTY, NEW YORK
NYSDEC SITE NUMBER 932054

DRAWING TITLE:
DEPTH TO TOP OF BEDROCK
CONTOUR MAP

LIRO JOB NO.: 17-013-0289
SHEET OF
FIGURE NO. 4-15




J:\17-013-0289 NYSDEC Standby\CAD\Call-Out 128321 - Niagara Sanitation\GM RI Report\4-16 - Bedrock Surface Contour.dwg 8/10/2023 9:54 AM

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DATE: JULY 2023
SCALE: AS SHOWN

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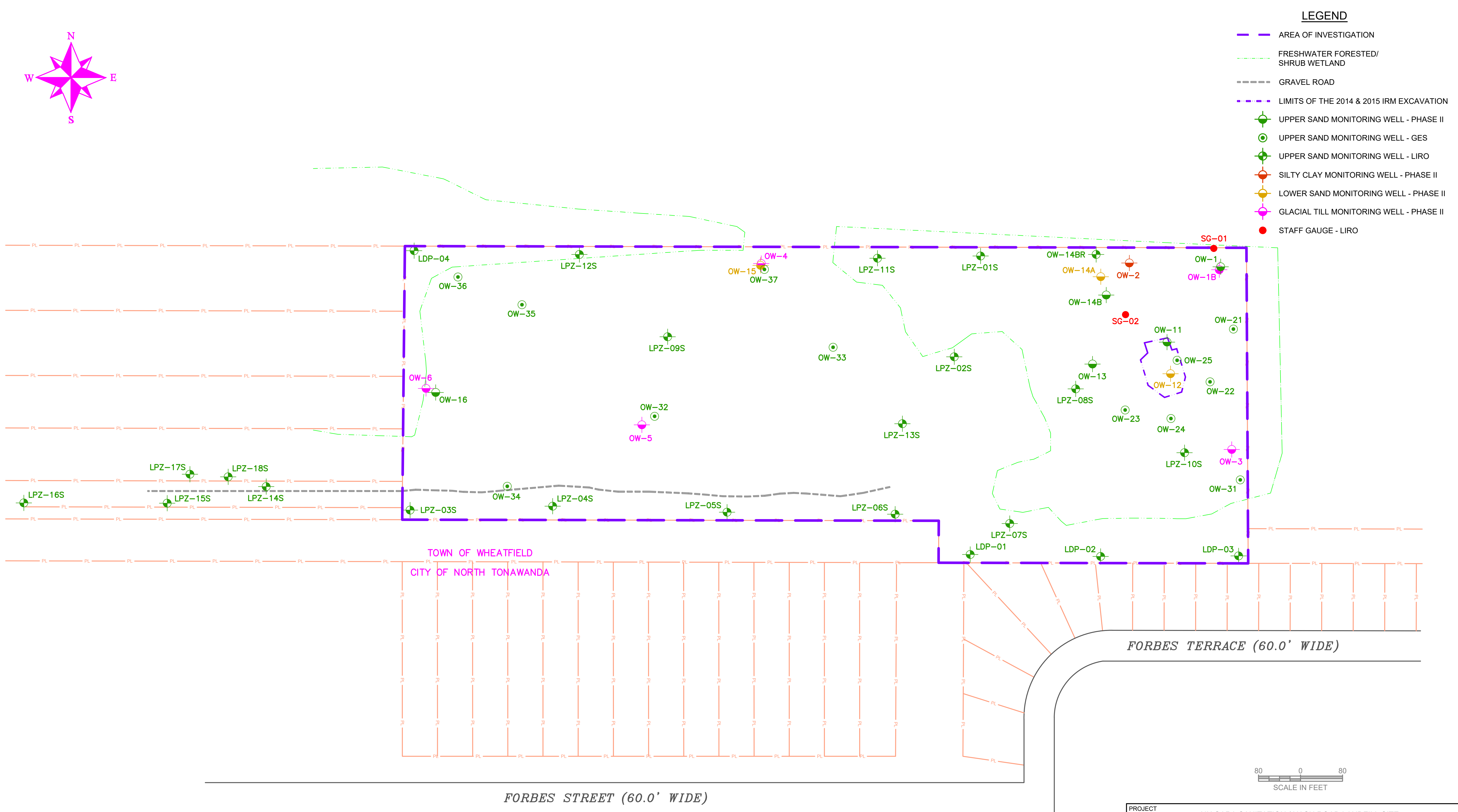
NIAGARA SANITATION / NASH ROAD LANDFILL SITE
7415 NASH ROAD
TOWN OF WHEATFIELD, NIAGARA COUNTY, NEW YORK
NYSDEC SITE NUMBER 932054

DRAWING TITLE:
BEDROCK SURFACE ELEVATION CONTOUR MAP

LIRO JOB NO.: 17-013-0289
SHEET OF
FIGURE NO. 4-16






GENERAL SURVEY NOTES:

1. ORIGINAL SURVEY COMPLETED BY McINTOSH & McINTOSH, P.C. IN 2014 FOR THE OCCIDENTAL CHEMICAL CORPORATION.
2. LIRO USED THIS SURVEY AS THEIR BASE MAP FOR THE 2017 NYSDEC REMEDIAL INVESTIGATION.
3. LIRO FIGURE 5-1 (MONITORING WELL LOCATION MAP) WAS IMPORTED INTO AUTOCAD BY GMM IN SEPTEMBER 2023 TO REPRODUCE THIS FIGURE.
4. LIRO FIGURE 4-1 (SOIL BORING LOCATION MAP) WAS IMPORTED INTO AUTOCAD BY GMM IN SEPTEMBER 2023 TO OBTAIN THE SOIL BORING LOCATIONS.
5. THE NYSDEC BORDER TEMPLATE WAS IMPORTED INTO THE DRAWING ON OCTOBER 8, 2023.



Drawing Name: 01 Sites - Active/Niagara Sanitation/2023 Sampling/AutoCAD/Niagara Sanitation - 2023 Sampling Report.dwg
Operator Name: Glenn M. May Plot Date: September 17, 2024

PROJECT
NIAGARA SANITATION / NASH ROAD LANDFILL SITE
7415 NASH ROAD
TOWN OF WHEATFIELD, NIAGARA COUNTY, NEW YORK
NYSDEC SITE NUMBER 932054

TITLE
MONITORING WELL AND STAFF GAUGE LOCATION MAP BY GEOLOGIC UNIT

NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

| | | | | |
|---|---|---|---|---|
| SITE NO.: C915299 A | | | FILE NO.: NOT APPLICABLE | |
| DESIGN | GMM | 10/08/2023 | SCALE AS SHOWN | REV. 0 |
| CADD | GMM | 10/08/2023 | FIGURE 5-1 | |
| REVISED | GMM | 09/17/2024 | | |
| REVIEW | | | | |

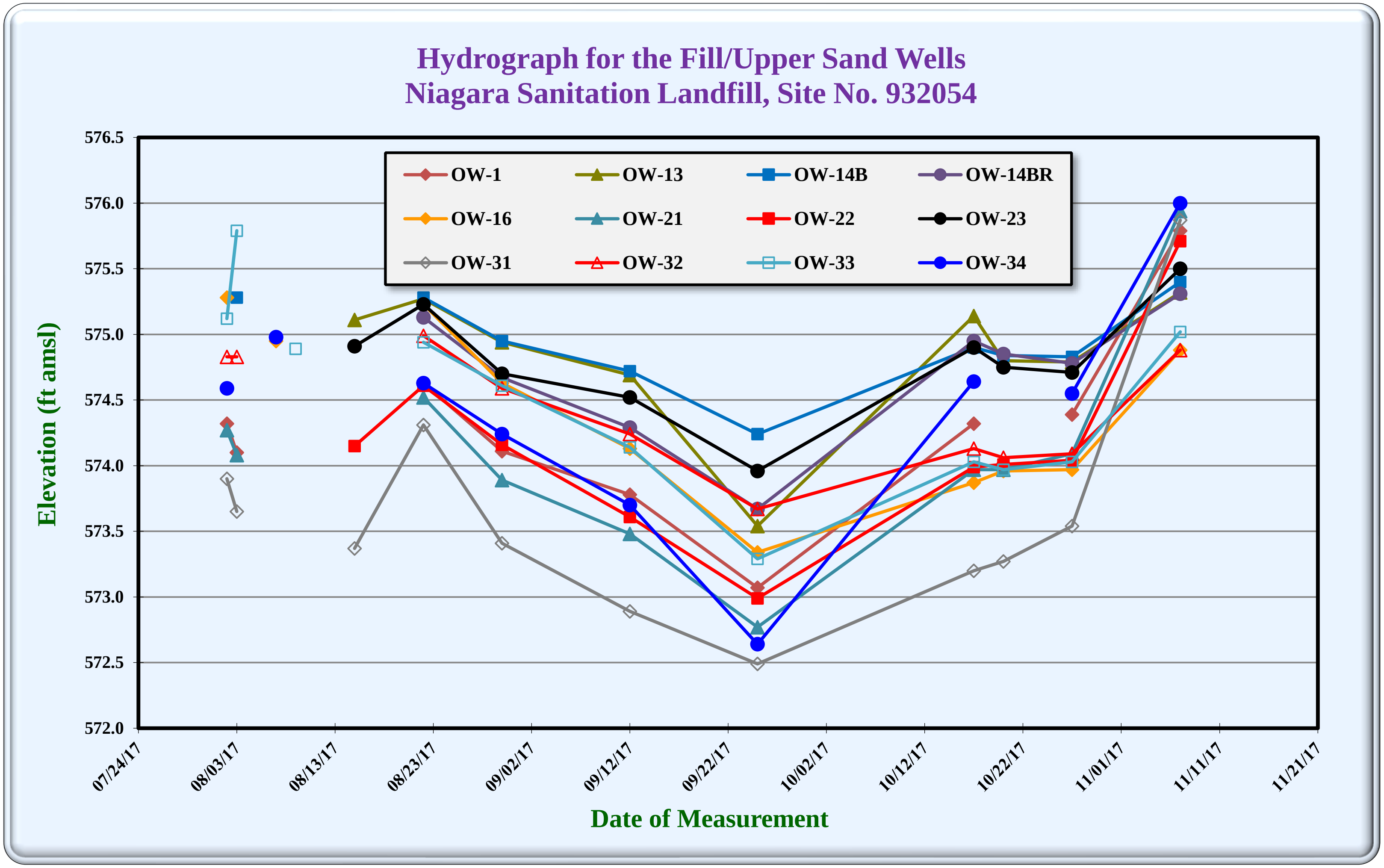



Figure 5-2. Hydrograph for the Fill/Upper Sand Wells at the Niagara Sanitation Landfill Site.

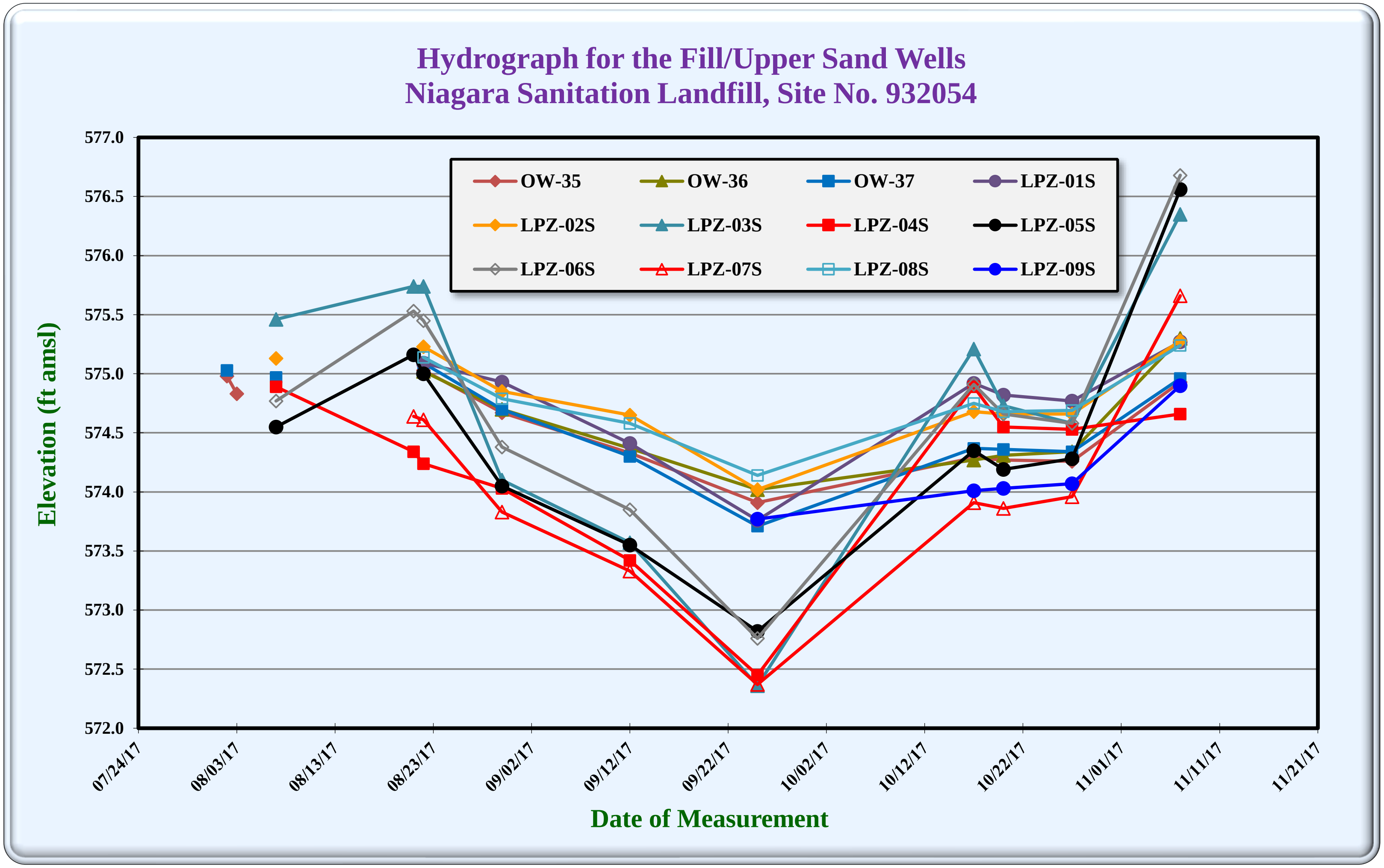



**Figure 5-3. Hydrograph for the Fill/Upper Sand Wells at the Niagara Sanitation Landfill Site.**

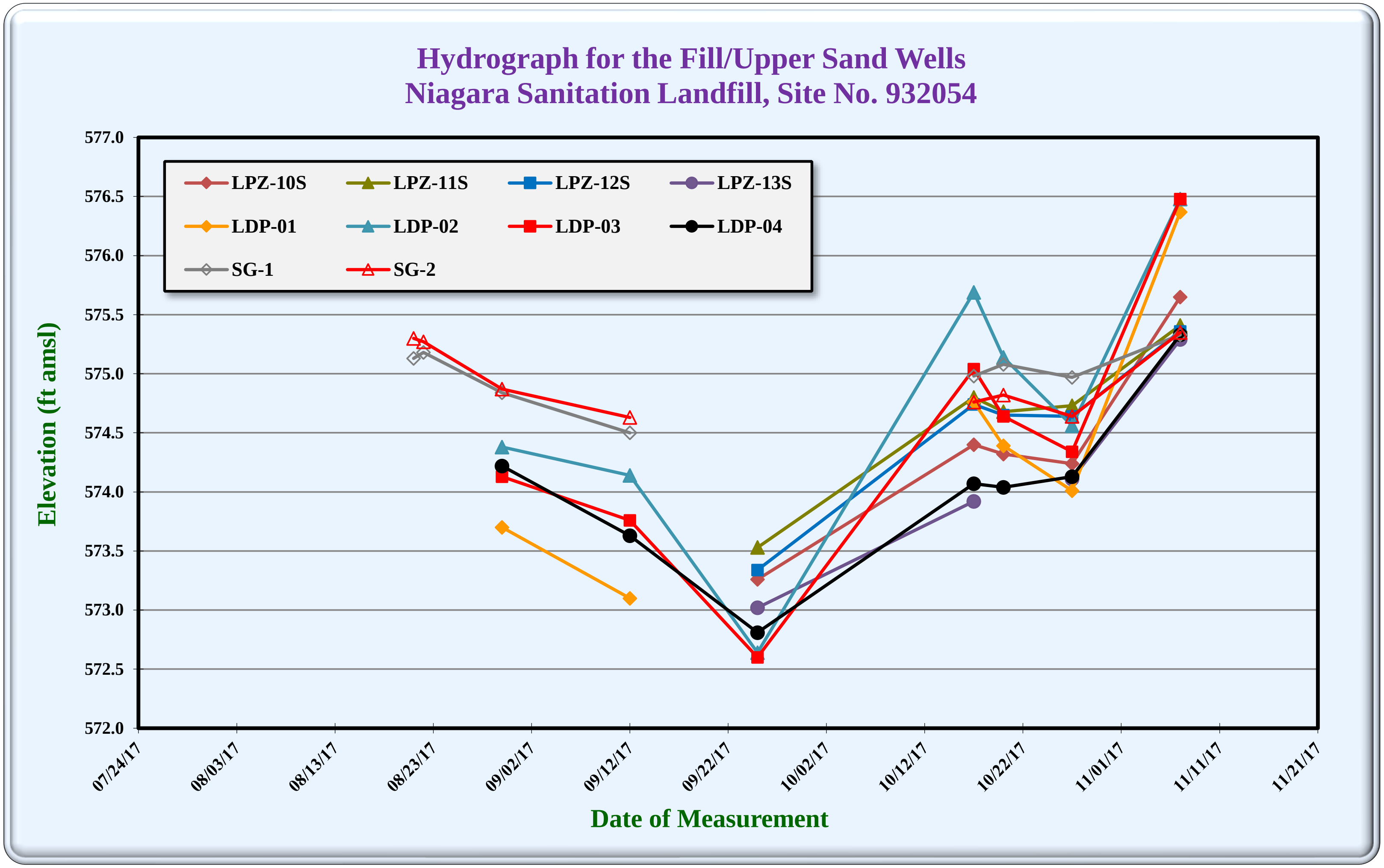



**Figure 5-4. Hydrograph for the Fill/Upper Sand Wells at the Niagara Sanitation Landfill Site.**

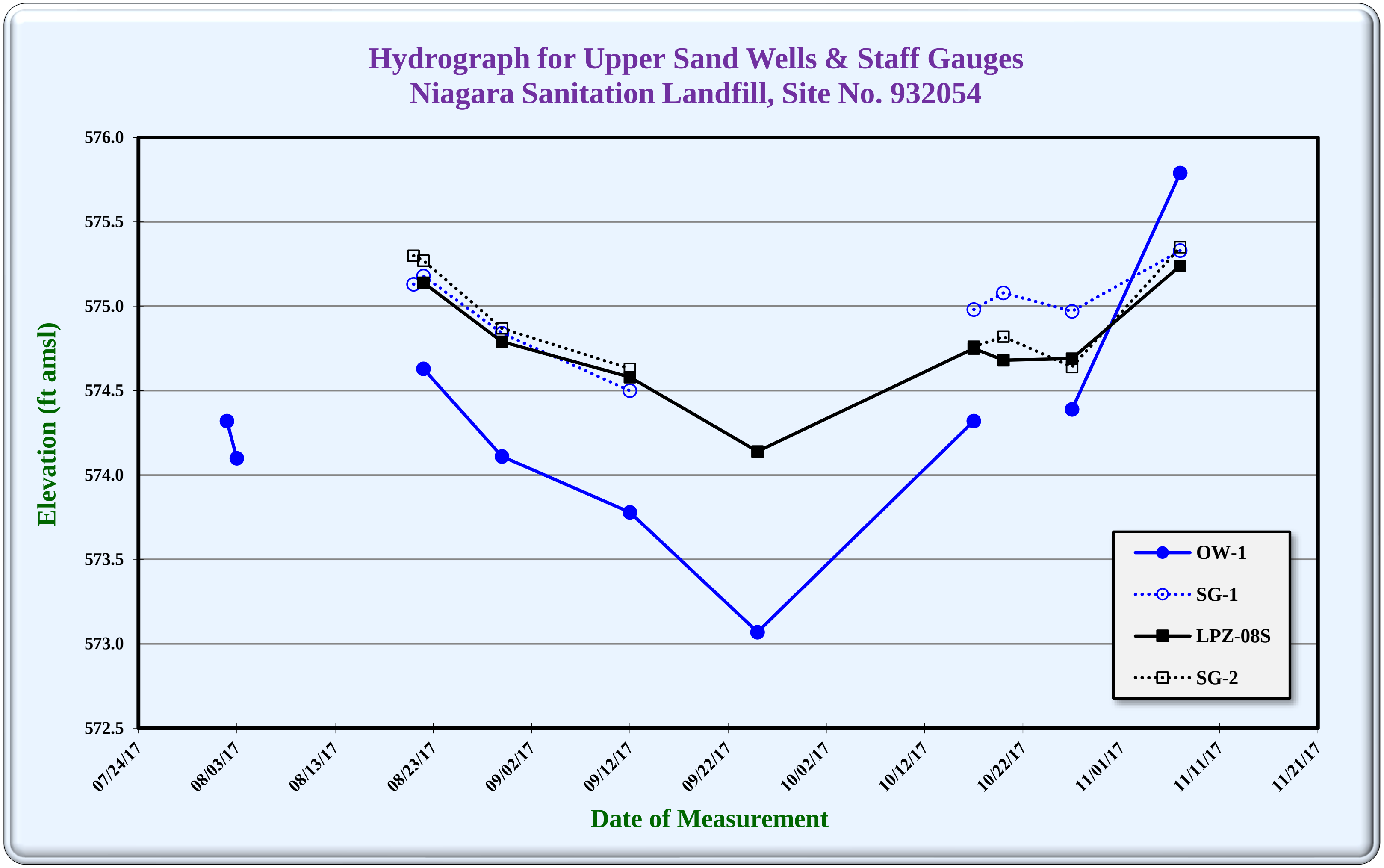
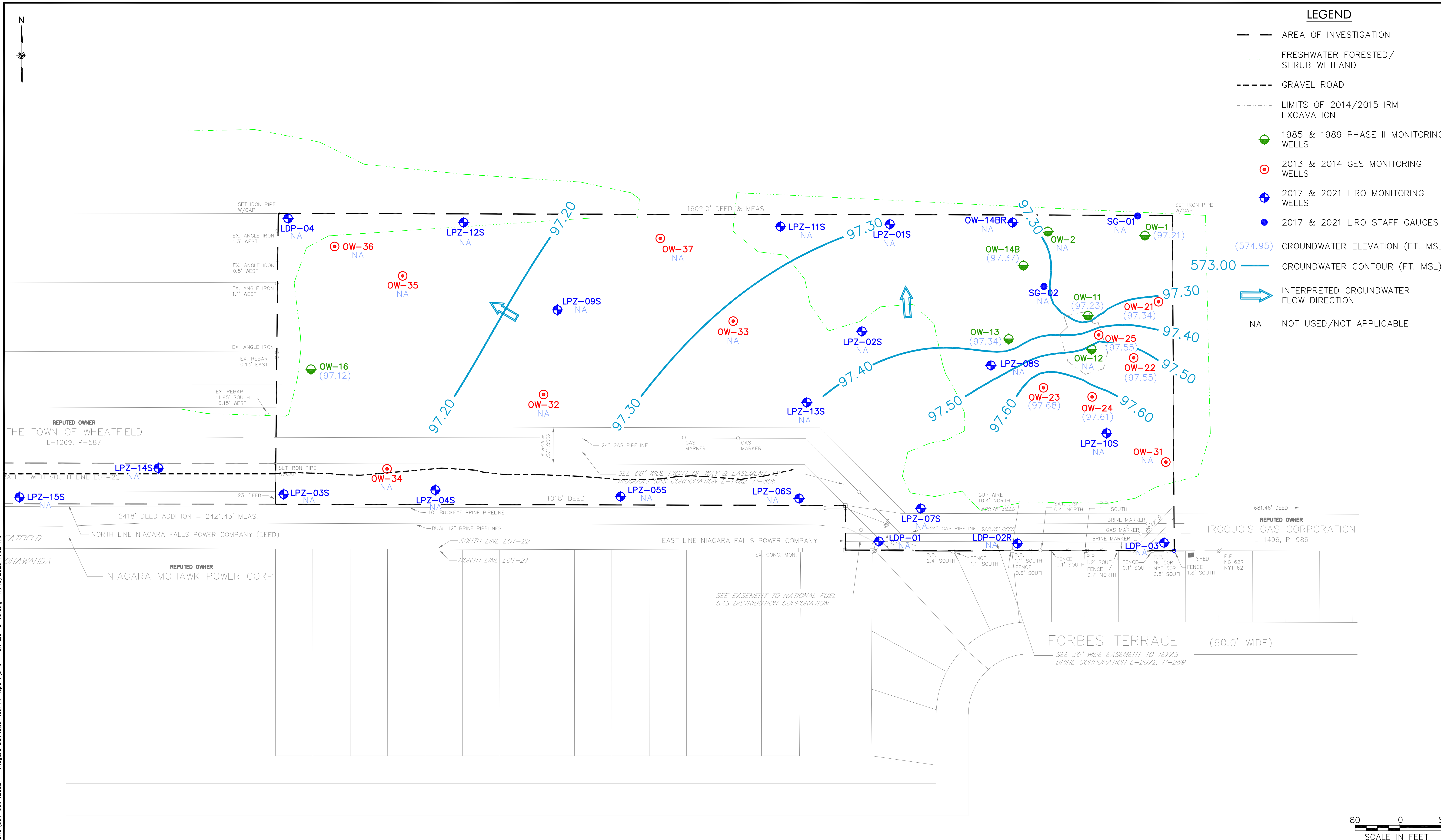



**Figure 5-5. Hydrograph for Upper Sand Well-Staff Gauge Couplets at the Niagara Sanitation Landfill Site.**

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|---|---|---|---|
| DESIGNED BY: | | | SHEET OF |
| CHECKED BY: | | DRAWING TITLE: GROUNDWATER ELEVATION CONTOUR MAP FILL/UPPER SAND: AUGUST 02, 2013 (GES SURVEY) | FIGURE NO. 5-6 |
| DRAWN BY: | DATE: NOVEMBER 2023 / SCALE: AS SHOWN | | |

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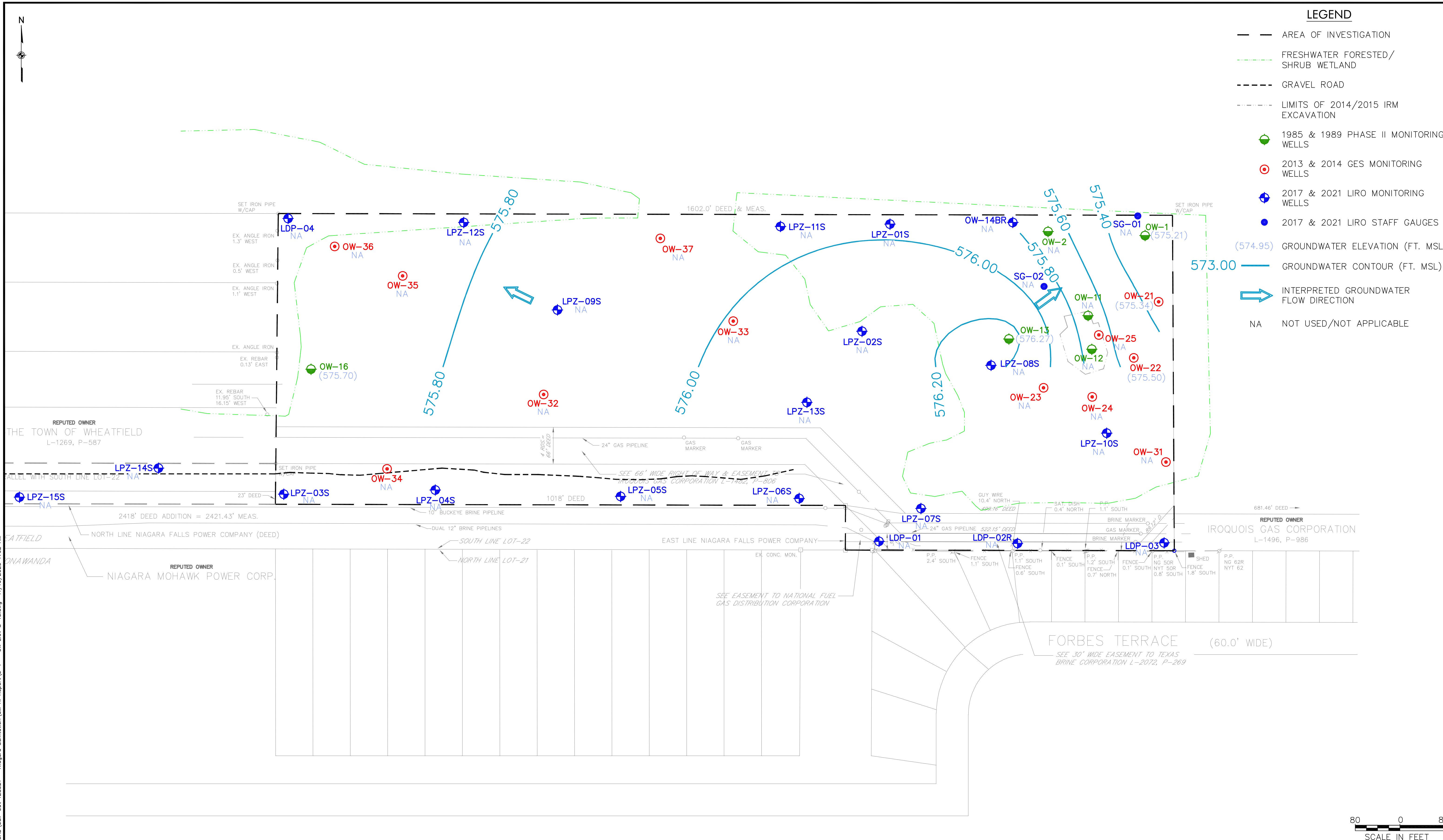


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DRAWN BY:

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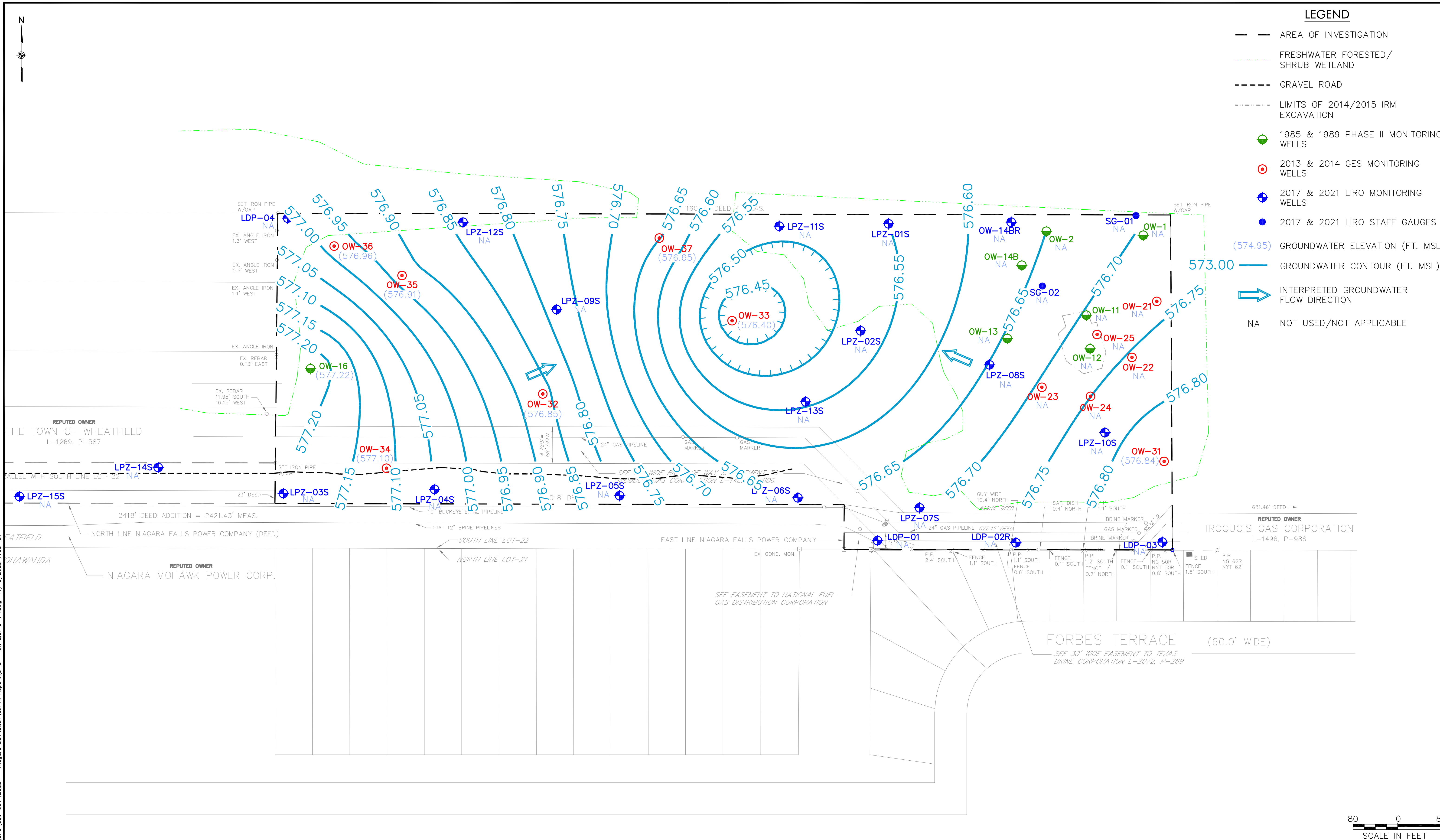
DATE: NOVEMBER 2023
SCALE: AS SHOWN

JOB TITLE AND LOCATION:
NIAGARA SANITATION / NASH ROAD LANDFILL SITE
7415 NASH ROAD
TOWN OF WHEATFIELD, NIAGARA COUNTY, NEW YORK
NYSDEC SITE NUMBER 932054

DRAWING TITLE:
GROUNDWATER ELEVATION CONTOUR MAP
FILL/UPPER SAND: AUGUST 02, 2013 (LIRO SURVEY)

LIRO JOB NO.: 17-013-0289
SHEET OF
FIGURE NO. 5-7



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CLIENT: NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

DATE: NOVEMBER 2023

SCALE: AS SHOWN

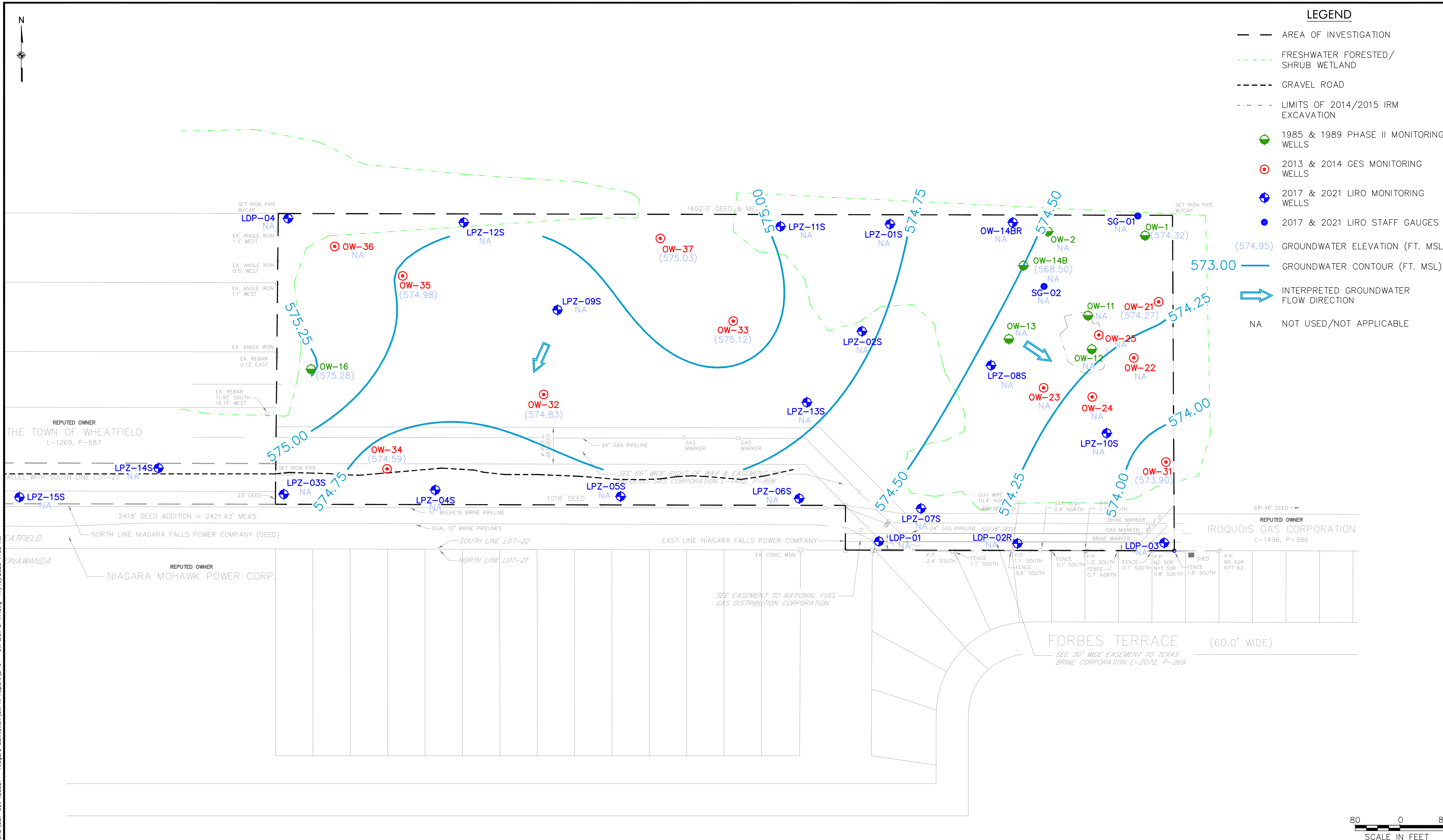
JOB TITLE AND LOCATION:
NIAGARA SANITATION / NASH ROAD LANDFILL SITE
7415 NASH ROAD
TOWN OF WHEATFIELD, NIAGARA COUNTY, NEW YORK
NYSDEC SITE NUMBER 932054

DRAWING TITLE:
GROUNDWATER ELEVATION CONTOUR MAP
FILL/UPPER SAND: MAY 19, 2014

LIRO JOB NO.: 17-013-0289

SHEET OF

FIGURE NO. 5-8




## LEGEND

- AREA OF INVESTIGATION
- FRESHWATER FORESTED/ SHRUB WETLAND
- GRAVEL ROAD
- LIMITS OF 2014/2015 IRM EXCAVATION
- 1985 & 1989 PHASE II MONITORING WELLS
- 2013 & 2014 GES MONITORING WELLS
- 2017 & 2021 LIRO MONITORING WELLS
- 2017 & 2021 LIRO STAFF GAUGES
- (574.95) GROUNDWATER ELEVATION (FT. MSL)
- 573.00 GROUNDWATER CONTOUR (FT. MSL)
- INTERPRETED GROUNDWATER FLOW DIRECTION
- NA NOT USED/NOT APPLICABLE

**WARNING**

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| PROJ. ENG.: | |
| DESIGNED BY: | |
| CHECKED BY: | |
| DRAWN BY: | |
| CLIENT: | NEW YORK STATE OF OPPORTUNITY — Department of Environmental Conservation |
| DATE: | NOVEMBER 2023 |
| SCALE: | AS SHOWN |
| JOB TITLE AND LOCATION: | NIAGARA SANITATION / NASH ROAD LANDFILL SITE<br>7415 NASH ROAD<br>TOWN OF WHEATFIELD, NIAGARA COUNTY, NEW YORK<br>NYSDEC SITE NUMBER 932054 |
| DRAWING TITLE: | GROUNDWATER ELEVATION CONTOUR MAP<br>FILL/UPPER SAND: AUGUST 2, 2017 |
| LIRO JOB NO.: | 17-013-0289 |
| SHEET OF | |
| FIGURE NO. | 5-9 |

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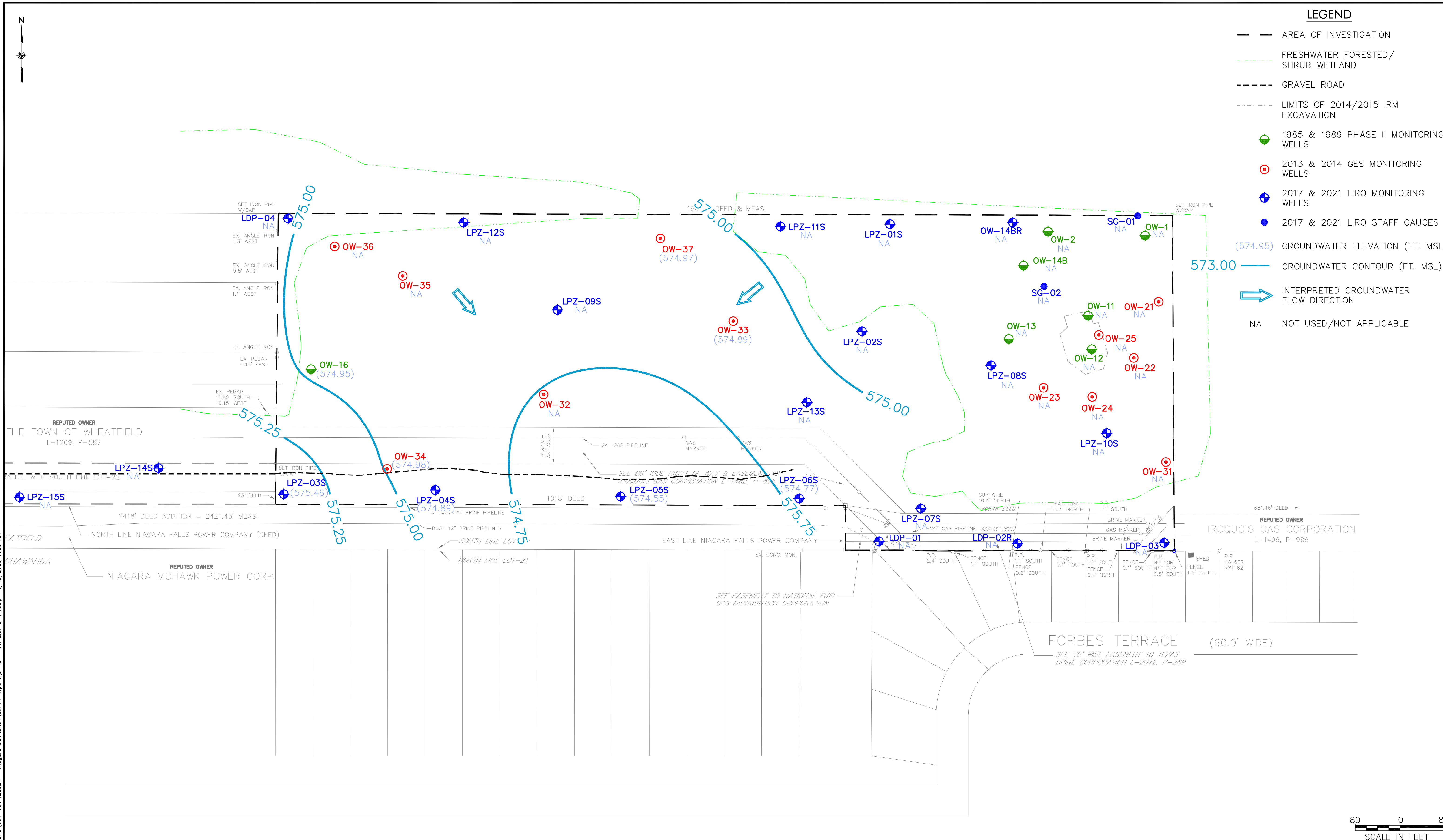


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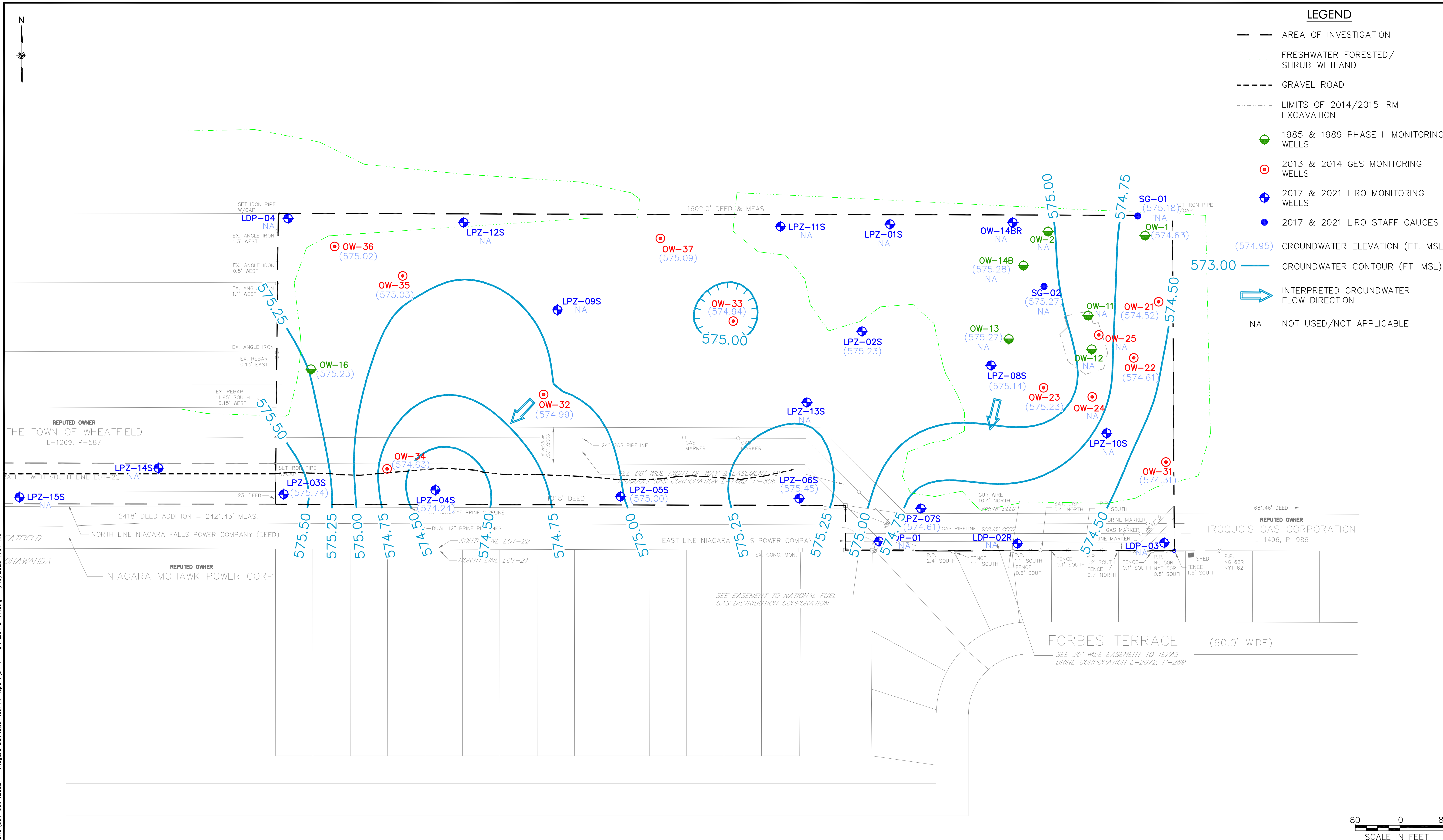
CLIENT: NEW YORK STATE OF OPPORTUNITY — Department of Environmental Conservation

DATE: NOVEMBER 2023
SCALE: AS SHOWN

JOB TITLE AND LOCATION:
NIAGARA SANITATION / NASH ROAD LANDFILL SITE
7415 NASH ROAD
TOWN OF WHEATFIELD, NIAGARA COUNTY, NEW YORK
NYSDEC SITE NUMBER 932054

DRAWING TITLE:
GROUNDWATER ELEVATION CONTOUR MAP
FILL/UPPER SAND: AUGUST 8, 2017

LIRO JOB NO.: 17-013-0289
SHEET OF
FIGURE NO. 5-10

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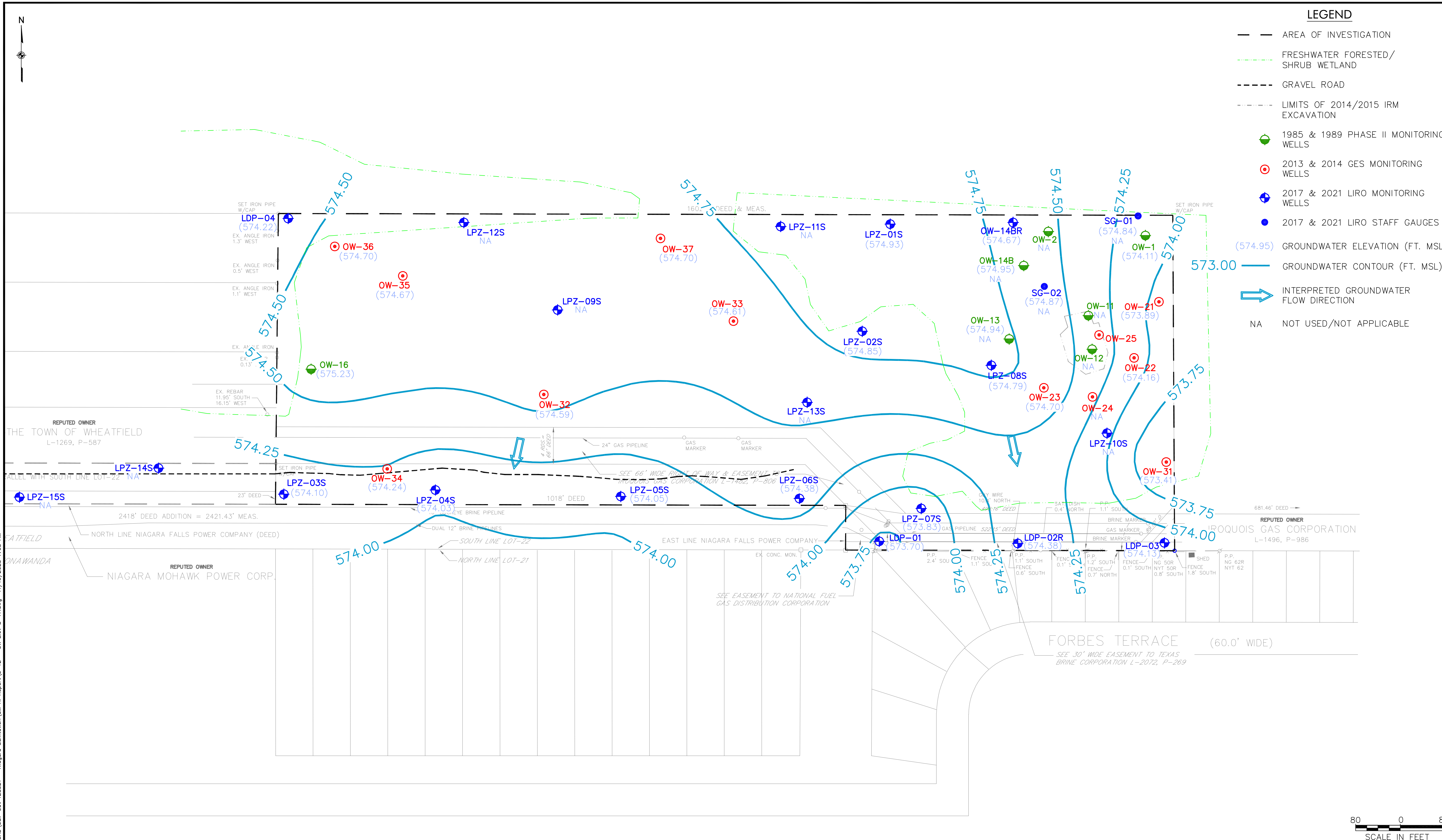
JOB TITLE AND LOCATION:
NIAGARA SANITATION / NASH ROAD LANDFILL SITE
7415 NASH ROAD
TOWN OF WHEATFIELD, NIAGARA COUNTY, NEW YORK
NYSDEC SITE NUMBER 932054

DRAWING TITLE:
GROUNDWATER ELEVATION CONTOUR MAP
FILL/UPPER SAND: AUGUST 22, 2017

LIRO JOB NO.: 17-013-0289
SHEET OF
FIGURE NO. 5-11

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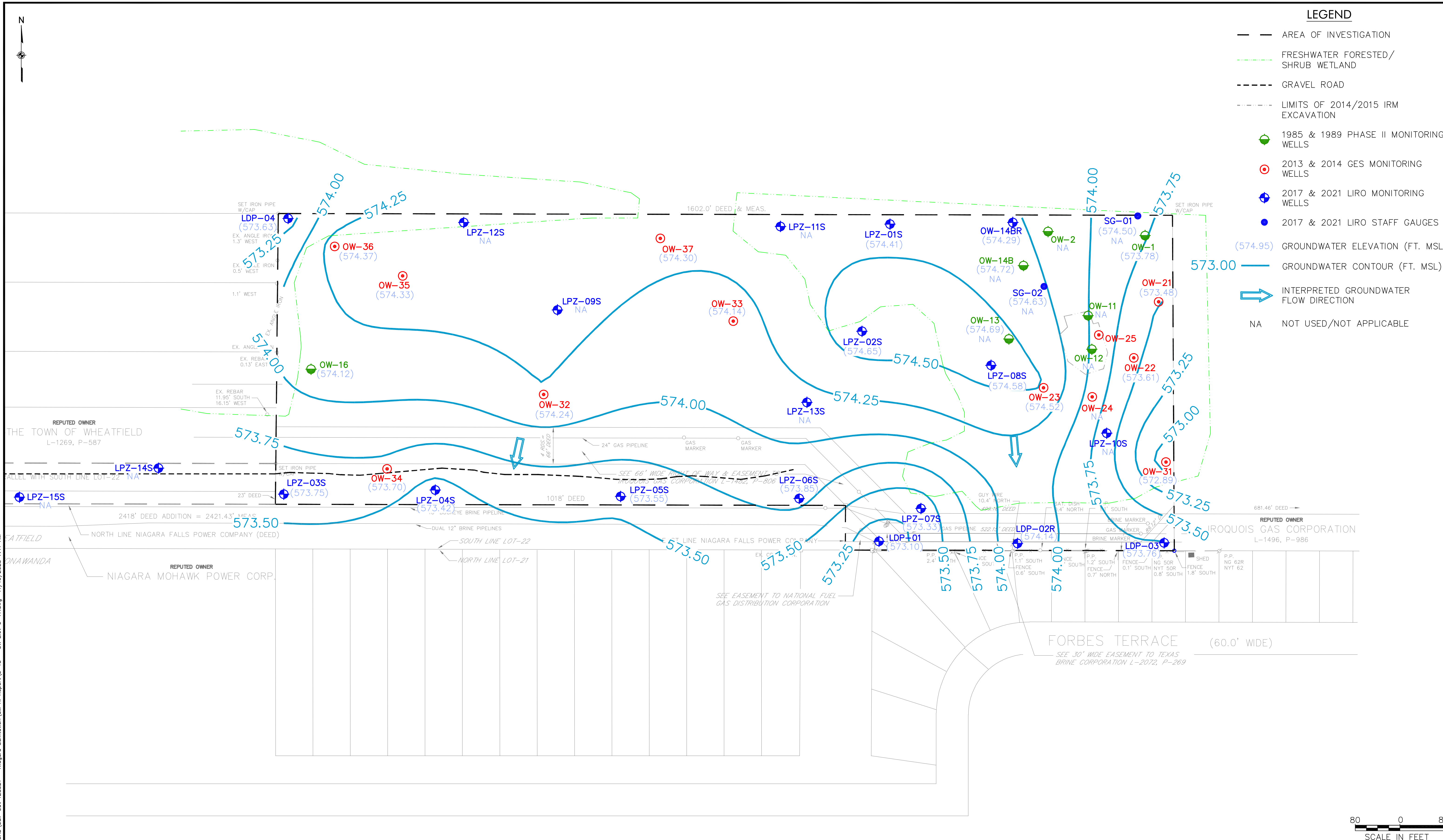
JOB TITLE AND LOCATION:
NIAGARA SANITATION / NASH ROAD LANDFILL SITE
7415 NASH ROAD
TOWN OF WHEATFIELD, NIAGARA COUNTY, NEW YORK
NYSDEC SITE NUMBER 932054

DRAWING TITLE:
GROUNDWATER ELEVATION CONTOUR MAP
FILL/UPPER SAND: AUGUST 30, 2017

LIRO JOB NO.: 17-013-0289
SHEET OF
FIGURE NO. 5-12

J:\17-013-0289 NYSDEC Standby\CAD\Call-Out 128321 – Niagara Sanitation\GM RI Report\5-12 – GW Elev 8-17.dwg 11/16/2023 7:08 AM

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DRAWN BY:

CLIENT: NEW YORK STATE OF OPPORTUNITY — Department of Environmental Conservation

DATE: NOVEMBER 2023

SCALE: AS SHOWN

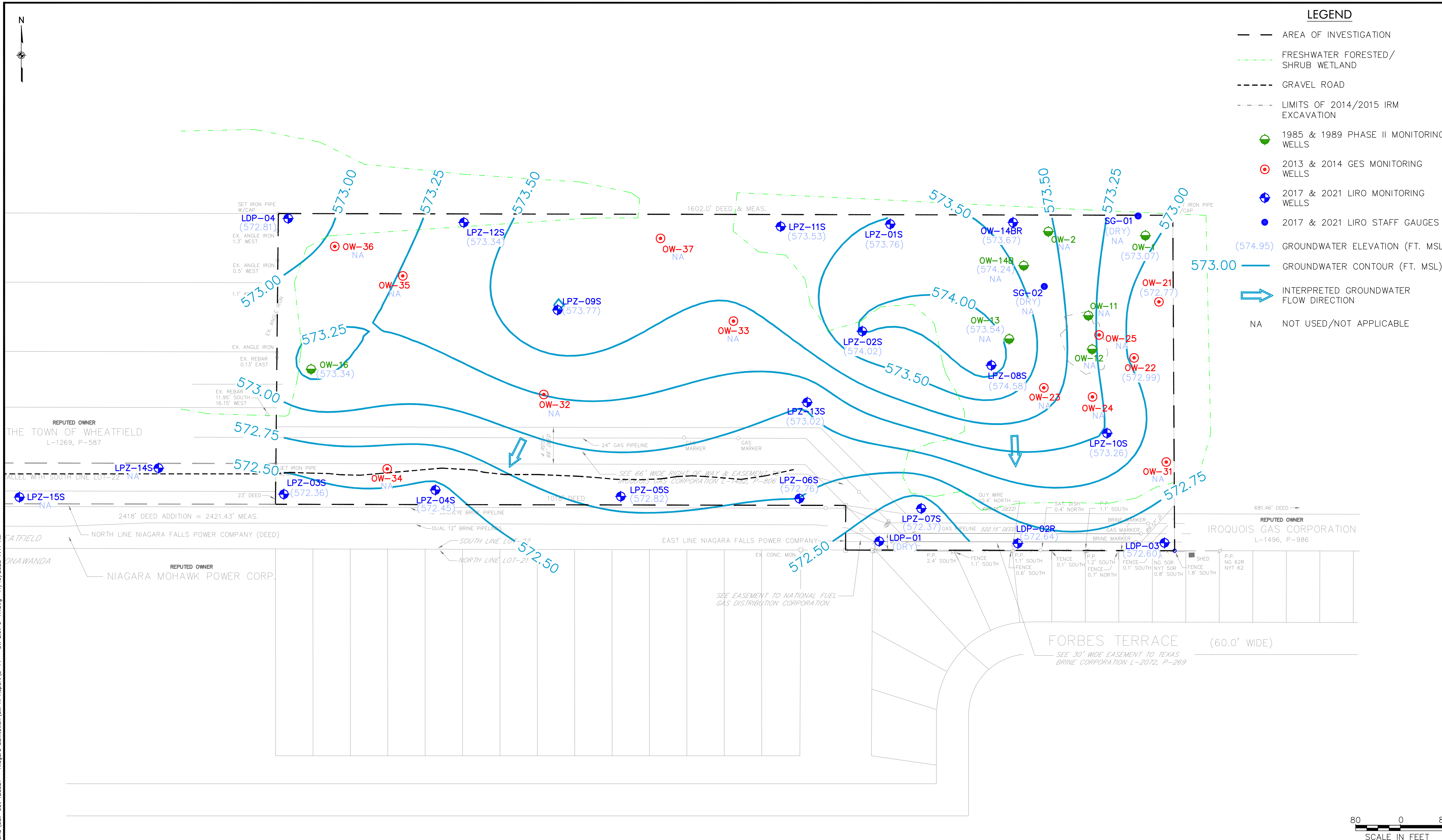
JOB TITLE AND LOCATION:
NIAGARA SANITATION / NASH ROAD LANDFILL SITE
7415 NASH ROAD
TOWN OF WHEATFIELD, NIAGARA COUNTY, NEW YORK
NYSDEC SITE NUMBER 932054

DRAWING TITLE:
GROUNDWATER ELEVATION CONTOUR MAP
FILL/UPPER SAND: SEPTEMBER 12, 2017

LIRO JOB NO.: 17-013-0289

SHEET OF

FIGURE NO. 5-13

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| CHECKED BY: | |
| DRAWN BY: | |

CLIENT: NEW YORK STATE OF OPPORTUNITY Department of Environmental Conservation

DATE: NOVEMBER 2023

SCALE: AS SHOWN

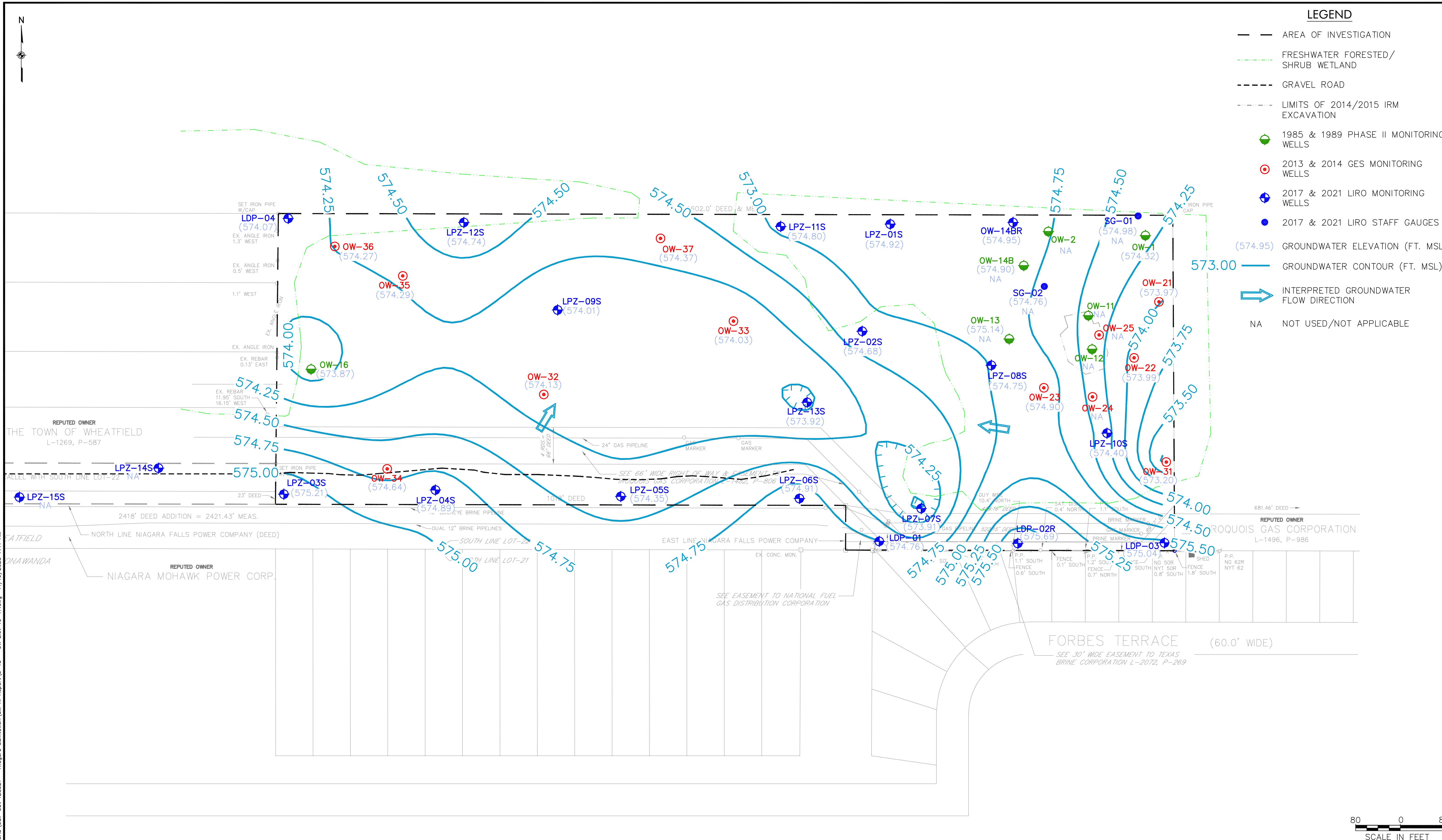
JOB TITLE AND LOCATION:
NIAGARA SANITATION / NASH ROAD LANDFILL SITE
7415 NASH ROAD
TOWN OF WHEATFIELD, NIAGARA COUNTY, NEW YORK
NYSDEC SITE NUMBER 932054

DRAWING TITLE:
GROUNDWATER ELEVATION CONTOUR MAP
FILL/UPPER SAND: SEPTEMBER 25, 2017

LIRO JOB NO.: 17-013-0289

SHEET OF

FIGURE NO. 5-14

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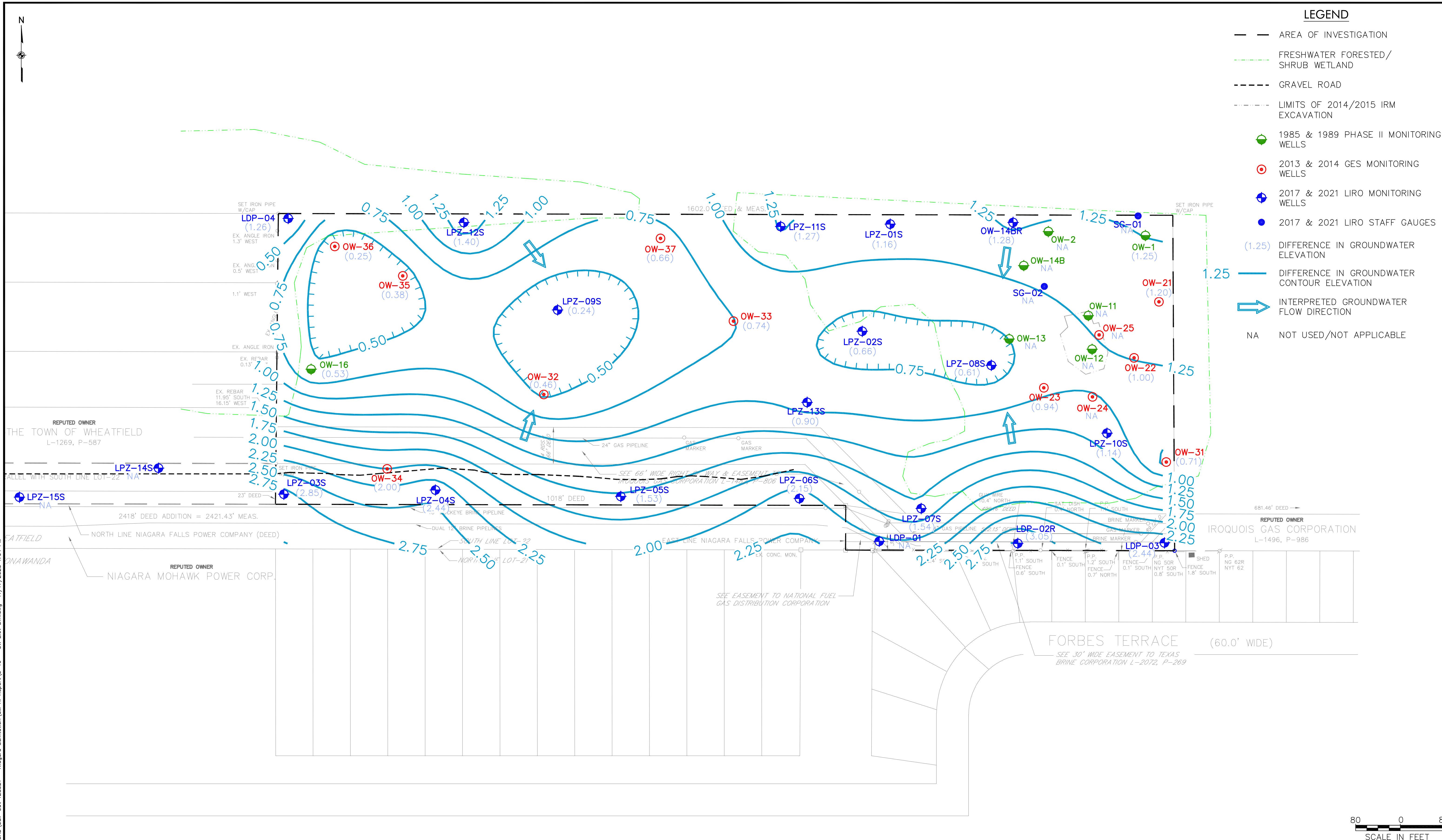
NIAGARA SANITATION / NASH ROAD LANDFILL SITE
7415 NASH ROAD
TOWN OF WHEATFIELD, NIAGARA COUNTY, NEW YORK
NYSDEC SITE NUMBER 932054

DRAWING TITLE:
GROUNDWATER ELEVATION CONTOUR MAP
FILL/UPPER SAND: OCTOBER 17, 2017

LIRO JOB NO.: 17-013-0289

SHEET OF

FIGURE NO. 5-15



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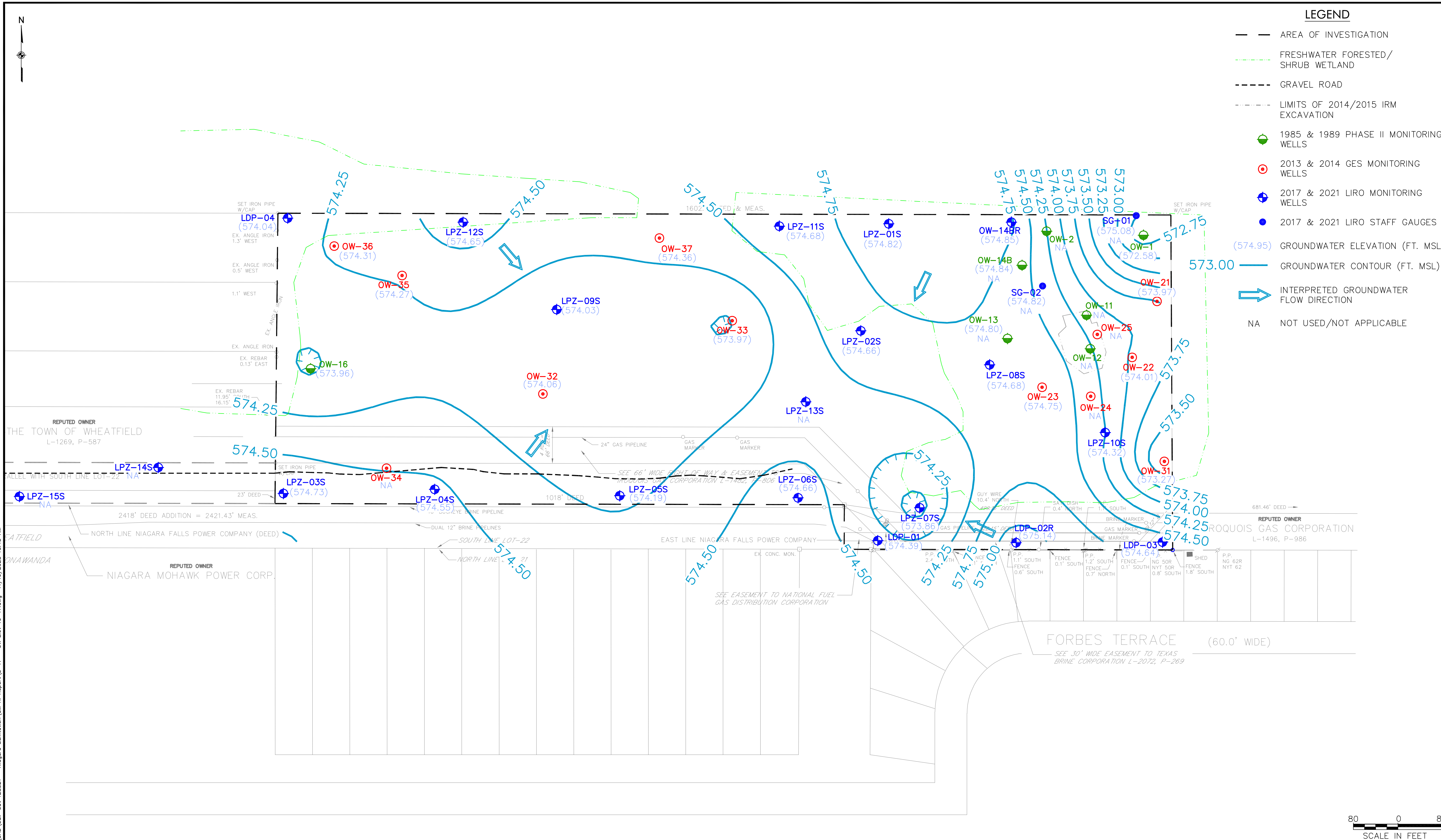
TOWN OF WHEATFIELD, NIAGARA COUNTY, NEW YORK
NYSDEC SITE NUMBER 932054

DRAWING TITLE:
DIFFERENCE IN GROUNDWATER ELEVATIONS
SEPTEMBER 25 TO OCTOBER 17, 2017

LIRO JOB NO.: 17-013-0289

SHEET OF

FIGURE NO. 5-16

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FILL/UPPER SAND: OCTOBER 20, 2017

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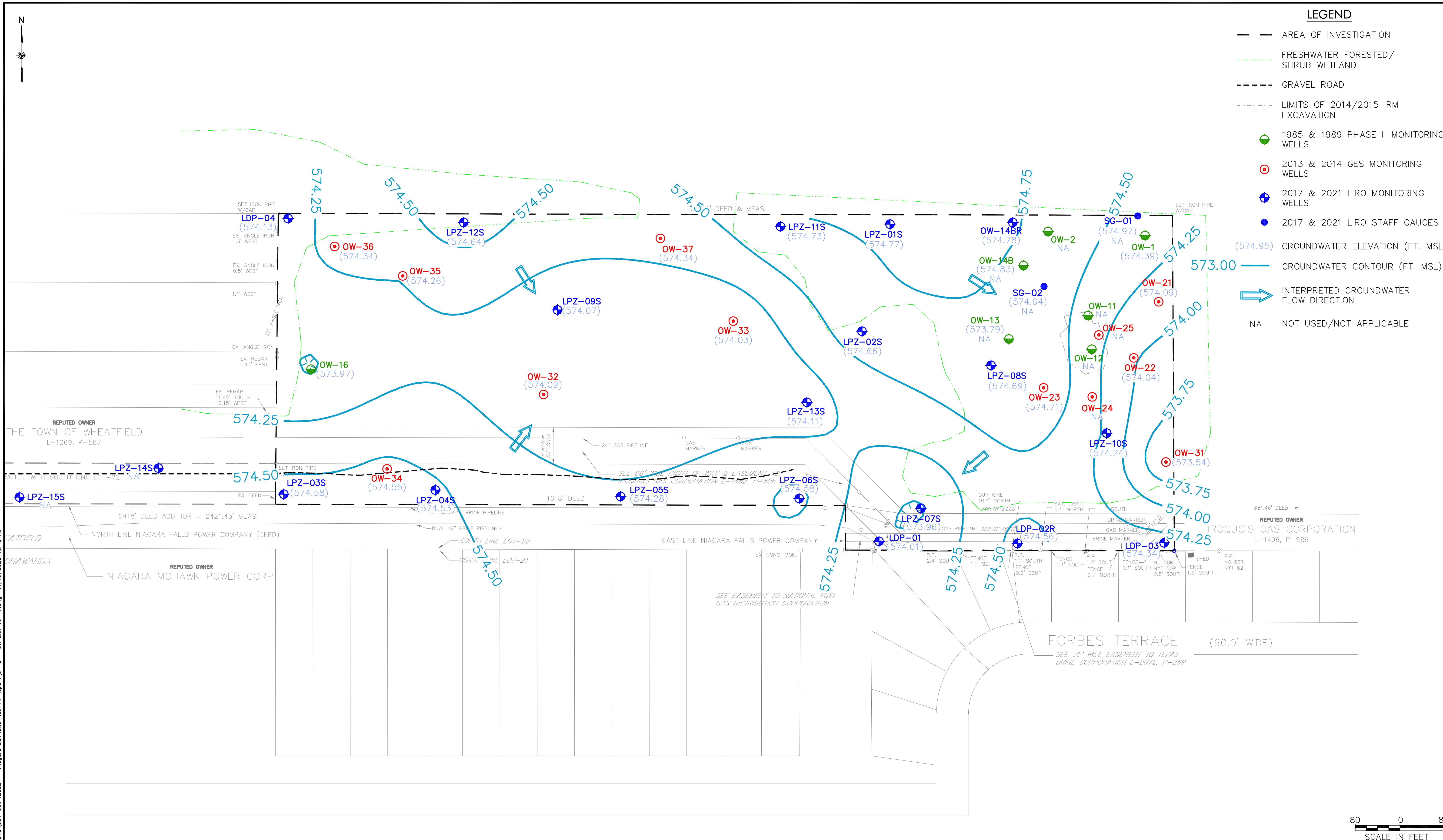
SHEET OF
FIGURE NO. 5-17

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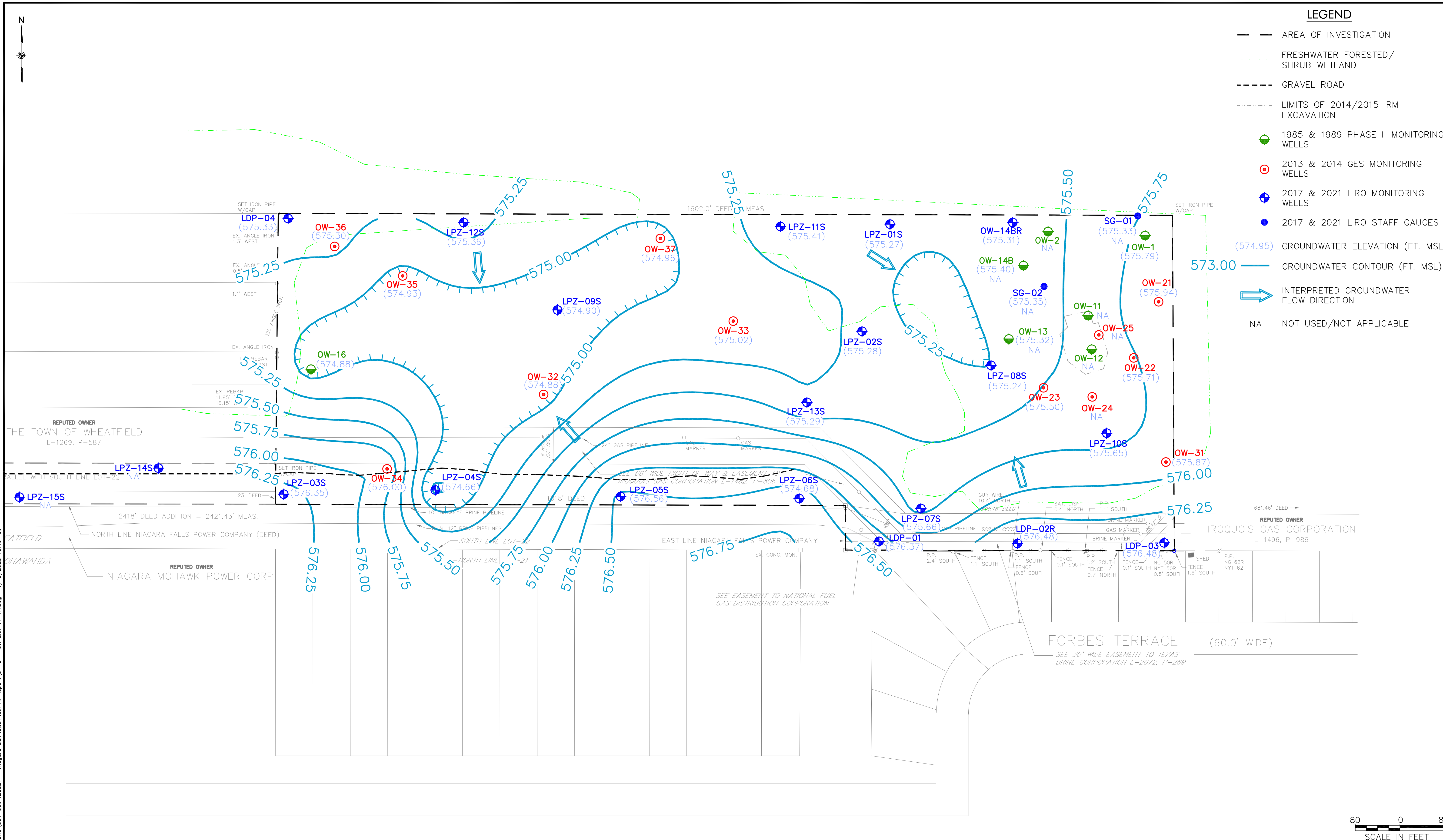
SHEET OF
FIGURE NO. 5-18

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FILL/UPPER SAND: NOVEMBER 7, 2017

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SHEET OF
FIGURE NO. 5-19

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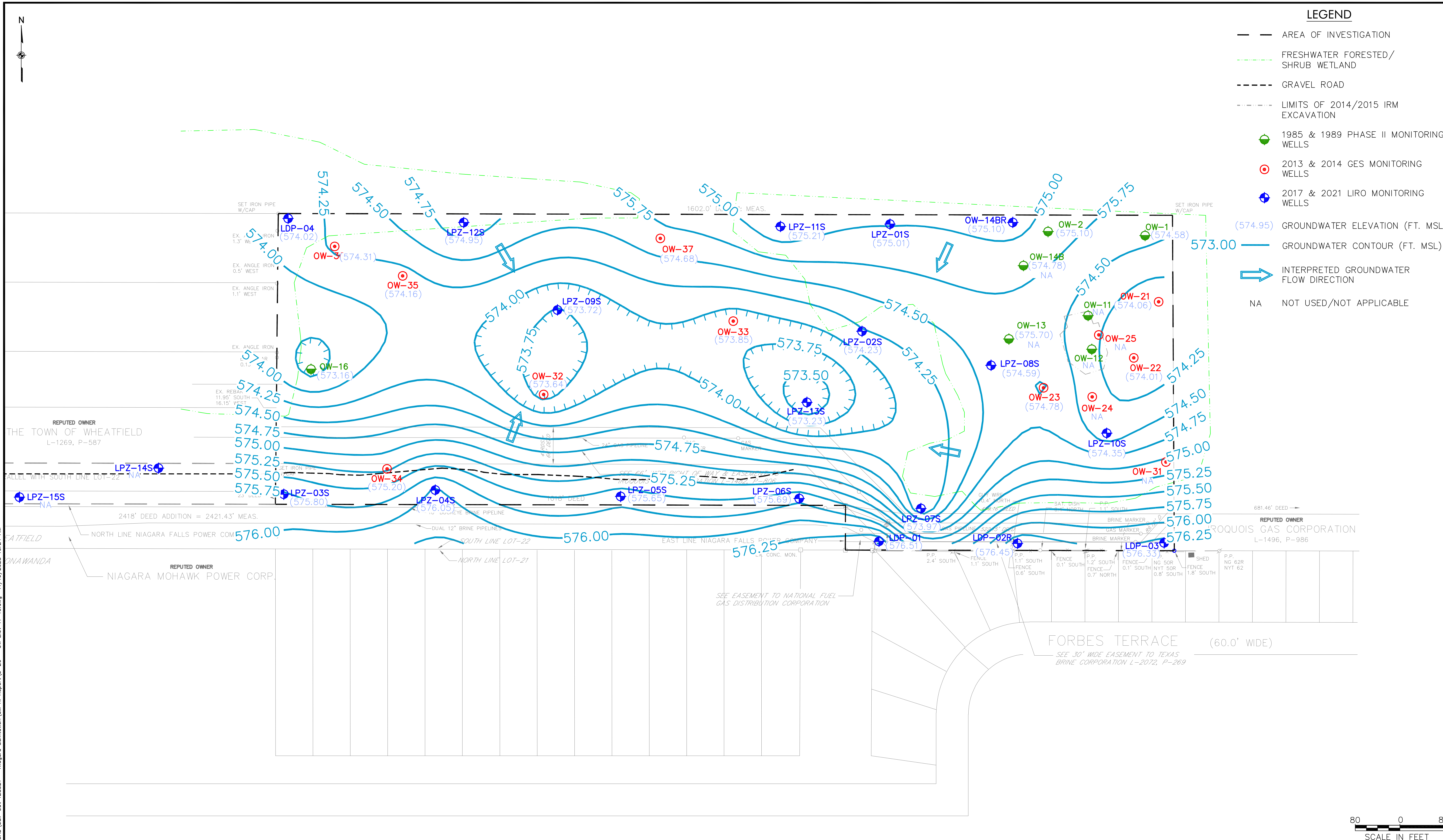


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TOWN OF WHEATFIELD, NIAGARA COUNTY, NEW YORK
NYSDEC SITE NUMBER 932054

DRAWING TITLE:
GROUNDWATER ELEVATION CONTOUR MAP
FILL/UPPER SAND: NOVEMBER 21, 2019

LIRO JOB NO.: 17-013-0289

SHEET OF

FIGURE NO. 5-20

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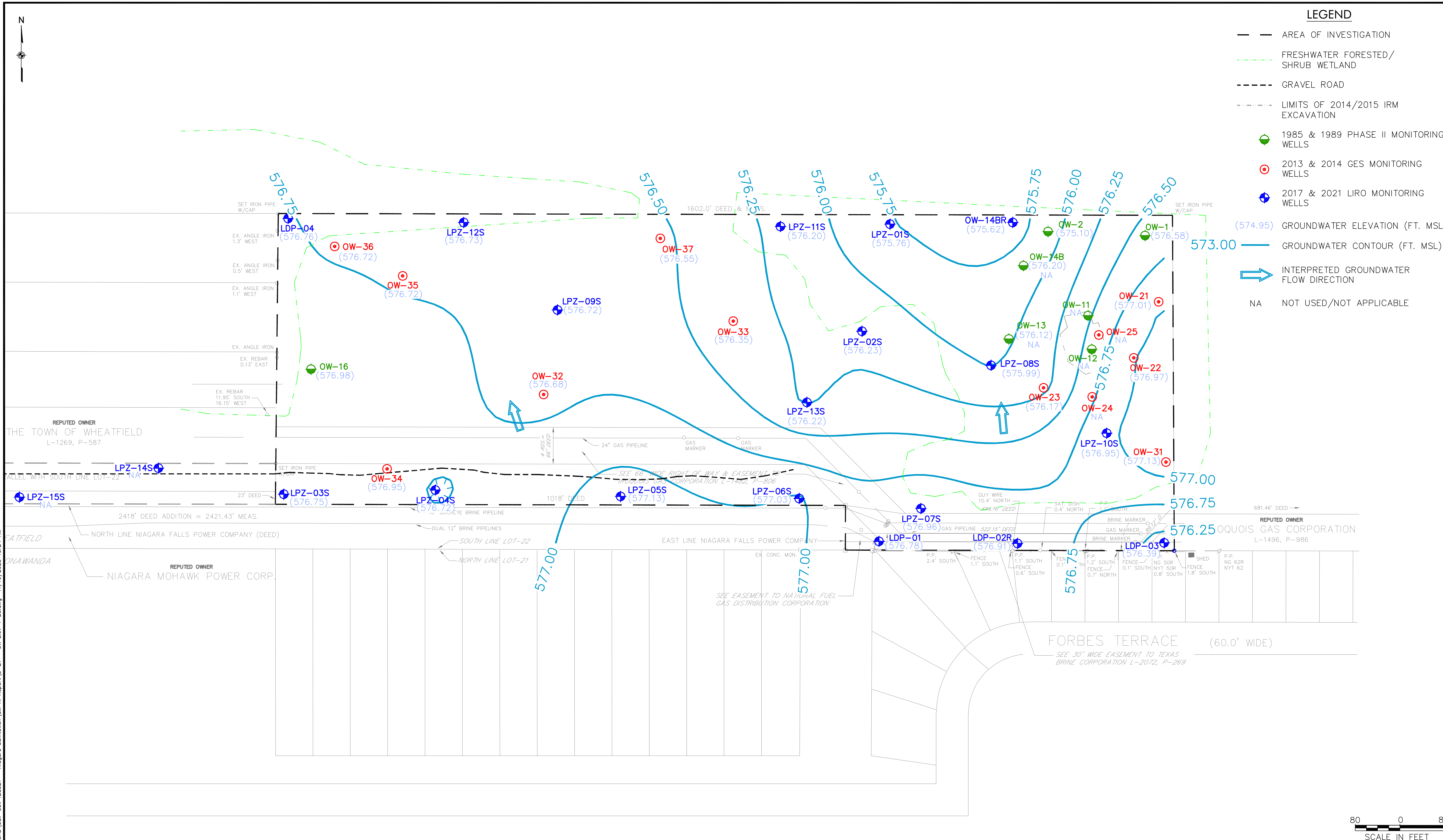


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DRAWING TITLE:
GROUNDWATER ELEVATION CONTOUR MAP
FILL/UPPER SAND: APRIL 03, 2020

LIRO JOB NO.: 17-013-0289
SHEET OF
FIGURE NO. 5-21

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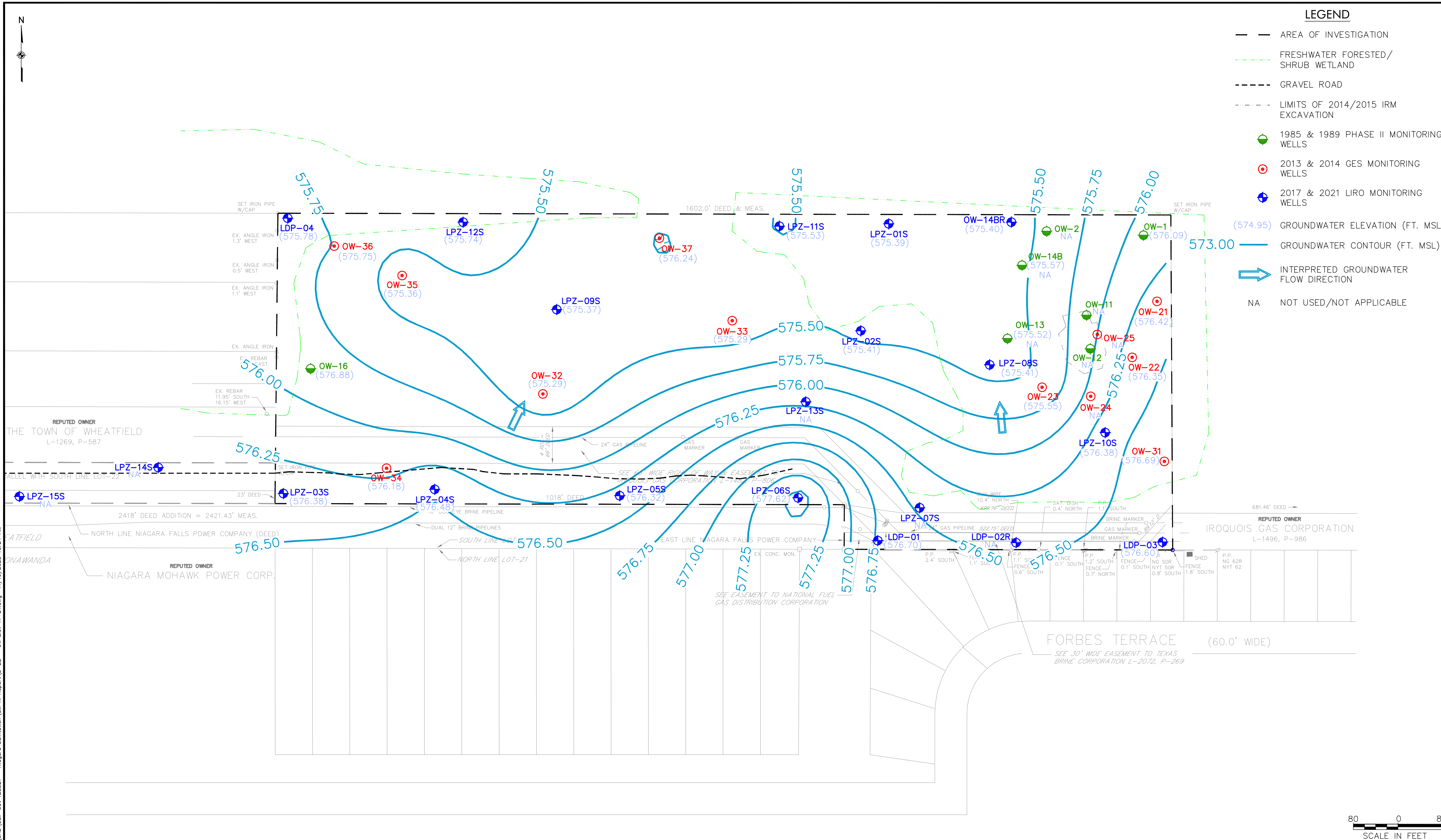


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TOWN OF WHEATFIELD, NIAGARA COUNTY, NEW YORK
NYSDEC SITE NUMBER 932054

DRAWING TITLE:
GROUNDWATER ELEVATION CONTOUR MAP
FILL/UPPER SAND: NOVEMBER 23, 2021

LIRO JOB NO.: 17-013-0289
SHEET OF
FIGURE NO. 5-22

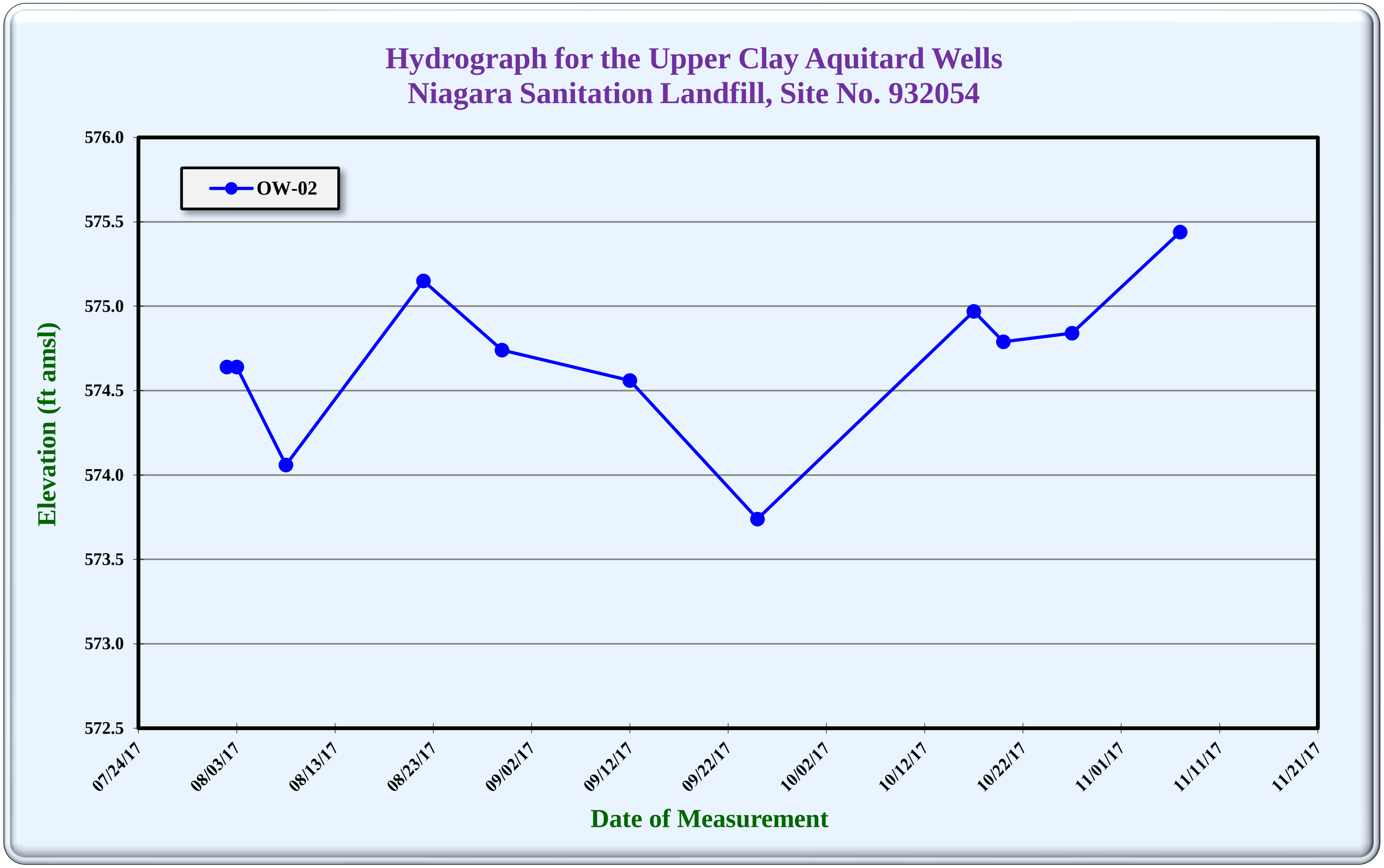



**Figure 5-23. Hydrograph for the Upper Clay Aquitard Well at the Niagara Sanitation Landfill Site.**

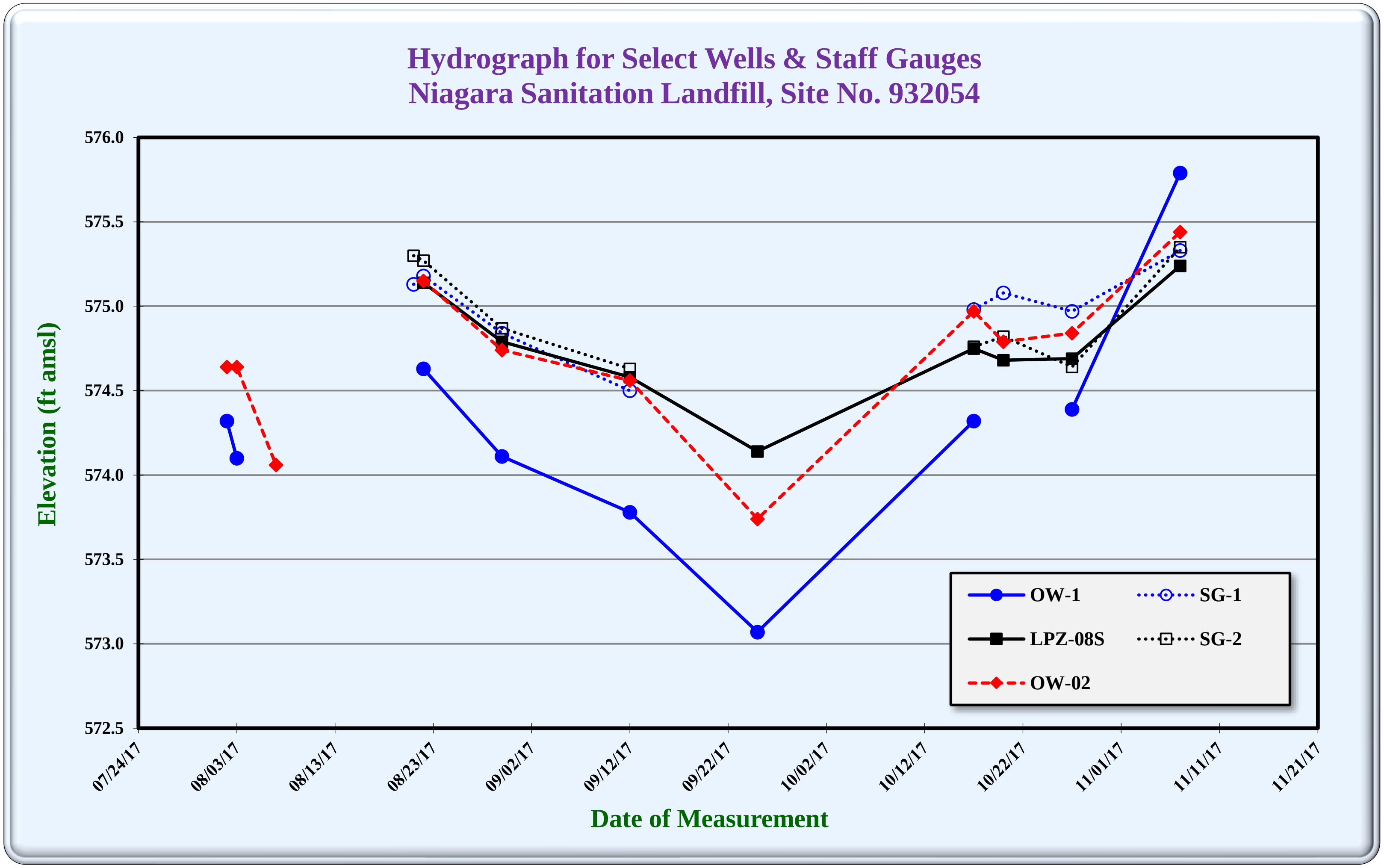



**Figure 5-24. Hydrograph for Select Wells and Staff Gauges at the Niagara Sanitation Landfill Site.**
**Solid lines denote the upper sand wells, dotted lines denote the staff gauges; and the dashed line denotes the upper clay aquitard well. Upper sand wells and staff guages with the same color are in close proximity to each other.**

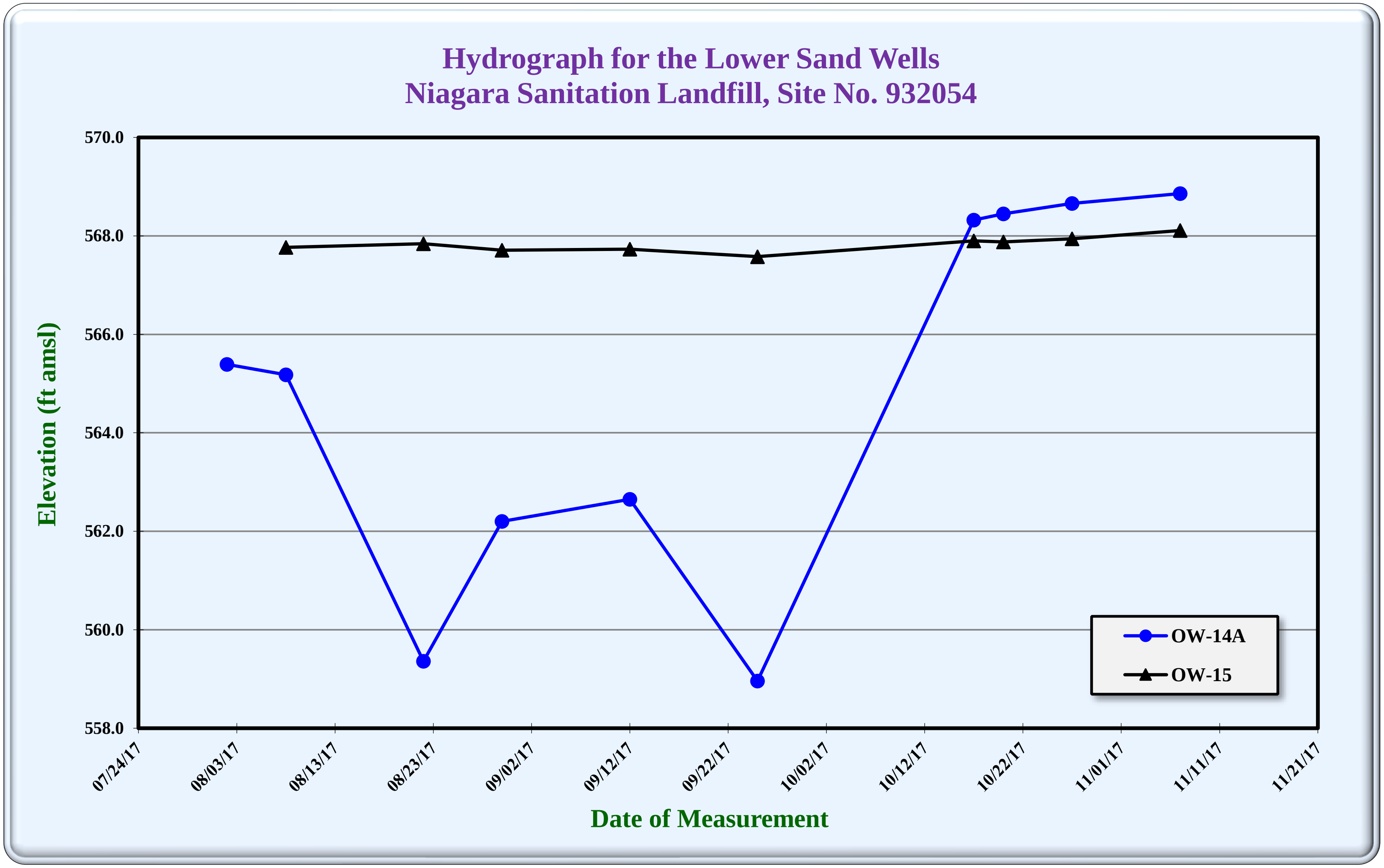



**Figure 5-25. Hydrograph for the Lower Sand Wells at the Niagara Sanitation Landfill Site.**

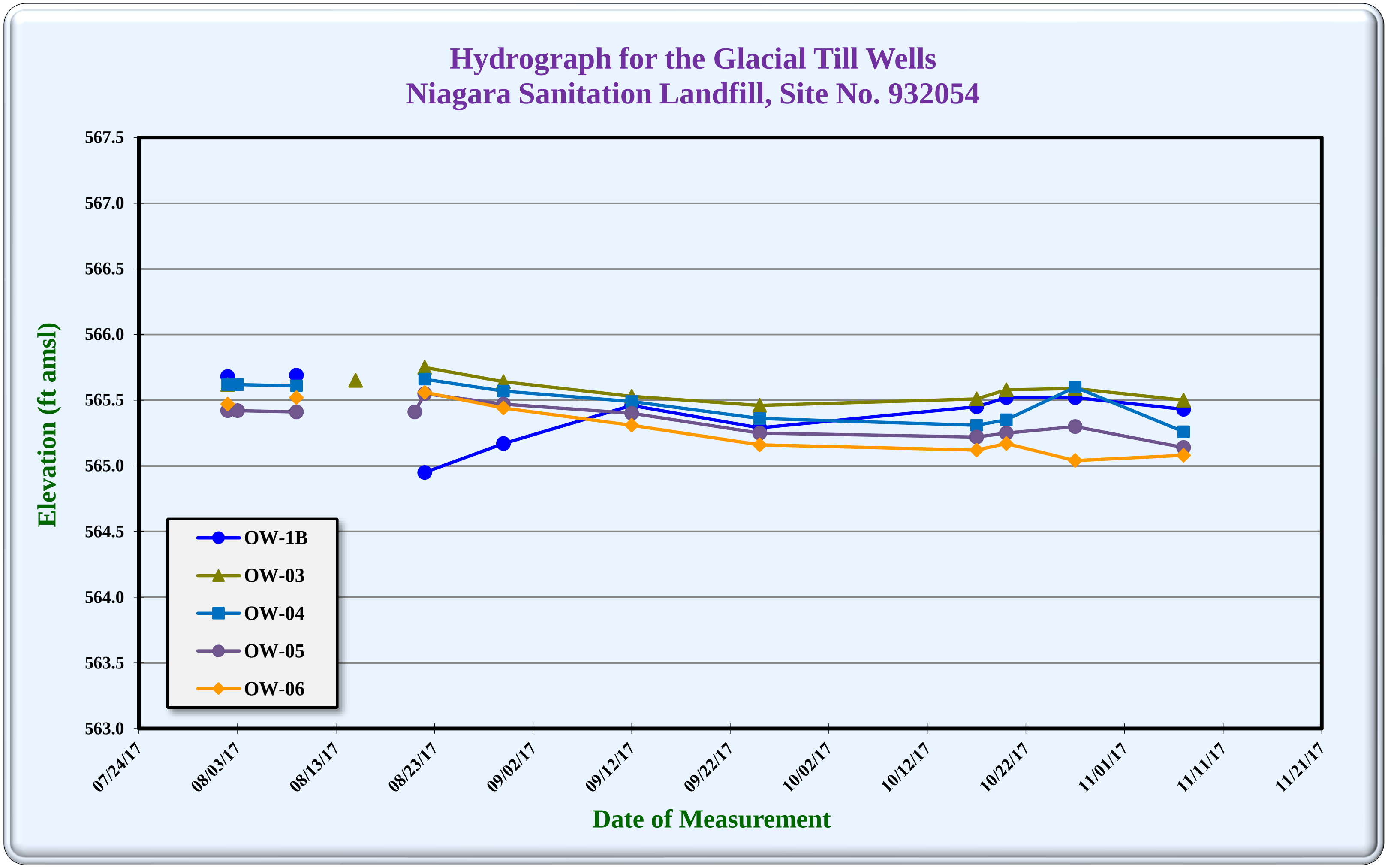



**Figure 5-26. Hydrograph for the Glacial Till Wells at the Niagara Sanitation Landfill Site.**

BY ______ DATE 2/25/84

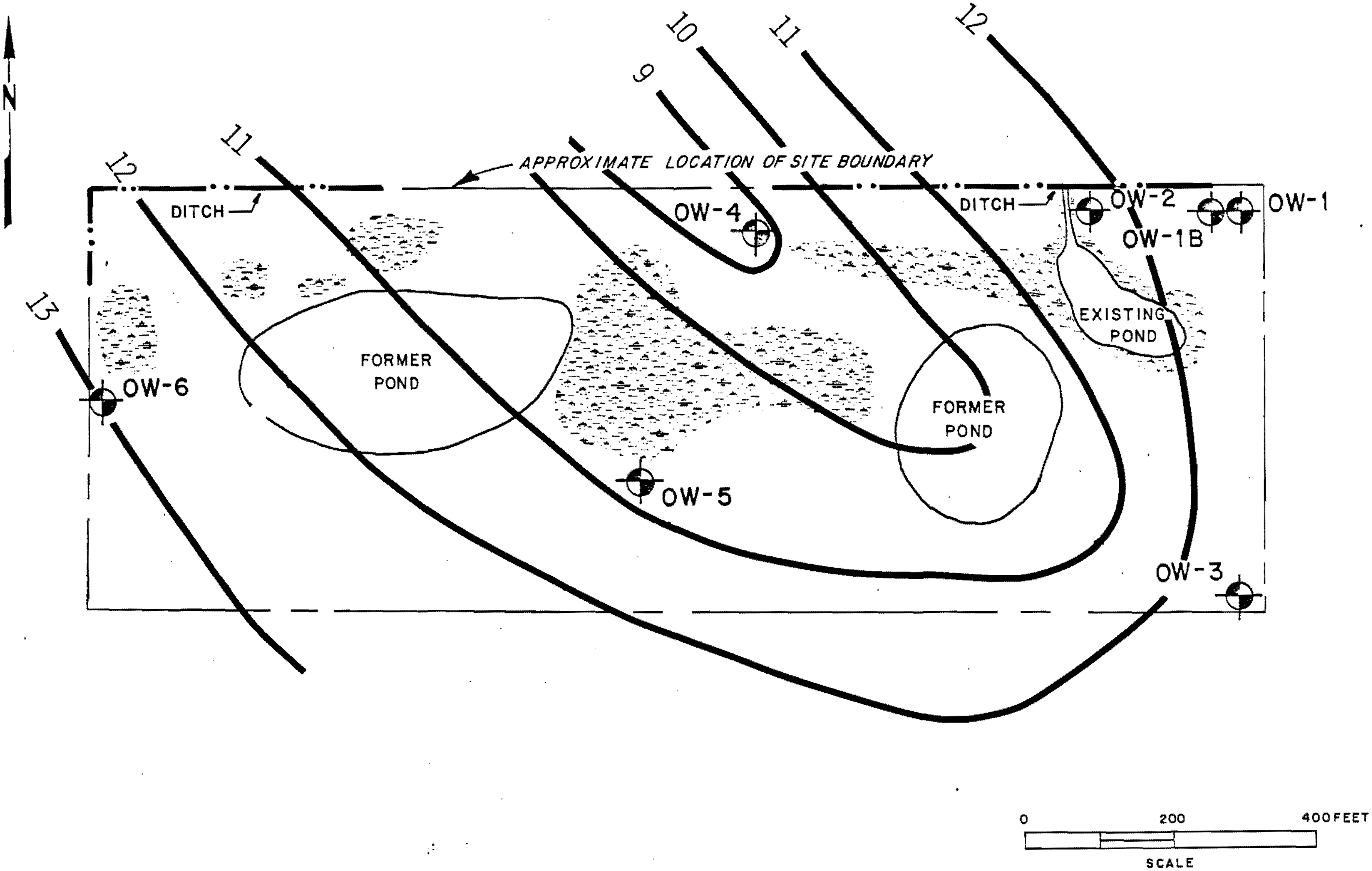


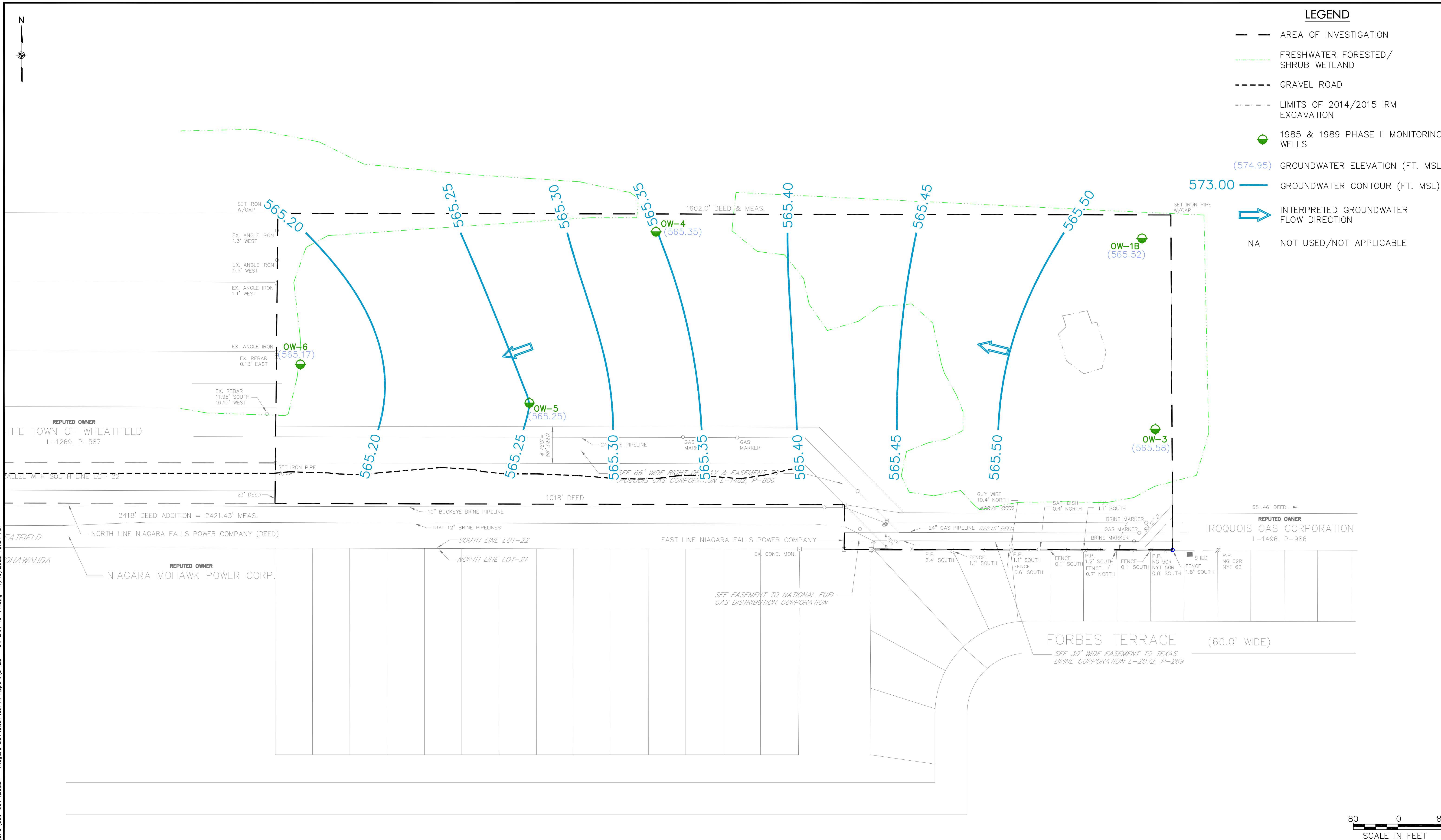

FIGURE 5-27

DEPTH TO PIEZOMETRIC SURFACE IN TILL

NASH ROAD SITE

Note: Values in feet below arbitrary datum.

DAMES & MOORE

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NYSDEC SITE NUMBER 932054

DRAWING TITLE:
GROUNDWATER ELEVATION CONTOUR MAP
GLACIAL TILL: OCTOBER 20, 2017

LIRO JOB NO.: 17-013-0289
SHEET OF
FIGURE NO. 5-28

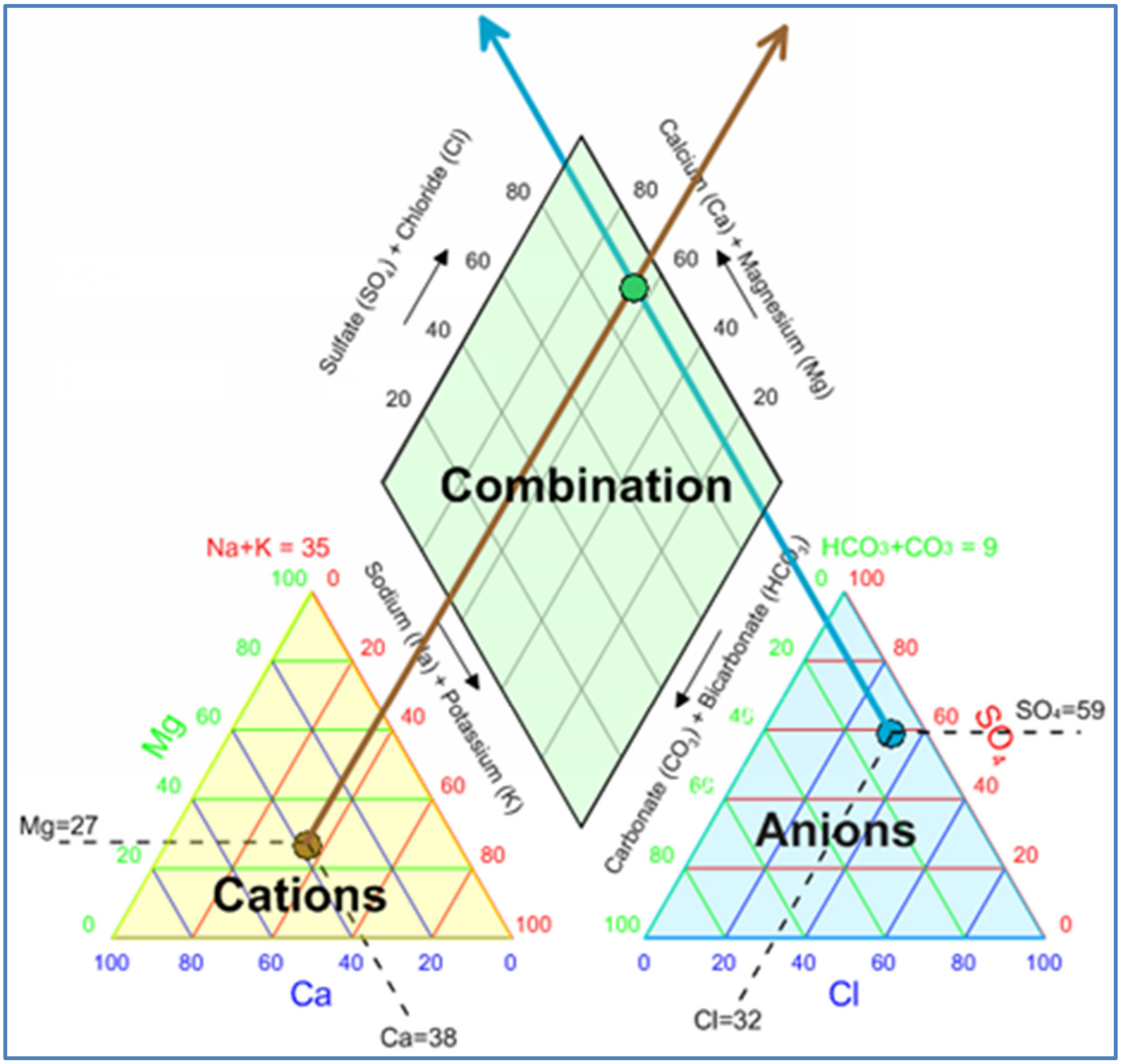



**Figure 6-1. The three components of the Piper plot. At bottom left is a ternary plot of the cations (magnesium, calcium, and sodium plus potassium), while at bottom right is a ternary plot of the anions (chloride, sulfate, and carbonate plus bicarbonate). At the top is a diamond plot of the projection from the two ternary plots. Image downloaded from the Golden Software website on November 7, 2022.**

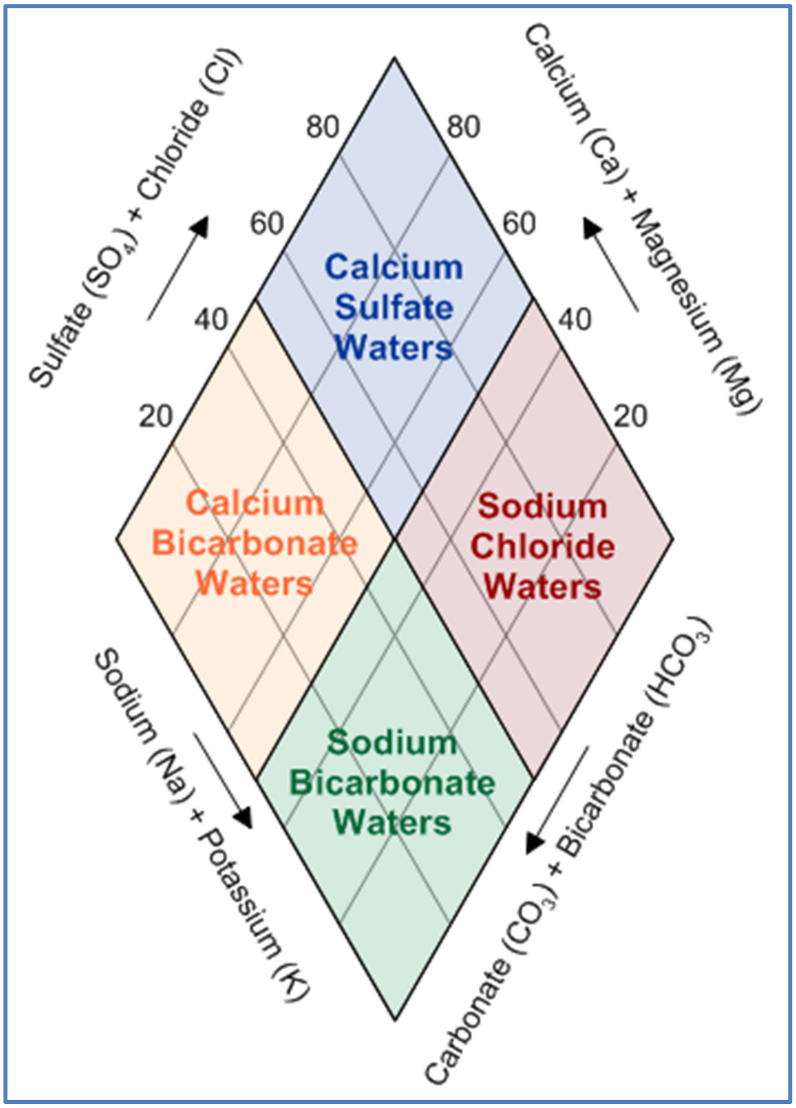



**Figure 6-2. Interpretation of the diamond plot. Samples in the top quadrant are calcium sulfate waters, which are typical of gypsum groundwater. Samples in the left quadrant are calcium bicarbonate waters, which are typical of shallow fresh groundwater. Samples in the right quadrant are sodium chloride waters, which are typical of marine and deep ancient ground water. Samples in the bottom quadrant are sodium bicarbonate waters, which are typical of deep ground water influenced by ion exchange. Image downloaded from the Golden Software website on November 7, 2022.**

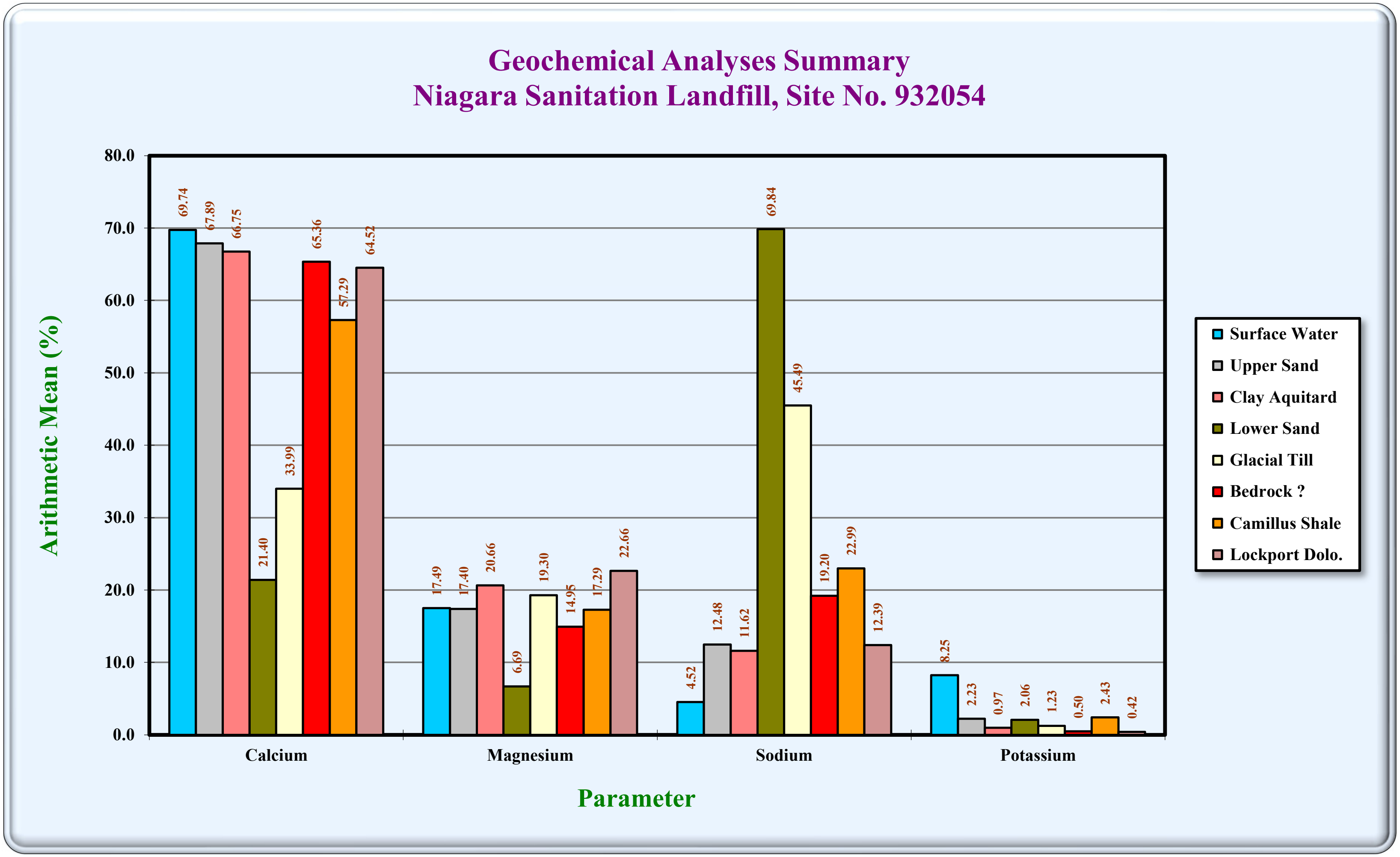



**Figure 6-3A. Plot of the Major Cations for the Various Hydrogeologic Zones Underlying the Niagara Sanitation Landfill. Results Shown are the Arithmetic Means (in Percent) of Each Cation.**

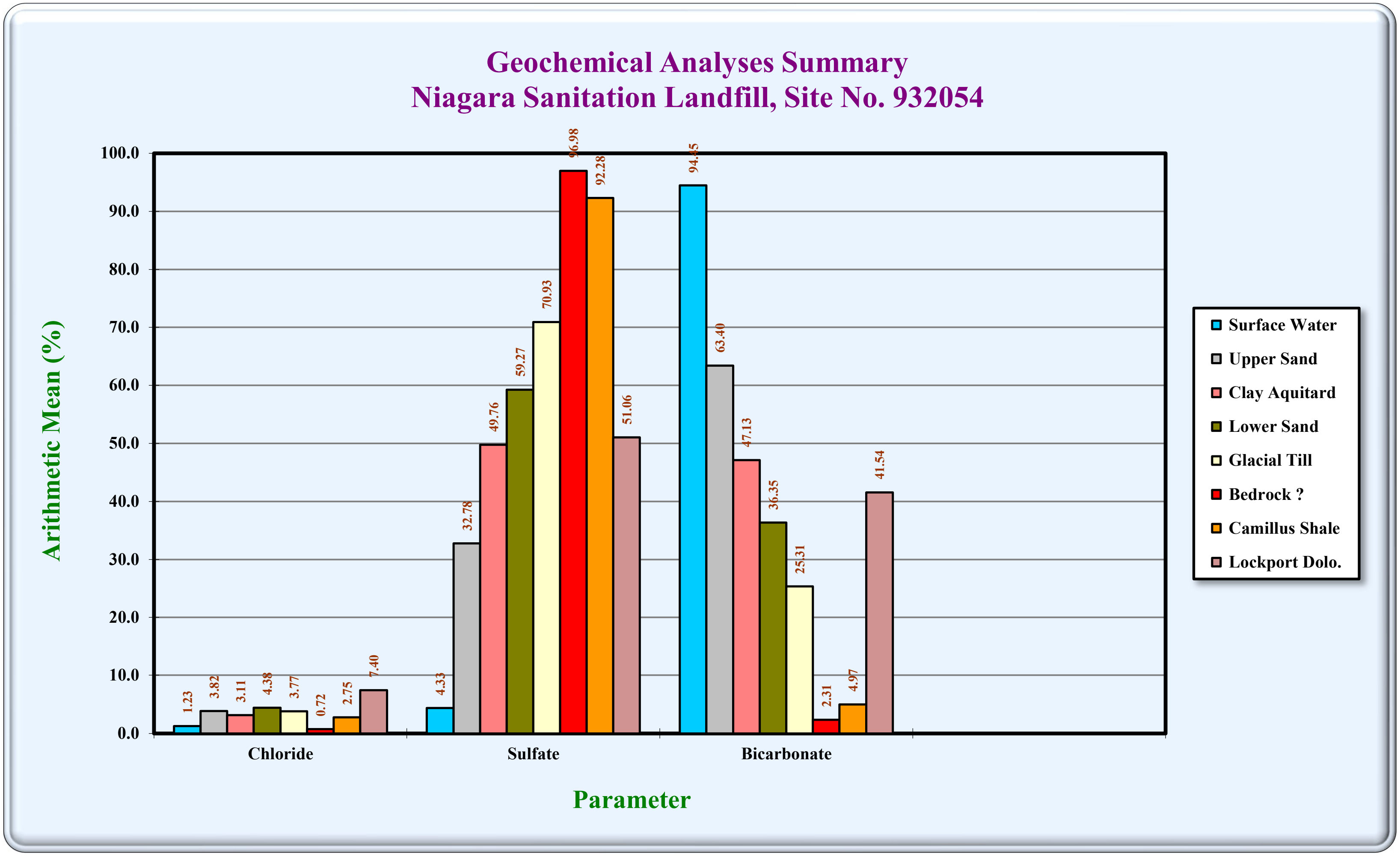



**Figure 6-3B. Plot of the Major Anions for the Various Hydrogeologic Zones Underlying the Niagara Sanitation Landfill. Results Shown are the Arithmetic Means (in Percent) of Each Anion.**

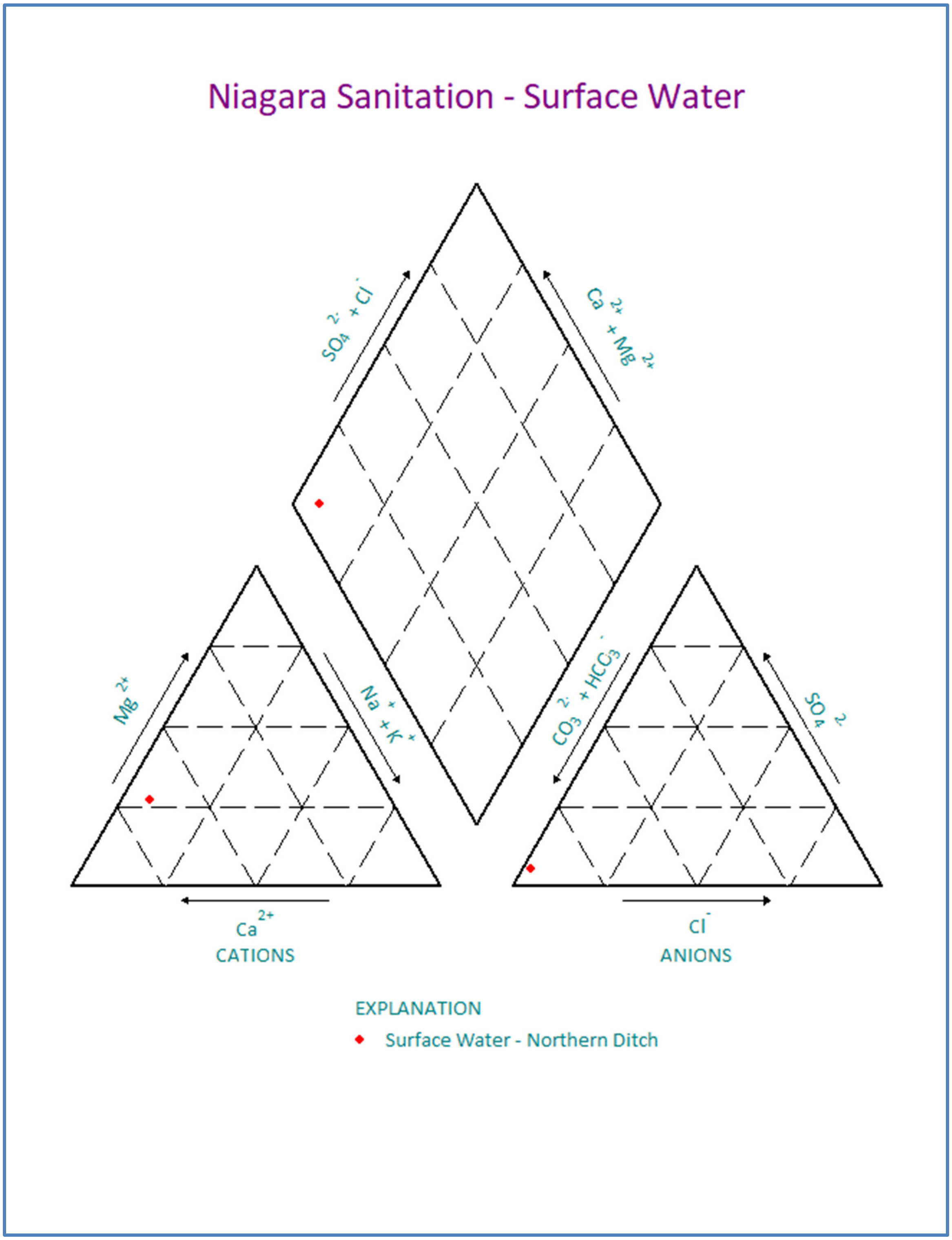



**Figure 6-4. Piper plot of surface water at the Niagara Sanitation Landfill.**

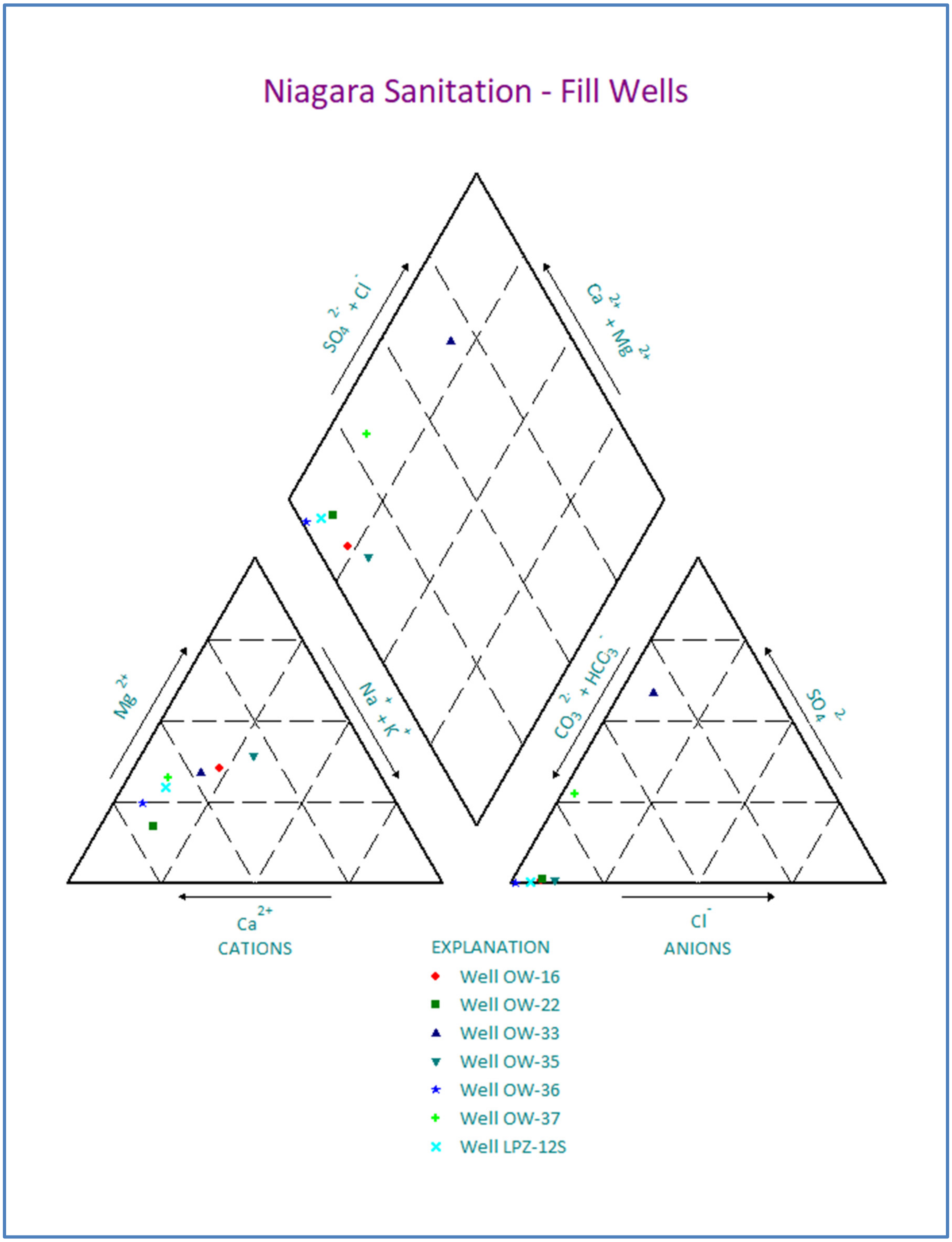



**Figure 6-5. Piper plot of fill wells at the Niagara Sanitation Landfill.**

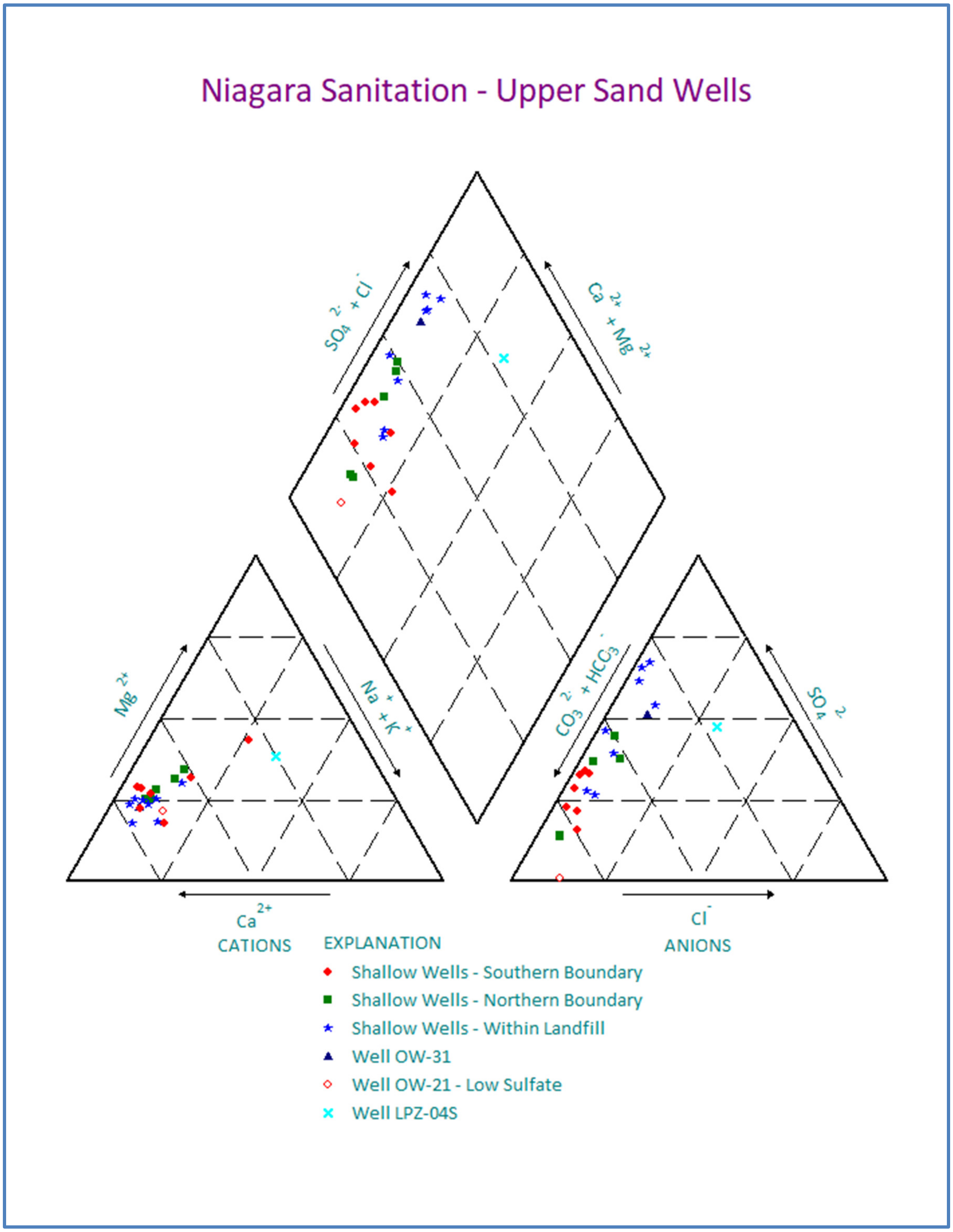



**Figure 6-6. Piper plot of upper sand deposit wells at the Niagara Sanitation Landfill.**

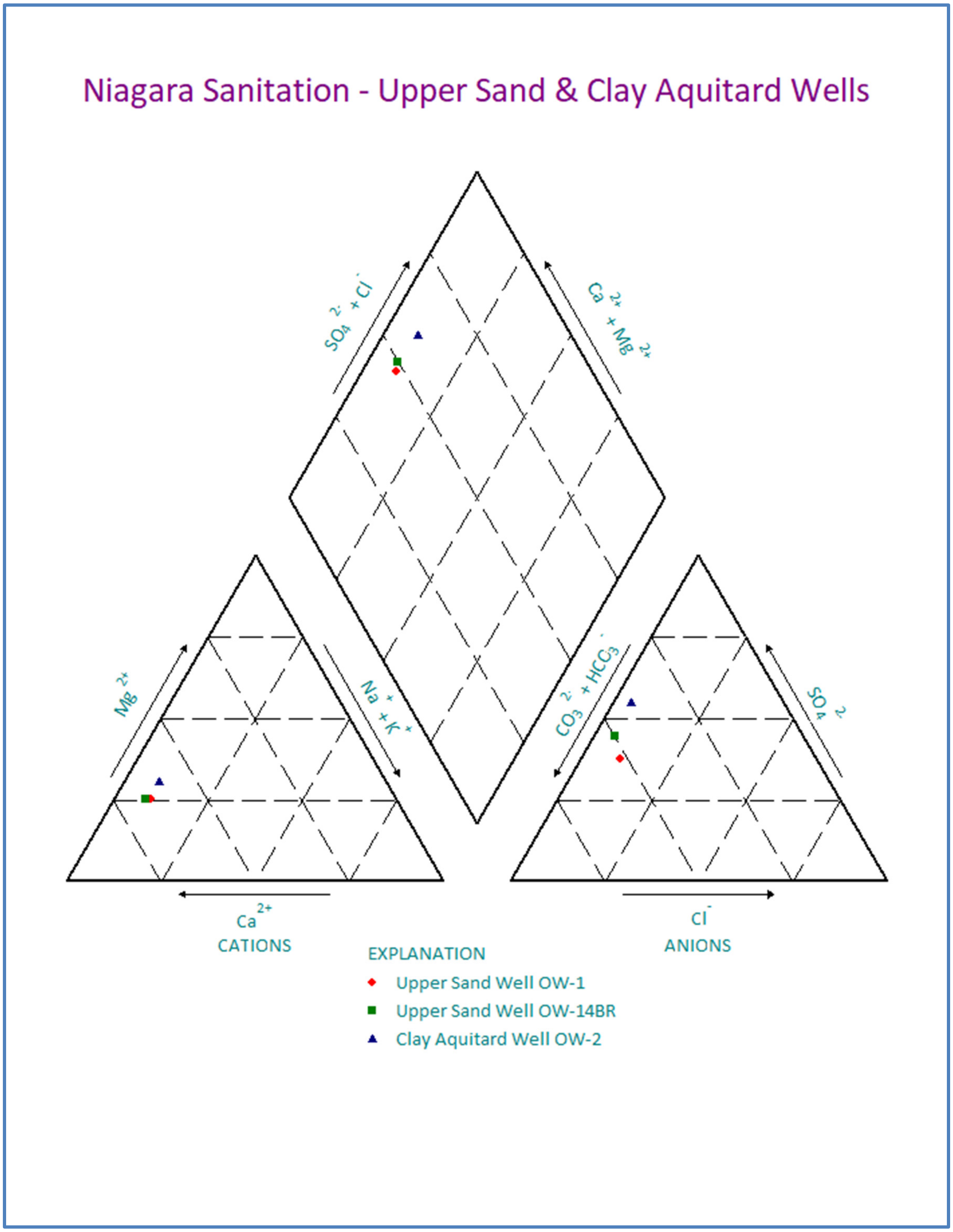



**Figure 6-7. Piper plot of the upper clay aquitard well at the Niagara Sanitation Landfill. This plot also shows two nearby upper sand wells.**

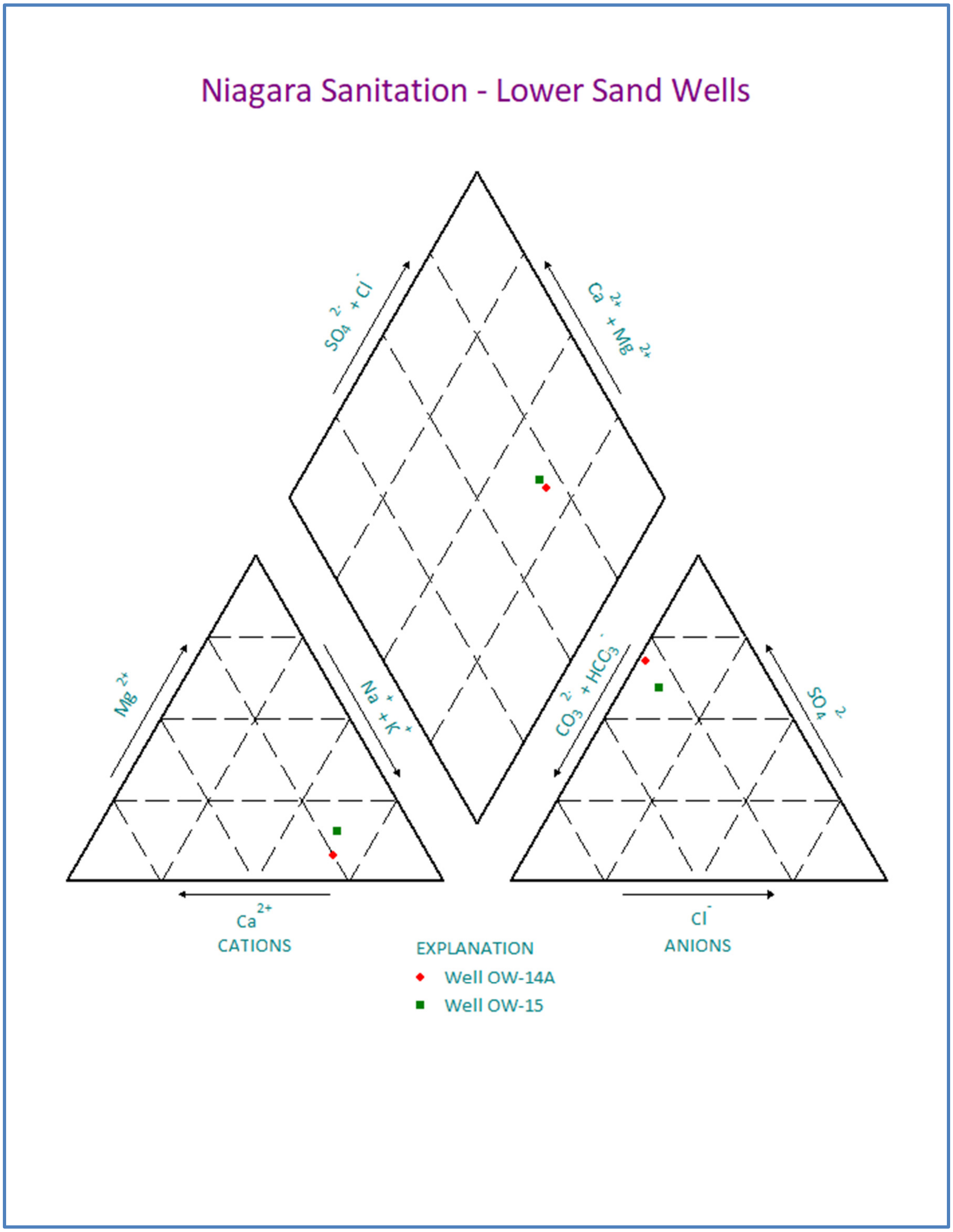



**Figure 6-8. Piper plot of lower sand deposit wells at the Niagara Sanitation Landfill.**

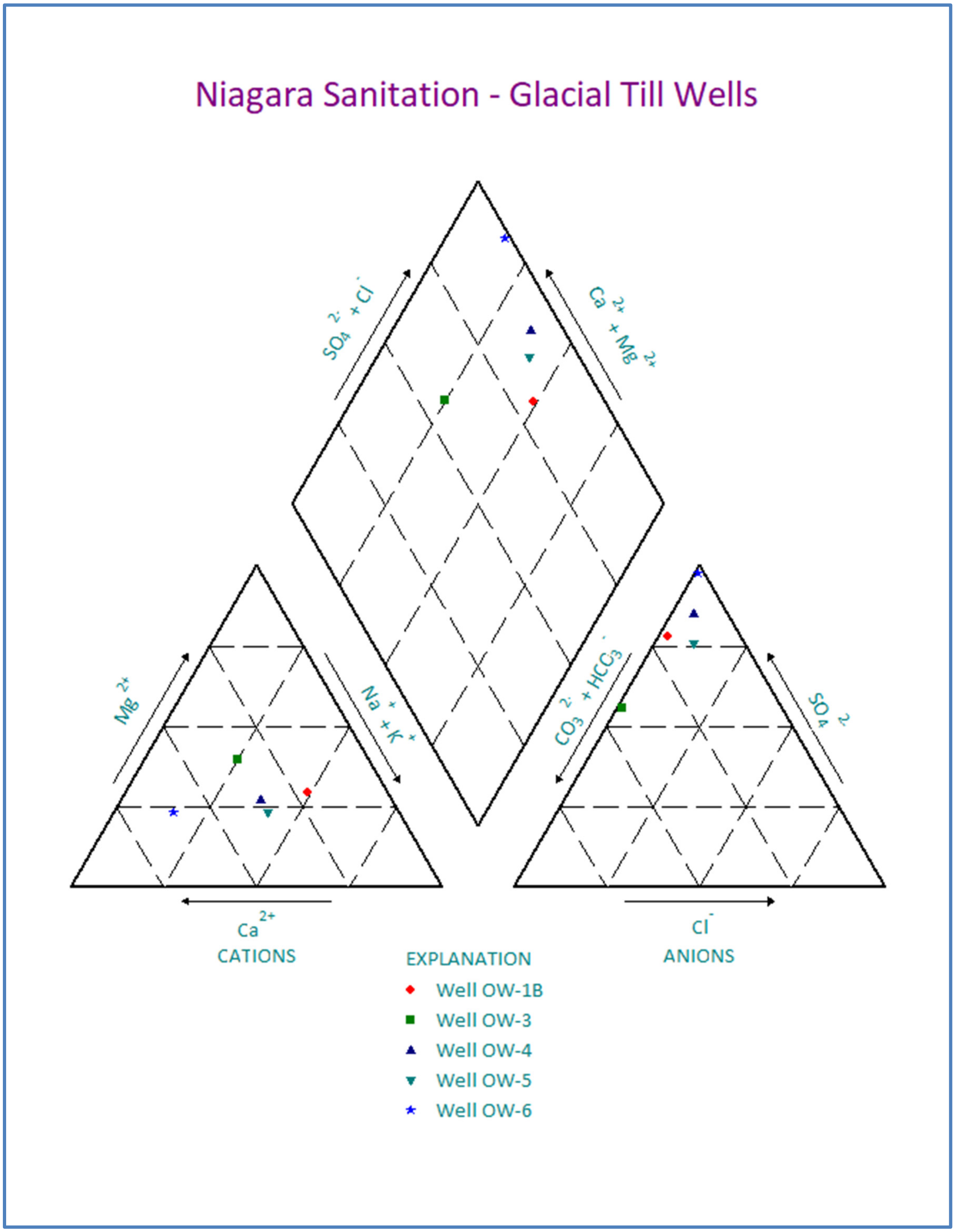



**Figure 6-9. Piper plot of glacial till deposit wells at the Niagara Sanitation Landfill.**

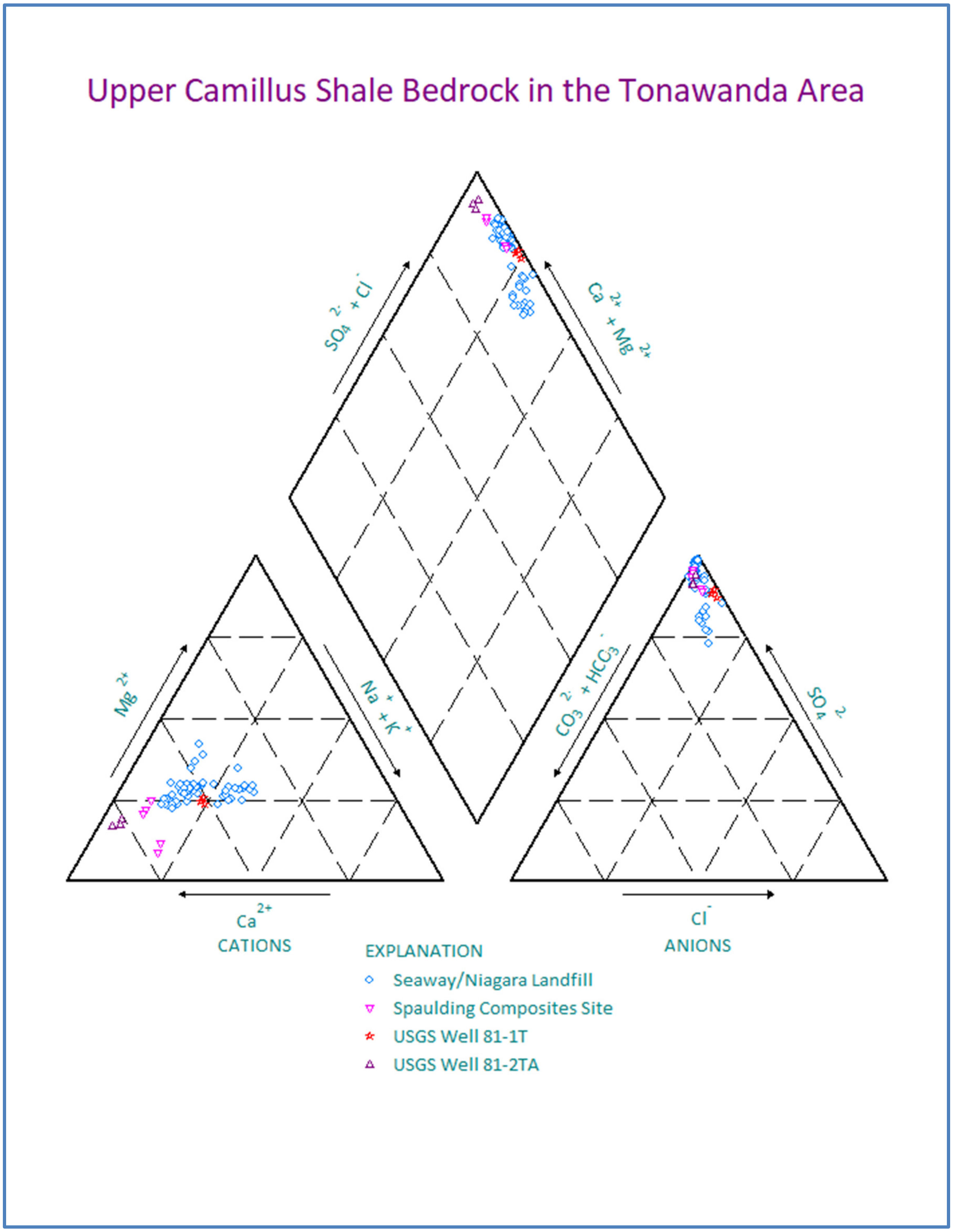



**Figure 6-10. Piper plot of upper Camillus Shale bedrock wells in the Tonawanda Area.**

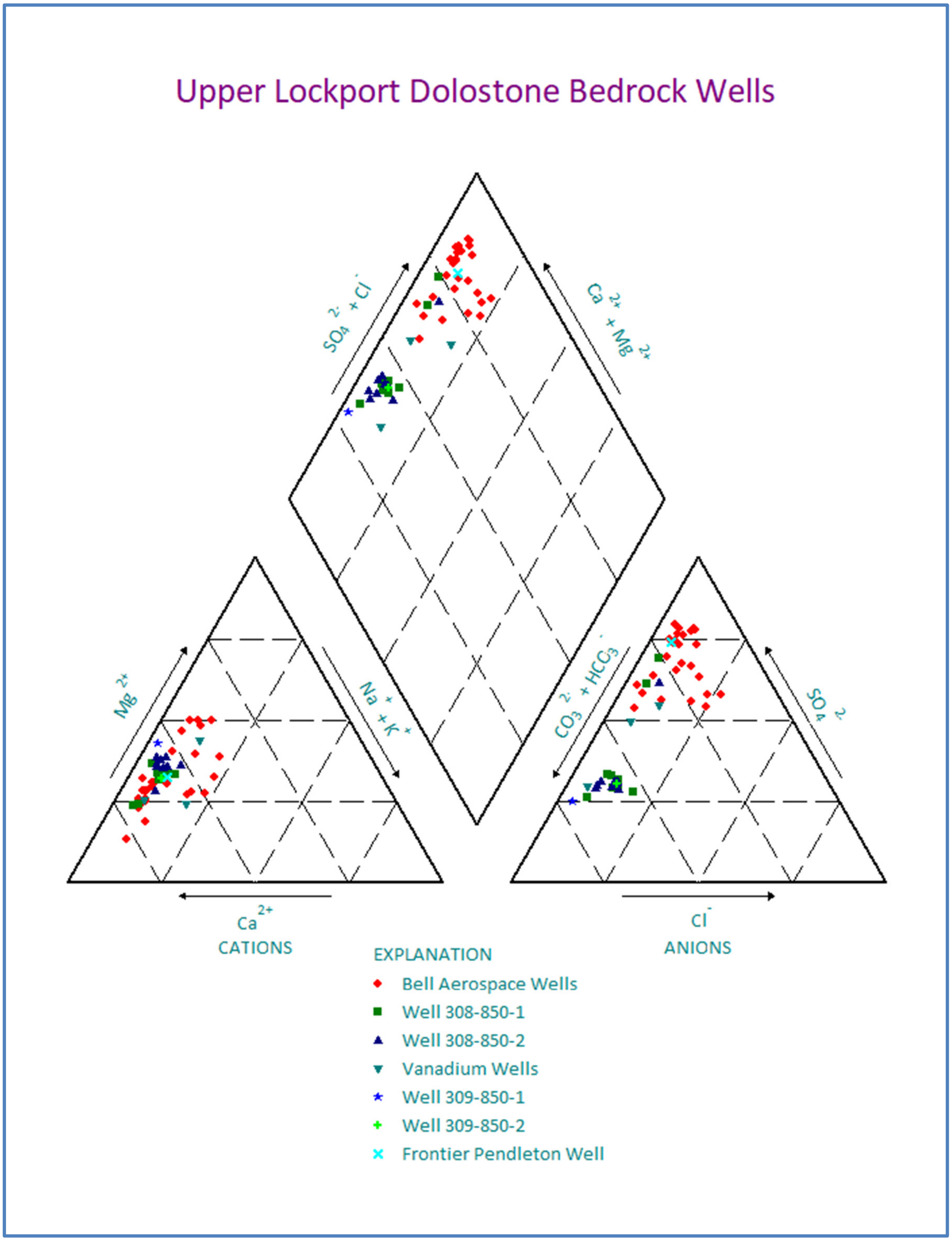



**Figure 6-11. Piper plot of Lockport Dolostone bedrock wells in the Niagara Falls Area.**

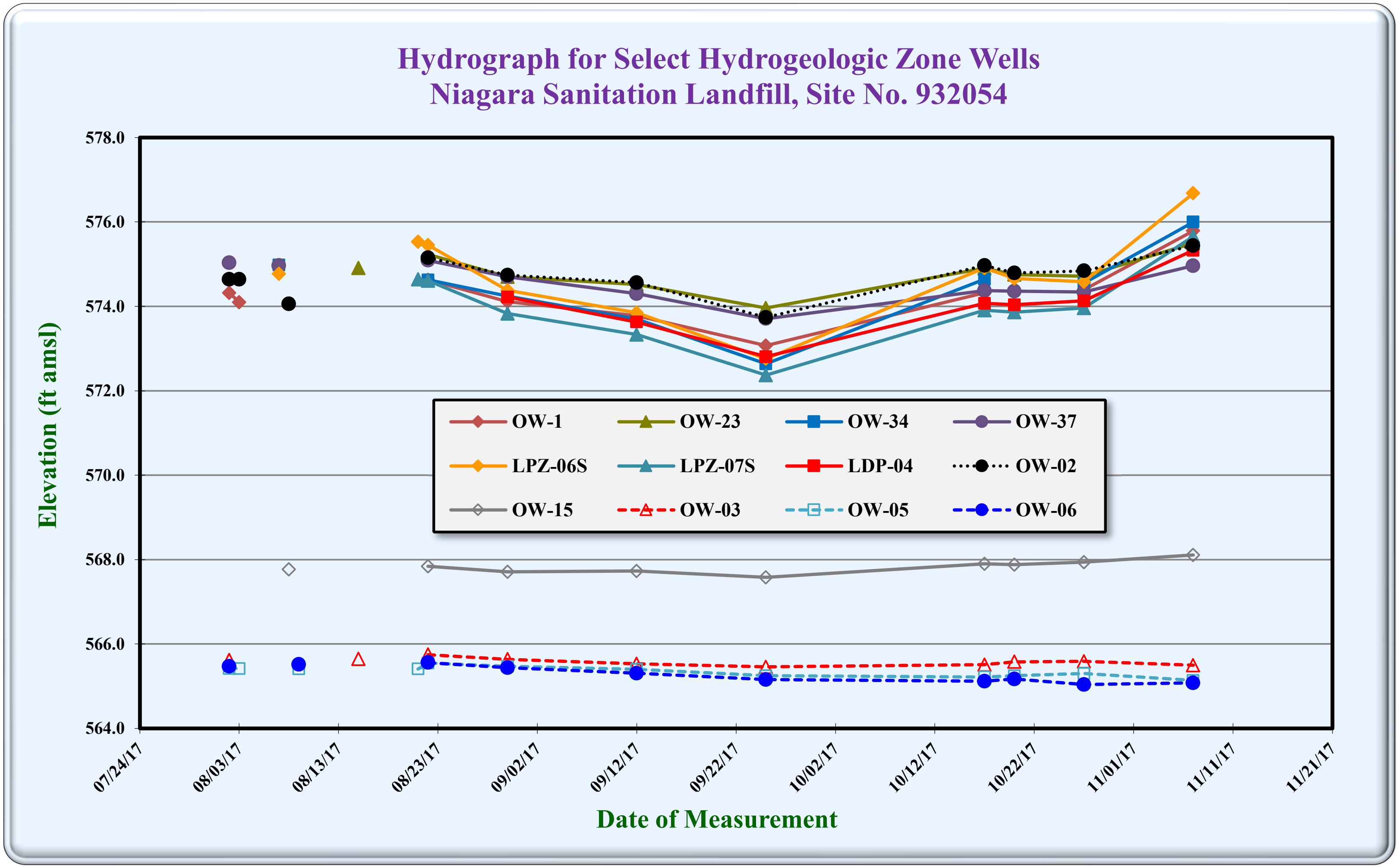
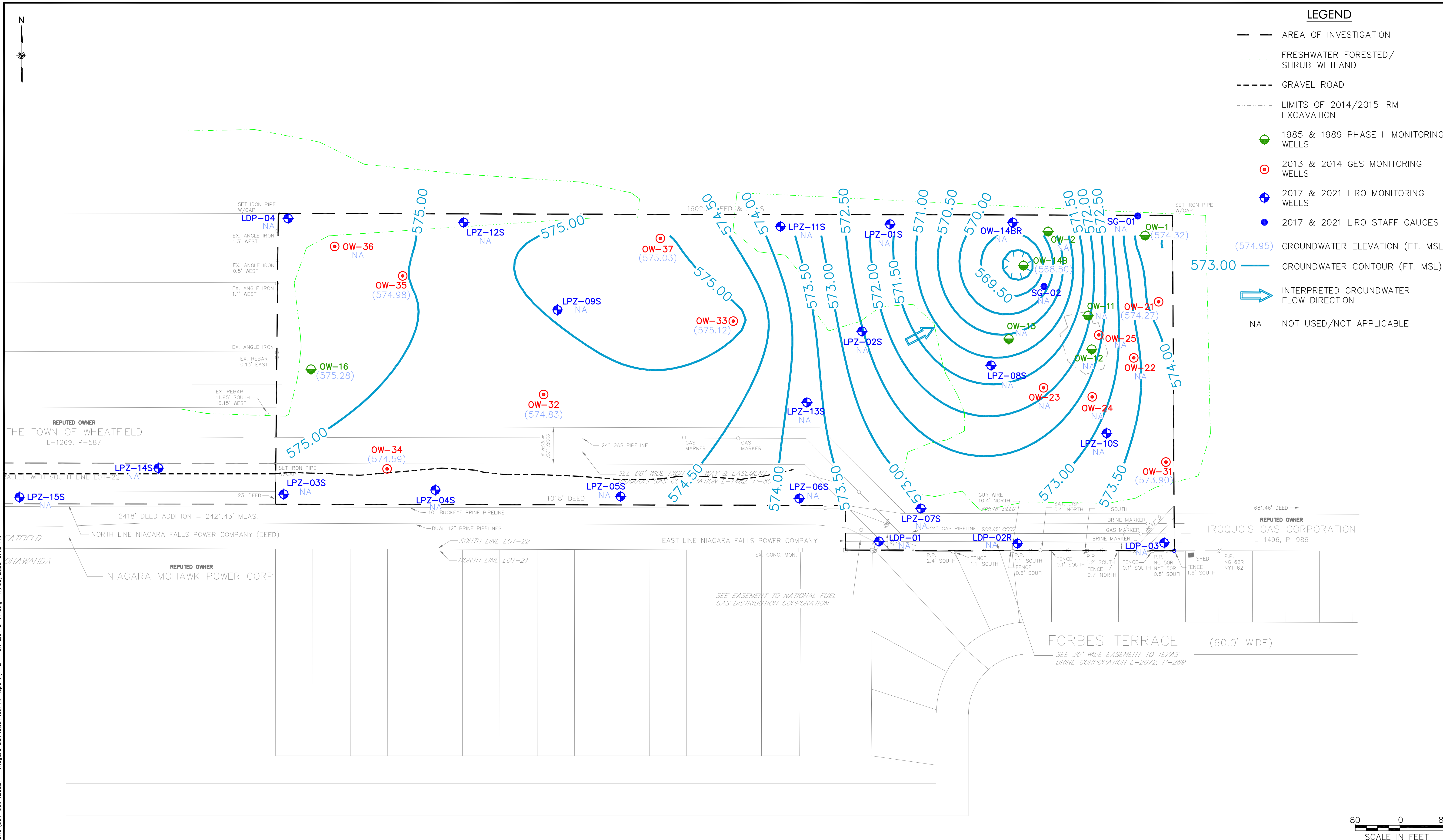



**Figure 7-1. Hydrograph for Representative Wells from All Hydrogeologic Zones at the Niagara Sanitation Landfill Site.** **Solid lines denote the fill/upper sand wells, the dotted line denotes the upper clay aquitard well; the gray open symbols with a solid line denote the lower sand well; and the dashed lines denote the glacial till wells.**

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TOWN OF WHEATFIELD, NIAGARA COUNTY, NEW YORK
NYSDEC SITE NUMBER 932054

DRAWING TITLE:
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FILL/UPPER SAND: AUGUST 2, 2017

LIRO JOB NO.: 17-013-0289

SHEET OF

FIGURE NO. 7-2

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# TABLES

**Table 3-1**
**Average Monthly Precipitation and Evapotranspiration Data**
**NYSDEC Hydrogeologic Evaluation Report**
**Niagara Sanitation Site, Site No. 932054**
**Wheatfield, New York**

NEW YORK STATE | Department of Environmental Conservation

| Month | Average Monthly Precipitation 1985-2015 (inches) | Average Monthly Precipitation 2016-2022 (inches) | Monthly Precipitation 2017 (inches) | Monthly Precipitation 2019 (inches) | Monthly Precipitation 2020 (inches) | Monthly Precipitation 2021 (inches) | Potential Evapotranspiration (Staubitz and Miller, 1987) |
|---|---|---|---|---|---|---|---|
| January | 3.14 | 3.19 | 2.92 | 5.71 | 2.72 | 1.85 | 0.46 |
| February | 2.57 | 3.11 | 2.26 | 3.28 | 2.50 | 2.06 | 0.43 |
| March | 2.84 | 2.89 | 4.36 | 2.73 | 3.20 | 1.92 | 0.89 |
| April | 3.20 | 3.49 | 6.38 | 3.07 | 3.54 | 2.77 | 1.69 |
| May | 3.43 | 3.19 | 6.35 | 3.53 | 3.87 | 1.63 | 3.13 |
| June | 3.64 | 2.73 | 2.21 | 4.60 | 3.55 | 1.77 | 4.26 |
| July | 3.22 | 3.38 | 4.65 | 1.83 | 3.42 | 7.49 | 5.31 |
| August | 3.21 | 3.31 | 3.15 | 3.62 | 2.10 | 3.68 | 4.32 |
| September | 3.94 | 4.22 | 3.17 | 6.28 | 3.40 | 5.28 | 2.55 |
| October | 3.96 | 4.87 | 5.01 | 5.83 | 3.60 | 6.14 | 1.51 |
| November | 3.70 | 3.57 | 5.09 | 1.97 | 2.81 | 3.28 | 0.71 |
| December | 3.77 | 3.86 | 2.93 | 5.37 | 4.96 | 2.46 | 0.48 |
| **Totals** | **40.62** | **41.81** | **48.48** | **47.82** | **39.67** | **40.33** | **25.74** |

**Notes:**

**From monthly precipitation data measured at the National Weather Service Station at the Buffalo Niagara International Airport.**

**Table 4-1**
**Stratigraphic Sequence of Western New York**
**Compiled from Buehler and Tesmer (1963) and Brett et al. (1995).**
**NYSDEC Hydrogeologic Evaluation Report**
**Niagara Sanitation Site, Site No. 932054**
**Wheatfield, New York**

| Epoch | Group | Formation | Member |
|---|---|---|---|
| Middle Devonian | Hamilton | Moscow Shale | Windom Shale<br>Kashong Shale |
| | | Ludlowville Formation | Tichenor Limestone<br>Wanakah Shale<br>Ledyard Shale<br>Centerfield Limestone |
| | | Skaneateles Formation | Levanna Shale<br>Stafford Limestone |
| | | Marcellus Shale | Oatka Creek Shale |
| | | Onondaga Limestone | Seneca Limestone<br>Morehouse Limestone<br>Nedrow Limestone<br>Clarence Limestone<br>Edgecliff Limestone |
| Late Silurian | Salina | Akron Dolostone | |
| | | Bertie Dolostone | Williamsville Dolostone<br>Scajaquada Dolostone<br>Falkirk Dolostone<br>Oatka Dolostone |
| | | Camillus Shale<br>Syracuse Formation<br>Vernon Shale | |
| Middle Silurian | Lockport | Guelph Dolostone<br>Eramosa Dolostone | |
| | | Goat Island Dolostone | Vinemount Dolostone<br>Ancaster Dolostone<br>Niagara Falls Dolostone |
| | | Gasport Limestone | Pekin Dolostone<br>Gothic Hill Limestone |
| | Clinton | Decew Dolostone | |
| | | Rochester Shale | Burleigh Hill Shale<br>Lewiston Shale |
| | | Irondequoit Limestone<br>Rockway Dolostone<br>Williamson Shale<br>Merritton Limestone | |
| | | Reynales Limestone | Hickory Corners Limestone |
| | | Neahga Shale | |
| Early Silurian | Medina | Kodak Sandstone<br>Cambria Shale<br>Thorold Sandstone<br>Grimsby Formation<br>Devils Hole Shale<br>Power Glen Shale<br>Whirlpool Sandstone | |
| Late Ordovician | Richmond | Queenston Shale<br>Oswego Sandstone | |

NEW YORK STATE | Department of Environmental Conservation

**Table 4-2**
**Stratigraphic Summary of the Niagara Sanitation Landfill**
**NYSDEC Hydrogeologic Report**
**Niagara Sanitation Site, Site No. 932054**
**Wheatfield, New York**

| Boring or Well Number | Coordinates * | | Total Depth | Ground ● Surface Elevation (ft. amsl) | Fill Material & Reworked Soil | | | Brown Silt & Clay Deposit | | | Upper Sand Deposit | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Latitude | Longitude | | | Depth | Surface Elevation | Thickness | Depth | Surface Elevation | Thickness | Depth | Surface Elevation | Thickness |
| **1985 Phase II Investigation** | | | | | | | | | | | | | |
| OW-1 | 43.069455 | -78.854876 | 10.0 | 577.31 | Same stratigraphic log as well OW-1B | | | | | | | | |
| OW-1B | 43.069447 | -78.854900 | 68.6 | 577.41 | ------- | ------- | ------- | 0.0 | 577.41 | 3.0 | ------- | ------- | ------- |
| OW-2 | 43.069495 | -78.855536 | 14.0 | 576.37 | ------- | ------- | ------- | 0.0 | 576.37 | 2.0 | 2.0 | 574.37 | 3.0 |
| OW-3 | 43.068537 | -78.854823 | 68.7 | 577.28 | 0.0 | 577.28 | 5.0 | ------- | ------- | ------- | ------- | ------- | ------- |
| OW-4 | 43.069497 | -78.858149 | 70.3 | 577.04 | 0.0 | 577.04 | 3.0 | 3.0 | 574.04 | 3.0 | 6.0 | 571.04 | 2.0 |
| OW-5 | 43.068641 | -78.859017 | 70.0 | 578.37 | ------- | ------- | ------- | ------- | ------- | ------- | 0.0 | 578.37 | 8.0 |
| OW-6 | 43.068793 | -78.860548 | 66.0 | 579.69 | 0.0 | 579.69 | 3.0 | ------- | ------- | ------- | 3.0 | 576.69 | 6.0 |
| **1989 Supplemental Phase II Investigation** | | | | | | | | | | | | | |
| OW-11 | 43.069089 | -78.855270 | 12.0 | 576.24 | 0.0 | 576.24 | > 12.0 | ------- | ------- | ------- | ------- | ------- | ------- |
| OW-12 | 43.068924 | -78.855244 | 34.0 | 576.94 | 0.0 | 576.94 | 5.0 | ------- | ------- | ------- | 5.0 | 571.94 | 1.5 |
| OW-13 | 43.068961 | -78.855806 | 6.0 | 575.52 | ------- | ------- | ------- | ------- | ------- | ------- | 1.5 | 574.02 | 3.5 |
| OW-14A | 43.069420 | -78.855733 | 40.0 | 576.73 | ------- | ------- | ------- | ------- | ------- | ------- | 0.0 | 576.73 | 7.0 |
| OW-14B | 43.069330 | -78.855709 | 10.0 | 576.91 | | | | | | | | | |
| OW-15 | 43.069471 | -78.858174 | 45.0 | 577.14 | ------- | ------- | ------- | 0.0 | 577.14 | 3.0 | 3.0 | 574.14 | 3.0 |
| OW-16 | 43.068802 | -78.860514 | 10.0 | 579.23 | 0.0 | 579.23 | 8.0 | ------- | ------- | ------- | ------- | ------- | ------- |
| **2013 Site Characterization** | | | | | | | | | | | | | |
| SB-A/OW-24 | 43.068690 | -78.855240 | 20.0 | 578.06 | 0.0 | 578.06 | ** | ------- | ------- | ---- | ------- | ------- | ------- |
| SB-B/OW-25 | 43.068995 | -78.855197 | 20.0 | 577.50 | 0.0 | 577.50 | 10.0 | ------- | ------- | ------- | 10.0 | 567.50 | 1.0 |
| SB-C/OW-22 | 43.068882 | -78.854962 | 12.0 | 577.45 | 0.0 | 577.45 | ■ | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-D/OW-21 | 43.069158 | -78.854797 | 12.0 | 577.71 | ------- | ------- | ------- | 0.0 | 577.71 | 1.0 | 1.0 | 576.71 | 6.0 |
| SB-E | 43.069356 | -78.854903 | 12.0 | 577.20 | 0.0 | 577.20 | 4.0 | ------- | ------- | ------- | 4.0 | 573.20 | 4.0 |
| SB-F/OW-23 | 43.068793 | -78.855565 | 8.0 | 577.16 | ------- | ------- | ------- | 0.0 | 577.16 | 1.0 | 1.0 | 576.16 | 5.0 |
| SB-G | 43.068947 | -78.856527 | 8.0 | 577.40 | 0.0 | 577.40 | 4.0 | ------- | ------- | ------- | 4.0 | 573.40 | 3.0 |
| SB-H | 43.069049 | -78.855222 | 10.0 | 576.75 | 0.0 | 576.75 | > 10.0 | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-I | 43.068917 | -78.855105 | 8.0 | 578.20 | 0.0 | 578.20 | 2.0 | ------- | ------- | ------- | 2.0 | 576.20 | 5.0 |
| SB-J | 43.069044 | -78.855312 | 16.0 | 577.00 | 0.0 | 577.00 | 2.5 | ------- | ------- | ------- | 2.5 | 574.50 | 7.5 |
| SB-K | 43.068768 | -78.855234 | 8.0 | 579.00 | 0.0 | 579.00 | 2.0 | ------- | ------- | ------- | 2.0 | 577.00 | 4.0 |
| SB-L | 43.068846 | -78.855227 | 8.0 | 578.50 | ------- | ------- | ------- | 0.0 | 578.50 | 4.0 | 4.0 | 574.50 | 2.0 |
| SB-M | 43.069045 | -78.855149 | 12.0 | 576.90 | 0.0 | 576.90 | 8.0 | ------- | ------- | ------- | ------- | ------- | ------- |

**Table 4-2**
**Stratigraphic Summary of the Niagara Sanitation Landfill**
**NYSDEC Hydrogeologic Report**
**Niagara Sanitation Site, Site No. 932054**
**Wheatfield, New York**

NEW YORK STATE | Department of Environmental Conservation

| Boring or Well Number | Gray-Brown Silty Clay Deposit | | | Red-Gray Layered Clay Deposit | | | Lower Sand Deposit | | | Glacial Till | | | Dolostone Bedrock | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Depth | Surface Elevation | Thickness | Depth | Surface Elevation | Thickness | Depth | Surface Elevation | Thickness | Depth | Surface Elevation | Thickness | Depth | Surface Elevation |
| **1985 Phase II Investigation** | | | | | | | | | | | | | | |
| OW-1 | Same stratigraphic log as well OW-1B | | | | | | | | | | | | | |
| OW-1B | 3.0 | 574.41 | 7.0 | 10.0 | 567.41 | 28.0 | ------- | ------- | ------- | 38.0 | 539.41 | 30.6 | 68.6 | 508.81 |
| OW-2 | 5.0 | 571.37 | 7.0 | 12.0 | 564.37 | > 2.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| OW-3 | 5.0 | 572.28 | 3.0 | 8.0 | 569.28 | 18.5 | 26.3 | 550.98 | 0.2 | 26.5 | 550.78 | 42.2 | 68.7 | 508.58 |
| OW-4 | 8.0 | 569.04 | 6.0 | 14.0 | 563.04 | 26.0 | 40.0 | 537.04 | 5.0 | 45.0 | 532.04 | 25.3 | 70.3 | 506.74 |
| OW-5 | 8.0 | 570.37 | 5.0 | 13.0 | 565.37 | 29.0 | 42.0 | 536.37 | 3.0 | 45.0 | 533.37 | 24.8 | 69.8 | 508.57 |
| OW-6 | 9.0 | 570.69 | 2.0 | 11.0 | 568.69 | 33.0 | ------- | ------- | ------- | 44.0 | 535.69 | 22.0 | 66.0 | 513.69 |
| **1989 Supplemental Phase II Investigation** | | | | | | | | | | | | | | |
| OW-11 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| OW-12 | 6.5 | 570.44 | 4.2 | 10.7 | 566.24 | 19.3 | 30.0 | 546.94 | > 4.0 | ------- | ------- | ------- | ------- | ------- |
| OW-13 | 5.0 | 570.52 | > 1.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| OW-14A | 7.0 | 569.73 | 4.0 | 11.0 | 565.73 | 22.0 | 33.0 | 543.73 | 3.0 | 36.0 | 540.73 | > 4.0 | ------- | ------- |
| OW-14B | | | | | | | | | | | | | | |
| OW-15 | 6.0 | 571.14 | 4.0 | 10.0 | 567.14 | 29.0 | 39.0 | 538.14 | 4.5 | 43.5 | 533.64 | > 1.5 | ------- | ------- |
| OW-16 | 8.0 | 571.23 | > 2.0 | ------- | ------- | ------- | ---- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| **2013 Site Characterization** | | | | | | | | | | | | | | |
| SB-A/OW-24 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-B/0W-25 | 11.0 | 566.50 | > 9.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-C/OW-22 | 8.0 | 569.45 | > 4.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-D/OW-21 | 7.0 | 570.71 | > 5.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-E | 8.0 | 569.20 | > 4.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-F/OW-23 | 6.0 | 571.16 | > 2.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-G | 7.0 | 570.40 | > 1.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-H | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-I | 7.0 | 571.20 | > 1.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-J | 10.0 | 567.00 | 2.0 | 12.0 | 565.00 | > 4.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-K | 6.0 | 573.00 | > 2.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-L | 6.0 | 572.50 | > 2.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-M | 8.0 | 568.90 | > 4.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |

NEW YORK STATE | Department of Environmental Conservation

**Table 4-2**
**Stratigraphic Summary of the Niagara Sanitation Landfill**
**NYSDEC Hydrogeologic Report**
**Niagara Sanitation Site, Site No. 932054**
**Wheatfield, New York**

| Boring or Well Number | Coordinates | | Total Depth | Ground Surface Elevation | Fill Material & Reworked Soil | | | Brown Silt & Clay Deposit | | | Upper Sand Deposit | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Latitude | Longitude | | | Depth | Surface Elevation | Thickness | Depth | Surface Elevation | Thickness | Depth | Surface Elevation | Thickness |
| **2014 Supplemental Site Characterization** | | | | | | | | | | | | | |
| SB-N | 43.068473 | -78.856715 | 8.0 | 577.25 | ------- | ------- | ------- | 0.0 | 577.25 | 2.0 | 2.0 | 575.25 | 4.0 |
| SB-O | 43.068676 | -78.856112 | 8.0 | 577.25 | ------- | ------- | ------- | 0.0 | 577.25 | 3.0 | 3.0 | 574.25 | 3.0 |
| SB-P | 43.069003 | -78.856958 | 8.0 | 577.00 | 0.0 | 577.00 | 2.0 | 2.0 | 575.00 | 2.0 | 4.0 | 573.00 | 2.0 |
| SB-Q | 43.069370 | -78.857714 | 12.0 | 577.50 | 0.0 | 577.50 | 2.0 | 2.0 | 575.50 | 2.0 | 4.0 | 573.50 | 4.0 |
| SB-R | 43.068368 | -78.855732 | 8.0 | 577.50 | ------- | ------- | ------- | 0.0 | 577.50 | 4.0 | 4.0 | 573.50 | 1.0 |
| SB-S/OW-31 | 43.068356 | -78.854756 | 8.0 | 577.71 | ------- | ------- | ------- | 0.0 | 577.71 | 1.0 | 1.0 | 576.71 | 5.0 |
| SB-T/OW-32 | 43.068678 | -78.858920 | 12.0 | 578.56 | 0.0 | 578.56 | 3.0 | ------- | ------- | ------- | 3.0 | 575.56 | 8.0 |
| SB-U | 43.068756 | -78.858189 | 12.0 | 578.10 | 0.0 | 578.10 | 4.0 | ------- | ------- | ------- | 4.0 | 574.10 | 6.0 |
| SB-V | 43.068862 | -78.858074 | 12.0 | 577.75 | 0.0 | 577.75 | 5.0 | ------- | ------- | ------- | 5.0 | 572.75 | 5.0 |
| SB-W/OW-33 | 43.069025 | -78.857664 | 12.0 | 579.83 | 0.0 | 579.83 | 4.0 | ------- | ------- | ------- | 4.0 | 575.83 | 7.0 |
| SB-X | 43.068359 | -78.858326 | 12.0 | 575.75 | 0.0 | 575.75 | 3.5 | ------- | ------- | ------- | 3.5 | 572.25 | 7.5 |
| SB-Y/OW-34 | 43.068330 | -78.859949 | 16.0 | 579.00 | ------- | ------- | ------- | 0.0 | 579.00 | 4.0 | 4.0 | 575.00 | 11.0 |
| SB-Z | 43.068313 | -78.860732 | 12.0 | 578.00 | 0.0 | 578.00 | 3.5 | ------- | ------- | ------- | 3.5 | 574.50 | 4.5 |
| SB-AA | 43.068316 | -78.861153 | 12.0 | 586.00 | 0.0 | 586.00 | > 12.0 | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-BB/OW-35 | 43.069245 | -78.859788 | 12.0 | 578.80 | ------- | ------- | ------- | 0.0 | 578.80 | 4.0 | 4.0 | 574.80 | 5.0 |
| SB-CC | 43.069426 | -78.860316 | 6.0 | 578.75 | 0.0 | 578.75 | > 6.0 | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-DD/OW-36 | 43.069399 | -78.860326 | 12.0 | 578.81 | 0.0 | 578.81 | 6.0 | ------- | ------- | ------- | 6.0 | 572.81 | 2.0 |
| SB-EE | 43.069335 | -78.860222 | 8.0 | 578.00 | 0.0 | 578.00 | 4.0 | 4.0 | 574.00 | 2.5 | 6.5 | 571.50 | 0.5 |
| SB-FF | 43.068814 | -78.860090 | 12.0 | 578.00 | 0.0 | 578.00 | 1.0 | ------- | ------- | ------- | 1.0 | 577.00 | 10.0 |
| SB-GG | 43.068861 | -78.860443 | 12.0 | 580.10 | 0.0 | 580.10 | 6.0 | ------- | ------- | ------- | 6.0 | 574.10 | 4.0 |
| SB-HH | 43.069029 | -78.860448 | 12.0 | 578.50 | 0.0 | 578.50 | 6.0 | ------- | ------- | ------- | 6.0 | 572.50 | 4.0 |
| SB-II/OW-37 | 43.069458 | -78.858134 | 8.0 | 577.32 | 0.0 | 577.32 | 4.0 | ------- | ------- | ------- | 4.0 | 573.32 | 2.0 |
| SB-JJ | 43.069020 | -78.858865 | 12.0 | 578.10 | 0.0 | 578.10 | 0.5 | 0.5 | 577.60 | 3.5 | 4.0 | 574.10 | 6.0 |
| SB-KK | 43.069127 | -78.859141 | 8.0 | 578.50 | 0.0 | 578.50 | 4.0 | ------- | ------- | ------- | 4.0 | 574.50 | 3.5 |
| **2017 Remedial Investigation** | | | | | | | | | | | | | |
| OW-14BR | 43.069546 | -78.855775 | 8.0 | 577.18 | ------- | ------- | ------- | 0.0 | 577.18 | 1.0 | 1.0 | 576.18 | 6.0 |
| LSB-01 | | | 6.0 | 576.50 | ------- | ------- | ------- | 0.0 | 576.50 | 1.5 | 1.5 | 575.00 | 3.8 |
| LSB-02 | | | 12.0 | 577.60 | 0.0 | 577.60 | 9.5 | ------- | ------- | ------- | ------- | ------- | ------- |
| LSB-03 | | | 6.0 | 577.00 | ------- | ------- | ------- | ------- | ------- | ------- | 0.0 | 577.00 | 4.0 |
| LPZ-01S | 43.069535 | -78.856600 | 7.0 | 577.25 | ------- | ------- | ------- | 0.0 | 577.25 | 1.0 | 1.0 | 576.25 | 4.9 |
| LPZ-02S | 43.069009 | -78.856784 | 6.0 | 577.66 | ------- | ------- | ------- | 0.0 | 577.66 | 1.5 | 1.5 | 576.16 | 4.3 |
| LPZ-03S | 43.068198 | -78.860660 | 18.0 | 577.86 | ------- | ------- | ------- | 0.0 | 577.86 | 1.0 | 1.0 | 576.86 | 7.0 |

**Table 4-2**
**Stratigraphic Summary of the Niagara Sanitation Landfill**
**NYSDEC Hydrogeologic Report**
**Niagara Sanitation Site, Site No. 932054**
**Wheatfield, New York**

NEW YORK STATE | Department of Environmental Conservation

| Boring or Well Number | Gray-Brown Silty Clay Deposit | | | Red-Gray Layered Clay Deposit | | | Lower Sand Deposit | | | Glacial Till | | | Dolostone Bedrock | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Depth | Surface Elevation | Thickness | Depth | Surface Elevation | Thickness | Depth | Surface Elevation | Thickness | Depth | Surface Elevation | Thickness | Depth | Surface Elevation |
| **2014 Supplemental Site Characterization** | | | | | | | | | | | | | | |
| SB-N | 6.0 | 571.25 | > 2.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-O | 6.0 | 571.25 | > 2.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-P | 6.0 | 571.00 | > 2.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-Q | 8.0 | 569.50 | > 4.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-R | 5.0 | 572.50 | > 3.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-S/OW-31 | 6.0 | 571.71 | > 2.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-T/OW-32 | 11.0 | 567.56 | > 1.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-U | 10.0 | 568.10 | > 2.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-V | 10.0 | 567.75 | > 2.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-W/OW-33 | 11.0 | 568.83 | > 1.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-X | 11.0 | 564.75 | > 1.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-Y/OW-34 | 15.0 | 564.00 | > 1.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-Z | 8.0 | 570.00 | > 4.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-AA | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-BB/OW-35 | 9.0 | 569.80 | > 3.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-CC | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-DD/OW-36 | 8.0 | 570.81 | > 4.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-EE | 7.0 | 571.00 | > 1.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-FF | 11.0 | 567.00 | > 1.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-GG | 10.0 | 570.10 | > 2.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-HH | 10.0 | 568.50 | > 2.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-II/OW-37 | 6.0 | 571.32 | > 2.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-JJ | 10.0 | 568.10 | > 2.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| SB-KK | 7.5 | 571.00 | > 0.5 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| **2017 Remedial Investigation** | | | | | | | | | | | | | | |
| OW-14BR | 7.0 | 570.18 | | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| LSB-01 | 5.3 | 571.20 | | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| LSB-02 | 9.5 | 568.10 | | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| LSB-03 | 4.0 | 573.00 | | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| LPZ-01S | 5.9 | 571.35 | | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| LPZ-02S | 5.75 | 571.91 | | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| LPZ-03S | 8.0 | 569.86 | 8.0 | 16.0 | 561.86 | > 2.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |

**Table 4-2**
**Stratigraphic Summary of the Niagara Sanitation Landfill**
**NYSDEC Hydrogeologic Report**
**Niagara Sanitation Site, Site No. 932054**
**Wheatfield, New York**

New York State Department of Environmental Conservation

| Boring or Well Number | Coordinates | | Total Depth | Ground Surface Elevation | Fill Material & Reworked Soil | | | Brown Silt & Clay Deposit | | | Upper Sand Deposit | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Latitude | Longitude | | | Depth | Surface Elevation | Thickness | Depth | Surface Elevation | Thickness | Depth | Surface Elevation | Thickness |
| **2017 Remedial Investigation (continued)** | | | | | | | | | | | | | |
| LPZ-04S | 43.068220 | -78.859642 | 6.0 | 576.87 | ------- | ------- | ------- | 0.0 | 576.87 | 1.0 | 1.0 | 575.87 | > 5.0 |
| LPZ-05S | 43.068193 | -78.858399 | 8.0 | 577.33 | ------- | ------- | ------- | 0.0 | 577.33 | 0.5 | 0.5 | 576.83 | 5.5 |
| LPZ-06S | 43.068187 | -78.857203 | 18.0 | 578.03 | ------- | ------- | ------- | 0.0 | 578.03 | 1.0 | 1.0 | 577.03 | 7.0 |
| LPZ-07S | 43.068139 | -78.856388 | 8.0 | 577.43 | ------- | ------- | ------- | 0.0 | 577.43 | 0.5 | 0.5 | 576.93 | 6.0 |
| LPZ-08S | 43.068842 | -78.855921 | 6.0 | 575.95 | 0.0 | 575.95 | 3.0 | ------- | ------- | ------- | 3.0 | 572.95 | 1.0 |
| LPZ-09S | 43.069109 | -78.858825 | 10.0 | 578.12 | 0.0 | 578.12 | 4.0 | ------- | ------- | ------- | 4.0 | 574.12 | 4.0 |
| LPZ-10S | 43.068511 | -78.855143 | 8.0 | 577.41 | 0.0 | 577.41 | 4.4 | ------- | ------- | ------- | 4.4 | 573.01 | 0.4 |
| LPZ-11S | 43.069523 | -78.857335 | 8.0 | 577.65 | 0.0 | 577.65 | 2.0 | ------- | ------- | ------- | 2.0 | 575.65 | 5.0 |
| LPZ-12S | 43.069538 | -78.859457 | 8.0 | 577.09 | 0.0 | 577.09 | 5.0 | ------- | ------- | ------- | 5.0 | 572.09 | 1.0 |
| LPZ-13S | 43.068658 | -78.857154 | 8.0 | 578.75 | 0.0 | 578.75 | 3.0 | ------- | ------- | ------- | 3.0 | 575.75 | 4.4 |
| LDP-01 | 43.067974 | -78.856667 | 5.3 | 576.92 | ------- | ------- | ------- | 0.0 | 576.92 | 1.6 | 1.6 | 575.32 | > 3.7 |
| LDP-02 | 43.067965 | -78.855737 | 5.3 | 577.46 | ------- | ------- | ------- | 0.0 | 577.46 | 1.6 | 1.6 | 575.86 | > 3.7 |
| LDP-03 | 43.067970 | -78.854756 | 5.1 | 577.25 | ------- | ------- | ------- | 0.0 | 577.25 | 1.0 | 1.0 | 576.25 | 3.9 |
| LDP-04 | 43.069556 | -78.860639 | 5.3 | 578.15 | 0.0 | 578.15 | 2.3 | 2.3 | 575.85 | 0.8 | 3.1 | 575.05 | > 2.2 |
| **2021 Supplemental Remedial Investigation** | | | | | | | | | | | | | |
| LPZ-14S | | | 12.0 | | 0.0 | 0.00 | 4.0 | ------- | ------- | ------- | 4.0 | -4.00 | 4.0 |
| LPZ-15S | | | 12.0 | | 0.0 | 0.00 | 3.0 | ------- | ------- | ------- | 3.0 | -3.00 | 4.5 |
| LPZ-16S | | | | | | 0.00 | 0.0 | | 0.00 | 0.0 | | 0.00 | 0.0 |
| LPZ-17S | | | | | | 0.00 | 0.0 | | 0.00 | 0.0 | | 0.00 | 0.0 |
| LPZ-18S | | | | | | 0.00 | 0.0 | | 0.00 | 0.0 | | 0.00 | 0.0 |

**Notes:**

* = Coordinates are from the LiRo surveyed completed during the 2017 Remedial Investigation.
● = Ground surface elevations for the monitoring wells are from Table 4-1 of the LiRo RI Report dated February 2019.
Depths in feet below ground surface.
---- = Indicates that the deposit was not encountered or identifed in the stated soil boring log.
Blue Shaded Boring: Located within the limits of the 2014/2015 IRM excavation.
Green Shaded Elevation: Estimated by adding the average elevation difference between the Engineering-Science & LiRo Surveys to the Engineering-Science elevation.
This well was destroyed during the OCC IRM.
Orange Shaded Coordinate: From the GES Site Characterization Report dated November 2013.
Yellow Shaded Coordinate: From the GES Site Characterization Report dated June 2014.
Yellow Shaded Elevation: Estimated on November 1 & 2, 2022 from LiRo's Ground Surface Topography Map (Figure 2-3 of the RI Report) with the well layers turned on.
Gray Shaded Depth: The silt & clay deposit was described as gray instead of brown.

Table 4-2
Stratigraphic Summary of the Niagara Sanitation Landfill
NYSDEC Hydrogeologic Report
Niagara Sanitation Site, Site No. 932054
Wheatfield, New York

New York State Department of Environmental Conservation

| Boring or Well Number | Gray-Brown Silty Clay Deposit | | | Red-Gray Layered Clay Deposit | | | Lower Sand Deposit | | | Glacial Till | | | Dolostone Bedrock | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Depth | Surface Elevation | Thickness | Depth | Surface Elevation | Thickness | Depth | Surface Elevation | Thickness | Depth | Surface Elevation | Thickness | Depth | Surface Elevation |
| **2017 Remedial Investigation (continued)** | | | | | | | | | | | | | | |
| LPZ-04S | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| LPZ-05S | 6.0 | 571.33 | > 2.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| LPZ-06S | 8.0 | 570.03 | > 2.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| LPZ-07S | 6.5 | 570.93 | > 4.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| LPZ-08S | 4.0 | 571.95 | > 3.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| LPZ-09S | 8.0 | 570.12 | > 2.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| LPZ-10S | 4.8 | 572.61 | > 1.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| LPZ-11S | 7.0 | 570.65 | > 2.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| LPZ-12S | 6.0 | 571.09 | > 2.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| LPZ-13S | 7.4 | 571.35 | > 1.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| LDP-01 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| LDP-02 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| LDP-03 | 4.9 | 572.35 | > 4.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| LDP-04 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| **2021 Supplemental Remedial Investigation** | | | | | | | | | | | | | | |
| LPZ-14S | 8.0 | -8.00 | > 2.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| LPZ-15S | 7.5 | -7.50 | > 2.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| LPZ-16S | | 0.00 | > 2.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| LPZ-17S | | 0.00 | > 4.0 | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| LPZ-18S | | | | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |

**Notes (continued):**

**Orange Shaded Depth: Laminated gray-red clay is identified above fill material. This is likely reworked soil from the excavation of the disposal pit.**

**** = Poor to no recovery from 4.0' to 20' depth.**

**■ = No recovery from 4' to 8' depth so it is not certain if the upper sand deposit is present at this location.**

**Boring SB-L was completed in an area of the IRM excavation that went to 30 feet depth. Since this boring was only completed to 8 feet depth, and since records indicate that 12 feet of soil was placed over the top of the LaSalle Expressway wastes, this boring likely only encountered reworked soils. The boring log, however, does show layered deposits.**

**Table 4-3**
**Summary of Grain Size Analyses**
**NYSDEC Hydrogeologic Report**
**Niagara Sanitation Site, Site No. 932054**
**Wheatfield, New York**

| Boring Number | Depth (ft) | Gravel (%) | Sand (%) | Silt (%) | Clay (%) | Unified Soil Classification | Stratigraphic Unit |
|---|---|---|---|---|---|---|---|
| **Reworked Soil** | | | | | | | |
| OW-11 | 2.0 - 4.0 | 14.8 | 20.8 | 66.8 | 4.6 | ML | red-gray clay (reworked) |
| OW-16 | 2.0 - 4.0 | 0.1 | 66.9 | 26.2 | 6.8 | SM | brown clay (reworked) |
| OW-16 | 6.0 - 8.0 | 26.9 | 26.6 | 25.3 | 21.2 | GM | gray-brown silt (reworked) |
| **Arithmetic Mean:** | | **13.93** | **38.10** | **39.43** | **10.87** | | |
| **Geometric Mean:** | | **3.41** | **33.33** | **35.38** | **8.72** | | |
| **Brown Silt & Clay Deposit** | | | | | | | |
| OW-1 | 2.0 - 4.0 | 0.0 | 18.0 | 59.0 | 23.0 | ML | brown silt & clay |
| **Upper Sand Deposit** | | | | | | | |
| OW-5 | 5.0 - 7.0 | 0.0 | 84.0 | 16.0 * | | SW | upper sand lens |
| OW-13 | 2.0 - 4.0 | 0.3 | 87.6 | 12.1 * | | SM | upper sand lens |
| OW-14B | 4.0 - 6.0 | 0.0 | 74.4 | 23.2 | 2.4 | SM | upper sand lens |
| **Arithmetic Mean:** | | **0.10** | **82.00** | **23.20** | **2.40** | | |
| **Geometric Mean:** | | **N/A** | **81.81** | **23.20** | **2.40** | | |
| **Gray-Brown Silty Clay Deposit** | | | | | | | |
| OW-4 | 12.0 - 13.0 | 0.0 | 0.0 | 14.0 | 86.0 | CL | gray-brown silty clay |
| OW-12 | 5.0 - 7.0 | 0.3 | 6.7 | 69.8 | 23.2 | ML | gray-brown silty clay |
| OW-13 | 4.0 - 6.0 | 0.1 | 4.8 | 95.1 * | | ML | gray-brown silty clay |
| **Arithmetic Mean:** | | **0.13** | **3.83** | **41.90** | **54.60** | | |
| **Geometric Mean:** | | **N/A** | **N/A** | **31.26** | **44.67** | | |
| **Red-Gray Layered Clay Deposit** | | | | | | | |
| OW-4 | 30.0 - 32.0 | 0.0 | 0.0 | 24.0 | 76.0 | CL | red-gray layered clay |
| OW-12 | 20.0 - 22.0 | 0.0 | 0.9 | 15.1 | 84.0 | CL | red-gray layered clay |
| OW-14A | 25.0 - 27.0 | 0.0 | 0.3 | 13.7 | 86.0 | CL | red-gray layered clay |
| OW-15 | 15.0 - 17.0 | 0.0 | 0.6 | 16.4 | 83.0 | CL | red-gray layered clay |
| **Arithmetic Mean:** | | **0.00** | **0.45** | **17.30** | **82.25** | | |
| **Geometric Mean:** | | **N/A** | **N/A** | **16.89** | **82.16** | | |
| **Lower Sand Deposit** | | | | | | | |
| OW-4 | 44.6 - 45.0 | 0.0 | 65.0 | 35.0 * | | SP | lower sand lens |
| OW-12 | 30.0 - 32.0 | 10.2 | 32.5 | 57.3 * | | ML | lower sand lens |
| OW-15 | 42.0 - 44.0 | 18.3 | 30.4 | 39.2 | 12.1 | ML | lower sand lens |
| **Arithmetic Mean:** | | **9.50** | **42.63** | **39.20** | **12.10** | | |
| **Geometric Mean:** | | **N/A** | **40.05** | **39.20** | **12.10** | | |
| **Glacial Till Deposit** | | | | | | | |
| OW-1B | 50.0 - 51.5 | 10.0 | 30.0 | 60.0 * | | ML | glacial till |
| OW-6 | 60.0 - 60.5 | 15.0 | 19.0 | 66.0 * | | ML | glacial till |
| OW-14A | 36.0 - 38.0 | 15.3 | 34.7 | 11.4 | 39.1 | CL | glacial till |
| **Arithmetic Mean:** | | **13.43** | **27.90** | **11.40** | **39.10** | | |
| **Geometric Mean:** | | **13.19** | **27.04** | **11.40** | **39.10** | | |

**Table 4-3**
**Summary of Grain Size Analyses**
**NYSDEC Hydrogeologic Report**
**Niagara Sanitation Site, Site No. 932054**
**Wheatfield, New York**

**Notes:**

*** = Percentage of clay and silt combined.**

**Green shaded stratigraphic unit was originally described as brown/gray silty clay. A review of the boring log indicates that this is the deposit that overlies the upper sand deposit.**

**Gray shaded stratigraphic unit was originally described as fill. A review of the boring log indicates that this deposit is reworked red-gray clay.**

**Blue shaded stratigraphic unit was originally described as glacial till. A review of the boring log suggests that this deposit is the lower sand.**

**Yellow shaded stratigraphic unit was originally described as brown/gray silty clay. This sample is above the one where trash was present so it must be reworked.**

**Orange shaded stratigraphic unit was originally described as the upper sand lens. At that depth, the log indicates that trash was present.**

**Table 5-1**
**Construction Summary of Existing and Decommissioned Wells at the Niagara Sanitation Landfill**
**NYSDEC Hydrogeologic Report**
**Niagara Sanitation Site, Site No. 932054**
**Wheatfield, New York**

NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

| Well Number | Ground ● Surface Elevation (ft. amsl) | Top of ● Riser Elevation (ft. amsl) | Total Boring Depth (ft. BGS) | Sandpack Interval (ft. BGS) | Sandpack Interval (ft. amsl) | Well Screen Interval (ft. BGS) | Well Screen Interval (ft. amsl) | Screened Water-Bearing Zone |
|---|---|---|---|---|---|---|---|---|
| **Upper Sand Deposit** | | | | | | | | |
| OW-1 | 577.31 | 578.30 | 10.0 | 4.0 to 10.0 | 573.31 to 567.31 | 4.0 to 9.0 | 573.31 to 568.31 | Silty Clay with Sand Seams |
| ~~OW-11~~ | ~~576.40~~ | ~~579.04~~ | ~~12.0~~ | ~~5.0 to 9.0~~ | ~~571.40 to 567.40~~ | ~~7.0 to 9.0~~ | ~~569.40 to 567.40~~ | ~~Fill/Reworked Soil~~ |
| OW-13 | 575.52 | 579.33 | 6.0 | 2.5 to 5.0 | 573.02 to 570.52 | 3.0 to 5.0 | 572.52 to 570.52 | Upper Sand |
| OW-14B | 576.91 | 579.92 | 10.0 | 2.5 to 7.0 | 574.41 to 569.91 | 3.0 to 7.0 | 573.91 to 569.91 | Upper Sand |
| OW-14BR | 577.18 | 580.03 | 8.0 | 4.0 to 7.0 | 573.18 to 570.18 | 5.0 to 7.0 | 572.18 to 570.18 | Upper Sand |
| OW-16 | 579.23 | 581.88 | 10.0 | 4.0 to 10.0 | 575.23 to 569.23 | 5.0 to 10.0 | 574.23 to 569.23 | Fill/Silty Clay |
| OW-21 | 577.71 | 580.00 | 12.0 | 2.5 to 8.0 | 575.21 to 569.71 | 3.0 to 8.0 | 574.71 to 569.71 | Upper Sand/Silty Clay |
| OW-22 | 577.45 | 579.46 | 12.0 | 2.5 to 8.0 | 574.95 to 569.45 | 3.0 to 8.0 | 574.45 to 569.45 | Fill/Upper Sand? |
| OW-23 | 577.16 | 579.26 | 8.0 | 2.5 to 8.0 | 574.66 to 569.16 | 3.0 to 8.0 | 574.16 to 569.16 | Upper Sand/Silty Clay |
| ~~OW-24~~ | ~~577.92~~ | ~~581.00~~ | ~~20.0~~ | ~~4.0 to 10.0~~ | ~~573.92 to 567.92~~ | ~~5.0 to 10.0~~ | ~~572.92 to 567.92~~ | ~~Fill~~ |
| ~~OW-25~~ | ~~577.36~~ | ~~579.91~~ | ~~20.0~~ | ~~5.0 to 12.0~~ | ~~572.36 to 565.36~~ | ~~7.0 to 12.0~~ | ~~570.36 to 565.36~~ | ~~Upper Sand/Silty Clay~~ |
| OW-31 | 577.71 | 580.64 | 8.0 | 1.0 to 6.0 | 576.71 to 571.71 | 1.0 to 6.0 | 576.71 to 571.71 | Upper Sand |
| OW-32 | 578.56 | 581.44 | 12.0 | 4.0 to 10.0 | 574.56 to 568.56 | 5.0 to 10.0 | 573.56 to 568.56 | Upper Sand |
| OW-33 | 579.83 | 582.43 | 12.0 | 3.0 to 9.0 | 576.83 to 570.83 | 4.0 to 9.0 | 575.83 to 570.83 | Fill/Upper Sand |
| OW-34 | 579.00 | 581.10 | 16.0 | 5.0 to 12.0 | 574.00 to 567.00 | 7.0 to 12.0 | 572.00 to 567.00 | Upper Sand |
| OW-35 | 578.80 | 581.57 | 12.0 | 3.0 to 9.0 | 575.80 to 569.80 | 4.0 to 9.0 | 574.80 to 569.80 | Fill/Upper Sand |
| OW-36 | 578.81 | 580.95 | 12.0 | 2.0 to 8.0 | 576.81 to 570.81 | 3.0 to 8.0 | 575.81 to 570.81 | Fill/Upper Sand |
| OW-37 | 577.32 | 580.15 | 8.0 | 1.0 to 6.0 | 576.32 to 571.32 | 1.0 to 6.0 | 576.32 to 571.32 | Fill/Upper Sand |
| LPZ-01S | 577.25 | 580.31 | 7.0 | 4.0 to 7.0 | 573.25 to 570.25 | 5.0 to 7.0 | 572.25 to 570.25 | Upper Sand/Silty Clay |
| LPZ-02S | 577.66 | 581.03 | 6.0 | 2.0 to 6.0 | 575.66 to 571.66 | 3.0 to 6.0 | 574.66 to 571.66 | Upper Sand/Silty Clay |
| LPZ-03S | 577.86 | 581.16 | 18.0 | 2.0 to 8.0 | 575.86 to 569.86 | 3.0 to 8.0 | 574.86 to 569.86 | Upper Sand/Silty Clay |
| LPZ-04S | 576.87 | 579.68 | 6.0 | 2.0 to 6.0 | 574.87 to 570.87 | 3.0 to 6.0 | 573.87 to 570.87 | Upper Sand/Silty Clay |
| LPZ-05S | 577.33 | 580.41 | 8.0 | 2.0 to 6.0 | 575.33 to 571.33 | 3.0 to 6.0 | 574.33 to 571.33 | Upper Sand/Silty Clay |
| LPZ-06S | 578.03 | 581.00 | 18.0 | 2.0 to 8.0 | 576.03 to 570.03 | 3.0 to 8.0 | 575.03 to 570.03 | Upper Sand/Silty Clay |

**Table 5-1**
**Construction Summary of Existing and Decommissioned Wells at the Niagara Sanitation Landfill**
**NYSDEC Hydrogeologic Report**
**Niagara Sanitation Site, Site No. 932054**
**Wheatfield, New York**

NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

| Well Number | Ground ● Surface Elevation (ft. amsl) | Top of ● Riser Elevation (ft. amsl) | Total Boring Depth (ft. BGS) | Sandpack Interval (ft. BGS) | Sandpack Interval (ft. amsl) | Well Screen Interval (ft. BGS) | Well Screen Interval (ft. amsl) | Screened Water-Bearing Zone |
|---|---|---|---|---|---|---|---|---|
| **Upper Sand Deposit (Continued)** | | | | | | | | |
| LPZ-07S | 577.43 | 580.56 | 8.0 | 2.0 to 7.0 | 575.43 to 570.43 | 3.0 to 7.0 | 574.43 to 570.43 | Upper Sand/Silty Clay |
| LPZ-08S | 575.95 | 579.47 | 6.0 | 2.0 to 4.0 | 573.95 to 571.95 | 2.5 to 4.0 | 573.45 to 571.95 | Upper Sand |
| LPZ-09S | 578.12 | 581.51 | 10.0 | 3.0 to 8.0 | 575.12 to 570.12 | 4.0 to 8.0 | 574.12 to 570.12 | Upper Sand |
| LPZ-10S | 577.41 | 580.38 | 8.0 | 3.0 to 6.0 | 574.41 to 571.41 | 4.0 to 6.0 | 573.41 to 571.41 | Upper Sand |
| LPZ-11S | 577.65 | 579.96 | 8.0 | 3.0 to 7.0 | 574.65 to 570.65 | 4.0 to 7.0 | 573.65 to 570.65 | Upper Sand |
| LPZ-12S | 577.09 | 580.03 | 8.0 | 3.0 to 7.0 | 574.09 to 570.09 | 3.0 to 7.0 | 574.09 to 570.09 | Fill/Upper Sand |
| LPZ-13S | 578.75 | 581.66 | 8.0 | 4.0 to 7.5 | 574.75 to 571.25 | 5.0 to 7.5 | 573.75 to 571.25 | Upper Sand |
| LPZ-14S | 579.68 | 582.13 | 12.0 | 3.0 to 12.0 | 576.68 to 567.68 | 4.0 to 9.0 | 575.68 to 570.68 | Upper Sand |
| LPZ-15S | 579.02 | 581.43 | 12.0 | 2.5 to 12.0 | 576.52 to 567.02 | 3.0 to 8.0 | 576.02 to 571.02 | Upper Sand |
| LPZ-16S | 577.76 | 580.13 | 16.0 | 3.0 to 16.0 | 574.76 to 561.76 | 5.0 to 15.0 | 572.76 to 562.76 | Upper Sand/Silty Clay |
| LPZ-17S | 576.69 | 579.45 | 18.0 | 3.0 to 18.0 | 573.69 to 558.69 | 5.0 to 15.0 | 571.69 to 561.69 | Upper Sand/Silty Clay |
| LPZ-18S | 578.66 | 581.90 | 16.0 | 3.0 to 16.0 | 575.66 to 562.66 | 5.0 to 15.0 | 573.66 to 563.66 | Upper Sand/Silty Clay |
| LDP-01 | 576.92 | 580.34 | 5.3 | 3.3 to 5.3 | 573.62 to 571.62 | 4.3 to 5.3 | 572.62 to 571.62 | Upper Sand |
| ~~LDP-02R ♦~~ | ~~577.46~~ | ~~581.03~~ | ~~5.3~~ | ~~3.3 to 5.3~~ | ~~574.16 to 572.16~~ | ~~4.3 to 5.3~~ | ~~573.16 to 572.16~~ | ~~Upper Sand/Silty Clay~~ |
| LDP-03 | 577.25 | 580.73 | 5.1 | 2.4 to 5.1 | 574.85 to 572.15 | 4.1 to 5.1 | 573.15 to 572.15 | Upper Sand/Silty Clay |
| LDP-04 | 578.15 | 581.42 | 5.3 | 3.3 to 5.3 | 574.85 to 572.85 | 4.3 to 5.3 | 573.85 to 572.85 | Upper Sand |
| **Silty Clay & Red-Gray Clay Aquitard** | | | | | | | | |
| OW-2 | 576.37 | 577.26 | 14.0 | 5.0 to 14.0 | 571.37 to 562.37 | 9.0 to 14.0 | 567.37 to 562.37 | Silty Clay/Red-Gray Clay |
| **Lower Sand Deposit** | | | | | | | | |
| ~~OW-12~~ | ~~577.10~~ | ~~579.74~~ | ~~34.0~~ | ~~27.5 to 32.5~~ | ~~549.60 to 544.60~~ | ~~29.5 to 32.5~~ | ~~547.60 to 544.60~~ | ~~Lower Sand~~ |
| OW-14A | 576.73 | 580.05 | 40.0 | 32.5 to 36.5 | 544.23 to 540.23 | 33.5 to 36.5 | 543.23 to 540.23 | Lower Sand |
| OW-15 | 577.14 | 579.56 | 45.0 | 38.0 to 45.0 | 539.14 to 532.14 | 40.0 to 45.0 | 537.14 to 532.14 | Lower Sand |

**Table 5-1**
**Construction Summary of Existing and Decommissioned Wells at the Niagara Sanitation Landfill**
**NYSDEC Hydrogeologic Report**
**Niagara Sanitation Site, Site No. 932054**
**Wheatfield, New York**

| Well Number | Ground ● Surface Elevation (ft. amsl) | Top of ● Riser Elevation (ft. amsl) | Total Boring Depth (ft. BGS) | Sandpack Interval (ft. BGS) | Sandpack Interval (ft. amsl) | Well Screen Interval (ft. BGS) | Well Screen Interval (ft. amsl) | Screened Water-Bearing Zone |
|---|---|---|---|---|---|---|---|---|
| **Glacial Till Deposit** | | | | | | | | |
| OW-1B | 577.41 | 579.14 | 68.6 | 55.0 to 68.6 | 522.41 to 508.81 | 58.6 to 68.6 | 518.81 to 508.81 | Glacial Till |
| OW-3 | 577.28 | 579.56 | 68.7 | 43.0 to 55.0 | 534.28 to 522.28 | 45.0 to 55.0 | 532.28 to 522.28 | Glacial Till |
| OW-4 | 577.04 | 579.45 | 70.3 | 56.0 to 69.0 | 521.04 to 508.04 | 59.0 to 69.0 | 518.04 to 508.04 | Glacial Till |
| OW-5 | 578.37 | 579.75 | 70.0 | 56.0 to 70.0 | 522.37 to 508.37 | 60.0 to 70.0 | 518.37 to 508.37 | Glacial Till |
| OW-6 | 579.69 | 582.36 | 66.0 | 55.0 to 66.0 | 524.69 to 513.69 | 56.0 to 66.0 | 523.69 to 513.69 | Glacial Till |
| **Staff Gauges** | | | | | | | | |
| SG-1 | 573.53 | -- | -- | -- to -- | -- to -- | -- to -- | -- to -- | Northern Boundary Ditch |
| SG-2 | 574.11 | -- | -- | -- to -- | -- to -- | -- to -- | -- to -- | Site Pond (NE Corner) |

**Notes:**
**● = Elevations are from the 2019 LiRo Remedial Investigation Report.**
**ft. amsl = feet above mean sea level.**
**ft. bgs = Feet below ground surface.**
**♦ = Well LDP-02 was found damaged in 2019 and was replaced during the 2019/2020 sampling event. Well LDP-02R was found damaged during the 2021 sampling event and was not replaced.**
**Orange shaded elevations were calculated from available information as the original survey of these wells used as assumed datum. These wells were decommissioned prior to the 2017 LiRo Remedial Investigation.**

**Table 5-2A**
**Summary of Water Level Measurements: February 8, 1988 To May 20, 2014**
**NYSDEC Hydrogeologic Report**
**Niagara Sanitation Landfill, Site No. 932054**
**Wheatfield, New York**

NEW YORK STATE | Department of Environmental Conservation

| Location ID | Measuring Point Elevation[1] (ft amsl[2]) | Measurement Date | Depth to Water (ft) | Water Elevation[1] (feet amsl) | Note |
|---|---|---|---|---|---|
| **Fill/Upper Sand Wells** | | | | | |
| OW-11 | NA | 2/10/1988 | 8.30 | NA | Destroyed prior to October 2017 Survey. |
| OW-14B | 579.92 | 2/10/1988 | 3.20 | 576.72 | |
| **Lower Sand Wells** | | | | | |
| OW-15 | 579.56 | 2/10/1988 | 10.80 | 568.76 | |

| Location ID | Measuring Point Elevation[1] (ft amsl[2]) | Measurement Date | Depth to Water (ft) | Water Elevation[1] (feet amsl) | Note |
|---|---|---|---|---|---|
| **Fill/Upper Sand Wells** | | | | | |
| OW-11 | NA | 2/18/1988 | 8.50 | NA | Destroyed prior to October 2017 Survey. |
| OW-13 | 579.33 | 2/18/1988 | 2.80 | 576.53 | |
| OW-14B | 579.92 | 2/18/1988 | 3.20 | 576.72 | |
| OW-16 | 581.88 | 2/18/1988 | 4.80 | 577.08 | |
| **Lower Sand Wells** | | | | | |
| OW-12 | NA | 2/18/1988 | 16.90 | NA | Destroyed prior to October 2017 Survey. |
| OW-14A | 580.05 | 2/18/1988 | 15.50 | 564.55 | |
| OW-15 | 579.56 | 2/18/1988 | 10.80 | 568.76 | |

| Location ID | Measuring Point Elevation[1] (ft amsl[2]) | Measurement Date | Depth to Water (ft) | Water Elevation[1] (feet amsl) | Note |
|---|---|---|---|---|---|
| **Fill/Upper Sand Wells** | | | | | |
| OW-01 | 578.30 | 6/20/1988 | 5.30 | 573.00 | |
| OW-11 | NA | 6/20/1988 | 4.60 | NA | Destroyed prior to October 2017 Survey. |
| OW-14B | 579.92 | 6/20/1988 | 4.20 | 575.72 | |
| OW-16 | 581.88 | 6/20/1988 | 6.30 | 575.58 | |
| **Silty Clay & Red-Gray Clay Aquitard Wells** | | | | | |
| OW-02 | 577.26 | 6/20/1988 | 3.90 | 573.36 | |
| **Lower Sand Wells** | | | | | |
| OW-12 | NA | 6/20/1988 | 11.50 | NA | Destroyed prior to October 2017 Survey. |
| OW-14A | 580.05 | 6/20/1988 | 11.30 | 568.75 | |
| OW-15 | 579.56 | 6/20/1988 | 11.40 | 568.16 | |
| **Glacial Till Wells** | | | | | |
| OW-03 | 579.56 | 6/20/1988 | 15.00 | 564.56 | |
| OW-04 | 579.45 | 6/20/1988 | 14.50 | 564.95 | |
| OW-05 | 579.75 | 6/20/1988 | 15.10 | 564.65 | |
| OW-06 | 582.36 | 6/20/1988 | 17.30 | 565.06 | |
| OW-1B | 579.14 | 6/20/1988 | 14.10 | 565.04 | |

Table 5-2A
Summary of Water Level Measurements: February 8, 1988 To May 20, 2014
NYSDEC Hydrogeologic Report
Niagara Sanitation Landfill, Site No. 932054
Wheatfield, New York

| Location ID | Measuring Point Elevation[1] (ft amsl[2]) | Measurement Date | Depth to Water (ft) | Water Elevation[1] (feet amsl) | Note |
|---|---|---|---|---|---|
| **Fill/Upper Sand Wells** | | | | | |
| OW-11 | NA | 10/12/1988 | 4.50 | NA | Destroyed prior to October 2017 Survey. |
| OW-16 | 581.88 | 10/12/1988 | 8.70 | 573.18 | |
| **Lower Sand Wells** | | | | | |
| OW-14A | 580.05 | 10/12/1988 | 11.70 | 568.35 | |
| OW-15 | 579.56 | 10/12/1988 | 11.80 | 567.76 | |
| **Glacial Till Wells** | | | | | |
| OW-03 | 579.56 | 10/12/1988 | 14.40 | 565.16 | |
| OW-05 | 579.75 | 10/12/1988 | 15.10 | 564.65 | |
| OW-06 | 582.36 | 10/12/1988 | 17.70 | 564.66 | |

| Location ID | Measuring Point Elevation[1] (ft amsl[2]) | Measurement Date | Depth to Water (ft) | Water Elevation[1] (feet amsl) | Note |
|---|---|---|---|---|---|
| **Fill/Upper Sand Wells** | | | | | |
| OW-01 | 578.30 | 8/2/2013 | 3.09 | 575.21 | |
| OW-11 | NA | 8/2/2013 | 4.29 | NA | Destroyed prior to October 2017 Survey. |
| OW-13 | 579.33 | 8/2/2013 | 3.06 | 576.27 | |
| OW-14B | 579.92 | 8/2/2013 | 3.23 | 576.69 | |
| OW-16 | 581.88 | 8/2/2013 | 6.18 | 575.70 | |
| OW-21 | 580.00 | 8/2/2013 | 4.66 | 575.34 | |
| OW-22 | 579.46 | 8/2/2013 | 3.96 | 575.50 | |
| OW-23 | 579.26 | 8/2/2013 | 3.68 | 575.58 | |
| OW-24 | NA | 8/2/2013 | 5.20 | NA | Destroyed prior to October 2017 Survey |
| OW-25 | NA | 8/2/2013 | 4.24 | NA | Destroyed prior to October 2017 Survey |
| **Silty Clay & Red-Gray Clay Aquitard Wells** | | | | | |
| OW-02 | 577.26 | 8/2/2013 | 2.17 | 575.09 | |

| Location ID | Measuring Point Elevation[1] (ft amsl[2]) | Measurement Date | Depth to Water (ft) | Water Elevation[1] (feet amsl) | Note |
|---|---|---|---|---|---|
| **Fill/Upper Sand Wells** | | | | | |
| OW-16 | 581.88 | 5/19/2014 | 4.66 | 577.22 | |
| OW-31 | 580.64 | 5/20/2014 | 3.80 | 576.84 | |
| OW-32 | 581.44 | 5/19/2014 | 4.59 | 576.85 | |
| OW-33 | 582.43 | 5/20/2014 | 6.03 | 576.40 | |
| OW-34 | 581.10 | 5/19/2014 | 4.00 | 577.10 | |
| OW-35 | 581.57 | 5/19/2014 | 4.66 | 576.91 | |
| OW-36 | 580.95 | 5/19/2014 | 3.99 | 576.96 | |
| OW-37 | 580.15 | 5/20/2014 | 3.50 | 576.65 | |

**Notes:**

**1 = Elevations are referenced to North American Vertical Datum of 1988 (NAVD 88).**

**2 = Above Mean Sea Level.**

**Green shaded dates are different than those shown in the RI table and were obtained from the original reports.**

**Table 5-2B**
**Summary of Water Level Measurements: August 2, 2017 To August 15, 2017**
**NYSDEC Hydrogeologic Report**
**Niagara Sanitation Landfill, Site No. 932054**
**Wheatfield, New York**

| Location ID | Measuring Point Elevation[1] (ft amsl[2]) | Measurement Date | Depth to Water (ft) | Water Elevation[1] (feet amsl) | Note |
|---|---|---|---|---|---|
| **Fill/Upper Sand Wells** | | | | | |
| OW-01 | 578.30 | 8/2/2017 | 3.98 | 574.32 | |
| OW-14B | 579.92 | 8/2/2017 | 11.42 | 568.50 | Outer casing has heaved. |
| OW-16 | 581.88 | 8/2/2017 | 6.60 | 575.28 | |
| OW-21 | 580.00 | 8/2/2017 | 5.73 | 574.27 | |
| OW-31 | 580.64 | 8/2/2017 | 6.74 | 573.90 | |
| OW-32 | 581.44 | 8/2/2017 | 6.61 | 574.83 | |
| OW-33 | 582.43 | 8/2/2017 | 7.31 | 575.12 | |
| OW-34 | 581.10 | 8/2/2017 | 6.51 | 574.59 | |
| OW-35 | 581.57 | 8/2/2017 | 6.59 | 574.98 | |
| OW-37 | 580.15 | 8/2/2017 | 5.12 | 575.03 | |
| **Silty Clay & Red-Gray Clay Aquitard Wells** | | | | | |
| OW-02 | 577.26 | 8/2/2017 | 2.62 | 574.64 | |
| **Lower Sand Wells** | | | | | |
| OW-14A | 580.05 | 8/2/2017 | 14.66 | 565.39 | Depth to water originally listed as 4.66 feet. |
| **Glacial Till Wells** | | | | | |
| OW-1B | 579.14 | 8/2/2017 | 13.46 | 565.68 | |
| OW-03 | 579.56 | 8/2/2017 | 13.94 | 565.62 | |
| OW-04 | 579.45 | 8/2/2017 | 13.83 | 565.62 | |
| OW-05 | 579.75 | 8/2/2017 | 14.33 | 565.42 | |
| OW-06 | 582.36 | 8/2/2017 | 16.89 | 565.47 | Casing tab for lock corroded. |

| Location ID | Measuring Point Elevation[1] (ft amsl[2]) | Measurement Date | Depth to Water (ft) | Water Elevation[1] (feet amsl) | Note |
|---|---|---|---|---|---|
| **Fill/Upper Sand Wells** | | | | | |
| OW-01 | 578.30 | 8/3/2017 | 4.20 | 574.10 | |
| OW-14B | 579.92 | 8/4/2017 | 4.64 | 575.28 | Outer casing has heaved. |
| OW-21 | 580.00 | 8/3/2017 | 5.92 | 574.08 | |
| OW-31 | 580.64 | 8/3/2017 | 6.99 | 573.65 | |
| OW-32 | 581.44 | 8/3/2017 | 6.61 | 574.83 | |
| OW-33 | 582.43 | 8/4/2017 | 6.64 | 575.79 | |
| OW-35 | 581.57 | 8/4/2017 | 6.74 | 574.83 | |
| **Silty Clay & Red-Gray Clay Aquitard Wells** | | | | | |
| OW-02 | 577.26 | 8/3/2017 | 2.62 | 574.64 | |
| **Glacial Till Wells** | | | | | |
| OW-04 | 579.45 | 8/3/2017 | 13.83 | 565.62 | |
| OW-05 | 579.75 | 8/3/2017 | 14.33 | 565.42 | |

Table 5-2B
Summary of Water Level Measurements: August 2, 2017 To August 15, 2017
NYSDEC Hydrogeologic Report
Niagara Sanitation Landfill, Site No. 932054
Wheatfield, New York

NEW YORK STATE | Department of Environmental Conservation

| Location ID | Measuring Point Elevation[1] (ft amsl[2]) | Measurement Date | Depth to Water (ft) | Water Elevation[1] (feet amsl) | Note |
|---|---|---|---|---|---|
| **Fill/Upper Sand Wells** | | | | | |
| OW-16 | 581.88 | 8/7/2017 | 6.93 | 574.95 | |
| OW-33 | 582.43 | 8/9/2017 | 7.54 | 574.89 | |
| OW-34 | 581.10 | 8/7/2017 | 6.12 | 574.98 | See note 1. |
| OW-37 | 580.15 | 8/8/2017 | 5.18 | 574.97 | |
| LPZ-02S | 581.03 | 8/8/2017 | 5.90 | 575.13 | |
| LPZ-02S | 581.03 | 8/9/2017 | 5.92 | 575.11 | |
| LPZ-03S | 581.16 | 8/7/2017 | 5.70 | 575.46 | |
| LPZ-04S | 579.68 | 8/7/2017 | 4.79 | 574.89 | |
| LPZ-05S | 580.41 | 8/7/2017 | 5.86 | 574.55 | |
| LPZ-06S | 581.00 | 8/7/2017 | 6.23 | 574.77 | |
| **Silty Clay & Red-Gray Clay Aquitard Wells** | | | | | |
| OW-02 | 577.26 | 8/8/2017 | 3.20 | 574.06 | |
| **Lower Sand Wells** | | | | | |
| OW-14A | 580.05 | 8/9/2017 | 14.87 | 565.18 | See note 2. |
| OW-15 | 579.56 | 8/8/2017 | 11.79 | 567.77 | Casing tab for lock corroded. May be well OW-14A. |
| **Glacial Till Wells** | | | | | |
| OW-1B | 579.14 | 8/9/2017 | 13.45 | 565.69 | |
| OW-04 | 579.45 | 8/8/2017 | 13.84 | 565.61 | |
| OW-05 | 579.75 | 8/10/2017 | 14.34 | 565.41 | |
| OW-06 | 582.36 | 8/7/2017 | 16.84 | 565.52 | Casing tab for lock corroded. |

| Location ID | Measuring Point Elevation[1] (ft amsl[2]) | Measurement Date | Depth to Water (ft) | Water Elevation[1] (feet amsl) | Note |
|---|---|---|---|---|---|
| **Fill/Upper Sand Wells** | | | | | |
| OW-13 | 579.33 | 8/15/2017 | 4.22 | 575.11 | Casing tab for lock corroded & outer casing heaved. |
| OW-22 | 579.46 | 8/15/2017 | 5.31 | 574.15 | |
| OW-23 | 579.26 | 8/15/2017 | 4.35 | 574.91 | |
| OW-31 | 580.64 | 8/15/2017 | 7.27 | 573.37 | |
| **Glacial Till Wells** | | | | | |
| OW-03 | 579.56 | 8/15/2017 | 13.91 | 565.65 | |

**Notes:**

**1 = Elevations are referenced to North American Vertical Datum of 1988 (NAVD 88).**

**2 = Above Mean Sea Level.**

**Green shaded dates are different than those shown in the RI table and were obtained from the original reports.**

**Yellow shaded depth to water is far lower that other water levels for this well. This is likely an incorrect reading.**

**Note 1: This well was originally listed as well OW-33. A review of the water level data indicates that depth to water at well OW-33 is always deeper than in well OW-34. This suggests that this Depth to Water is likely for well OW-34.**

**Note 2: This well was originally listed as well OW-15. The hydrographs for the lower sand wells suggest that this is well OW-14A.**

**Table 5-2C**
**Summary of Water Level Measurements: August 21, 2017 To August 22, 2017**
**NYSDEC Hydrogeologic Report**
**Niagara Sanitation Landfill, Site No. 932054**
**Wheatfield, New York**

NEW YORK STATE | Department of Environmental Conservation

| Location ID | Measuring Point Elevation[1] (ft amsl[2]) | Measurement Date | Depth to Water (ft) | Water Elevation[1] (feet amsl) | Note |
|---|---|---|---|---|---|
| **Fill/Upper Sand Wells** | | | | | |
| LPZ-03S | 581.16 | 8/21/2017 | 5.42 | 575.74 | |
| LPZ-04S | 579.68 | 8/21/2017 | 5.34 | 574.34 | |
| LPZ-05S | 580.41 | 8/21/2017 | 5.25 | 575.16 | |
| LPZ-06S | 581.00 | 8/21/2017 | 5.47 | 575.53 | |
| LPZ-07S | 580.56 | 8/21/2017 | 5.92 | 574.64 | |
| **Glacial Till Wells** | | | | | |
| OW-05 | 579.75 | 8/21/2017 | 14.34 | 565.41 | |
| **Staff Gauges** | | | | | |
| SG-01 | 579.33 | 8/21/2017 | 4.20 | 575.13 | |
| SG-02 | 579.57 | 8/21/2017 | 4.27 | 575.30 | |

| Location ID | Measuring Point Elevation[1] (ft amsl[2]) | Measurement Date | Depth to Water (ft) | Water Elevation[1] (feet amsl) | Note |
|---|---|---|---|---|---|
| **Fill/Upper Sand Wells** | | | | | |
| OW-01 | 578.30 | 8/22/2017 | 3.67 | 574.63 | |
| OW-13 | 579.33 | 8/22/2017 | 4.06 | 575.27 | Casing tab for lock corroded & outer casing heaved. |
| OW-14B | 579.92 | 8/22/2017 | 4.64 | 575.28 | Outer casing has heaved. |
| OW-14BR | 580.03 | 8/22/2017 | 4.90 | 575.13 | |
| OW-16 | 581.88 | 8/22/2017 | 6.65 | 575.23 | |
| OW-21 | 580.00 | 8/22/2017 | 5.48 | 574.52 | |
| OW-22 | 579.46 | 8/22/2017 | 4.85 | 574.61 | |
| OW-23 | 579.26 | 8/22/2017 | 4.03 | 575.23 | |
| OW-31 | 580.64 | 8/22/2017 | 6.33 | 574.31 | |
| OW-32 | 581.44 | 8/22/2017 | 6.45 | 574.99 | |
| OW-33 | 582.43 | 8/22/2017 | 7.49 | 574.94 | |
| OW-34 | 581.10 | 8/22/2017 | 6.47 | 574.63 | |
| OW-35 | 581.57 | 8/22/2017 | 6.54 | 575.03 | |
| OW-36 | 580.95 | 8/22/2017 | 5.93 | 575.02 | |
| OW-37 | 580.15 | 8/22/2017 | 5.06 | 575.09 | |
| LPZ-01S | 580.31 | 8/22/2017 | 5.22 | 575.09 | |
| LPZ-02S | 581.03 | 8/22/2017 | 5.80 | 575.23 | |
| LPZ-03S | 581.16 | 8/22/2017 | 5.42 | 575.74 | |
| LPZ-04S | 579.68 | 8/22/2017 | 5.44 | 574.24 | Corrected field recorded DTW from 4.44 to 5.44. |
| LPZ-05S | 580.41 | 8/22/2017 | 5.41 | 575.00 | |
| LPZ-06S | 581.00 | 8/22/2017 | 5.55 | 575.45 | |
| LPZ-07S | 580.56 | 8/22/2017 | 5.95 | 574.61 | |
| LPZ-08S | 579.47 | 8/22/2017 | 4.33 | 575.14 | |
| **Silty Clay & Red-Gray Clay Aquitard Wells** | | | | | |
| OW-02 | 577.26 | 8/22/2017 | 2.11 | 575.15 | |
| **Lower Sand Wells** | | | | | |
| OW-14A | 580.05 | 8/22/2017 | 20.69 | 559.36 | |
| OW-15 | 579.56 | 8/22/2017 | 11.72 | 567.84 | Casing tab for lock corroded. |

**Table 5-2C**
**Summary of Water Level Measurements: August 21, 2017 To August 22, 2017**
**NYSDEC Hydrogeologic Report**
**Niagara Sanitation Landfill, Site No. 932054**
**Wheatfield, New York**

| Location ID | Measuring Point Elevation[1] (ft amsl[2]) | Measurement Date | Depth to Water (ft) | Water Elevation[1] (feet amsl) | Note |
|---|---|---|---|---|---|
| **Glacial Till Wells** | | | | | |
| OW-01B | 579.14 | 8/22/2017 | 14.19 | 564.95 | |
| OW-03 | 579.56 | 8/22/2017 | 13.81 | 565.75 | |
| OW-04 | 579.45 | 8/22/2017 | 13.79 | 565.66 | |
| OW-05 | 579.75 | 8/22/2017 | 14.20 | 565.55 | |
| OW-06 | 582.36 | 8/22/2017 | 16.80 | 565.56 | Casing tab for lock corroded. |
| **Staff Gauges** | | | | | |
| SG-01 | 579.33 | 8/22/2017 | 4.15 | 575.18 | |
| SG-02 | 579.57 | 8/22/2017 | 4.30 | 575.27 | |

**Notes:**

**1 = Elevations are referenced to North American Vertical Datum of 1988 (NAVD 88).**

**2 = Above Mean Sea Level.**

**Table 5-2D**
**Summary of Water Level Measurements: August 30, 2017**
**NYSDEC Hydrogeologic Report**
**Niagara Sanitation Landfill, Site No. 932054**
**Wheatfield, New York**

NEW YORK STATE | Department of Environmental Conservation

| Location ID | Measuring Point Elevation[1] (ft amsl[2]) | Measurement Date | Depth to Water (ft) | Water Elevation[1] (feet amsl) | Note |
|---|---|---|---|---|---|
| **Fill/Upper Sand Wells** | | | | | |
| OW-01 | 578.30 | 8/30/2017 | 4.19 | 574.11 | |
| OW-13 | 579.33 | 8/30/2017 | 4.39 | 574.94 | Casing tab for lock corroded & outer casing heaved. |
| OW-14B | 579.92 | 8/30/2017 | 4.97 | 574.95 | Outer casing has heaved. |
| OW-14BR | 580.03 | 8/30/2017 | 5.36 | 574.67 | |
| OW-16 | 581.88 | 8/30/2017 | 7.25 | 574.63 | |
| OW-21 | 580.00 | 8/30/2017 | 6.11 | 573.89 | |
| OW-22 | 579.46 | 8/30/2017 | 5.30 | 574.16 | |
| OW-23 | 579.26 | 8/30/2017 | 4.56 | 574.70 | |
| OW-31 | 580.64 | 8/30/2017 | 7.23 | 573.41 | |
| OW-32 | 581.44 | 8/30/2017 | 6.85 | 574.59 | |
| OW-33 | 582.43 | 8/30/2017 | 7.82 | 574.61 | |
| OW-34 | 581.10 | 8/30/2017 | 6.86 | 574.24 | |
| OW-35 | 581.57 | 8/30/2017 | 6.90 | 574.67 | |
| OW-36 | 580.95 | 8/30/2017 | 6.25 | 574.70 | |
| OW-37 | 580.15 | 8/30/2017 | 5.45 | 574.70 | |
| LDP-01 | 580.34 | 8/30/2017 | 6.64 | 573.70 | TD = 8.36 (TOIC), BTM Elev = 571.98 |
| LDP-02 | 581.03 | 8/30/2017 | 6.65 | 574.38 | |
| LDP-03 | 580.73 | 8/30/2017 | 6.60 | 574.13 | |
| LDP-04 | 581.42 | 8/30/2017 | 7.20 | 574.22 | |
| LPZ-01S | 580.31 | 8/30/2017 | 5.38 | 574.93 | |
| LPZ-02S | 581.03 | 8/30/2017 | 6.18 | 574.85 | |
| LPZ-03S | 581.16 | 8/30/2017 | 7.06 | 574.10 | |
| LPZ-04S | 579.68 | 8/30/2017 | 5.65 | 574.03 | |
| LPZ-05S | 580.41 | 8/30/2017 | 6.36 | 574.05 | |
| LPZ-06S | 581.00 | 8/30/2017 | 6.62 | 574.38 | |
| LPZ-07S | 580.56 | 8/30/2017 | 6.73 | 573.83 | |
| LPZ-08S | 579.47 | 8/30/2017 | 4.68 | 574.79 | |
| **Silty Clay & Red-Gray Clay Aquitard Wells** | | | | | |
| OW-02 | 577.26 | 8/30/2017 | 2.52 | 574.74 | |
| **Lower Sand Wells** | | | | | |
| OW-14A | 580.05 | 8/30/2017 | 17.85 | 562.20 | |
| OW-15 | 579.56 | 8/30/2017 | 11.85 | 567.71 | Casing tab for lock corroded. |
| **Glacial Till Wells** | | | | | |
| OW-01B | 579.14 | 8/30/2017 | 13.97 | 565.17 | |
| OW-03 | 579.56 | 8/30/2017 | 13.92 | 565.64 | |
| OW-04 | 579.45 | 8/30/2017 | 13.88 | 565.57 | |
| OW-05 | 579.75 | 8/30/2017 | 14.28 | 565.47 | |
| OW-06 | 582.36 | 8/30/2017 | 16.92 | 565.44 | Casing tab for lock corroded. |
| **Staff Gauges** | | | | | |
| SG-01 | 579.33 | 8/30/2017 | 4.49 | 574.84 | |
| SG-02 | 579.57 | 8/30/2017 | 4.70 | 574.87 | |

**Notes:**

**1 = Elevations are referenced to North American Vertical Datum of 1988 (NAVD 88).**

**2 = Above Mean Sea Level.**

**Table 5-2E**
**Summary of Water Level Measurements: September 12, 2017**
**NYSDEC Hydrogeologic Report**
**Niagara Sanitation Landfill, Site No. 932054**
**Wheatfield, New York**

New York State Department of Environmental Conservation

| Location ID | Measuring Point Elevation[1] (ft amsl[2]) | Measurement Date | Depth to Water (ft) | Water Elevation[1] (feet amsl) | Note |
|---|---|---|---|---|---|
| **Fill/Upper Sand Wells** | | | | | |
| OW-01 | 578.30 | 9/12/2017 | 4.52 | 573.78 | |
| OW-13 | 579.33 | 9/12/2017 | 4.64 | 574.69 | Casing tab for lock corroded & outer casing heaved. |
| OW-14B | 579.92 | 9/12/2017 | 5.20 | 574.72 | Outer casing has heaved. |
| OW-14BR | 580.03 | 9/12/2017 | 5.74 | 574.29 | |
| OW-16 | 581.88 | 9/12/2017 | 7.75 | 574.13 | |
| OW-21 | 580.00 | 9/12/2017 | 6.52 | 573.48 | |
| OW-22 | 579.46 | 9/12/2017 | 5.85 | 573.61 | |
| OW-23 | 579.26 | 9/12/2017 | 4.74 | 574.52 | |
| OW-31 | 580.64 | 9/12/2017 | 7.75 | 572.89 | |
| OW-32 | 581.44 | 9/12/2017 | 7.20 | 574.24 | |
| OW-33 | 582.43 | 9/12/2017 | 8.29 | 574.14 | |
| OW-34 | 581.10 | 9/12/2017 | 7.40 | 573.70 | |
| OW-35 | 581.57 | 9/12/2017 | 7.24 | 574.33 | |
| OW-36 | 580.95 | 9/12/2017 | 6.58 | 574.37 | |
| OW-37 | 580.15 | 9/12/2017 | 5.85 | 574.30 | |
| LDP-01 | 580.34 | 9/12/2017 | 7.24 | 573.10 | TD = 8.36 (TOIC), BTM Elev = 571.98 |
| LDP-02 | 581.03 | 9/12/2017 | 6.89 | 574.14 | |
| LDP-03 | 580.73 | 9/12/2017 | 6.97 | 573.76 | |
| LDP-04 | 581.42 | 9/12/2017 | 7.79 | 573.63 | |
| LPZ-01S | 580.31 | 9/12/2017 | 5.90 | 574.41 | |
| LPZ-02S | 581.03 | 9/12/2017 | 6.38 | 574.65 | |
| LPZ-03S | 581.16 | 9/12/2017 | 7.59 | 573.57 | |
| LPZ-04S | 579.68 | 9/12/2017 | 6.26 | 573.42 | |
| LPZ-05S | 580.41 | 9/12/2017 | 6.86 | 573.55 | |
| LPZ-06S | 581.00 | 9/12/2017 | 7.15 | 573.85 | |
| LPZ-07S | 580.56 | 9/12/2017 | 7.23 | 573.33 | |
| LPZ-08S | 579.47 | 9/12/2017 | 4.89 | 574.58 | |
| **Silty Clay & Red-Gray Clay Aquitard Wells** | | | | | |
| OW-02 | 577.26 | 9/12/2017 | 2.70 | 574.56 | |
| **Lower Sand Wells** | | | | | |
| OW-14A | 580.05 | 9/12/2017 | 17.40 | 562.65 | |
| OW-15 | 579.56 | 9/12/2017 | 11.83 | 567.73 | Casing tab for lock corroded. |
| **Glacial Till Wells** | | | | | |
| OW-01B | 579.14 | 9/12/2017 | 13.68 | 565.46 | |
| OW-03 | 579.56 | 9/12/2017 | 14.03 | 565.53 | |
| OW-04 | 579.45 | 9/12/2017 | 13.96 | 565.49 | |
| OW-05 | 579.75 | 9/12/2017 | 14.35 | 565.40 | |
| OW-06 | 582.36 | 9/12/2017 | 17.05 | 565.31 | Casing tab for lock corroded. |
| **Staff Gauges** | | | | | |
| SG-01 | 579.33 | 9/12/2017 | 4.83 | 574.50 | |
| SG-02 | 579.57 | 9/12/2017 | 4.94 | 574.63 | |

**Notes:**

**1 = Elevations are referenced to North American Vertical Datum of 1988 (NAVD 88).**

**2 = Above Mean Sea Level.**

**Table 5-2F**
**Summary of Water Level Measurements: September 25, 2017**
**NYSDEC Hydrogeologic Report**
**Niagara Sanitation Landfill, Site No. 932054**
**Wheatfield, New York**

New York State Department of Environmental Conservation

| Location ID | Measuring Point Elevation[1] (ft amsl[2]) | Measurement Date | Depth to Water (ft) | Water Elevation[1] (feet amsl) | Note |
|---|---|---|---|---|---|
| **Fill/Upper Sand Wells** | | | | | |
| OW-01 | 578.30 | 9/25/2017 | 5.23 | 573.07 | |
| OW-13 | 579.33 | 9/25/2017 | 5.79 | 573.54 | Casing tab for lock corroded & outer casing heaved. |
| OW-14B | 579.92 | 9/25/2017 | 5.68 | 574.24 | Outer casing has heaved. |
| OW-14BR | 580.03 | 9/25/2017 | 6.36 | 573.67 | |
| OW-16 | 581.88 | 9/25/2017 | 8.54 | 573.34 | |
| OW-21 | 580.00 | 9/25/2017 | 7.23 | 572.77 | |
| OW-22 | 579.46 | 9/25/2017 | 6.47 | 572.99 | |
| OW-23 | 579.26 | 9/25/2017 | 5.30 | 573.96 | |
| OW-31 | 580.64 | 9/25/2017 | 8.15 | 572.49 | |
| OW-32 | 581.44 | 9/25/2017 | 7.77 | 573.67 | |
| OW-33 | 582.43 | 9/25/2017 | 9.14 | 573.29 | |
| OW-34 | 581.10 | 9/25/2017 | 8.46 | 572.64 | |
| OW-35 | 581.57 | 9/25/2017 | 7.66 | 573.91 | |
| OW-36 | 580.95 | 9/25/2017 | 6.93 | 574.02 | |
| OW-37 | 580.15 | 9/25/2017 | 6.44 | 573.71 | |
| LDP-01 | 580.34 | 9/25/2017 | Dry | NA | TD = 8.36 (TOIC), BTM Elev = 571.98 |
| LDP-02 | 581.03 | 9/25/2017 | 8.39 | 572.64 | |
| LDP-03 | 580.73 | 9/25/2017 | 8.13 | 572.60 | |
| LDP-04 | 581.42 | 9/25/2017 | 8.61 | 572.81 | |
| LPZ-01S | 580.31 | 9/25/2017 | 6.55 | 573.76 | |
| LPZ-02S | 581.03 | 9/25/2017 | 7.01 | 574.02 | |
| LPZ-03S | 581.16 | 9/25/2017 | 8.80 | 572.36 | |
| LPZ-04S | 579.68 | 9/25/2017 | 7.23 | 572.45 | |
| LPZ-05S | 580.41 | 9/25/2017 | 7.59 | 572.82 | |
| LPZ-06S | 581.00 | 9/25/2017 | 8.24 | 572.76 | |
| LPZ-07S | 580.56 | 9/25/2017 | 8.19 | 572.37 | |
| LPZ-08S | 579.47 | 9/25/2017 | 5.33 | 574.14 | |
| LPZ-09S | 581.51 | 9/25/2017 | 7.74 | 573.77 | |
| LPZ-10S | 580.38 | 9/25/2017 | 7.12 | 573.26 | |
| LPZ-11S | 579.96 | 9/25/2017 | 6.43 | 573.53 | |
| LPZ-12S | 580.03 | 9/25/2017 | 6.69 | 573.34 | |
| LPZ-13S | 581.66 | 9/25/2017 | 8.64 | 573.02 | |
| **Silty Clay & Red-Gray Clay Aquitard Wells** | | | | | |
| OW-02 | 577.26 | 9/25/2017 | 3.52 | 573.74 | |
| **Lower Sand Wells** | | | | | |
| OW-14A | 580.05 | 9/25/2017 | 21.09 | 558.96 | |
| OW-15 | 579.56 | 9/25/2017 | 11.98 | 567.58 | Casing tab for lock corroded. |
| **Glacial Till Wells** | | | | | |
| OW-01B | 579.14 | 9/25/2017 | 13.85 | 565.29 | |
| OW-03 | 579.56 | 9/25/2017 | 14.10 | 565.46 | |
| OW-04 | 579.45 | 9/25/2017 | 14.09 | 565.36 | |
| OW-05 | 579.75 | 9/25/2017 | 14.50 | 565.25 | |
| OW-06 | 582.36 | 9/25/2017 | 17.20 | 565.16 | Casing tab for lock corroded. |
| **Staff Gauges** | | | | | |
| SG-01 | 579.33 | 9/25/2017 | Dry | NA | Ground Elevation = 574.12. |
| SG-02 | 579.57 | 9/25/2017 | Dry | NA | Ground Elevation = 573.53. |

**Notes:**

**1 = Elevations are referenced to North American Vertical Datum of 1988 (NAVD 88).**

**2 = Above Mean Sea Level.**

**Table 5-2G**
**Summary of Water Level Measurements: October 17, 2017**
**NYSDEC Hydrogeologic Report**
**Niagara Sanitation Landfill, Site No. 932054**
**Wheatfield, New York**

NEW YORK STATE | Department of Environmental Conservation

| Location ID | Measuring Point Elevation[1] (ft amsl[2]) | Measurement Date | Depth to Water (ft) | Water Elevation[1] (feet amsl) | Note |
|---|---|---|---|---|---|
| **Fill/Upper Sand Wells** | | | | | |
| OW-01 | 578.30 | 10/17/2017 | 3.98 | 574.32 | |
| OW-13 | 579.33 | 10/17/2017 | 4.19 | 575.14 | Casing tab for lock corroded & outer casing heaved. |
| OW-14B | 579.92 | 10/17/2017 | 5.02 | 574.90 | Outer casing has heaved. |
| OW-14BR | 580.03 | 10/17/2017 | 5.08 | 574.95 | |
| OW-16 | 581.88 | 10/17/2017 | 8.01 | 573.87 | |
| OW-21 | 580.00 | 10/17/2017 | 6.03 | 573.97 | |
| OW-22 | 579.46 | 10/17/2017 | 5.47 | 573.99 | |
| OW-23 | 579.26 | 10/17/2017 | 4.36 | 574.90 | |
| OW-31 | 580.64 | 10/17/2017 | 7.44 | 573.20 | |
| OW-32 | 581.44 | 10/17/2017 | 7.31 | 574.13 | |
| OW-33 | 582.43 | 10/17/2017 | 8.40 | 574.03 | |
| OW-34 | 581.10 | 10/17/2017 | 6.46 | 574.64 | |
| OW-35 | 581.57 | 10/17/2017 | 7.28 | 574.29 | |
| OW-36 | 580.95 | 10/17/2017 | 6.68 | 574.27 | |
| OW-37 | 580.15 | 10/17/2017 | 5.78 | 574.37 | |
| LDP-01 | 580.34 | 10/17/2017 | 5.58 | 574.76 | TD = 8.36 (TOIC), BTM Elev = 571.98 |
| LDP-02 | 581.03 | 10/17/2017 | 5.34 | 575.69 | |
| LDP-03 | 580.73 | 10/17/2017 | 5.69 | 575.04 | |
| LDP-04 | 581.42 | 10/17/2017 | 7.35 | 574.07 | |
| LPZ-01S | 580.31 | 10/17/2017 | 5.39 | 574.92 | |
| LPZ-02S | 581.03 | 10/17/2017 | 6.35 | 574.68 | |
| LPZ-03S | 581.16 | 10/17/2017 | 5.95 | 575.21 | |
| LPZ-04S | 579.68 | 10/17/2017 | 4.79 | 574.89 | |
| LPZ-05S | 580.41 | 10/17/2017 | 6.06 | 574.35 | |
| LPZ-06S | 581.00 | 10/17/2017 | 6.09 | 574.91 | |
| LPZ-07S | 580.56 | 10/17/2017 | 6.65 | 573.91 | |
| LPZ-08S | 579.47 | 10/17/2017 | 4.72 | 574.75 | |
| LPZ-09S | 581.51 | 10/17/2017 | 7.50 | 574.01 | |
| LPZ-10S | 580.38 | 10/17/2017 | 5.98 | 574.40 | |
| LPZ-11S | 579.96 | 10/17/2017 | 5.16 | 574.80 | |
| LPZ-12S | 580.03 | 10/17/2017 | 5.29 | 574.74 | |
| LPZ-13S | 581.66 | 10/17/2017 | 7.74 | 573.92 | |
| **Silty Clay & Red-Gray Clay Aquitard Wells** | | | | | |
| OW-02 | 577.26 | 10/17/2017 | 2.29 | 574.97 | |
| **Lower Sand Wells** | | | | | |
| OW-14A | 580.05 | 10/17/2017 | 11.73 | 568.32 | |
| OW-15 | 579.56 | 10/17/2017 | 11.66 | 567.90 | Casing tab for lock corroded. |
| **Glacial Till Wells** | | | | | |
| OW-01B | 579.14 | 10/17/2017 | 13.69 | 565.45 | |
| OW-03 | 579.56 | 10/17/2017 | 14.05 | 565.51 | |
| OW-04 | 579.45 | 10/17/2017 | 14.14 | 565.31 | |
| OW-05 | 579.75 | 10/17/2017 | 14.53 | 565.22 | |
| OW-06 | 582.36 | 10/17/2017 | 17.24 | 565.12 | Casing tab for lock corroded. |
| **Staff Gauges** | | | | | |
| SG-01 | 579.33 | 10/17/2017 | 4.35 | 574.98 | |
| SG-02 | 579.57 | 10/17/2017 | 4.81 | 574.76 | |

NEW YORK STATE | Department of Environmental Conservation

**Notes:**

1 = Elevations are referenced to North American Vertical Datum of 1988 (NAVD 88).

2 = Above Mean Sea Level.

**Table 5-2H**
**Summary of Water Level Measurements: October 20, 2017**
**NYSDEC Hydrogeologic Report**
**Niagara Sanitation Landfill, Site No. 932054**
**Wheatfield, New York**

New York State Department of Environmental Conservation

| Location ID | Measuring Point Elevation[1] (ft amsl[2]) | Measurement Date | Depth to Water (ft) | Water Elevation[1] (feet amsl) | Note |
|---|---|---|---|---|---|
| **Fill/Upper Sand Wells** | | | | | |
| OW-01 | 578.30 | 10/20/2017 | 5.72 | 572.58 | 4.91' from TOC (0.89' above TOIC) |
| OW-13 | 579.33 | 10/20/2017 | 4.53 | 574.80 | Casing tab for lock corroded & outer casing heaved. |
| OW-14B | 579.92 | 10/20/2017 | 5.08 | 574.84 | Outer casing has heaved. |
| OW-14BR | 580.03 | 10/20/2017 | 5.18 | 574.85 | |
| OW-16 | 581.88 | 10/20/2017 | 7.92 | 573.96 | |
| OW-21 | 580.00 | 10/20/2017 | 6.03 | 573.97 | |
| OW-22 | 579.46 | 10/20/2017 | 5.45 | 574.01 | |
| OW-23 | 579.26 | 10/20/2017 | 4.51 | 574.75 | |
| OW-31 | 580.64 | 10/20/2017 | 7.37 | 573.27 | |
| OW-32 | 581.44 | 10/20/2017 | 7.38 | 574.06 | |
| OW-33 | 582.43 | 10/20/2017 | 8.46 | 573.97 | |
| OW-35 | 581.57 | 10/20/2017 | 7.30 | 574.27 | |
| OW-36 | 580.95 | 10/20/2017 | 6.64 | 574.31 | |
| OW-37 | 580.15 | 10/20/2017 | 5.79 | 574.36 | |
| LDP-01 | 580.34 | 10/20/2017 | 5.95 | 574.39 | TD = 8.36 (TOIC), BTM Elev = 571.98 |
| LDP-02 | 581.03 | 10/20/2017 | 5.89 | 575.14 | |
| LDP-03 | 580.73 | 10/20/2017 | 6.09 | 574.64 | |
| LDP-04 | 581.42 | 10/20/2017 | 7.38 | 574.04 | |
| LPZ-01S | 580.31 | 10/20/2017 | 5.49 | 574.82 | |
| LPZ-02S | 581.03 | 10/20/2017 | 6.37 | 574.66 | |
| LPZ-03S | 581.16 | 10/20/2017 | 6.43 | 574.73 | |
| LPZ-04S | 579.68 | 10/20/2017 | 5.13 | 574.55 | |
| LPZ-05S | 580.41 | 10/20/2017 | 6.22 | 574.19 | |
| LPZ-06S | 581.00 | 10/20/2017 | 6.34 | 574.66 | |
| LPZ-07S | 580.56 | 10/20/2017 | 6.70 | 573.86 | |
| LPZ-08S | 579.47 | 10/20/2017 | 4.79 | 574.68 | |
| LPZ-09S | 581.51 | 10/20/2017 | 7.48 | 574.03 | |
| LPZ-10S | 580.38 | 10/20/2017 | 6.06 | 574.32 | |
| LPZ-11S | 579.96 | 10/20/2017 | 5.28 | 574.68 | |
| LPZ-12S | 580.03 | 10/20/2017 | 5.38 | 574.65 | |
| **Silty Clay & Red-Gray Clay Aquitard Wells** | | | | | |
| OW-02 | 577.26 | 10/20/2017 | 2.47 | 574.79 | **Original depth to water was 4.27. See note 1.** |
| **Lower Sand Wells** | | | | | |
| OW-14A | 580.05 | 10/20/2017 | 11.60 | 568.45 | Casing tab for lock corroded. |
| OW-15 | 579.56 | 10/20/2017 | 11.68 | 567.88 | Casing tab for lock corroded. |
| **Glacial Till Wells** | | | | | |
| OW-01B | 579.14 | 10/20/2017 | 13.62 | 565.52 | |
| OW-03 | 579.56 | 10/20/2017 | 13.98 | 565.58 | 14.50' from TOC (0.52' above TOIC). |
| OW-04 | 579.45 | 10/20/2017 | 14.10 | 565.35 | |
| OW-05 | 579.75 | 10/20/2017 | 14.50 | 565.25 | |
| OW-06 | 582.36 | 10/20/2017 | 17.19 | 565.17 | Casing tab for lock corroded. |
| **Staff Gauges** | | | | | |
| SG-01 | 579.33 | 10/20/2017 | 4.25 | 575.08 | |
| SG-02 | 579.57 | 10/20/2017 | 4.75 | 574.82 | |

**Table 5-2H**
**Summary of Water Level Measurements: October 20, 2017**
**NYSDEC Hydrogeologic Report**
**Niagara Sanitation Landfill, Site No. 932054**
**Wheatfield, New York**

**Notes:**

**1 = Elevations are referenced to North American Vertical Datum of 1988 (NAVD 88).**

**2 = Above Mean Sea Level.**

**Hydrographs suggest that the yellow shaded depth to water is likely an incorrect reading.**

**Note 1: Historic water level data suggests that 2 numbers were transposed.**

**Table 5-2I**
**Summary of Water Level Measurements: October 27, 2017**
**NYSDEC Hydrogeologic Report**
**Niagara Sanitation Landfill, Site No. 932054**
**Wheatfield, New York**

New York State Department of Environmental Conservation

| Location ID | Measuring Point Elevation[1] (ft amsl[2]) | Measurement Date | Depth to Water (ft) | Water Elevation[1] (feet amsl) | Note |
|---|---|---|---|---|---|
| **Fill/Upper Sand Wells** | | | | | |
| OW-01 | 578.30 | 10/27/2017 | 3.91 | 574.39 | |
| OW-13 | 579.33 | 10/27/2017 | 4.54 | 574.79 | **Original depth to water was 5.54. See note 1.** |
| OW-14B | 579.92 | 10/27/2017 | 5.09 | 574.83 | Heaved |
| OW-14BR | 580.03 | 10/27/2017 | 5.25 | 574.78 | |
| OW-16 | 581.88 | 10/27/2017 | 7.91 | 573.97 | |
| OW-21 | 580.00 | 10/27/2017 | 5.91 | 574.09 | |
| OW-22 | 579.46 | 10/27/2017 | 5.42 | 574.04 | |
| OW-23 | 579.26 | 10/27/2017 | 4.55 | 574.71 | |
| OW-31 | 580.64 | 10/27/2017 | 7.10 | 573.54 | |
| OW-32 | 581.44 | 10/27/2017 | 7.35 | 574.09 | |
| OW-33 | 582.43 | 10/27/2017 | 8.40 | 574.03 | |
| OW-34 | 581.10 | 10/27/2017 | 6.55 | 574.55 | |
| OW-35 | 581.57 | 10/27/2017 | 7.31 | 574.26 | |
| OW-36 | 580.95 | 10/27/2017 | 6.61 | 574.34 | |
| OW-37 | 580.15 | 10/27/2017 | 5.81 | 574.34 | |
| LDP-01 | 580.34 | 10/27/2017 | 6.33 | 574.01 | TD = 8.36 (TOIC), BTM Elev = 571.98 |
| LDP-02 | 581.03 | 10/27/2017 | 6.47 | 574.56 | |
| LDP-03 | 580.73 | 10/27/2017 | 6.39 | 574.34 | |
| LDP-04 | 581.42 | 10/27/2017 | 7.29 | 574.13 | |
| LPZ-01S | 580.31 | 10/27/2017 | 5.54 | 574.77 | |
| LPZ-02S | 581.03 | 10/27/2017 | 6.37 | 574.66 | |
| LPZ-03S | 581.16 | 10/27/2017 | 6.58 | 574.58 | |
| LPZ-04S | 579.68 | 10/27/2017 | 5.15 | 574.53 | |
| LPZ-05S | 580.41 | 10/27/2017 | 6.13 | 574.28 | |
| LPZ-06S | 581.00 | 10/27/2017 | 6.42 | 574.58 | |
| LPZ-07S | 580.56 | 10/27/2017 | 6.60 | 573.96 | |
| LPZ-08S | 579.47 | 10/27/2017 | 4.78 | 574.69 | |
| LPZ-09S | 581.51 | 10/27/2017 | 7.44 | 574.07 | |
| LPZ-10S | 580.38 | 10/27/2017 | 6.14 | 574.24 | |
| LPZ-11S | 579.96 | 10/27/2017 | 5.23 | 574.73 | |
| LPZ-12S | 580.03 | 10/27/2017 | 5.39 | 574.64 | |
| LPZ-13S | 581.66 | 10/27/2017 | 7.55 | 574.11 | |
| **Silty Clay & Red-Gray Clay Aquitard Wells** | | | | | |
| OW-02 | 577.26 | 10/27/2017 | 2.42 | 574.84 | 3.35' from TOC (0.92' above TOIC) |
| **Lower Sand Wells** | | | | | |
| OW-14A | 580.05 | 10/27/2017 | 11.39 | 568.66 | Casing tab for lock corroded. |
| OW-15 | 579.56 | 10/27/2017 | 11.62 | 567.94 | Casing tab for lock corroded. |
| **Glacial Till Wells** | | | | | |
| OW-01B | 579.14 | 10/27/2017 | 13.62 | 565.52 | |
| OW-03 | 579.56 | 10/27/2017 | 13.97 | 565.59 | 14.50' from TOC (0.52' above TOIC) |
| OW-04 | 579.45 | 10/27/2017 | 13.85 | 565.60 | |
| OW-05 | 579.75 | 10/27/2017 | 14.45 | 565.30 | |
| OW-06 | 582.36 | 10/27/2017 | 17.32 | 565.04 | Casing tab for lock corroded. |
| **Staff Gauges** | | | | | |
| SG-01 | 579.33 | 10/27/2017 | 4.36 | 574.97 | |
| SG-02 | 579.57 | 10/27/2017 | 4.93 | 574.64 | |

**Notes:**

**1 = Elevations are referenced to North American Vertical Datum of 1988 (NAVD 88).**

**2 = Above Mean Sea Level.**

**Note 1: Hydrographs suggest that the original depth to water is 1 foot too high.**

**Table 5-2J**
**Summary of Water Level Measurements: November 7 & 8, 2017**
**NYSDEC Hydrogeologic Report**
**Niagara Sanitation Landfill, Site No. 932054**
**Wheatfield, New York**

NEW YORK STATE | Department of Environmental Conservation

| Location ID | Measuring Point Elevation[1] (ft amsl[2]) | Measurement Date | Depth to Water (ft) | Water Elevation[1] (feet amsl) | Note |
|---|---|---|---|---|---|
| **Fill/Upper Sand Wells** | | | | | |
| OW-01 | 578.30 | 11/7/2017 | 2.51 | 575.79 | |
| OW-13 | 579.33 | 11/7/2017 | 4.01 | 575.32 | Casing tab for lock corroded & outer casing heaved |
| OW-14B | 579.92 | 11/7/2017 | 4.52 | 575.40 | Outer casing has heaved. |
| OW-14BR | 580.03 | 11/7/2017 | 4.72 | 575.31 | |
| OW-16 | 581.88 | 11/7/2017 | 7.00 | 574.88 | |
| OW-21 | 580.00 | 11/7/2017 | 4.06 | 575.94 | |
| OW-22 | 579.46 | 11/7/2017 | 3.75 | 575.71 | |
| OW-23 | 579.26 | 11/7/2017 | 3.76 | 575.50 | |
| OW-31 | 580.64 | 11/7/2017 | 4.77 | 575.87 | |
| OW-32 | 581.44 | 11/7/2017 | 6.56 | 574.88 | |
| OW-33 | 582.43 | 11/7/2017 | 7.41 | 575.02 | |
| OW-34 | 581.10 | 11/7/2017 | 5.10 | 576.00 | |
| OW-35 | 581.57 | 11/7/2017 | 6.64 | 574.93 | |
| OW-36 | 580.95 | 11/7/2017 | 5.65 | 575.30 | |
| OW-37 | 580.15 | 11/7/2017 | 5.19 | 574.96 | |
| LDP-01 | 580.34 | 11/7/2017 | 3.97 | 576.37 | TD = 8.36 (TOIC), BTM Elev = 571.98 |
| LDP-02 | 581.03 | 11/7/2017 | 4.55 | 576.48 | |
| LDP-03 | 580.73 | 11/7/2017 | 4.25 | 576.48 | |
| LDP-04 | 581.42 | 11/7/2017 | 6.09 | 575.33 | |
| LPZ-01S | 580.31 | 11/7/2017 | 5.04 | 575.27 | |
| LPZ-02S | 581.03 | 11/7/2017 | 5.75 | 575.28 | |
| LPZ-03S | 581.16 | 11/7/2017 | 4.81 | 576.35 | |
| LPZ-04S | 579.68 | 11/7/2017 | 5.02 | 574.66 | |
| LPZ-05S | 580.41 | 11/7/2017 | 3.85 | 576.56 | |
| LPZ-06S | 581.00 | 11/7/2017 | 4.32 | 576.68 | |
| LPZ-07S | 580.56 | 11/7/2017 | 4.90 | 575.66 | |
| LPZ-08S | 579.47 | 11/7/2017 | 4.23 | 575.24 | |
| LPZ-09S | 581.51 | 11/7/2017 | 6.61 | 574.90 | |
| LPZ-10S | 580.38 | 11/7/2017 | 4.73 | 575.65 | |
| LPZ-11S | 579.96 | 11/8/2017 | 4.55 | 575.41 | |
| LPZ-12S | 580.03 | 11/7/2017 | 4.67 | 575.36 | |
| LPZ-13S | 581.66 | 11/7/2017 | 6.37 | 575.29 | |
| **Silty Clay & Red-Gray Clay Aquitard Wells** | | | | | |
| OW-02 | 577.26 | 11/7/2017 | 1.82 | 575.44 | 3.35' from TOC (0.92' above TOIC) |
| **Lower Sand Wells** | | | | | |
| OW-14A | 580.05 | 11/7/2017 | 11.19 | 568.86 | Casing tab for lock corroded. |
| OW-15 | 579.56 | 11/7/2017 | 11.45 | 568.11 | Casing tab for lock corroded. |
| **Glacial Till Wells** | | | | | |
| OW-01B | 579.14 | 11/7/2017 | 13.71 | 565.43 | |
| OW-03 | 579.56 | 11/7/2017 | 14.06 | 565.50 | 14.50' from TOC (0.52' above TOIC) |
| OW-04 | 579.45 | 11/7/2017 | 14.19 | 565.26 | |
| OW-05 | 579.75 | 11/7/2017 | 14.61 | 565.14 | |
| OW-06 | 582.36 | 11/7/2017 | 17.28 | 565.08 | Casing tab for lock corroded. |
| **Staff Gauges** | | | | | |
| SG-01 | 579.33 | 11/7/2017 | 4.00 | 575.33 | |
| SG-02 | 579.57 | 11/7/2017 | 4.22 | 575.35 | |

Table 5-2J
Summary of Water Level Measurements: November 7 & 8, 2017
NYSDEC Hydrogeologic Report
Niagara Sanitation Landfill, Site No. 932054
Wheatfield, New York

**Notes:**

1 = Elevations are referenced to North American Vertical Datum of 1988 (NAVD 88).

2 = Above Mean Sea Level.

**Table 5-2K**
**Summary of Water Level Measurements: November 21, 2019**
**NYSDEC Hydrogeologic Report**
**Niagara Sanitation Landfill, Site No. 932054**
**Wheatfield, New York**

NEW YORK STATE | Department of Environmental Conservation

| Location ID | Measuring Point Elevation[1] (ft amsl[2]) | Measurement Date | Depth to Water (ft) | Water Elevation[1] (feet amsl) | Note |
|---|---|---|---|---|---|
| **Fill/Upper Sand Wells** | | | | | |
| OW-01 | 578.30 | 11/21/2019 | 3.72 | 574.58 | |
| OW-13 | 579.33 | 11/21/2019 | 4.63 | 574.70 | |
| OW-14B | 579.92 | 11/21/2019 | 5.14 | 574.78 | |
| OW-14BR | 580.03 | 11/21/2019 | 4.93 | 575.10 | |
| OW-16 | 581.88 | 11/21/2019 | 8.25 | 573.63 | |
| OW-21 | 580.00 | 11/21/2019 | 5.94 | 574.06 | |
| OW-22 | 579.46 | 11/21/2019 | 5.45 | 574.01 | |
| OW-23 | 579.26 | 11/21/2019 | 4.48 | 574.78 | |
| OW-31 | 580.64 | 11/21/2019 | NM | NA | |
| OW-32 | 581.44 | 11/21/2019 | 7.80 | 573.64 | |
| OW-33 | 582.43 | 11/21/2019 | 8.58 | 573.85 | |
| OW-34 | 581.10 | 11/21/2019 | 5.90 | 575.20 | |
| OW-35 | 581.57 | 11/21/2019 | 7.41 | 574.16 | |
| OW-36 | 580.95 | 11/21/2019 | 6.64 | 574.31 | |
| OW-37 | 580.15 | 11/21/2019 | 5.47 | 574.68 | |
| LDP-01 | 580.34 | 11/21/2019 | 3.83 | 576.51 | |
| LDP-02 | 581.03 | 11/21/2019 | 4.58 | 576.45 | |
| LDP-03 | 580.73 | 11/21/2019 | 4.40 | 576.33 | |
| LDP-04 | 581.42 | 11/21/2019 | 7.40 | 574.02 | |
| LPZ-01S | 580.31 | 11/21/2019 | 5.30 | 575.01 | |
| LPZ-02S | 581.03 | 11/21/2019 | 6.80 | 574.23 | |
| LPZ-03S | 581.16 | 11/21/2019 | 5.36 | 575.80 | |
| LPZ-04S | 579.68 | 11/21/2019 | 3.63 | 576.05 | |
| LPZ-05S | 580.41 | 11/21/2019 | 4.76 | 575.65 | |
| LPZ-06S | 581.00 | 11/21/2019 | 5.31 | 575.69 | |
| LPZ-07S | 580.56 | 11/21/2019 | 6.59 | 573.97 | |
| LPZ-08S | 579.47 | 11/21/2019 | 4.88 | 574.59 | |
| LPZ-09S | 581.51 | 11/21/2019 | 7.79 | 573.72 | |
| LPZ-10S | 580.38 | 11/21/2019 | 6.03 | 574.35 | |
| LPZ-11S | 579.96 | 11/21/2019 | 4.75 | 575.21 | |
| LPZ-12S | 580.03 | 11/21/2019 | 5.08 | 574.95 | |
| LPZ-13S | 581.66 | 11/21/2019 | 8.43 | 573.23 | |
| **Silty Clay & Red-Gray Clay Aquitard Wells** | | | | | |
| OW-02 | 577.26 | 11/21/2019 | NM | NA | |
| **Lower Sand Wells** | | | | | |
| OW-14A | 580.05 | 11/21/2019 | NM | NA | |
| OW-15 | 579.56 | 11/21/2019 | NM | NA | |
| **Glacial Till Wells** | | | | | |
| OW-01B | 579.14 | 11/21/2019 | NM | NA | |
| OW-03 | 579.56 | 11/21/2019 | NM | NA | |
| OW-04 | 579.45 | 11/21/2019 | NM | NA | |
| OW-05 | 579.75 | 11/21/2019 | NM | NA | |
| OW-06 | 582.36 | 11/21/2019 | NM | NA | |
| **Staff Gauges** | | | | | |
| SG-01 | 579.33 | 11/21/2019 | NM | NA | |
| SG-02 | 579.57 | 11/21/2019 | NM | NA | |

Notes:

1 = Elevations are referenced to North American Vertical Datum of 1988 (NAVD 88).

2 = Above Mean Sea Level.

NA = Not applicable.

NM = Not measured.

**Table 5-2L**
**Summary of Water Level Measurements: April 3, 2020**
**NYSDEC Hydrogeologic Report**
**Niagara Sanitation Landfill, Site No. 932054**
**Wheatfield, New York**

NEW YORK STATE | Department of Environmental Conservation

| Location ID | Measuring Point Elevation[1] (ft amsl[2]) | Measurement Date | Depth to Water (ft) | Water Elevation[1] (feet amsl) | Note |
|---|---|---|---|---|---|
| **Fill/Upper Sand Wells** | | | | | |
| OW-01 | 578.30 | 4/3/2020 | 1.72 | 576.58 | |
| OW-13 | 579.33 | 4/3/2020 | 3.21 | 576.12 | |
| OW-14B | 579.92 | 4/3/2020 | 3.72 | 576.20 | |
| OW-14BR | 580.03 | 4/3/2020 | 4.41 | 575.62 | |
| OW-16 | 581.88 | 4/3/2020 | 4.90 | 576.98 | |
| OW-21 | 580.00 | 4/3/2020 | 2.99 | 577.01 | |
| OW-22 | 579.46 | 4/3/2020 | 2.49 | 576.97 | |
| OW-23 | 579.26 | 4/3/2020 | 3.09 | 576.17 | |
| OW-31 | 580.64 | 4/3/2020 | 3.51 | 577.13 | |
| OW-32 | 581.44 | 4/3/2020 | 4.76 | 576.68 | |
| OW-33 | 582.43 | 4/3/2020 | 6.08 | 576.35 | |
| OW-34 | 581.10 | 4/3/2020 | 4.15 | 576.95 | |
| OW-35 | 581.57 | 4/3/2020 | 4.85 | 576.72 | |
| OW-36 | 580.95 | 4/3/2020 | 4.23 | 576.72 | |
| OW-37 | 580.15 | 4/3/2020 | 3.60 | 576.55 | |
| LDP-01 | 580.34 | 4/3/2020 | 3.56 | 576.78 | |
| LDP-02 | 581.03 | 4/3/2020 | 4.12 | 576.91 | |
| LDP-03 | 580.73 | 4/3/2020 | 4.34 | 576.39 | |
| LDP-04 | 581.42 | 4/3/2020 | 4.66 | 576.76 | |
| LPZ-01S | 580.31 | 4/3/2020 | 4.55 | 575.76 | |
| LPZ-02S | 581.03 | 4/3/2020 | 4.80 | 576.23 | |
| LPZ-03S | 581.16 | 4/3/2020 | 4.41 | 576.75 | |
| LPZ-04S | 579.68 | 4/3/2020 | 2.96 | 576.72 | |
| LPZ-05S | 580.41 | 4/3/2020 | 3.28 | 577.13 | |
| LPZ-06S | 581.00 | 4/3/2020 | 3.97 | 577.03 | |
| LPZ-07S | 580.56 | 4/3/2020 | 3.60 | 576.96 | |
| LPZ-08S | 579.47 | 4/3/2020 | 3.48 | 575.99 | |
| LPZ-09S | 581.51 | 4/3/2020 | 4.79 | 576.72 | |
| LPZ-10S | 580.38 | 4/3/2020 | 3.43 | 576.95 | |
| LPZ-11S | 579.96 | 4/3/2020 | 3.76 | 576.20 | |
| LPZ-12S | 580.03 | 4/3/2020 | 3.30 | 576.73 | |
| LPZ-13S | 581.66 | 4/3/2020 | 5.44 | 576.22 | |
| **Silty Clay & Red-Gray Clay Aquitard Wells** | | | | | |
| OW-02 | 577.26 | 4/3/2020 | NM | NA | |
| **Lower Sand Wells** | | | | | |
| OW-14A | 580.05 | 4/3/2020 | NM | NA | |
| OW-15 | 579.56 | 4/3/2020 | NM | NA | |
| **Glacial Till Wells** | | | | | |
| OW-01B | 579.14 | 4/3/2020 | NM | NA | |
| OW-03 | 579.56 | 4/3/2020 | NM | NA | |
| OW-04 | 579.45 | 4/3/2020 | NM | NA | |
| OW-05 | 579.75 | 4/3/2020 | NM | NA | |
| OW-06 | 582.36 | 4/3/2020 | NM | NA | |
| **Staff Gauges** | | | | | |
| SG-01 | 579.33 | 4/3/2020 | NM | NA | |
| SG-02 | 579.57 | 4/3/2020 | NM | NA | |

**Notes:**

**1 = Elevations are referenced to North American Vertical Datum of 1988 (NAVD 88).**

**2 = Above Mean Sea Level.**

**NA = Not applicable.**

**NM = Not measured.**

**Table 5-2M**
**Summary of Water Level Measurements: November 23, 2021**
**NYSDEC Hydrogeologic Report**
**Niagara Sanitation Landfill, Site No. 932054**
**Wheatfield, New York**

NEW YORK STATE | Department of Environmental Conservation

| Location ID | Measuring Point Elevation[1] (ft amsl[2]) | Measurement Date | Depth to Water (ft) | Water Elevation[1] (feet amsl) | Note |
|---|---|---|---|---|---|
| **Fill/Upper Sand Wells** | | | | | |
| OW-01 | 578.30 | 11/23/2021 | 2.21 | 576.09 | |
| OW-13 | 579.33 | 11/23/2021 | 3.81 | 575.52 | |
| OW-14B | 579.92 | 11/23/2021 | 4.35 | 575.57 | |
| OW-14BR | 580.03 | 11/23/2021 | 4.63 | 575.40 | |
| OW-16 | 581.88 | 11/23/2021 | 6.00 | 575.88 | |
| OW-21 | 580.00 | 11/23/2021 | 3.58 | 576.42 | |
| OW-22 | 579.46 | 11/23/2021 | 3.11 | 576.35 | |
| OW-23 | 579.26 | 11/23/2021 | 3.71 | 575.55 | |
| OW-31 | 580.64 | 11/23/2021 | 3.95 | 576.69 | |
| OW-32 | 581.44 | 11/23/2021 | 6.15 | 575.29 | |
| OW-33 | 582.43 | 11/23/2021 | 7.14 | 575.29 | |
| OW-34 | 581.10 | 11/23/2021 | 4.92 | 576.18 | |
| OW-35 | 581.57 | 11/23/2021 | 6.21 | 575.36 | |
| OW-36 | 580.95 | 11/23/2021 | 5.20 | 575.75 | |
| OW-37 | 580.15 | 11/23/2021 | 4.91 | 575.24 | |
| LDP-01 | 580.34 | 11/23/2021 | 3.64 | 576.70 | |
| LDP-02 | 581.03 | 11/23/2021 | NM | NA | |
| LDP-03 | 580.73 | 11/23/2021 | 4.13 | 576.60 | |
| LDP-04 | 581.42 | 11/23/2021 | 5.64 | 575.78 | |
| LPZ-01S | 580.31 | 11/23/2021 | 4.92 | 575.39 | |
| LPZ-02S | 581.03 | 11/23/2021 | 5.62 | 575.41 | |
| LPZ-03S | 581.16 | 11/23/2021 | 4.78 | 576.38 | |
| LPZ-04S | 579.68 | 11/23/2021 | 3.20 | 576.48 | |
| LPZ-05S | 580.41 | 11/23/2021 | 4.09 | 576.32 | |
| LPZ-06S | 581.00 | 11/23/2021 | 3.38 | 577.62 | |
| LPZ-07S | 580.56 | 11/23/2021 | NM | NA | |
| LPZ-08S | 579.47 | 11/23/2021 | 4.06 | 575.41 | |
| LPZ-09S | 581.51 | 11/23/2021 | 6.14 | 575.37 | |
| LPZ-10S | 580.38 | 11/23/2021 | 4.00 | 576.38 | |
| LPZ-11S | 579.96 | 11/23/2021 | 4.43 | 575.53 | |
| LPZ-12S | 580.03 | 11/23/2021 | 4.29 | 575.74 | |
| LPZ-13S | 581.66 | 11/23/2021 | NM | NA | |
| **Silty Clay & Red-Gray Clay Aquitard Wells** | | | | | |
| OW-02 | 577.26 | 11/23/2021 | NM | NA | |
| **Lower Sand Wells** | | | | | |
| OW-14A | 580.05 | 11/23/2021 | NM | NA | |
| OW-15 | 579.56 | 11/23/2021 | NM | NA | |
| **Glacial Till Wells** | | | | | |
| OW-01B | 579.14 | 11/23/2021 | NM | NA | |
| OW-03 | 579.56 | 11/23/2021 | NM | NA | |
| OW-04 | 579.45 | 11/23/2021 | NM | NA | |
| OW-05 | 579.75 | 11/23/2021 | NM | NA | |
| OW-06 | 582.36 | 11/23/2021 | NM | NA | |
| **Staff Gauges** | | | | | |
| SG-01 | 579.33 | 11/23/2021 | NM | NA | |
| SG-02 | 579.57 | 11/23/2021 | NM | NA | |

Table 5-2M
Summary of Water Level Measurements: November 23, 2021
NYSDEC Hydrogeologic Report
Niagara Sanitation Landfill, Site No. 932054
Wheatfield, New York

New York State Department of Environmental Conservation

**Notes:**

**1 = Elevations are referenced to North American Vertical Datum of 1988 (NAVD 88).**

**2 = Above Mean Sea Level.**

**NA = Not applicable.**

**NM = Not measured.**

**Table 5-3**
**Summary of Hydraulic Conductivity Testing Results**
**NYSDEC Hydrogeologic Report**
**Niagara Sanitation Site, Site No. 932054**
**Wheatfield, New York**

NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

| Well Number | Screened * Interval (ft. bgs) | Test Type | Transmissivity ($ft^2$/day) | Hydraulic Conductivity (cm/sec) | Description * of Screened Material |
|---|---|---|---|---|---|
| **Upper Sand Deposit** | | | | | |
| OW-1 | 4.0 - 9.0 | Falling Head | N/A | 4.37E-04 | Upper Sand/Silty Clay |
| | **Arithmetic Mean:** | **N/A** | **N/A** | **4.37E-04** | |
| | **Geometric Mean:** | **N/A** | **N/A** | **4.37E-04** | |
| **Silty Clay & Red-Gray Clay Aquitard** | | | | | |
| OW-2 | 9.0 - 14.0 | Falling Head | N/A | 6.75E-04 | Silty Clay/Red-Gray Clay |
| | **Arithmetic Mean:** | **N/A** | **N/A** | **6.75E-04** | |
| | **Geometric Mean:** | **N/A** | **N/A** | **6.75E-04** | |
| **Glacial Till Deposit** | | | | | |
| OW-1B | 58.6 - 68.6 | Falling Head | N/A | 8.43E-07 | Glacial Till |
| OW-3 | 45.0 - 55.0 | Falling Head | N/A | 1.43E-06 | Wet Zone in Till |
| OW-4 | 59.0 - 69.0 | Falling Head | N/A | 7.88E-07 | Glacial Till |
| | **Arithmetic Mean:** | **N/A** | **N/A** | **1.02E-06** | |
| | **Geometric Mean:** | **N/A** | **N/A** | **9.83E-07** | |
| **Glacial Till Deposit** | | | | | |
| OW-5 | 60.0 - 70.0 | Falling Head | N/A | 7.50E-04 | Glacial Till |
| OW-6 | 56.0 - 66.0 | Falling Head | N/A | 6.80E-04 | Glacial Till |
| | **Arithmetic Mean:** | **N/A** | **N/A** | **7.15E-04** | |
| | **Geometric Mean:** | **N/A** | **N/A** | **7.14E-04** | |

**Notes:**
*** = Information from Table 4-1.**
**ft. bgs = Feet below ground surface.**
**N/A = Not Available.**
**Hydraulic conductivities for the Niagara Sanitation Landfill are summarized in Table IV.1 of the Phase II Report dated July 1985.**