Cassadaga Wind Project

Case No. 14-F-0490

1001.21 Exhibit 21

Geology, Seismology, and Soils

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EXHIBIT 21 GEOLOGY, SEISMOLOGY, AND SOILS

This exhibit includes a study of the geology, seismology, and soil impacts of the facility consisting of the identification and mapping of existing conditions, an impact analysis, and proposed impact avoidance and mitigation measures.

(a) Existing Slopes Map

See Figure 21-1 for a map delineating existing slopes (0-3%, 3-8%, 8-15%, 15-25%, 25-35%, 35% and over) on and within the drainage area potentially influenced by the Facility Site. Slopes within the Facility Site range from 0% to 50%.

(b) Proposed Site Plan

Please see the preliminary design drawings included with Exhibit 11, which includes proposed and existing contours at two-foot intervals, for the facility site and interconnections.

(c) Cut and Fill

Based on preliminary cut and fill calculations on 2-foot contours interpolated from publically available 5-foot contour data, and preliminary engineering of the proposed Facility, it is anticipated that 9,395,487 cubic feet of material will be excavated for the construction of the proposed facility. Of this, approximately 142,063 cubic feet will be topsoil, 1,390,397 cubic feet will be subsoil, 3,146,856 cubic feet will be substratum, and 4,716,171 will be bedrock. It should be noted that for the purposes of these calculations, any depth greater than 72 inches was considered to be bedrock. However, the depth to bedrock is greater than 72 inches in many areas based on geotechnical boring results. Soil profiles of the soil map units within the Facility Site were generated from data in the Soil Survey of Chautauqua County, New York (USDA 1994). Cut calculations for each soil map unit were generated using ArcGIS software by overlaying a layer containing preliminary cut and fill data with a layer containing the profiles of soils within the Facility Site.

In addition, approximately 3,591,756 cubic feet of fill (of which 1,495,127 will be gravel) is anticipated to be utilized for construction of the facility. With the exception of gravel, fill material will be derived from excavated material, and no fill will need to be imported for construction of the Facility.

Please note that these estimates are preliminary only and are based on publicly available 5-foot contour data, which has been interpolated to generate 2-foot contours associated with the Facility. The final footprint of the Facility will not be known until post-Certification and after a turbine model has been determined, which could very well result in fewer turbines (and correspondingly less infrastructure such as access roads) than proposed in this Application. Once the final footprint of the Facility is determined, the Applicant will finalize engineering with the objective of balancing the cut and fill required to construct and operate the Facility.

The construction of the access roads, crane pads, and other site features will require the final grades of several areas of the Facility to result in cut or fill. In the initial design process, the Applicant developed a basis of design for these features. Within these design parameters, the Applicant has aimed to minimize significant areas of cut or fill. However, various scenarios such as the access road traversing an existing grade that is in excess of the maximum design slope, being constructed on a side slope, or needing to flatten the top of an existing high point would create areas of cut and/or fill. Also creating a minimally sloping area for the crane pad on a steep area will require areas of cut and/or fill.

Additionally, in order to identify the presence of invasive species, and prevent the spread of invasive species by the transportation of materials to and from the Facility Site, the Applicant has developed an Invasive Species Control Plan (ISCP) (Appendix FF). The stated goal of the ISCP is to have no net increase in invasive plant species coverage within the area disturbed by Facility construction. The ISCP will be appended to the Facility construction contract, requiring the BOP Contractor to implement the control measures outline within the ISCP. The principal construction-related control measures contained within the ISCP are: 1) construction materials inspection; 2) target species treatment and removal; 3) construction equipment sanitation; and 4) restoration.

(d) Fill, Gravel, Asphalt, and Surface Treatment Material

Based on preliminary calculations, approximately 3,591,756 cubic feet of fill (of which 1,495,127 will be gravel) is anticipated to be utilized for construction and operation of the Facility. Fill will be utilized to create appropriate grades for access roads, crane pads, substations, and laydown areas. Gravel will be used as surface material for access roads, crane pads, MET tower pads, and other Facility components. As stated above, with the exception of gravel, fill material will be derived from excavated material, and no new fill will need to be imported for the purposes of Facility construction and operation.

(e) Type and Amount of Materials to be Removed from the Facility and Interconnection Sites

It will not be necessary for materials to be removed from the Facility Site. Stockpiled soils along the construction corridors will be used in site restoration, and all such materials will be re-graded to approximate pre-construction contours.

Based on the preliminary cut and fill estimates provided above, when accounting for all anticipated cut and fill there will be an excess of approximately 7,298,858 cubic feet of fill. However, as also previously indicated the preliminary cut and fill calculations are based on publicly available 5-foot contour data, which has been extrapolated to generate 2-foot contours associated with the Facility, and the final footprint of the Facility may have fewer turbines, access roads, etc. once the turbine model is determined post-Certification. The Applicant will require that final engineering efforts maximize the balance of cut and fill, and ultimately any excess cut material will be utilized during site restoration.

With respect to imported material, please see (d) above.

(f) Excavation Techniques to be Employed

Pending the receipt of all required permits, construction is currently scheduled to start in winter of 2017/2018. Project construction will be performed in several stages and will include the main elements and activities described below.

(1) Pre-Construction Activities

Before construction commences, a site survey will be performed to stake out the exact location of proposed Facility components. To assure compliance with various environmental protection commitments and permit conditions, the Applicant will provide funding for an Environmental Monitor to oversee Facility construction and restoration activities and to ensure compliance with all applicable environmental conditions. Prior to the start of construction at any given site, an Environmental Monitor and a representative of the construction contractor will conduct a walk-over of areas to be affected, or potentially affected, by proposed construction activities. This pre-construction walk-over will focus on the previously identified sensitive resources to avoid (e.g., wetlands, archaeological, or agricultural resources), as well as the limits of clearing, location of wetland and stream crossings, location of drainage features (e.g., culverts, ditches), location of underground utilities and tile lines, and layout of sedimentation and erosion control measures. Upon identification of these features, they will be marked in the field (by staking, flagging, fencing, etc.).

(2) Laydown Yard Construction

The construction laydown yard will be developed by stripping and stockpiling the topsoil and grading and compacting the subsoil. Geotextile fabric and approximately eight inches of gravel will then be installed to create a level working area. Electric and communication lines will be brought in from existing distribution poles to allow connection with construction trailers.

(3) Site Preparation for Construction

Facility construction will be initiated by clearing woody vegetation from all turbine sites, access roads, and electrical collection line routes. Trees cleared from the work area will be removed and disposed of off-site (outside of any wetlands, streams or floodways). It is generally assumed that a radius of up to 200 feet will be cleared around each turbine, a 75-foot wide corridor will be cleared along access roads, and a 40-foot-wide corridor will be cleared along underground electric collection lines that are not adjacent to access roads. In addition, a 100-foot-wide corridor will be cleared along overhead sections of the electrical collection lines, and the overhead transmission line. Actual clearing impacts on this Facility will be based on final engineering design, and are described and quantified in 22(b).

(4) Public Road Improvements

An appropriate turning radius (typically a 150-foot radius) will be established at the intersection of Facility access roads and public roads to accommodate flow of construction traffic. Public roadway intersections along the construction and delivery routes may also require spot radii improvements and the construction of short temporary road segments to accommodate the turning radius of over-length delivery vehicles, and minimize disruption of local roads and traffic caused by large construction/delivery vehicles and equipment. Based on the transportation route analysis conducted for this Facility, a total of 17 public road intersection improvements are currently anticipated (See Exhibit 25 for additional detail). These improvements will generally require soil stripping and the temporary placement of gravel over geotextile fabric. It is anticipated that some of these improvements will be removed, and the affected areas restored to their preconstruction condition following construction. In addition, during the operational phase of the Facility, it may be necessary to temporarily re-constitute certain intersection improvements for the purposes of accommodating over-length deliveries associated with Facility maintenance.

(5) Access Road Construction

Wherever feasible, existing roads and farm drives will be upgraded for use as Facility access roads in order to minimize impacts to active agricultural areas, forest, and wetland/stream areas. Where an existing road or farm drive is unavailable or unsuitable, new gravel surfaced access roads will be constructed. Road construction will involve topsoil stripping and grubbing of stumps, as necessary. Stripped topsoil will be stockpiled (and segregated from subsoil) along the road corridor for use in site restoration. Any grubbed stumps will be removed, chipped, or buried in upland areas of the site. Following removal of topsoil, subsoil will be graded, compacted, and surfaced with approximately 12 inches of gravel or crushed stone. A geotextile fabric or grid will be installed beneath the road surface, if necessary, to provide additional support.

Culverts and waterbars shall be installed to maintain natural drainage patterns. Where access roads must cross wetlands with flowing water or streams with flowing water, a temporary pump-around or coffer dam will be used to install crossings “in the dry”. Appropriate sediment and erosion control measures will be installed and maintained according to the Facility-specific NYSDEC-approved stormwater pollution prevention plan (SWPPP) for the Facility (see the preliminary SWPPP provided in Appendix GG). During construction, roads with a travel surface of up to 40 feet wide will be required to accommodate large cranes and oversized construction vehicles. At the completion of construction, the travel surface of access roads will generally be reduced to 20 feet. During the operational phase of the Facility, it may be necessary to temporarily re-constitute the travel surface of certain access roads to construction widths in order to accommodate over-sized deliveries associated with Facility maintenance. Typical access road details are included in Exhibit 11.

(6) Foundation Construction

Once the roads are complete for a particular group of turbine sites, turbine foundation construction will commence on that completed access road section. Initial activity at each tower site will typically involve clearing and leveling (as needed) up to a 200-foot radius around each tower location. Topsoil will be stripped from the excavation area, and stockpiled for future site restoration. Following topsoil removal, tracked excavators will be used to excavate the foundation hole. Subsoil and rock will be segregated from topsoil and stockpiled for reuse as backfill. Blasting is not anticipated. All stockpiled soils will be located outside of wetlands and will be stabilized in accordance with the final SWPPP. If necessary, dewatering of foundation excavations will involve pumping the water to a discharge point, which will include measures/devices to slow water velocities and trap any suspended sediment. Dewatering activities will not result in the direct discharge of water into any streams or wetlands, and will be conducted in accordance with the SWPPP.

Turbine foundations will be reinforced concrete, approximately 10 feet deep, and 50 to 65 feet in diameter. Any excess concrete and concrete wash water at turbine sites will be properly disposed of by pouring it into an excavation (either into the foundation excavation or “wash-out pits” created for this purpose) and then burying it or removing it from the site. No concrete will be buried or otherwise disposed of in wetlands. Once the foundation concrete is sufficiently cured, the excavation area around and over it is backfilled with the excavated on-site material. The top of the foundation is typically an 18-foot diameter pedestal that extends six to eight inches above grade. The base of each tower will be surrounded by a 6-foot wide gravel skirt, and an area approximately 100 feet by 60 feet will remain as a permanent gravel crane pad.

(7) Electrical Collection System Installation

Direct burial methods utilizing appropriate industry equipment including, but not limited to, a cable plow, rock saw, rock wheel and/or trencher will be used during the installation of underground electrical collection system whenever possible. Direct burial involves the installation of bundled cable (electrical and fiber optic bundles) directly into a narrow cut or "rip" in the ground. The rip disturbs an area approximately 24 inches wide with bundled cable installed to a minimum depth of 36 inches in most areas, and 48 inches in active agriculture and pasture lands. Where direct burial is not possible, an open trench will be excavated. Using this installation technique, topsoil and subsoil are excavated, segregated, and stockpiled adjacent to the trench. Following cable installation, the trench is backfilled with suitable fill material and any additional spoils are spread out or otherwise properly disposed of. Following installation of the buried collection line, areas will be returned to pre-construction grades. Installation of buried electrical lines would typically require a width of up to 40 feet of vegetation clearing. However, in areas where buried electrical lines are collinear with proposed access roads or public roads, no additional vegetation or soil disturbance, beyond that anticipated for road construction, is typically expected. The cleared area along the buried electrical line will be restored through seeding and mulching, and allowed to regenerate naturally. In some places, directional drilling or short sections of overhead line will be used to reduce wetland and stream impacts during construction. At locations where only electrical collection line crosses state-protected streams, or state-protected forested wetlands, directional drilling will be used to completely avoid impacts. In the case of streams, an overhead span may be used. For more information on exact locations where directional drilling and overhead spanning will be utilized, see Exhibit 22 and 23.

Directional drilling involves installing the cable under the wetland or stream using boring equipment set up on either side of the crossing. No surface disturbance is required between the bore pits, and all existing vegetation along the streams and within the wetlands (including mature trees) can remain in place. The only potential impact associated with directional drilling is a surface release of drilling mud. Such "frac-outs" are rare, and the contractor will be required to develop a final frac-out plan that will be implemented during construction. However, a draft inadvertent return (frac-out) plan is included as Appendix HH.

(8) Wind Turbine Assembly, Erection and Commissioning

Turbine assembly and erection involves mainly the use of large track mounted cranes, smaller rough terrain cranes, boom trucks, and rough terrain fork-lifts for loading and off-loading materials. The tower sections, rotor components, and nacelle for each turbine will be delivered to each site by flatbed trucks and unloaded by crane. A large erection crane will set the tower segments on the foundation, place the nacelle on top of the tower, and install the rotor either by individual blade installation or, following ground assembly, place the rotor onto the nacelle.

(9) Substation

Substation construction (for both the collection and POI substation) will begin with clearing the site and stockpiling topsoil for later use in site restoration. The site will be graded, and a laydown area for construction equipment, materials, and parking will be prepared. Concrete foundations for major equipment and structural supports will be placed, followed by the installation of various conduits, cable trenches, and grounding grid conductors. Above-ground construction will involve the installation of structural steel, bus conductors and insulators, switches, circuit breakers, transformers, control buildings, etc. The final steps involve laying down crushed stone across the station, erecting the chain link fence, connecting the high voltage links, and testing the control systems. Restoration of the area immediately adjacent to the substations will then be completed.

(g) Temporary Cut and Fill Storage Areas

The construction of the access roads, crane pads, and other site features will require the final grades of several areas of the Facility to result in cut or fill. In the initial design process, the Applicant developed a basis of design for these features. Within these design parameters, the Applicant has aimed to minimize significant areas of cut or fill. However, various scenarios such as the access road traversing an existing grade that is in excess of the maximum design slope, being constructed on a side slope, or needing to flatten the top of an existing high point would create areas of cut and/or fill. Also creating a minimally sloping area for the crane pad on a steep area will require areas of cut and/or fill.

Proper methods for segregating stockpiled and spoil material shall be implemented, and excavated soil will be reused to the maximum extent possible on the site that it was excavated from, as a means to limit opportunities for proliferation of non-native flora and other invasive species. Final cut and fill storage areas will be available following Certification, and included in the construction drawings.

(h) Suitability for Construction

GeoEnvironmental of New York (GZA) conducted a Preliminary Geotechnical Evaluation, to evaluate the surface and subsurface soils, bedrock, and groundwater conditions in the vicinity of the Facility (see Appendix II). As part of this evaluation, GZA conducted a literature review of publicly available data, and a site visit to observe surficial features and assess general constructability of the proposed Facility at eight test borings throughout the Facility Site. The review of publically available data includes an assessment of each soil type within the Facility Site with regard to factors such as permeability, pH, water capacity, and risk of corrosion to concrete and steel (see Appendix II, Table 4).

Based on GZA's findings, the Facility Site is generally suitable for the proposed wind Facility. However, due to the variability in the soil types, overburden thickness, and groundwater depths across the Facility Site, GZA recommends additional soil borings be performed prior to construction to assess localized subsurface conditions at proposed structure locations. The Preliminary Geotechnical Evaluation is discussed further in the subparts that follow and available in full in Appendix II.

Prior to construction, a detailed geotechnical investigation will be performed to verify subsurface conditions at each turbine location and ancillary buildings and allow development of final wind turbine foundation and electrical design, and other Facility components as necessary. Based on the results of the geotechnical investigation, a final site survey for all Facility components will be completed.

(i) Preliminary Blasting Plan

According to the Preliminary Geotechnical Assessment (see Appendix II), based on the depth of bedrock and its weathered and very poor rock quality conditions observed, blasting would likely not be necessary for construction of proposed wind turbine foundations and associated equipment. If bedrock or boulders are encountered and require removing, the bedrock and boulders are assumed to be rippable with an excavator and/or able to be broken with a pneumatic hammer. After review of this information, and based on its experience, the Applicant has determined that blasting will not be anticipated, and therefore a Preliminary Blasting Plan is not necessary.

(j) Potential Blasting Impacts

As indicated above, blasting will not be necessary for this Facility due to the depth of bedrock and very poor rock quality conditions. Therefore, blasting-related impacts will not occur.

(k) Mitigation Measures for Blasting Impacts

No blasting will be required, and therefore mitigation related to blasting will not be necessary.

(l) Regional Geology, Tectonic Setting, and Seismology

Information regarding geology, tectonic setting, and seismology was obtained from on-site investigations conducted by GZA and from existing published sources, including the Soil Survey of Chautauqua County (USDA, 1994), statewide bedrock geology mapping (NYS Museum/NYS Geological Survey, 1999a), New York State surficial geology mapping (NYS Museum/NYS Geological Survey, 1999b), 2014 New York State Hazard Map (USGS, 2014b), and USGS Earthquake Hazards Program (USGS, 2015). Investigations conducted by GZA included a literature review of publicly available data, a site visit to observe surficial features and assess general constructability of the proposed Facility, and a preliminary subsurface investigation including eight test borings throughout the Facility Site (GZA's Preliminary Geotechnical Evaluation is provided in Appendix II).

The location of the Facility is within the Allegheny Plateau physiographic province of New York State. The Allegheny Plateau in Chautauqua County is characterized by many broad, flat-bottomed valleys, occupied by meandering streams. The Facility is located approximately 10 miles southeast of the Allegheny escarpment, which parallels the Lake Erie shoreline, and marks the northern boundary of the Appalachian Plateau. The Facility Site is comprised of rounded, elongated ridges, which were shaped by glaciers during the most recent Wisconsin glacial stage (~12,000 to 80,000 years ago) and may have resulted from the presence of bedrock that was relatively resistant to glacial erosion (Muller, 1963). The wind turbines are primarily sited on the upper elevations of these ridges. The Cassadaga Creek and Conewango Creek valleys on the eastern and western boundaries, respectively, were enlarged by glacial erosion, and consist of broad, U-shaped valleys with smooth, steep walls (Muller, 1963). Elevations in the Facility Site range between 1,300 feet amsl in the Cassadaga Creek valley in the western portion of the Facility Site to 2,100 feet amsl in the east-central portion of the Facility Site

The topography is strongly influenced by the underlying bedrock, which is nearly level bedded (USDA, 1994). Bedrock in this region is typified by stratified beds of shale, sandstone, and siltstone which gently tilt towards the south-southeast. The bedrock underlying the vicinity of the Facility Site (from oldest to newest) consists of the Northeast Shale (400 to 600 feet thick) of the Canadaway Formation, Dexterville Siltstone (100 feet thick) and Ellicott Shale (150 feet thick) members of the Chadokin Formation, and undifferentiated sandstone, siltstone, and shale of the Cattaraugus Formation (650 feet thick), all of which are of the upper Devonian (Muller, 1963; Tesmer, 1963). The Cattaraugus Formation occasionally outcrops at the highest elevations within the Facility Site (GZA, 2016). See Figure 21-3 for a map of Bedrock underlying the Facility Site. See subpart 21(q) for a more detailed description of bedrock within the Facility Site.

Based on GZA's literature review and test boring locations, evidence of karst geology does not appear to be present or reported within the regional geology associated with the Facility.

The surficial geology underlying the Facility Site and vicinity is dominated by glacial till, which exhibits a wide range of particle and rock fragment size. The layer of glacial till itself is often of varying thickness and can range from a few feet on some ridge tops to more than 10 feet below higher ridges. The surficial geology of the lower portions of the Facility Site such as the Cassadaga Creek river valley is characterized by lacustrine silt and clay of varying thickness as well as proglacial fluvial outwash (USDA, 1994).

Based on the 2014 New York State Hazard Map (USGS, 2014a), the Facility Site is located in an area of relatively low seismic hazard, with a 2% or less chance that peak ground acceleration in a 50 year window is between 4% and 8% of standard gravity. An earthquake occurred in Attica, New York (about 75 miles northeast of the Facility Site) in 1966 with a Richter scale magnitude of 4.7 (USGS, 2015). There are several faults mapped in Chautauqua County (Jacobi, 2002). The Mayville fault, Charlotte Center fault and an unnamed fault are located within the vicinity of the Facility Site. However, these faults are not associated with any historic earthquakes (USGS, 2015). Furthermore, the USGS Earthquake Hazards Program does not list any young faults, or faults that have had displacement in the Holocene epoch within the vicinity of the Facility Site.

(m) Facility Impacts on Regional Geology

GZA concludes that the bedrock encountered in the Facility Site is structurally suitable for support of wind turbines foundations, support buildings, and access roads. GZA indicates that a detailed subsurface survey should be completed in the footprint of each of the turbines prior to Facility construction. The Facility is not anticipated to result in any significant impacts to geology. However, depth to bedrock in the Facility Site is expected to be variable and it is possible that some turbine foundations may be anchored to bedrock (Appendix II). Based on the weathered and very poor rock quality conditions observed at the eight test boring locations, blasting will not be required. The bedrock encountered at the test boring locations is expected to be rippable using typical construction excavation equipment (i.e. backhoe) and/or broken up using a pneumatic hammer. Based on the Applicant's experience constructing other wind power Facilities (including in New York State), only temporary, minor impacts to geology are expected as a result of construction activities. For example, where turbine and access road sites are not located on completely level terrain, some cut and fill will be required; however, the impact to overall topography will be minor. Once operational, Facility impacts to geology will be minimal.

(n) Impacts of Seismic Activity on Facility Operation

Faults within the vicinity of the Facility are not associated with any historic earthquakes. In addition, the USGS Earthquakes Hazards Program does not identify any young faults (including those with displacement in the Holocene epoch) within the vicinity of the Facility. Therefore, this topic will not be further addressed in this Application.

(o) Soil Types Map

See Figure 21-2 for a map delineating soil types within the Facility Site. These soils within the Facility Site are discussed in the following subpart.

(p) Characteristics of Each Soil Type and Suitability for Construction

Information regarding on-site soils was obtained from on-site investigations conducted by GZA and from existing published sources, including Soil Survey of Chautauqua County (USDA, 1994), USDA Web Soil Survey (2013), and Soil Survey Geographic (SSURGO, 2016).

The Soil Survey of Chautauqua County, New York (USDA, 1994) indicates that the Facility Site consists of three General Soil Associations, Busti-Chautauqua-Chadakoin, Fremont-Schuyler, and Raynham-Canandaigua-Getzville. However, all turbines are currently sited within the Busti-Chautauqua-Chadakoin map unit and the proposed POI substation is proposed to be located within the Raynham-Canandaigua-Getzville association. Table 21-1 lists the soils associations found within the Facility Site and their characteristics. From these associations, there are 31 soil series within the Facility Site, of which there are 66 individual soil map units. However, four soil series, Busti, Chadakoin, Chautauqua, and Fremont, comprise approximately 82% of the soils by area within the Facility Site. General descriptions of these four series are provided in Table 21-2. Additionally, all 66 of the individual soil map units that occur within the Facility Site, as well as their respective areas, are provided in Table 21-3 below.

Table 21-1. Soil Associations within the Facility Site.

Soil Association	Main Characteristics
Busti-Chautauqua-Chadakoin	• Dominantly nearly level to very steep and very deep • Somewhat poorly drained to well drained • Medium textured soils • Found on uplands
Fremont-Schuyler	• Dominantly nearly level to very steep and very deep • Somewhat poorly drained and moderately well drained • Medium to moderately fine textured soils that have a low content of lime • Found on uplands
Raynham-Canandaigua-Getzville	• Dominantly nearly level and gently sloping, and very deep • Somewhat poorly drained to very poorly drained • Medium textured soils that have a medium content of lime • Found on broad flats in valleys

Source: (USDA, 1994)

Table 21-2. Dominant Soil Series within the Facility Site.

Soil Series	Main Characteristics
Busti Silt Loam	• Somewhat poorly drained, medium textured • Depth to bedrock greater than 78 inches • Found along lower side of slopes, drainage ways, and flat areas (0% to 8% slopes) • Rate of water movement is slow to moderate in both the surface layer and substratum
Chadakoin Silt Loam	• Well drained, medium textured • Depth to bedrock greater than 78 inches • Found on convex hilltops, hillsides, and valley sides that are strongly dissected by intermittent streams (3% - 50% slopes) • Rate of water movement is moderate through both the surface layer and the substratum
Chautauqua Silt Loam	• Moderately well drained, medium textured • Depth to bedrock greater than 78 inches • Found on convex hilltops and side slopes that receive little runoff from adjacent soils (3% to 25% slopes) • Rate of water movement is moderate to moderately slow in the surface layer and substratum

Soil Series	Main Characteristics
Fremont Series	• Somewhat poorly drained, medium to moderately fine textured • Depth to bedrock greater than 78 inches • Found on broad upland flats, in saddles, and on side slopes (0% to 25% slopes) • Rate of water movement is moderately slow in the surface layers and very slow in the substratum

Source: (USDA, 2013)

Table 21-3. Soil Map Units within the Facility Site

Soil Unit	Area within Facility Site (acres)	Percent of Facility Site Area
Busti silt loam, 3 to 8 percent slopes	2,444.1	30.4
Chautauqua silt loam, 8 to 15 percent slopes	991.9	12.3
Chautauqua silt loam, 3 to 8 percent slopes	691.8	8.6
Fremont silt loam, 3 to 8 percent slopes	650.8	8.1
Busti silt loam, 0 to 3 percent slopes	358.4	4.5
Chadakoin silt loam, 25 to 35 percent slopes	282.9	3.5
Busti silt loam, 8 to 15 percent slopes	235.3	2.9
Chautauqua silt loam, 15 to 25 percent slopes	220.0	2.7
Fremont silt loam, 8 to 15 percent slopes	218.5	2.7
Ashville silt loam	189.9	2.4
Chadakoin silt loam, 35 to 50 percent slopes	181.5	2.3
Chadakoin silt loam, 15 to 25 percent slopes	164.7	2.0
Schuyler silt loam, 8 to 15 percent slopes	154.8	1.9
Fremont silt loam, 0 to 3 percent slopes	83.9	1.0
Chenango channery loam, fan, 3 to 8 percent slopes	76.6	1.0
Schuyler silt loam, 3 to 8 percent slopes	75.2	0.9
Dalton silt loam, 0 to 3 percent slopes	74.6	0.9
Volusia channery silt loam, 3 to 8 percent slopes	66.3	0.8
Orpark silt loam, 3 to 8 percent slopes	56.5	0.7
Fluvaquents-Udifluvents complex, frequently flooded	56.4	0.7
Alden mucky silt loam	50.1	0.6
Schuyler silt loam, 15 to 25 percent slopes	44.8	0.6
Valois gravelly silt loam, 25 to 35 percent slopes	44.8	0.6
Valois gravelly silt loam, 15 to 25 percent slopes	44.7	0.6
Red Hook silt loam	43.5	0.5

Soil Unit	Area within Facility Site (acres)	Percent of Facility Site Area
Chadakoin silt loam, 8 to 15 percent slopes	43.2	0.5
Valois gravelly silt loam, rolling	37.0	0.5
Holderton silt loam, 0 to 3 percent slopes, occasionally flooded	35.8	0.4
Valois gravelly silt loam, 3 to 8 percent slopes	35.3	0.4
Mardin channery silt loam, 3 to 8 percent slopes	28.8	0.4
Chenango channery loam, fan, 0 to 3 percent slopes	27.8	0.3
Valois gravelly silt loam, 8 to 15 percent slopes	26.1	0.3
Chenango gravelly loam, 3 to 8 percent slopes	24.3	0.3
Chadakoin silt loam, 3 to 8 percent slopes	23.1	0.3
Towerville silt loam, 35 to 50 percent slopes	18.3	0.2
Minoa fine sandy loam	17.8	0.2
Orpark silt loam, 8 to 15 percent slopes	17.8	0.2
Chenango silt loam, 0 to 3 percent slopes	16.4	0.2
Chenango gravelly loam, 8 to 15 percent slopes	16.2	0.2
Canandaigua mucky silt loam	13.6	0.2
Lamson silt loam	13.4	0.2
Towerville silt loam, 15 to 25 percent slopes	12.5	0.2
Raynham silt loam, flooded	12.1	0.2
Langford silt loam, 3 to 8 percent slopes	12.0	0.1
Chenango gravelly loam, 15 to 25 percent slopes	11.7	0.1
Getzville silt loam	11.6	0.1
Langford silt loam, 8 to 15 percent slopes	11.3	0.1
Erie silt loam, 3 to 8 percent slopes	10.7	0.1
Canandaigua silt loam, loamy substratum	8.9	0.1
Towerville silt loam, 8 to 15 percent slopes	8.7	0.1
Water	8.5	0.1
Volusia channery silt loam, 0 to 3 percent slopes	8.5	0.1
Wayland soils complex, 0 to 3 percent slopes, frequently flooded	8.0	0.1
Raynham silt loam, 0 to 3 percent slopes	7.2	0.1
Allard silt loam, 0 to 3 percent slopes	2.6	<0.1
Orpark silt loam, 0 to 3 percent slopes	2.5	<0.1
Chenango gravelly loam, 0 to 3 percent slopes	2.1	<0.1
Elnora fine sandy loam, 0 to 3 percent slopes	1.8	<0.1
Valois gravelly silt loam, 35 to 50 percent slopes	1.4	<0.1

Soil Unit	Area within Facility Site (acres)	Percent of Facility Site Area
Raynham silt loam, 3 to 8 percent slopes	1.4	<0.1
Tioga silt loam	0.9	<0.1
Erie silt loam, 0 to 3 percent slopes	0.4	<0.1
Pompton silt loam	0.3	<0.1
Middlebury silt loam	0.3	<0.1
Dalton silt loam, 3 to 8 percent slopes	0.2	<0.1
Swormville silt loam	0.1	<0.1

Source: (USDA, 2013)

The vast majority of soils in the Facility vicinity are silt loams, but textures such as gravelly silt loam, channery silt loam, mucky silt loam, fine sandy loam, and channery loam are present in small areas. Soil drainage is predominantly somewhat poorly drained, with approximately 54 percent of the on-site soils somewhat poorly drained, 28 percent moderately well drained, 14 percent well drained, and four percent poorly to very poorly drained (USDA, 2013). Soils that are listed as hydric by the NRCS cover approximately four percent of the Facility Site, with Ashville silt loam (map unit As) being the prominent hydric soil. Approximately 85 percent of the Facility Site contains soils classified as either prime farmland soils, prime farmland soils, if drained or farmland of statewide importance (USDA, 2013). For additional information about agricultural resources within the Facility Site, including designated Agricultural District lands, see Exhibits 4 and 22 of this Application.

The primary impact to the physical features of the Facility Site will be the disturbance of soils during construction. Based on the assumptions outlined in 1001.22(b), Table 22-1, disturbance to soils from all anticipated construction activities will total approximately 450 acres. Of this total, only approximately 90 acres will be converted to built facilities (roads, turbine foundations/cranepads, and structures), while the remaining will be restored and stabilized following completion of construction. The area of disturbance calculations presented above assume that significant soil disturbance will occur in all areas in which construction occurs. Actual disturbance will include overlap of some components (e.g. buried collection line within the access road disturbance) will be highly variable based on the specific construction activity, the construction techniques employed, and soil/weather conditions at the time of construction. Table 21-4 provides a summary of the anticipated impacts from construction and operation of the facility to each soil map unit.

Table 21-4. Anticipated Impacts to soils

Soil Series Name	Temporary (acres)	Permanent (acres)	Total (acres)
Alden mucky silt loam	0.9	0.2	1.2
Ashville silt loam	5.5	1.5	7.0
Busti silt loam, 0 to 3 percent slopes	25.5	4.2	29.7
Busti silt loam, 3 to 8 percent slopes	127.1	27.3	154.5
Busti silt loam, 8 to 15 percent slopes	3.1	2.0	5.1
Canandaigua silt loam, loamy substratum	0.0	0.0	0.0
Canandaigua mucky silt loam	0.0	0.1	0.1
Chadakoin silt loam, 3 to 8 percent slopes	3.2	0.6	3.8
Chadakoin silt loam, 15 to 25 percent slopes	1.2	0.4	1.6
Chadakoin silt loam, 25 to 35 percent slopes	4.6	1.5	6.1
Chadakoin silt loam, 35 to 50 percent slopes	0.0	1.5	1.5
Chautauqua silt loam, 3 to 8 percent slopes	54.5	10.4	64.9
Chautauqua silt loam, 8 to 15 percent slopes	38.5	9.7	48.2
Chautauqua silt loam, 15 to 25 percent slopes	0.5	1.7	2.2
Chenango silt loam, 0 to 3 percent slopes	0.0	0.1	0.1
Chenango gravelly loam, 3 to 8 percent slopes	0.0	0.5	0.5
Chenango channery loam, fan, 0 to 3 percent slopes	0.0	0.3	0.3
Chenango channery loam, fan, 3 to 8 percent slopes	0.5	0.2	0.7
Dalton silt loam, 0 to 3 percent slopes	4.8	0.8	5.6
Erie silt loam, 3 to 8 percent slopes	0.0	0.1	0.1
Fluvaquents-Udifluvents complex, frequently flooded	0.0	0.5	0.5
Fremont silt loam, 0 to 3 percent slopes	5.4	1.6	7.0
Fremont silt loam, 3 to 8 percent slopes	29.7	6.3	35.9
Fremont silt loam, 8 to 15 percent slopes	12.9	1.9	14.8
Getzville silt loam	2.0	3.3	5.3
Holderton silt loam	0.0	0.3	0.3
Lamson silt loam	0.0	0.1	0.1
Langford silt loam, 3 to 8 percent slopes	0.6	0.0	0.6
Langford silt loam, 8 to 15 percent slopes	0.0	0.3	0.3
Mardin channery silt loam, 3 to 8 percent slopes	5.8	3.3	9.1
Middlebury silt loam	0.0	0.0	0.0
Orpark silt loam, 0 to 3 percent slopes	0.1	0.0	0.1
Orpark silt loam, 3 to 8 percent slopes	2.6	0.4	3.0
Raynham silt loam, flooded	0.0	0.1	0.1

Soil Series Name	Temporary (acres)	Permanent (acres)	Total (acres)
Red Hook silt loam	0.4	0.5	0.9
Schuyler silt loam, 3 to 8 percent slopes	8.9	1.3	10.2
Schuyler silt loam, 8 to 15 percent slopes	9.0	1.3	10.3
Schuyler silt loam, 15 to 25 percent slopes	-0.7	2.1	1.4
Towerville silt loam, 8 to 15 percent slopes	0.1	0.0	0.1
Towerville silt loam, 35 to 50 percent slopes	0.0	0.0	0.0
Valois gravelly silt loam, 8 to 15 percent slopes	0.0	0.1	0.1
Valois gravelly silt loam, 25 to 35 percent slopes	0.3	0.1	0.4
Valois gravelly silt loam, 35 to 50 percent slopes	0.0	0.1	0.1
Valois gravelly silt loam, rolling	3.3	1.2	4.6
Volusia channery silt loam, 0 to 3 percent slopes	0.2	1.1	1.3
Volusia channery silt loam, 3 to 8 percent slopes	5.6	2.0	7.5
Water	0.3	0.0	0.3
	356.3	91.1	447.4

In addition, based on a review of USGS hazard maps, the Facility Site has a low incidence of landslides (USGS, 2014a). The erosion hazard of on-site soils is "slight" for 13 percent of the Facility Site, "moderate" for 53 percent of the Facility Site, and "severe" for 34 percent of the Facility Site (USDA, 2013). Areas of severe erosion hazard occur in small patches throughout the Facility Site, primarily associated with slopes in excess of eight percent. 13 turbines (T6, T14, T15, T21, T27, T30, T31, T32, T36, T42, T48, T53, and T58) of the 58 proposed Facility turbines are located on soils with a severe erosion hazard rating. Additionally, approximately 3.8 miles of proposed access road (21% of the total for the Facility) are located on soils with a severe erosion hazard rating. With respect to electrical collection lines, approximately 8.8 miles (26.6% of the Facility total) are located on soils with a severe erosion hazard rating. Neither the laydown yard, O&M building, MET Towers, nor substations (POI and Collection) are located on soils with a severe erosion hazard rating.

Earth moving and general soil disturbance will increase the potential for wind/water erosion and sedimentation into surface waters. Based on engineering for the Facility and sediment/erosion control procedures, construction on steep slopes (i.e., in excess of 15 percent) has been avoided to the extent practicable within the Facility Site by siting access roads and wind turbines in a linear fashion along the ridgelines as opposed to traversing the hillsides in multiple locations. Implementing the erosion and sediment control measures outlined in the Preliminary Stormwater Pollution Prevention Plan (SWPPP) (Appendix GG) will minimize impacts to steep slopes and highly erodible soils that may occur in the event of extreme rainfall or other event that could potentially lead to severe erosion and downstream water quality issues. In addition, impacts to soils will be further minimized by the following means:

- Public road ditches and other locations where Facility-related runoff is concentrated will be armored with rip-rap to dissipate the energy of flowing water and to hold the soils in place.
- Prior to commencing construction activities, erosion control devices will be installed between the work areas and downslope areas, to reduce the risk of soil erosion and siltation. Erosion control devices will be monitored continuously throughout construction and restoration for function and effectiveness.
- During construction activities, hay bales, silt fence, or other appropriate erosion control measures will be placed as needed around disturbed areas and stockpiled soils.
- Following construction, all temporarily disturbed areas will be stabilized and restored in accordance with approved plans.

Impacts to soil resources will be minimized by adherence to best management practices that are designed to avoid or control erosion and sedimentation and stabilize disturbed areas. In addition, erosion and sedimentation impacts during construction will be minimized by the implementation of an erosion and sedimentation control plan developed as part of the State Pollution Discharge Elimination System (SPDES) General Permit for the Facility. Erosion and sediment control measures shall be constructed and implemented in accordance with a SWPPP to be prepared and approved prior to construction, and at a minimum will include the measures set forth in the Preliminary SWPPP provided in Appendix GG.

Soil units found within the Facility Site also are generally considered to be acidic (having a pH of 3.5 to 6.0) (USDA, 2013). Acidic soils are likely to be corrosive to bare steel or concrete. Bare steel may need a protective coating and concrete may require additives in the mixture to protect against corrosion. Detailed design requirements will be determined during the final engineering phase of the Facility. Based on information from the Chautauqua County Soil Survey, construction excavations may encounter areas of perched groundwater if construction occurs during a time when a seasonally high water table may be present (spring and fall). In addition, construction during rainy periods may see an increase in perched groundwater due to the low hydraulic conductivity within the Facility Site. Soils within the Facility Site have a moderate to high risk of frost action because of seasonally high water table or perched water table due to low permeability. GZA recommends that foundations in these areas be constructed at suitable depths below the frost line, assumed to be three to four feet below ground surface. A technical discussion of additional construction considerations, procedures, and recommendations from an engineering perspective are presented in GZA's report provided in Appendix II.

(q) Bedrock Analyses and Maps

A general discussion of bedrock within the Facility Site is provided in subpart 21(l) above. Bedrock in the region of the Facility Site is typified by stratified beds of shale, sandstone, and siltstone which gently tilt towards the south-southeast. See Figure 21-3 for a map of Bedrock underlying the Facility Site.

GZA accessed publicly available oil and gas and water wells drilling logs from NYSDEC (2016) and USGS (2016) to determine depth to bedrock in wells drilled in the Facility Site. These sources indicated that depth to bedrock in wells drilled in the upland areas of the Facility Site were generally reported as ranging from 10 feet to 70 feet below ground surface, with greater depths reported in wells proximate to valleys in the southeastern portion of the Facility Site (NYSDEC, 2016; USGS, 2016). In the higher elevations of the Facility Site, the till deposits are generally thin and bedrock is presumed to be present within 10 feet of the ground surface. Most of the proposed turbine locations are located in these areas of presumed thin till cover (see Figure 21-3). Depth to bedrock in wells completed at these higher elevations were reported as ranging from 10 to 30 feet bgs. Depth to bedrock in wells completed over the Ellicott Shale were reported as generally ranging from 30 to 60 feet bgs, which includes the turbine of clusters in the western portion of the Facility Site. According to GZA's report, most of the proposed structure locations are not proximate to a completed well. Therefore, bedrock depths at each proposed structure location would need to be confirmed through additional soil boring investigations.

GZA completed a preliminary subsurface investigation, which included subsurface soil and bedrock sampling and geotechnical laboratory testing, at six proposed turbine locations and two proposed electrical substation locations within the Facility Site (see Appendix II). Based on the subsurface soil testing, the majority of values ranged between medium to very dense relative density, for granular soils, or stiff to hard consistency for fine-grained cohesive soils. Soils that exhibit a relative density of medium dense and consistency of medium, at a minimum, are suitable for shallow foundation construction. Moderately to severely weathered sedimentary bedrock (shale and/or siltstone) was encountered within 10 feet bgs at three soil boring locations for proposed turbines. At the remaining soil borings locations for proposed turbines, evidence of severely weathered bedrock was observed at depths typically greater than 30 feet bgs. Weathered bedrock was not observed within the two soil borings in the location of the two proposed substations. In general, rock core samples identified thinly-bedded formations consisting of interbedded shale and/or siltstone. The bedrock encountered at the completed test boring locations is identified as a soft rock that is expected to be rippable using typical construction excavation equipment and/or could easily be broken up using pneumatic hammer. However, excavations at these depths is considered to be unlikely. According to GZA's report, based on the depth of bedrock and its weathered and very poor rock quality conditions observed, blasting would likely not be necessary for construction of proposed wind turbine foundations and associated equipment.

Based on the Preliminary Geotechnical Assessment, the bedrock encountered is considered to be structurally suitable for support of foundations for wind turbines, support buildings, and access road construction. However, GZA recommends that all turbine locations undergo additional subsurface investigation prior to turbine construction.

With regard to water tables, the county soil survey provides the depth to the seasonally high water table, evaluated to a depth of six feet, for soils within the Facility Site. According to this information, the seasonally high water table is within one foot of the soil surface over approximately 70 percent of the Facility Site (USDA, 1994, 2013). For additional information about groundwater and surface waters in the Facility Area, see Exhibit 23 of this Application.

During GZA's subsurface investigation, groundwater was encountered at three of the eight boring locations. The remaining five subsurface investigations did not have any standing water at completion of soil sampling. Therefore, some locations are expected to have a moderate to high permeability or hydraulic conductivity allowing for good drainage. In addition, these locations are typically located at higher elevations. According to GZA, it is unlikely that foundation construction activities associated with the turbines, support structures, collection lines, and transmission lines will encounter or impact subsurface groundwater.

The complete results of GZA's Preliminary Geotechnical Investigation, including boring logs for all subsurface investigations are included in Appendix II.

(r) Foundation Evaluation

Foundation construction occurs in several stages, which typically includes excavation, pouring of concrete mud mat, rebar and bolt cage assembly, outer form setting, casting and finishing of the concrete, removal of the forms, backfilling and compacting, and site restoration. Excavation and foundation construction will be conducted in a manner that will minimize the size and duration of excavated areas required to install foundations.

(1) Preliminary Engineering Assessment

As previously mentioned, based on GZA's research, the overburden soils and shale/siltstone bedrock encountered is generally considered to be structurally suitable for support of foundations for wind turbines, support buildings, and access road construction. However, GZA recommends additional soil borings be performed prior to construction to assess localized subsurface conditions at proposed structure locations. GZA states that conventional shallow mat foundations for wind turbine support and shallow continuous spread wall foundations for ancillary building support may be used. However, foundations in some locations might require anchoring into bedrock, depending on location. Medium-dense or very stiff soil or bedrock, which is found within the Facility Site, is a suitable bearing surface for the bottom of foundations. GZA recommends constructing foundations at least 4.5-feet below existing and final ground surface to prevent soil heave due to frost action or anchored into bedrock. For footings supported on soil, continuous wall footings should be at least 24-inches wide and isolated footings at least 48-inches wide.

(2) Pile Driving Assessment

The Applicant has concluded that pile driving is not needed for the Facility. Therefore, further assessment was not conducted.

(3) Mitigation Measures for Pile Driving Impacts

The Applicant has concluded that pile driving is not needed for the Facility. Therefore, mitigation measures related to pile driving are not necessary.

(s) Vulnerability to Earthquake and Tsunami Events

The Facility appears to have minimal vulnerability associated with seismic events based on review of publicly available data. In addition, because the Facility is located approximately eight miles from the nearest large water body (Lake Erie), there is no vulnerability associated with tsunami events. Therefore, further analysis was not conducted.

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