New York State Great Lakes Wind Energy Feasibility Study: Visual Impacts

Final Report | Report Number 22-12j | December 2022

NEW YORK STATE | NYSERDA

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New York State Great Lakes Wind Energy Feasibility Study: Visual Impacts

Final Report

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Abstract

The Great Lakes Wind Feasibility Study investigates the feasibility of adding wind generated renewable energy projects to the New York State waters of Lake Erie and Lake Ontario. The study examines myriad issues, including environmental, maritime, economic, and social implications of wind energy areas in these bodies of freshwater and the potential contributions of these projects to the State's renewable energy portfolio and decarbonization goals under the New York State Climate Act.

The study, which was prepared in response to the New York Public Service Commission Order Case 15-E-0302, presents research conducted over an 18-month period. Twelve technical reports were produced in describing the key investigations while the overall feasibility study presents a summary and synthesis of all twelve relevant topics. This technical report offers the data modeling and scientific research collected to support and ascertain Great Lakes Wind feasibility to New York State.

To further inform the study in 2021, NYSERDA conducted four public webinars and a dedicated public feedback session via webinar, to collect verbal and written comments. Continuous communication with stakeholders was available through greatlakeswind@nyserda.ny.gov NYSERDA's dedicated study email address. Additionally, NYSERDA and circulated print advertisements in the counties adjacent to both Lake Erie and Lake Ontario as to collect and incorporate stakeholder input to the various topics covered by the feasibility study.

Keywords

Great Lakes Wind Energy, Lake Erie, Lake Ontario, visual impacts

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Acronyms and Abbreviations

BOEM	Bureau of Ocean Energy Management
DEM	Digital Elevation Model
DSM	Digital Surface Model
EA	environmental assessment
EDR	Environmental Design & Research
EIS	Environmental Impact Statement
EPSG	European Petroleum Survey Group
ESRI	Environmental Systems Research Institute
Ft	feet
GE	General Electric
GIS	Geographic Information System
IEMA	Institute of Environmental Management & Assessment
IGLD 85	International Great Lakes Datum of 1985
km	kilometers
KOP	key observation point
LI	Landscape Institute
LiDAR	light detection and ranging
LWD	low water datum
m	meters
mi	miles
MRLC	multi-resolution land characteristics
NAD 83	North American Datum of 1983
NAVD 88	North American Vertical Datum of 1988
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
NREL	National Renewable Energy Laboratory
NRHP	National Register of Historic Places
NYSERDA	New York State Energy Research and Development Authority
OCS	Outer Continental Shelf
SHPO	State Historic Preservation Office
Sq km	square kilometer
Sq mi	square mile
VIA	Visual Impact Assessment
ZTV	Zone of Theoretical Visibility

Executive Summary

This Visual Impact Study, hereafter referred as the "study," supports the New York State Energy Research and Development Authority's (NYSERDA) New York State Great Lakes Wind Energy Feasibility Study. First, the study describes the standard procedure for conducting a visual impact assessment and how viewshed analyses would be used to help define the geographic extents of such assessments in the Great Lakes. Second, the study describes the significant factors that affect viewshed calculations and limitations, and what it means for assessments of visual impact for wind energy in the Great Lakes. Third, the study presents high-level viewshed analyses for select hypothetical turbine locations to provide a general sense of theoretical visibility in the region.

The study focuses on New York State waters of Lake Ontario and Lake Erie. It is recognized that potential future offshore wind developments in NYS waters in these lakes may introduce visual impacts to Canada and neighboring states which should be evaluated and addressed as part of any proposed development plan.

At this time, no formal sites within Lake Erie or Lake Ontario have been selected for specific consideration for offshore wind development as part of the New York State Great Lakes Wind Energy Feasibility Study. No specific turbine design, foundation technology option, or wind farm layout has been officially designated for use in NYS waters of the Great Lakes. Without specific details of a preferred site, turbine design, and wind farm layout plan, most of the traditional steps in conducting a visual impact assessment cannot be addressed at this time. As a result, this study was constrained to evaluate the potential geographic extents of visibility associated with offshore wind development in the lakes.

The study uses generic model parameters and six hypothetical single-turbine locations in order to conduct a viewshed analysis and establish a high-level understanding of theoretical visibility across the lakes and nearshore areas. The study used a 10 mile (mi; 16 kilometer [km]) minimum distance to shore to site hypothetical turbines in Lake Ontario; a precedent based on typical offshore wind siting in the Atlantic Ocean. Substantial lake area exists farther out in Lake Ontario for possible development, suggesting proposed developments could be farther from the lakeshore than modeled herein. In the narrow, east end of Lake Erie, a distance of 5 mi (8 km) from shore was applied when siting the modeled hypothetical turbines for this study. These distances (10 mi [16 km] and 5 mi [8 km], respectively) do not represent any decision by New York State regarding placement of wind turbines should Great Lakes Wind development move forward in the future.

The viewsheds are calculated for a single turbine at various representative locations across the lakes, not an entire wind generation facility. The results demonstrate how local terrain and distance from shore can affect potential visibility inland. The study shows that the modeled distances are not large enough to eliminate the turbines from the shoreline views, although the curvature of the Earth does begin to reduce visibility at those distances.

There are limitations, caveats, and assumptions inherent in this high-level study. Turbine locations, fundamental geometric sensitivities of the viewshed model, definition of viewshed scenarios, extent of the viewshed model, elevation and screening sensitivities, and other visibility factors are among some of the key considerations that will impact the results of any viewshed calculation. Because of the uncertainties at this early phase associated with the location of any specific wind generation facility, turbine model, and elements such as the number of turbines and their layout, this high-level assessment does not evaluate multiple height viewshed scenarios, establish key observation points, analyze full windfarm visibility, or involve preparation of visual simulations. This study also does not address radar and aviation interference.

1 Introduction

The Viewshed Analysis supports the New York State Energy Research and Development Authority's (NYSERDA) New York State Great Lakes Wind Energy Feasibility Study and provides a preliminary review of visual impact for the region. This analysis focuses on New York State waters of Lake Ontario and Lake Erie, along with portions inland that fall within the interpreted zone of theoretical visibility (ZTV). Because no Great Lakes Wind project has been designed or developed to date, this study is constrained to evaluate the potential geographic extents of visibility associated with potential offshore wind development in the lakes. The potential visibility described within this document is entirely theoretical, using a baseline wind turbine design at selected hypothetical sites, publicly available regional elevation and land cover data sets, and Geographic Information System (GIS)-based line-of-sight geometric analyses.

The purpose of this document is to provide NYSERDA and the public with a high-level assessment of potential visibility associated with a standard turbine as a gauge for evaluating potential visual impact, should New York State decide to pursue offshore wind generation developments. Parameters used for the viewshed analysis were provided by NYSERDA and the National Renewable Energy Laboratory (NREL), based on early findings of the feasibility study. Zones of visibility for the nominal size and height of baseline turbines are established for hypothetical sites, to evaluate the visibility of such structures from lakeshore communities. Potential visibility maps, a discussion of sensitive visual areas along the coastline, and a high-level assessment of visibility risks are presented herein. Considerations for siting wind turbines for potential future development in consideration of potential impacts, distance from shore, and other parameters are also discussed. The viewshed characteristics and potential impacts described herein will be considered by the NYS in determining the feasibility of development of Great Lakes Wind energy in NYS waters.

2 Visual Impact Assessments and Viewshed Analyses

A visual impact assessment, or VIA, is an evaluation of a proposed project and the potential impacts it may have on the visual contrast, perceived aesthetics, and viewer experience in the areas surrounding the project site. A VIA begins with identifying the areas that may have visibility of the project and then proceeds to evaluate how the landscape will change due to the project, who (in a general sense) the potential observers at various selected key observation points (KOP) might be, what activities they typically engage in at the site where visibility may be possible, what value do those individuals place on the view, and what perception do they have of offshore wind projects. The combined information is then translated into an assessment of potential impacts.

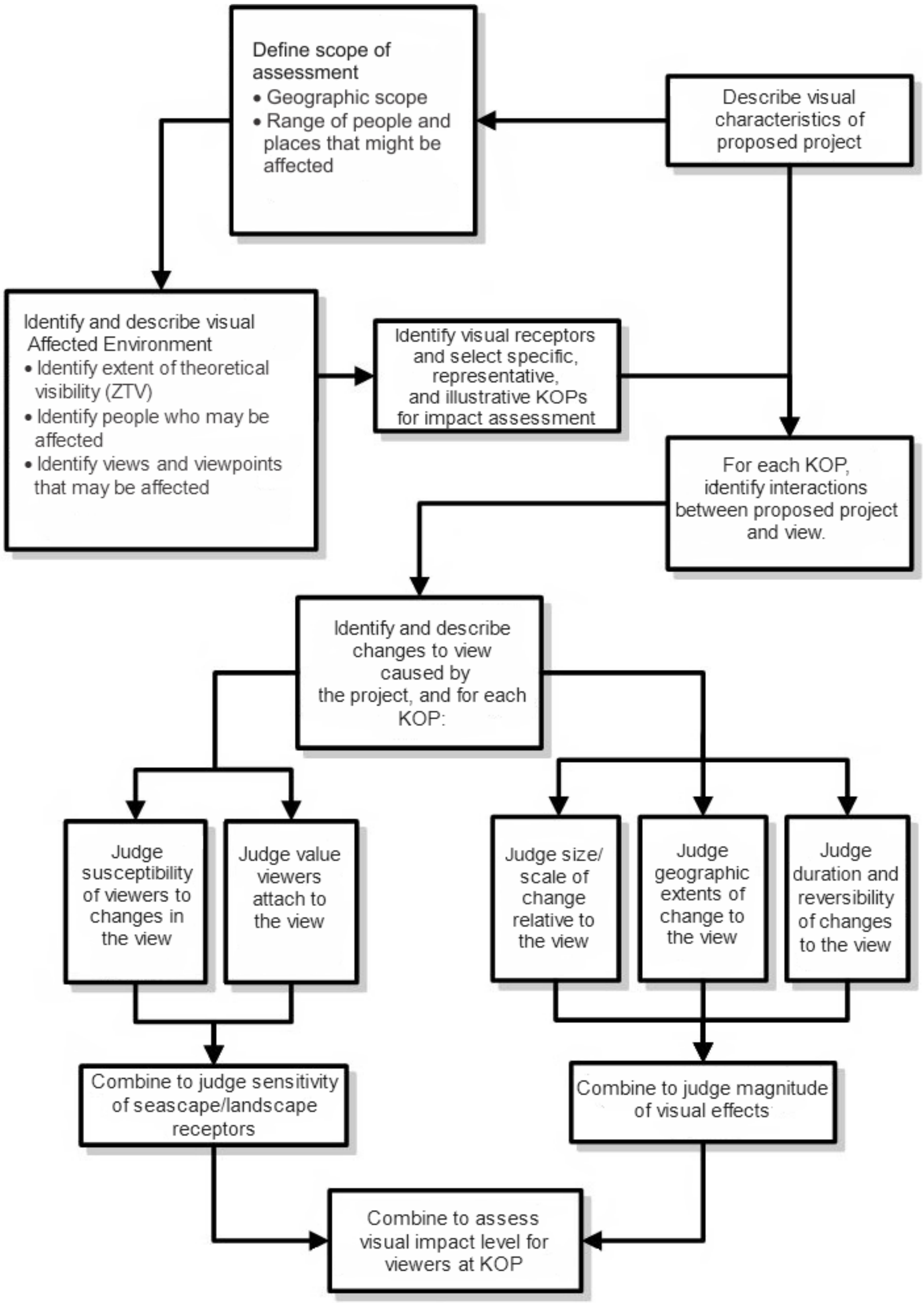
2.1 Introduction of Visual Impact Assessments

The focus of an offshore wind VIA is ultimately to evaluate the potential impacts the proposed structures may have on people who may see the structures from various observation points. The VIA is intended to capture the magnitude of proposed changes to the views (for Great Lakes Wind Energy, that means the views of Lake Erie and Lake Ontario) and the public's perception of those changes. Understanding how a proposed project is expected to change the visual landscape and public perception are key to navigating the permitting requirements and potential challenges that may arise during a project's lifecycle.

An example of the general process for these types of offshore wind VIA studies is shown in Figure 1 (R. G. Sullivan 2021). Additional methodologies for conducting VIAs and related considerations are described by (Sullivan and Meyer 2014) for the National Park Service, the Bureau of Land Management (1986), and the U.S. Forest Service (1995), among others.

Figure 1. Process for Visual Impact Assessments

Source: (R. G. Sullivan 2021) after (Landscape Institute (LI) and Institute of Environmental Management & Assessment (IEMA) 2013).



At this time, no formal sites within Lake Erie or Lake Ontario have been selected for consideration of offshore wind development as part of the New York State Great Lakes Wind Energy Feasibility Study. No specific turbine design, foundation technology option, or wind farm layout has been officially designated for use in NYS waters of the Great Lakes. Without specific details of a preferred site, turbine design, and wind farm layout plan, most of the VIA steps cannot be completely addressed at this time. One of the first steps in conducting a VIA is to identify the geographic scope that the assessment will cover. This is initially defined as a radius of investigation surrounding the project site. For offshore wind generation facilities, the industry standard is to consider an extent that is appropriately scaled to the size of the turbines. Once a radius of investigation and the necessary parameters of the turbine are defined, a viewshed can be generated using available elevation data and standard GIS-based, line-of-sight geometric calculations.

2.2 Viewshed Methodology

A viewshed is a region that encompasses points with direct line-of-sight to the site of interest and differentiates regions that are hidden from view. For the purposes of this assessment, the focus will be on the portion of the viewshed that is expected to have visibility with the site of interest, also referred to as the ZTV (Figure 1). Viewshed analyses identify the geographic areas that may or may not have visibility with the proposed project. For wind projects specifically, a viewshed analysis can provide enhanced clarity regarding the range of numbers of turbines potentially visible from particular areas, as well as the extent of visibility of portions of turbines. Key parameters, such as modeled geometric and atmospheric conditions will influence what features might be included in the visible portion of a viewshed. Intervening terrain, surficial screening elements/obstructions, and the natural curvature of the earth reduce the calculated visible area of the viewshed by blocking lines-of-sight. Mutual visibility, or intervisibility, is assumed between the project site and observation points connected by line-of-sight.

In this assessment, the viewsheds are calculated using standard GIS functionality in Environmental Systems Research Institute (ESRI), Inc.'s ArcGIS Desktop, version 10.7, with the Spatial Analyst Tools extension (ESRI, Inc. 2018). A set of hypothetical sites, each representing the location of a single turbine, are selected, along with various geometric assumptions. Viewsheds for each hypothetical site are generated as an example of the visibility that might be expected from a single turbine. Should offshore wind development proceed in the lakes, a detailed viewshed analysis would take into consideration the composite viewsheds for the entire wind generation facility. There are limitations, caveats, and assumptions inherent in this high-level study, several of which are discussed further in section 3 of this study.

2.3 Input Data

Calculating a viewshed involves geometry and requires input parameters including elevation data, modeled baseline turbine height, and viewer height. Details of the assumptions made for this study are described in the sections that follow.

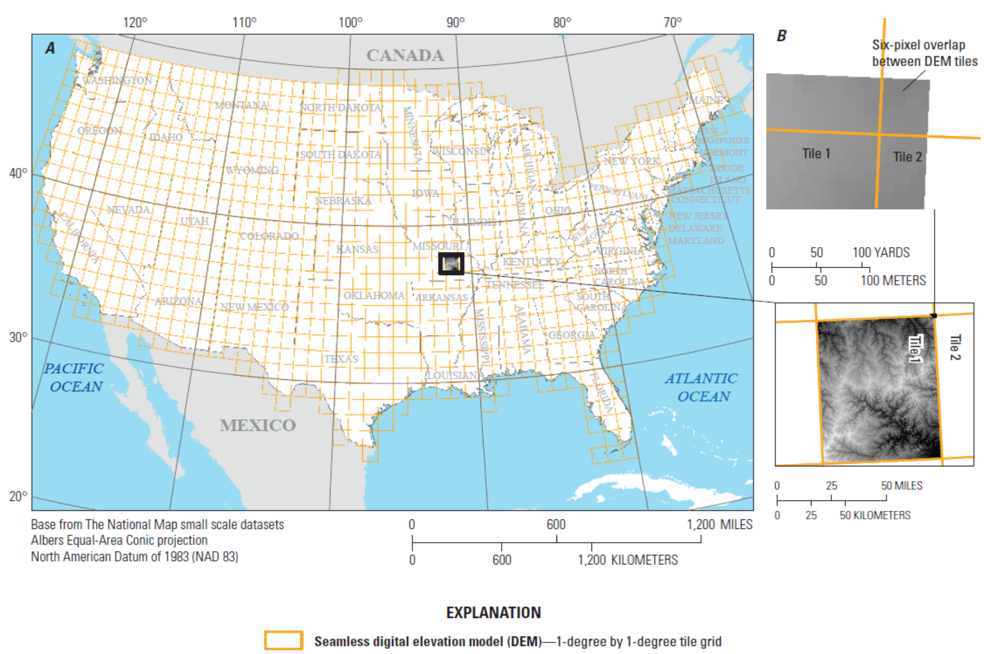
2.3.1 Elevation Model

The elevation data referenced in this preliminary assessment are derived from the National Map seamless digital elevation model (DEM) data set, made available by the U.S. Geological Survey (Archuleta, et al. 2017).

These high-quality elevation data sets are part of the 3-Dimensional Elevation Program and are arranged as tiled raster data. Each tile provides coverage that is 1-degree by 1-degree (Figure 2). The elevations represent bare earth topography compiled from various sources and processed according to established data quality and consistency standards. The data set does not include any elevation information associated with surficial features such as buildings or vegetation, as might be captured in a surface model.

Figure 2. Available Coverage of the National Map Seamless Digital Elevation Model for the Continental United States

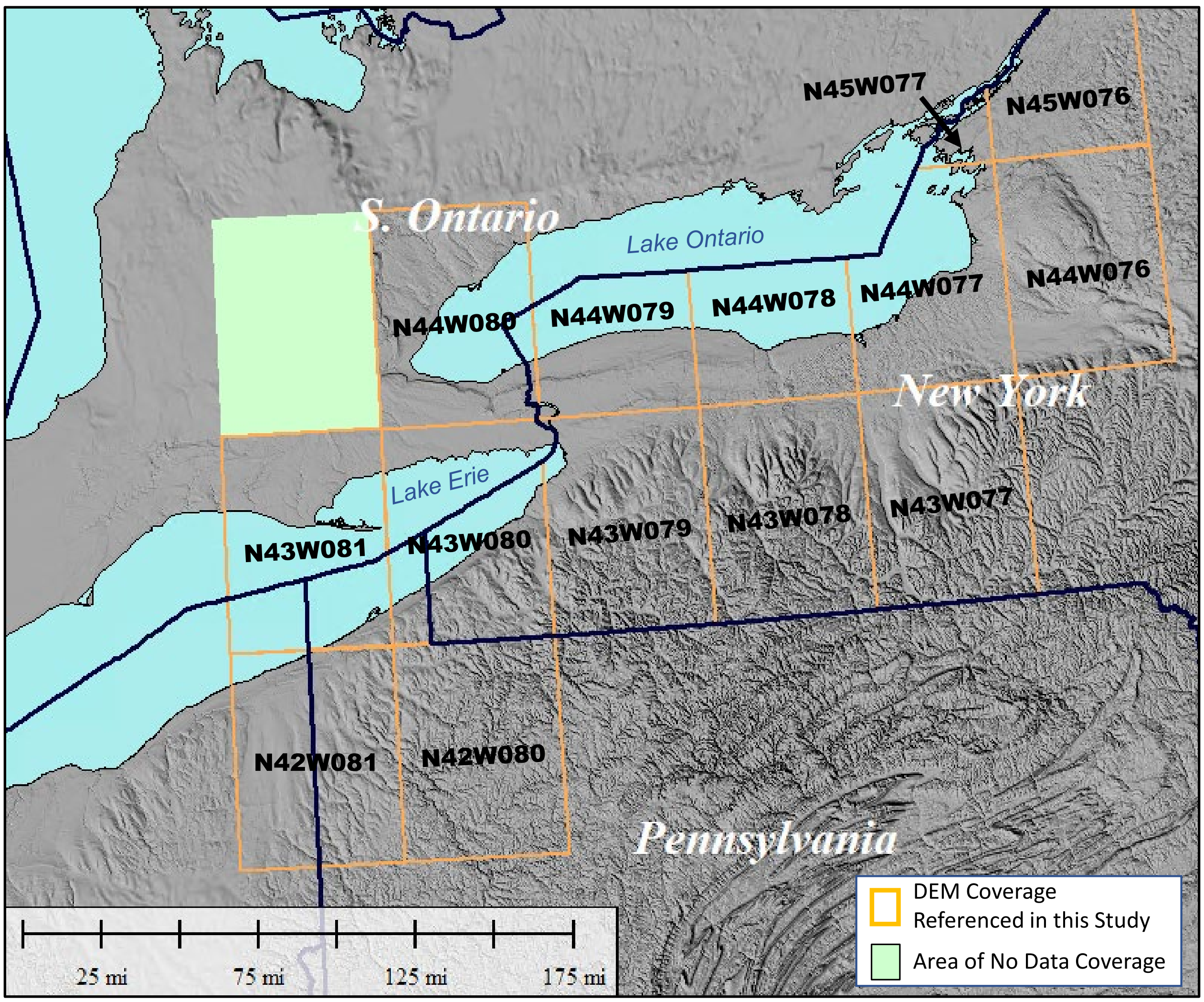
Source: (Archuleta, et al. 2017).



The relevant tiles considered for the analyses herein focus on New York State and the surrounding landscape of Lake Erie and Lake Ontario, as illustrated in fFigure 3. Horizontal resolution of the referenced data sets is about ~32.8 feet (ft; 10 meters [m]). It is recognized that potential future offshore wind developments in the State's portion of the lakes may introduce visual impacts to Canada and neighboring states which may require additional evaluation as part of any proposed development plan.

Figure 3. Relevant Elevation Data and Three-Dimensional Elevation Program Tiles Referenced in this Study

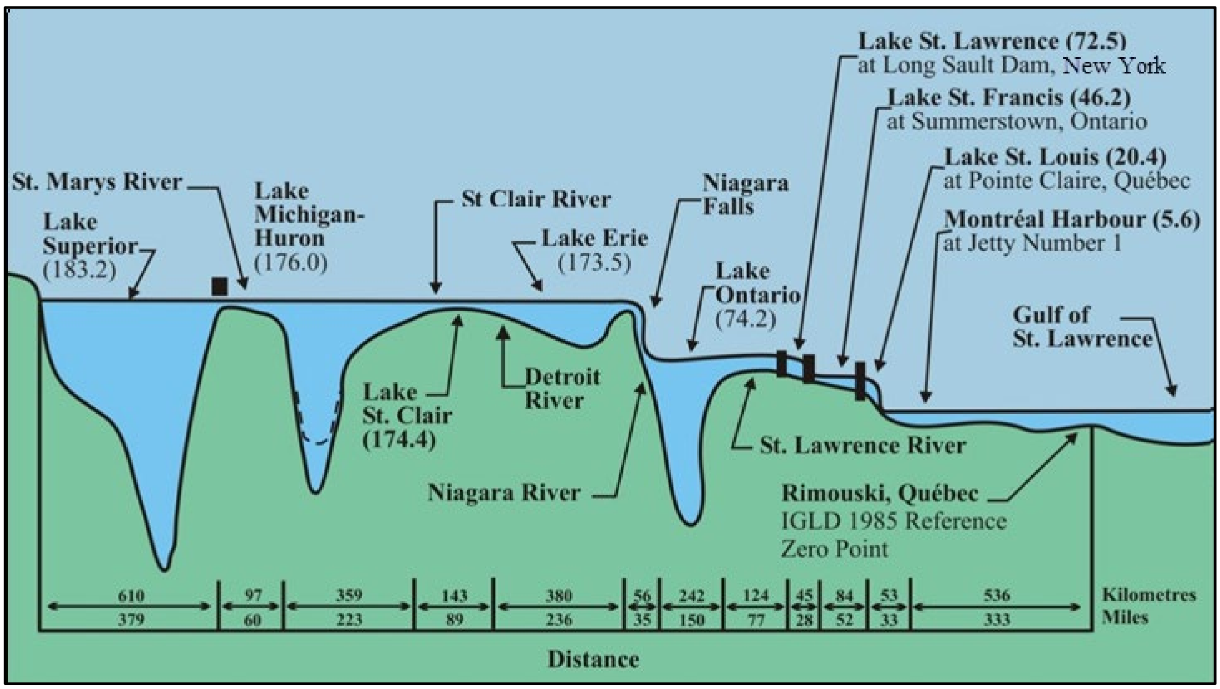
Source: (Archuleta, et al. 2017)



Elevation values in the National Map are referenced to North American Vertical Datum of 1988 (NAVD 88). Water levels within the Lake are referenced to Low Water Datum (LWD), which is unique to each lake and derived from the International Great Lakes Datum of 1985 (IGLD 85). Figure 4 provides a general schematic of the water levels (LWD, in m) across the Great Lakes—St. Lawrence River System (NOAA 2021).

Figure 4. Schematic Illustration of Water Levels (Low Water Datum in meters) Across the Great Lakes/St. Lawrence River System

Source: (NOAA 2021).



According to (Zilkoski, Richards and Young 1992), NAVD 88 and the IGLD 85 datums are equivalent. However, review of the tiled elevation data set found that the National Map includes elevation values within the Lakes that approximate, but do not explicitly match, the established LWD reference values for each Lake. NOAA indicates a LWD level at Lake Erie of ~569.2 ft (173.5 m), while the National Map data approximates Lake Erie's surface to be about ~570.5 ft (173.9 m). Similarly, NOAA indicates a LWD level at Lake Ontario of ~243.4 ft (74.2 m), and the National Map data approximates Lake Ontario's surface to be about ~245.4 ft (74.8 m) (NOAA 2021) and (Archuleta, et al. 2017).

Viewshed analyses are sensitive to geometric parameters including elevations. Therefore, it is imperative to reference a common datum across all elevation data sets and ensure full documentation of the referenced standard. This high-level assessment utilized the National Map elevation data as is, without any further calibration or integration with other elevation data sets. As such, there may be differences in the viewshed results if modeled water levels in the Lakes were to be adjusted.

2.3.2 Baseline Turbine Model

Based on guidance from NREL, this preliminary assessment assumes the baseline turbine model to be a General Electric Renewable Energy (GE) Cypress wind turbine, model 6.0-164. GE's specifications for the Cypress 6.0-164 turbine model, according to their product website, are as noted in Figure 5. Maximum height (including blade tip) of the baseline turbine is ~636 ft (194 m). While the Cypress model is not specifically designed for offshore applications at this time, the height is considered to be a reasonable approximation of turbines that may be considered for Great Lakes Wind energy development. More discussion on turbine design considerations is presented in the New York State Great Lakes Wind Energy Feasibility Study: Substructure report (NYSERDA 22-12e).

Figure 5. Photo of a Prototype GE Cypress Wind Turbine and Specifications for the Model 6.0-164

Source: (GE Renewable Energy 2021).

GE Cypress 6.0-164 Wind Turbine

- Output: 6.0 MW
- Rotor Diameter: 164 m (~538 ft)
- Hub Height: 112 m (~367.5 ft)
- Frequency: 50 / 60 Hz
- Cut-in: 3 m/s
- IEC Wind Class: S

Hub height, representing the full height of the tower from the waterline to the nacelle, is the most important turbine metric for this assessment, as it is the modeled height selected for use in the viewshed analyses. The hub height is commonly modeled in VIAs for wind turbines as a proxy for assessing night visibility because aviation obstruction lighting is typically placed at that approximate level.

Given the uncertainties in possible project placement, turbine model, and facility layout in this early stage of consideration, this high-level assessment does not evaluate multiple height viewshed scenarios. The selection of the modeled height for this study was based on guidance received from NREL. It is recommended that any proposed development plan within the lakes include a detailed analysis considering viewsheds of variable heights associated with blade tip (top), hub, and blade tip (bottom).

2.3.3 Viewer Height

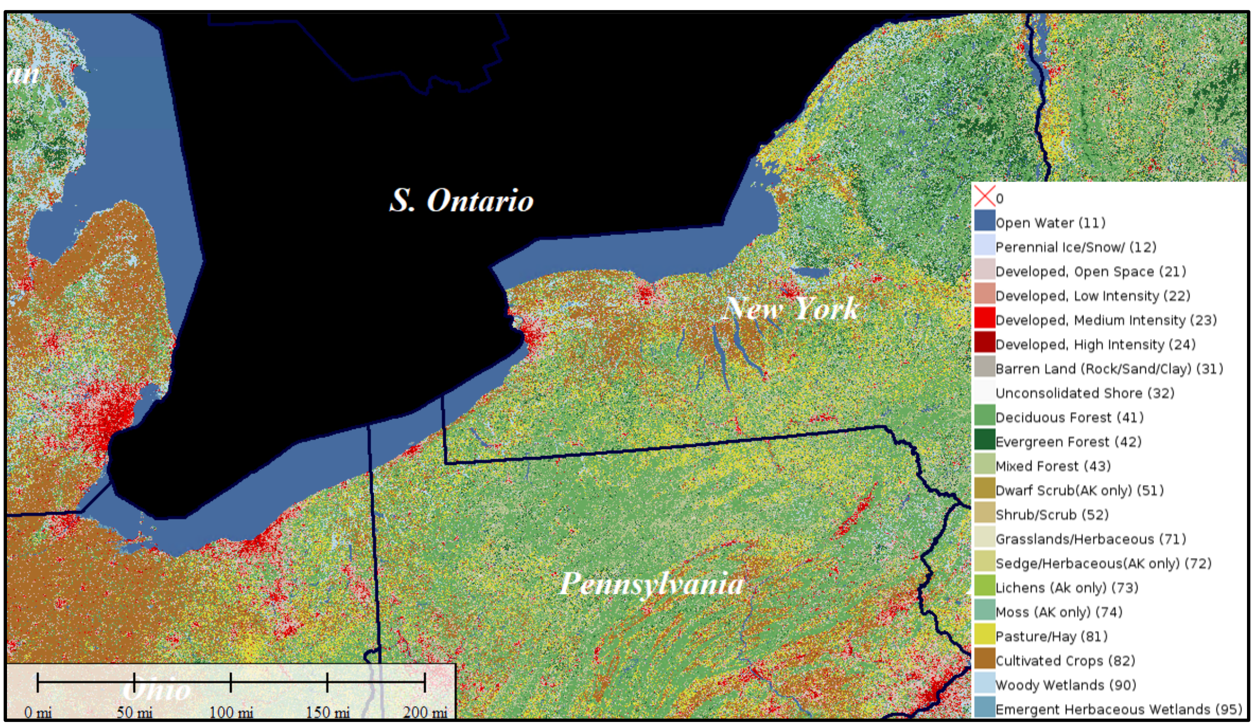
Viewer height is assumed in this study to be 6 ft (1.8288 m). The viewer height is added to the DEM elevations on a per-cell basis in the viewshed calculations so that the viewshed appropriately represents the eye-level view of a standing observer, as opposed to a view from the ground.

2.3.4 Land Cover Data

For this high-level assessment, land cover data is reviewed as a means to gain insight into potential visual impacts and possible screening elements that might be encountered in that region. Land cover information referenced in this assessment is derived from the 2019 data set provided in the National Land Cover Database (NLCD) (Yang, et al. 2018). The database is hosted by the Multi-Resolution Land Characteristics Consortium (MRLC) and is derived from "Landsat Satellite Imagery and Other Supplementary Datasets" with coverage over the entire continental United States (MRLC 2021a). An overview of the NLCD 2019 data in the vicinity of New York State, Lake Erie, and Lake Ontario is illustrated in Figure 6.

Figure 6. National Land Cover Database 2019 Data in the Vicinity of New York, Lake Erie, and Lake Ontario

Source: (MRLC 2021a)



The NLCD 2019 data are a raster data set with 30 m by 30 m pixels. There are 20 formal class codes defined for land cover types, as described in Table 1, although four of the classes are applicable only to Alaska and not relevant for this study. Not listed in Table 1 or counted as a formal class, is Class 0, which is shown in the raster data as the color black and represents unclassified areas within the coverage. Areas noted as unclassified in this study are exclusive to regions beyond the international border that are part of Canada.

Table 1. National Land Cover Database 2019 Legend and Classification Descriptions

Source: (MRLC 2021a).

Class \ Value	Classification Description
Water	
11	Open Water – areas of open water, generally with less than 25% cover of vegetation or soil.
12	Perennial Ice/Snow – areas characterized by a perennial cover of ice and/or snow, generally greater than 25% of total cover.
Developed	
21	Developed, Open Space – areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
22	Developed, Low-Intensity – areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% percent of total cover. These areas most commonly include single-family housing units.
23	Developed, Medium Intensity – areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50% to 79% of the total cover. These areas most commonly include single-family housing units.
24	Developed High Intensity – highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80% to 100% of the total cover.
Barren	
31	Barren Land (Rock/Sand/Clay) – areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.
Forest	
41	Deciduous Forest – areas dominated by trees generally greater than 5 m tall, and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change.
42	Evergreen Forest – areas dominated by trees generally greater than 5 m tall, and greater than 20% of total vegetation cover. More than 75% of the tree species maintain their leaves all year. Canopy is never without green foliage.
43	Mixed Forest – areas dominated by trees generally greater than 5 m tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% of total tree cover.

Table 1 continued

Class \ Value	Classification Description
Shrubland	
51	Dwarf Scrub – Alaska only areas dominated by shrubs less than 20 centimeters tall with shrub canopy typically greater than 20% of total vegetation. This type is often co-associated with grasses, sedges, herbs, and non-vascular vegetation.
52	Shrub/Scrub – areas dominated by shrubs; less than 5 m tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.
Herbaceous	
71	Grassland/Herbaceous – areas dominated by gramanoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling but can be utilized for grazing.
72	Sedge/Herbaceous – Alaska only areas dominated by sedges and forbs, generally greater than 80% of total vegetation. This type can occur with significant other grasses or other grass like plants, and includes sedge tundra, and sedge tussock tundra.
73	Lichens – Alaska only areas dominated by fruticose or foliose lichens generally greater than 80% of total vegetation.
74	Moss – Alaska only areas dominated by mosses, generally greater than 80% of total vegetation.
Planted/Cultivated	
81	Pasture/Hay – areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation.
82	Cultivated Crops – areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled.
Wetlands	
90	Woody Wetlands – areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
95	Emergent Herbaceous Wetlands – Areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

* Row colors correspond to the legend in Figure 6.

The NLCD 2019 data do not have elevation parameters associated with them, and as such are not a direct input for calculating the viewsheds in this study. For this high-level assessment, referencing the NLCD 2019 data allows for a qualitative classification of the identified visible areas within the viewsheds as a means to gain insight into potential visual impacts and possible screening elements that might be encountered in that region.

Visual impacts depend on a multitude of considerations including number of viewers, activities the viewers may be involved in, and concerns they may have about the view. Important qualitative insights can be derived from the land cover classifications. For instance, visible areas of the viewshed that are classified as one of the four "Developed" types will likely have potential for increased exposure to viewers because those regions represent areas where most people reside and work. Higher concentrations of people in those regions suggest a potential increase in visual impacts, although the magnitude of impact could vary based on other considerations, including viewer sensitivity.

While the population numbers may be greater in the "Developed" areas, those regions are likely to have buildings and surface structures not captured in the bare earth DEM that may serve as obstructions to the view of proposed structures. When a viewshed incorporates the surface model elements, these regions would be expected to show a decrease in visibility due to the inherent screening effects of obstructions. Similar assumptions can be made regarding the elevated screening potential for forests or limited screening potential for areas of barren land, pastures, or grasslands, for example.

If projects are proposed for development in New York State waters of the Great Lakes understanding the nuances of the viewshed model and the data available to inform the nature of potential visual impacts will be important for setting up appropriately detailed VIAs and interpreting the results. Land cover data can provide some qualitative insights. More discussion about screening sensitivities and land cover versus land use is presented in section 3 of this study.

2.3.5 Additional Modeling Parameters

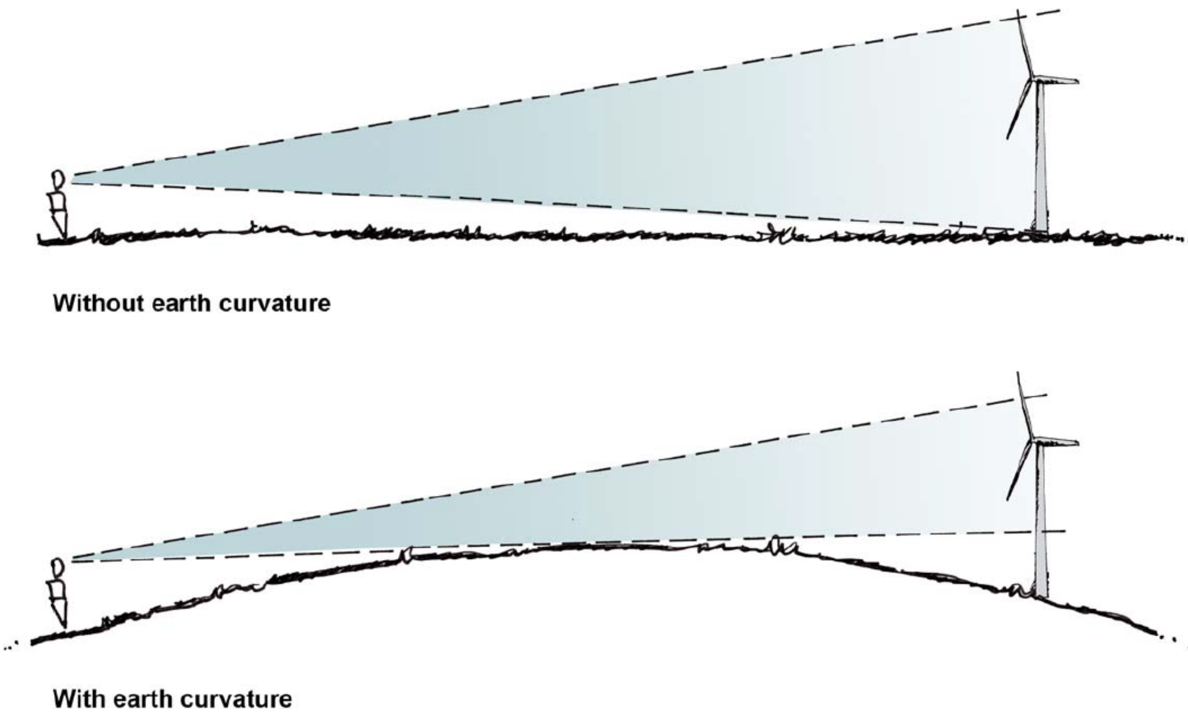
Standard viewshed calculations include a few additional modelling parameters, including assumptions for the Earth's curvature, defined geographic limits for the assessment, and a parameter to address refraction of light in the atmosphere.

2.3.5.1 Curvature of the Earth

When calculating viewsheds over long distances, the curvature of the Earth may have a notable impact on the extents of identified visible areas. The Earth's curvature affects the geometry of the view such that objects may be partially or completely obstructed by the horizon (Sullivan and Meyer 2014). Viewsheds that ignore the Earth's curvature will consider line-of-sight views to be more extensive than would actually be realistic. An example illustration of this concept is presented in Figure 7. Settings for addressing the Earth's curvature are standard in ArcMap and were incorporated into the assessment conducted herein.

Figure 7. Example Long-Distance View (not to scale) with and without Considering Earth's Curvature

Source: (Sullivan and Meyer 2014), Credit: Argonne National Laboratory.



2.3.5.2 Atmospheric Refraction

Atmospheric conditions that affect air density can cause light to refract, or bend, as it passes through the atmosphere. Temperature, humidity, pressure, and altitude can play a role in how light will behave. The behavior of light is dynamic at any one location, as the atmospheric conditions change continuously. Under certain conditions, atmospheric refraction can cause objects to be visible when they might normally be obstructed beyond the horizon. Viewshed calculations can compensate for this phenomenon by applying a refraction correction.

ArcMap's default correction for atmospheric refraction sets the "refractivity coefficient of light" at 0.13, which "is considered appropriate under standard atmospheric pressure for daytime conditions with a clear sky" (ESRI, Inc. 2019). This standard correction is often used in viewshed analyses, including this study, unless a site-specific correction is derived from local atmospheric details.

2.3.5.3 Geographic Limits of the Viewshed

Once a baseline turbine model was identified, the following visibility equation (Equation 1) was utilized to calculate the maximum theoretical distance that the turbine would be visible based on the assumed observer height.

Equation 1.

$$\boldsymbol{D_v = \sqrt{2R_0h_t} + \sqrt{2R_0h_r}}$$

Where
D_v = Visibility distance, in km
R_0 = Radius of the Earth (assumed to be the mean radius of 3958.761 mi (6,371.009 km), for simplicity)
h_t = Modeled turbine height, converted to km
h_r = Observer height, converted to km

This equation provides the theoretical distance, 26.48 mi (42.6 km), at which an observer with a height of 6 ft (1.8288 m) could potentially view the hub of the GE Cypress 6.0-164 wind turbine at ~367.5 ft (112 m) above the lake level, on a hypothetical, flat landscape without any intervening topography.

This value was established as the limit of the viewshed analyses, or the maximum radius of the viewshed calculation. Based on a radius of 26.48 mi (42.6 km), the total area of the viewshed in this study is about ~2,201 square mi (5,701 square km). Discussion in section 4 will reference results of the viewshed calculations relative to the percentage of the total viewshed area, as well as relative to the portion that is identified as being in the ZTV.

It should be noted there are several methods for considering the geographic extents that constrain the viewshed calculation, although there is no prescribed "one-size-fits-all" solution. Further discussion on defining the geographic limits of the viewshed is presented in section 3.4 of this study.

2.4 Hypothetical Sites

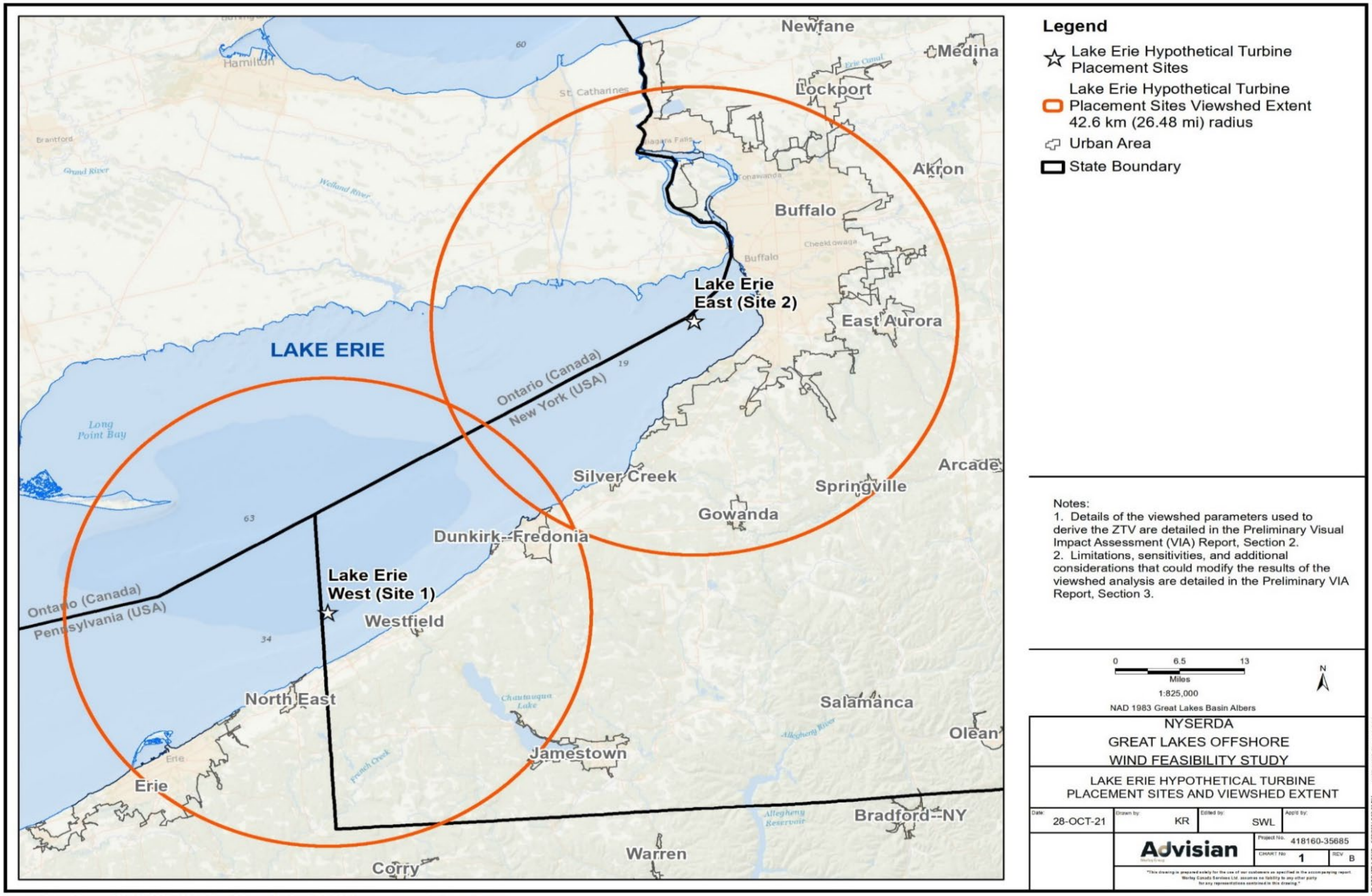
In the case of Great Lakes Wind, a specific site for development of an offshore wind farm within the lakes is not under consideration. Evaluating every possible site within the lakes for potential visibility is impractical. Instead, the assessment herein focuses on the characteristics of six selected hypothetical sites for turbine placement for which viewsheds are calculated, to provide a general sense of the potential visibility of a turbine within its surrounding environment. The sites were chosen by the study authors and agreed to by NREL and NYSERDA. Proposed development projects would need to accommodate for the visibility of the full wind generation facility, and the composite visual effects of multiple turbines.

There is no established regulatory requirement for offshore wind turbines' minimum distance from shore for Atlantic Ocean sites, but existing ocean sites tend to be at least 10 mi (16 km) from shore. Based on guidance from NREL and NYSERDA this 10-mi minimum distance to shore was used as a precedent to model theoretical visibility in Lake Ontario, where substantial lake area for possible development still exists farther out. In the narrow, east end of Lake Erie, the same 10-mi minimum distance would eliminate most of the lake area on the New York State side. Therefore, a closer minimum reference distance was required. For the purposes of this analysis, a distance of 5 mi (8 km) from shore in Lake Erie was used. These minimum distances from shore were used as references to illustrate possible impacts but do not represent any decision by New York State regarding placement of wind turbines should Great Lakes Wind energy development move forward in the future.

2.4.1 Lake Erie

There are two hypothetical sites for turbine placement selected in Lake Erie for which viewsheds are calculated and reviewed as part of this assessment. As previously stated, hypothetical turbine placement within Lake Erie is about 5 mi (8 km) or more from shore. A minimum half-mile standoff from State and international borders is maintained to ensure any modeled hypothetical turbine is definitively within New York State waters. The two sites represent a hypothetical western-most and eastern-most likely turbine placements with the lakes. Coordinates for the hypothetical sites are presented in Table 2 and illustrated in Figure 8.

Figure 8. Lake Erie Hypothetical Turbine Placement Sites and Viewshed Extent



Imagery Source: Sources: Esri, GEBCO, NOAA, National Geographic, Garmin, HERE, Geonames.org, and other contributors
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors
FILE LOCATION: E:\GIS\Projects\418160-35685\01_MXD\Final_Maps\RevB\NYSERDA_Lake_Erie_Hypothetical_Turbine_Plaement_Sites_and_Viewshed_Extent.mxd

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Table 2. Lake Erie Hypothetical Turbine Placement Site Coordinates

	Projected Coordinates (Albers Conic, North American Datum of 1983 (NAD 83), m)		Geographic Coordinates	
Site ID	X	Y	Latitude	Longitude
Lake Erie West (Site 1)	1,387,438.99	653,693.04	42° 21' 14.91" N	79° 44' 58.97" W
Lake Erie East (Site 2)	1,446,714.59	706,721.54	42° 47' 47.86" N	78° 59' 16.78" W

Note: ESRI's ArcGIS Projection Details: NAD_1983_Great_Lakes_Basin_Albers (WKIS: 3174 Authority: EPSG [European Petroleum Survey Group]).

The western-most hypothetical site is referred to as Lake Erie West (site 1) and the eastern-most is referred to as Lake Erie East (site 2). Both are located the minimum distance from shore, 5 mi (8 km), representing a potentially greater visual impact than locations that may be selected farther from shore. Site 1 is approximately 0.67 mi (1.1 km) east of the Pennsylvania border and site 2 is approximately 0.79 mi (1.3 km) southeast of the international border with Canada.

The viewshed investigation area for Lake Erie West (site 1) is 59% open water and 41% land. Lake Erie East (site 2) has a comparatively less open water coverage, only 27%, with a larger land component (73%). Details of the total viewshed coverage area for the Lake Erie Hypothetical Turbine Placement Sites are provided in Table 3.

Table 3. Total Viewshed Coverage Metrics for Lake Erie Hypothetical Turbine Placement Sites

Site ID	Total Viewshed Coverage	Approx. Total Viewshed Areal Extent over Open Water	Approx. % of Total Viewshed Coverage over Open Water	Approx. Total Viewshed Areal Extent over Land	Approx. % of Total Viewshed Coverage over Land
Lake Erie West (Site 1)	2,201 sq mi (5,701 sq km)	1,298 sq mi (3,361 sq km)	59%	903 sq mi (2,340 sq km)	41%
Lake Erie East (Site 2)	2,201 sq mi (5,701 sq km)	585 sq mi (1,516 sq km)	27%	1,616 sq mi (4,185 sq km)	73%

Sq km= square kilometers; Sq mi = square miles

2.4.2 Lake Ontario

There are four hypothetical sites for turbine placement selected in Lake Ontario for which viewsheds were calculated and reviewed as part of this assessment. As previously stated, hypothetical turbine placement within Lake Ontario is about 10 mi (16 km) or more from shore. A minimum half-mile

standoff from State and international borders is maintained to ensure any modeled hypothetical turbine is definitively within New York State waters. Coordinates for the hypothetical sites are presented in Table 4 and illustrated in Figure 9.

Table 4. Lake Ontario Hypothetical Turbine Placement Site Coordinates

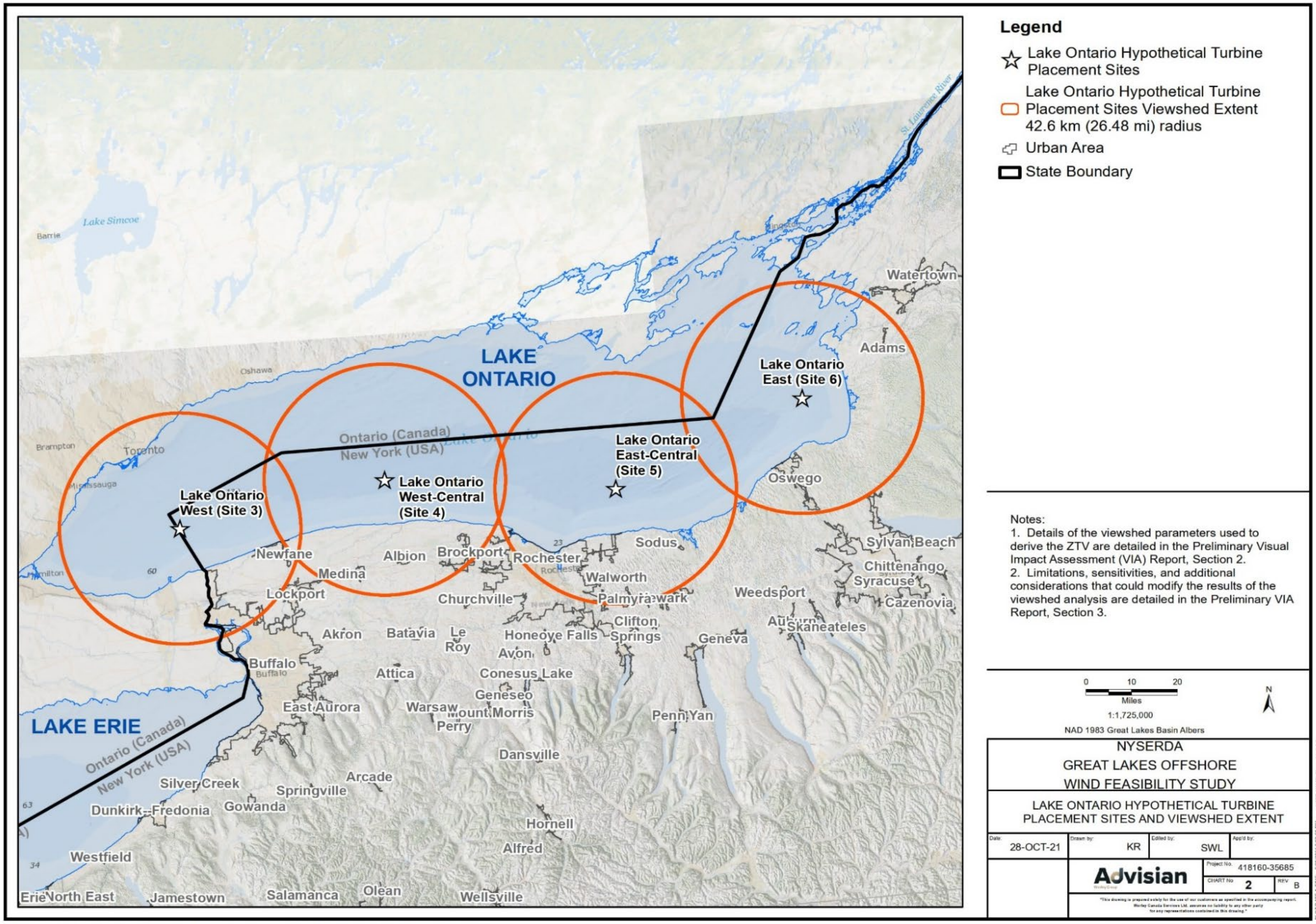
	Projected Coordinates (Albers Conic, NAD 83, m)		Geographic Coordinates	
Site ID	X	Y	Latitude	Longitude
Lake Ontario West (Site 3)	1,428,555.18	772,958.33	43° 24’ 07.00” N	79° 09’ 22.47” W
Lake Ontario West-Central (Site 4)	1,500,711.14	791,014.52	43° 31’ 02.94” N	78° 15’ 00.00” W
Lake Ontario East-Central (Site 5)	1,582,094.32	787,709.85	43° 25’ 36.83” N	77° 15’ 00.00” W
Lake Ontario East (Site 6)	1,647,849.70	821,182.55	43° 40’ 13.58” N	76° 23’ 59.06” W

Note: ESRI’s ArcGIS Projection Details: NAD_1983_Great_Lakes_Basin_Albers (WKIS: 3174 Authority: EPSG)

The westernmost hypothetical site is referred to as Lake Ontario West (site 3) and the easternmost is referred to as Lake Ontario East (site 6). Two additional sites were selected in the central portion of the lake, referred to as Lake Ontario West-Central (site 4) and Lake Ontario East-Central (site 5). All four hypothetical Lake Ontario sites are located the minimum distance from shore, 10 mi (16 km), representing a potentially greater visual impact than locations that may be selected father from shore. Hypothetical sites 3 and 6 are east of the international border with Canada, approximately 0.5 mi (0.8 km) and 15.9 mi (25.6 km), respectively. Hypothetical sites 4 and 5 are south of the international border with Canada, 7.9 mi (12.7 km) and 14.1 mi (22.7 km), respectively.

The viewshed investigation area for Lake Ontario West (site 3) is 67% open water and 33% land. Lake Ontario West-Central (site 4) is 75% open water and 25% land. Lake Ontario East-Central (site 5) is similar, with 74% open water and 26% land. Lake Ontario East (site 6) is 59% open water and 41% land. Details of the total viewshed coverage area for the Lake Ontario Hypothetical Turbine Placement Sites are provided in Table 5.

Figure 9. Lake Ontario Hypothetical Turbine Placement Sites and Viewshed Extent



Imagery Source: Sources: Esri, GEBCO, NOAA, National Geographic, Garmin, HERE, Geonames.org, and other contributors
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors
FILE LOCATION: E:\GIS\Projects\418160-35685\01_MXD\Final_Maps\RevB\NYSERDA_Lake_Ontario_Hypothetical_Turbine_Plaement_Sites_and_Viewshed_Extent.mxd

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Table 5. Total Viewshed Coverage Metrics for Lake Ontario Hypothetical Turbine Placement Sites

Site ID	Total Viewshed Coverage	Approx. Total Viewshed Areal Extent over Open Water	Approx. % of Total Viewshed Coverage over Open Water	Approx. Total Viewshed Areal Extent over Land	Approx. % of Total Viewshed Coverage over Land
Lake Ontario West (Site 3)	2,201 sq mi (5,701 sq km)	1,477 sq mi (3,826 sq km)	67%	724 sq mi (1,875 sq km)	33%
Lake Ontario West-Central (Site 4)	2,201 sq mi (5,701 sq km)	1,646 sq mi (4,263 sq km)	75%	555 sq mi (1,438 sq km)	25%
Lake Ontario East-Central (Site 5)	2,201 sq mi (5,701 sq km)	1,629 sq mi (4,219 sq km)	74%	572 sq mi (1,482 sq km)	26%
Lake Ontario East (Site 6)	2,201 sq mi (5,701 sq km)	1,303 sq mi (3,374 sq km)	59%	898 sq mi (2,327 sq km)	41%

Sq ki= square kilometers; sq mi = square miles.

3 Limitations of this Study

There are many variables involved with selecting sites and parameters for modeling visibility and assessing visual impact, some of which are not feasible to address without a development concept in mind, especially given the expanse of New York State waters in the Great Lakes. This section describes important sensitivities, limitations, and key considerations that will need to be revisited if/when a specific development concept is proposed.

3.1 Turbine Locations

Areas of avoidance for siting within the lakes related to existing infrastructure, geologic conditions, foundation suitability, environmental sensitivities, regulatory requirements, or other such constraints are not considered in the example placement of hypothetical turbine sites presented in this study. The viewshed analyses are examples only, not anticipated to offer a complete representation of potential visibility or fully quantify visual impact for any specific development concept. A more detailed VIA can be conducted to accommodate the appropriate site-specific considerations in the future.

The hypothetical turbine sites in this study are modeled as a single turbine, not considering the full array of turbines that is common for wind farms. When, or if, a specific project is considered, the individual and composite viewsheds for the full wind farm project can be part of a more detailed VIA.

3.2 Fundamental Geometric Sensitivities of the Viewshed Model

Viewsheds are based on geometric models that are sensitive to several parameters. Different turbine models, for instance, are likely to have different height characteristics from the baseline turbine presented in this study. Additionally, the visual impact associated with an entire windfarm is going to be different from the visual impact associated with a single turbine. Thus, viewshed analyses can be revisited if/when a formal project plan is developed for the Great Lakes. A representative turbine model and viewshed scenarios (see section 3.3) can be selected and the full-field layout option(s) can be considered for specific projects.

Similarly, individuals who are taller or shorter than the modeled viewer height would also experience differences in their views compared to what might be suggested from the modeled viewshed. While the current assessment considers an average height of 6 ft (1.8288 m), that assumption may be modified in the model if another height is found to be a more appropriate representation of the average observer heights in the affected area.

3.3 Viewshed Scenarios

Detailed VIAs typically model viewsheds for multiple turbine tower heights to capture a range of visibility scenarios. Upper blade tip height may be modeled to capture a viewshed that represents a turbine's full height and daytime visibility. Lower blade tip height may be modeled to compare with the modeled upper blade tip height in order to identify portions of the viewshed that may have visibility of a turbine's blade movement. The hub height, also referred to as the nacelle height, is commonly used as a proxy for night visibility due to the co-location of aviation obstruction lighting typically placed at that height. The base of the turbine and the height of substation structures may also be modeled to capture additional elements that would be visible, although they tend to have more localized viewsheds for impact consideration.

3.4 Extent of the Viewshed Model

The viewshed model in this study is constrained to a radius of ~26.5 mi (42.6 km) around the hypothetical turbine site (see section 2.3.5.3 for how that distance is derived). That value is based on a theoretical calculation of geometric target visibility, using the baseline turbine model, average observer height, and assuming a flat landscape and no intervening topography. It is possible that sufficiently elevated topography beyond the theoretical limit may provide additional unobstructed line-of-sight views that would be excluded in this assessment.

There are several methods for considering the geographic extents that constrain the viewshed calculation, although there is no prescribed "one-size-fits-all" solution. The Bureau of Ocean Energy Management (BOEM) guidelines for evaluating offshore wind projects on the Outer Continental Shelf (OCS) suggest it would be unnecessary to calculate a viewshed beyond ~46 mi (74 km), as the "facility would create only a negligible impact beyond that distance" (R. G. Sullivan 2021). Consideration of the geographic limits to bound the viewshed and impact assessment may be revisited if/when a formal development plan is proposed for Great Lakes Wind development.

3.5 Elevation and Screening Sensitivities

Preliminary viewsheds presented herein are based on 10 m grid spacing, bare-earth DEM. This results in a very preliminary "worst case" presentation of potential visibility. Higher resolution bare-earth data, such as Light Detection and Ranging (LiDAR) data, may further reduce the interpreted visible areas by resolving intervening features that are not captured in the coarser data sets. High resolution or not, bare-earth models typically overestimate the potential visibility because they do not consider the screening effects of buildings, trees, or other above-ground obstructions that exist and could block the view of the project site. Refining the elevation model and accommodating for above-ground screening elements are options that can be explored if/when a site is proposed for Great Lakes Wind development.

3.5.1 Digital Surface Models

More accurate and reduced viewshed areas are best modeled using what is referred to as a "digital surface model" (DSM) data set. LiDAR data can be processed to retain the elevation data of above-ground features and categorize them for further analysis. Typical above-ground features identifiable in LiDAR surface models include trees, shrubs, buildings, and roadways. The above-ground features can serve as obstructions to viewing, depending on their dimensions and position relative to the project site and potential observer.

If a LiDAR DSM is not available for a future site of interest, there are methods to simulate the surface features using vector land use and building details or by estimating surface feature elevations based on land cover classification. Use of a DSM data set, or simulated similar surface feature model, in the more detailed viewshed analysis could be applied to evaluation of proposed project sites.

3.5.2 Example of Icebreaker Wind Visual Impact Assessment

The Icebreaker Wind project provides an example of the differences in viewshed characteristics using a bare-earth model compared to the more detailed surface model. The Icebreaker Wind VIA, included as a study to inform the Environmental Assessment (EA), presented four viewshed scenarios referencing two different elevation data sets and two different turbine height considerations. One elevation data set was high-resolution LiDAR data that represented a bare earth model. The other elevation data set was high-resolution LiDAR data that represented a surface model incorporating "buildings, trees, and other objects large enough to be resolved by LiDAR technology" (Environmental Design & Research, Landscape Architecture, Engineering & Environmental Services, D.P.C. (EDR) 2017). Turbine height considerations included the height to blade tip and the height to the hub.

The viewshed (blade tip height) generated from the LiDAR bare earth elevation data, topography only, resulted in 86.5% of the landward study area predicted to have visibility of the proposed turbines. When including the screening effects of buildings and vegetation, the visible areas were drastically reduced to 5.9% of the landward study a. A similar trend was observed whether or not blade tip height or hub height was modeled.

Unfortunately, the LiDAR data sets are very large and attempting to investigate the entire NYS lakefront areas along both Lake Erie and Lake Ontario without guidance on a specific area of focus would not be efficient at this stage. Nonetheless, the nature of the elevation data is an important concept to keep in mind. Viewshed results derived from only bare-earth model data, as in this preliminary study, are anticipated to overestimate the visible area significantly.

3.5.3 Additional Screening Caveats for Consideration

It is important to realize that even when utilizing the highest resolution data sets and including the screening effects of above-ground features captured in the surface model details, there are still aspects of the viewshed calculation that may not fully characterize the visibility of the site. For instance, foliage may change as seasons change, offering less screening in the winter when the trees lose their leaves or increased screening in the summer when vegetation is thriving. Knowledge about the elevation source data can help to understand the inherent assumptions and limitations in its use.

The vintage of the elevation data is also very important, especially when considering detailed, site-specific surface model conditions. Features change over time and for the most accurate representation, the data should be as current as possible. Human development and natural processes may increase or decrease the number and type of features in an area, some temporary and some more enduring, which may impact the visibility or potential for obstructions to the view, now and in the future. If current data cannot be obtained, an evaluation of potential differences between the available data and key features can be conducted to understand the implications to the viewshed analysis.

Additionally, multistory office and residential buildings may have visibility of the project site from the higher floors that might not be represented in a standard viewshed analysis. This is because the standard viewshed is generally designed to evaluate the viewpoint of an observer at ground-level. A building represented in the surface model might obstruct the view of someone standing on the street, for example, but the resulting viewshed will not capture the visibility that someone might have if they are looking out a window from a higher floor or from the rooftop of that building. At select key observation points, specific parameters may be defined to evaluate the view from critical heights of interest. If details of the surface feature classifications are available, such as from tax parcel records, a more sophisticated viewshed analyses may be designed to consider both scenarios of ground-level and roof-top viewpoints while maintaining the screening effects of the vegetation or other obstructions.

3.5.4 Elevation Datums

The IGLD 85 datum, which serves as the current standard for referencing water depths (i.e., LWD) in the Great Lakes, is expected to be replaced by an updated version, IGLD 2020, possibly as soon as 2025. That timing is likely to coincide with Great Lakes offshore wind development if such projects proceed. Implications of a datum shift to ongoing and future projects can be considered. Data products, both input and output, can document datum references and be reviewed for consistency and accuracy relative to the appropriate datums, not only for detailed viewshed analyses, but across other relevant design and installation aspects of Great Lakes Wind projects.

3.6 Other Visibility Factors

Unique atmospheric conditions associated with the Great Lakes, such as temperature inversions (Pijanowski 2019) and local microclimates, suggest that applying standard atmospheric corrections may oversimplify the impact that refraction may have on visibility in the region. Because site conditions can vary widely across the Great Lakes region, this preliminary assessment does not include an extensive study to determine site-specific refractivity correction factors that may be more suitable at individual locations than the default 0.13 value. When, or if, a proposed site for Great Lakes Wind development is selected, a thorough review of the atmospheric data in the vicinity could result in identifying representative correction values to model the visibility of the site more realistically, possibly under different scenarios of common atmospheric conditions. Such information could also aid in the preparation of visual simulations, another method for evaluating visual impact.

3.7 Radar and Aviation Interference

This high-level viewshed assessment does not address potential for radar or aviation interference from Great Lakes Wind development. There are several airports and weather monitoring stations in proximity to the Lakes, where potential interferences from any proposed offshore wind development could be investigated. While such investigations may involve similar line-of-sight methodologies, they are not quite the same and not typically part of a VIA. If development plans progress and proposed sites for wind generation facilities are selected within New York State waters of Lake Ontario or Lake Erie, a radar and aviation interference study would likely be required.

3.8 Land Cover versus Land Use

While they sound similar and are sometimes (erroneously) referred to interchangeably, land cover and land use are not the same. Land cover data is a representation of the ground cover, whether it is classified as water, bare earth, vegetation, or human-made structures. Land-use data, on the other hand, is a representation of "how people are using the land" (Coffey 2013).

The assessment presented herein references the land cover data, but additional insight for evaluating the visual impacts of a proposed project can be derived by incorporating the details of land use, which is often prepared to similar levels of resolution as high-resolution LiDAR data sets. Land-use details are generally maintained by individual communities and serve an important role in local development and conservation planning. Land-use data would be a valuable supplemental input for future VIAs if/when specific sites are selected for proposed Great Lakes Wind development.

4 Viewshed Results

Viewsheds calculated at the hypothetical turbine placement sites provide examples of what a turbine's visibility might be within the region, given the proposed standard turbine size and the surrounding elevation.

4.1 Lake Erie

The two hypothetical turbine placement sites within Lake Erie provide some insight into visibility differences between the western and eastern portions of Lake Erie within NYS waters. Both locations are sited at the hypothetical minimum distance from shore, 5 mi (8 km) and yield a "worst case" hub-height view for turbine visibility (Figure 8). Siting a project farther from shore will reduce potential for visibility from land, as will considering surficial features, structures, and vegetation through use of a refined DSM.

Figure 10 through Figure 13 provide the viewshed results for the Lake Erie hypothetical sites. Detailed metrics for the calculated ZTV for the two Lake Erie hypothetical sites are presented in Table 6. The metrics presented are not exclusive to coverage within New York State; however, land cover classification is US-centric, and areas noted as "unclassified" include both open water and land areas associated with Canada.

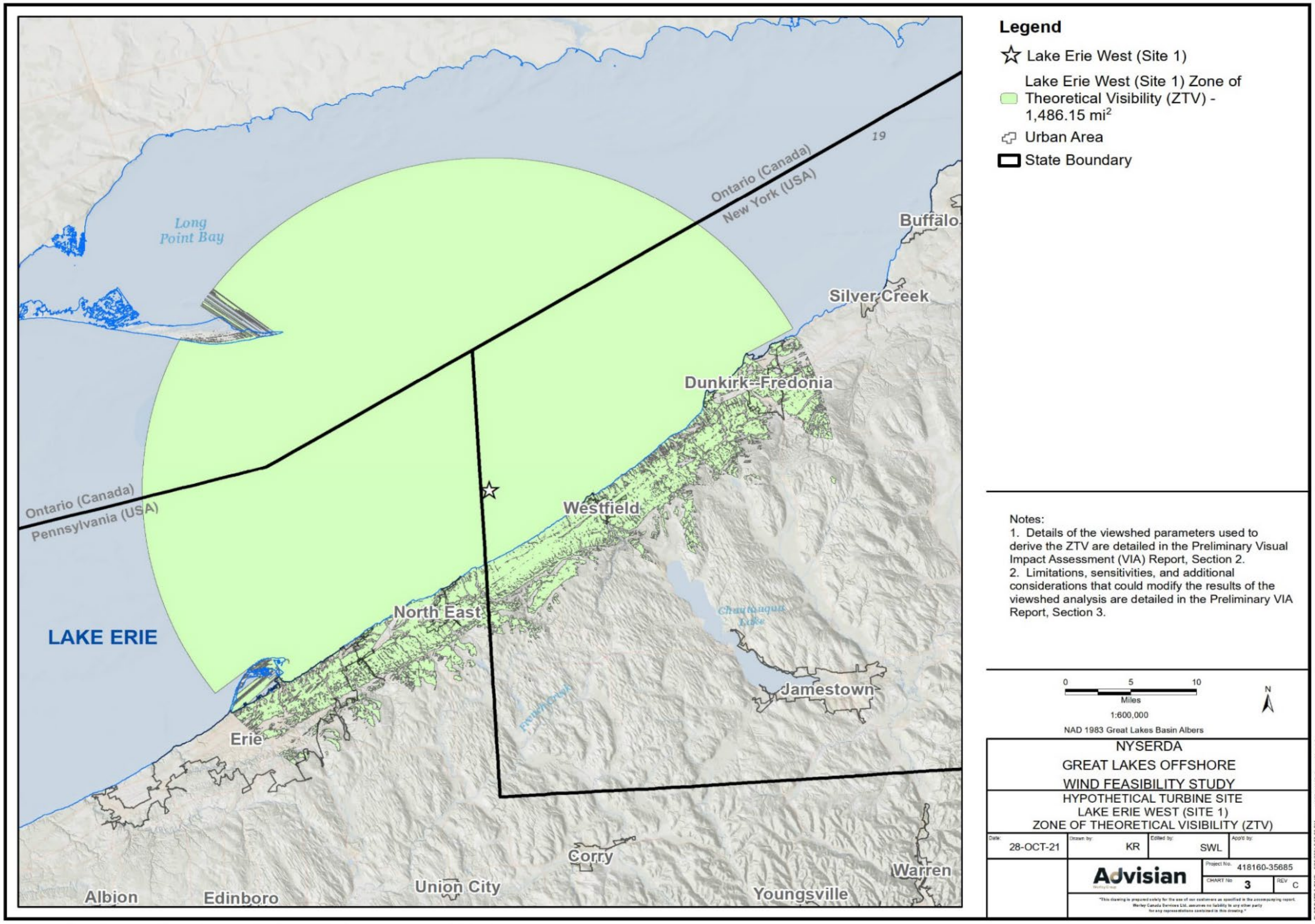
Table 6. Coverage Metrics for Zone of Theoretical Visibility Associated with Lake Erie Hypothetical Sites

Site ID	Calculated Area of ZTV	Approx. % of Total Viewshed Coverage Identified as ZTV	Approx. Total Areal Extent of ZTV over Open Water	Approx. % of ZTV over Open Water	Approx. Total Areal Extent of ZTV over Land	Approx. % of ZTV over Land
Lake Erie West (Site 1)	1,486 sq mi (3,849 sq km)	68%	1,280 sq mi (3,316 sq km)	86%	206 sq mi (533 sq km)	14%
Lake Erie East (Site 2)	1,375 sq mi (3,561 sq km)	62%	571 sq mi (1,478 sq km)	42%	804 sq mi (2,083 sq km)	58%

Sq km= square kilometers; Sq mi = square miles

At site 1, 68% of the total viewshed extent is considered to have potential visibility with a turbine at that location (Figure 10). Of that, 86% of the visible area is expected to be classified as open water and the other 14% covering land. Site 2 results indicate that 62% of the total viewshed extent may have visibility of a turbine at that location, with 42% of that area over open water and 58% over land (Figure 12).

Figure 10. Lake Erie Hypothetical Turbine Placement Site 1 Zone of Theoretical Visibility



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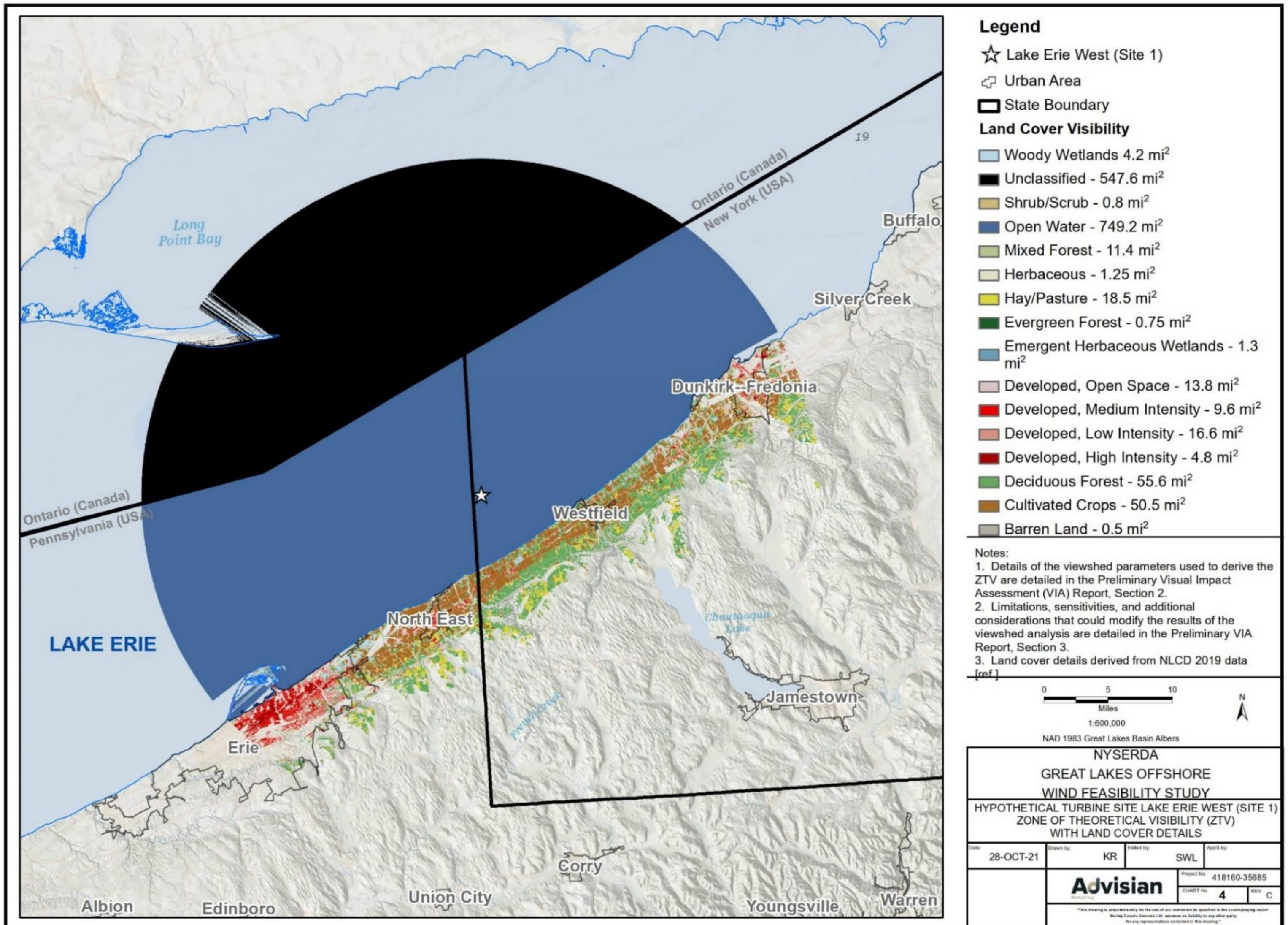
Imagery Source: Sources: Esri, GEBCO, NOAA, National Geographic, Garmin, HERE, Geonames.org, and other contributors
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors
FILE LOCATION: E:\GIS\Projects\418160-35685\01_MXD\Final_Maps\RevB\NYSERDA_Hypothetical_Turbine_Site_Lake_Erie_West_Site1_ZTV.mxd

Figure 11. Lake Erie Hypothetical Turbine Placement Site 1 Zone of Theoretical Visibility with Land Cover



Imagery Source: Sources: Esri, GEBCO, NOAA, National Geographic, Garmin, HERE, Geonames.org, and other contributors
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors
[ref.] Yang, L., Jin, S., Danielson, P., Homer, C., Gass, L., Case, A., Costello, C., Dewitz, J., Fry, J., Funk, M., Grannemann, B., Rigge, M. and G. Xian. 2018. A New Generation of the United States National Land Cover Database: Requirements, Research Priorities, Design, and Implementation Strategies, ISPRS Journal of Photogrammetry and Remote Sensing, 146, pp.108-123.
FILE LOCATION: E:\GIS\Projects\418160-35685\01 MXD\Final Maps\RevB\NYSERDA Hypothetical Turbine Site Lake Erie West Site1 ZTV with Land Cover Details.mxd

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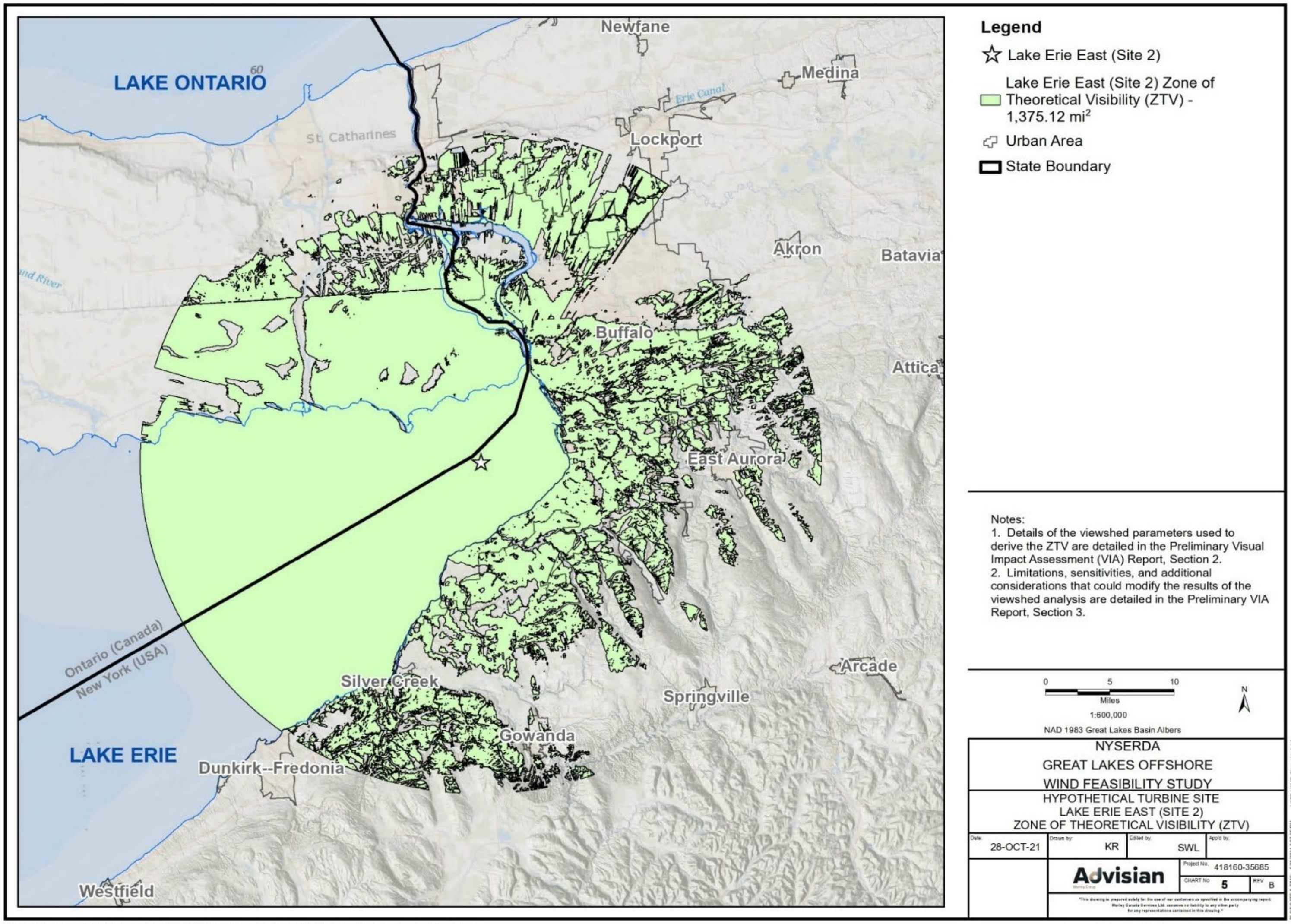
Figure 12. Lake Erie Hypothetical Turbine Placement Site 2 Zone of Theoretical Visibility



Imagery Source: Sources: Esri, GEBCO, NOAA, National Geographic, Garmin, HERE, Geonames.org, and other contributors
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors
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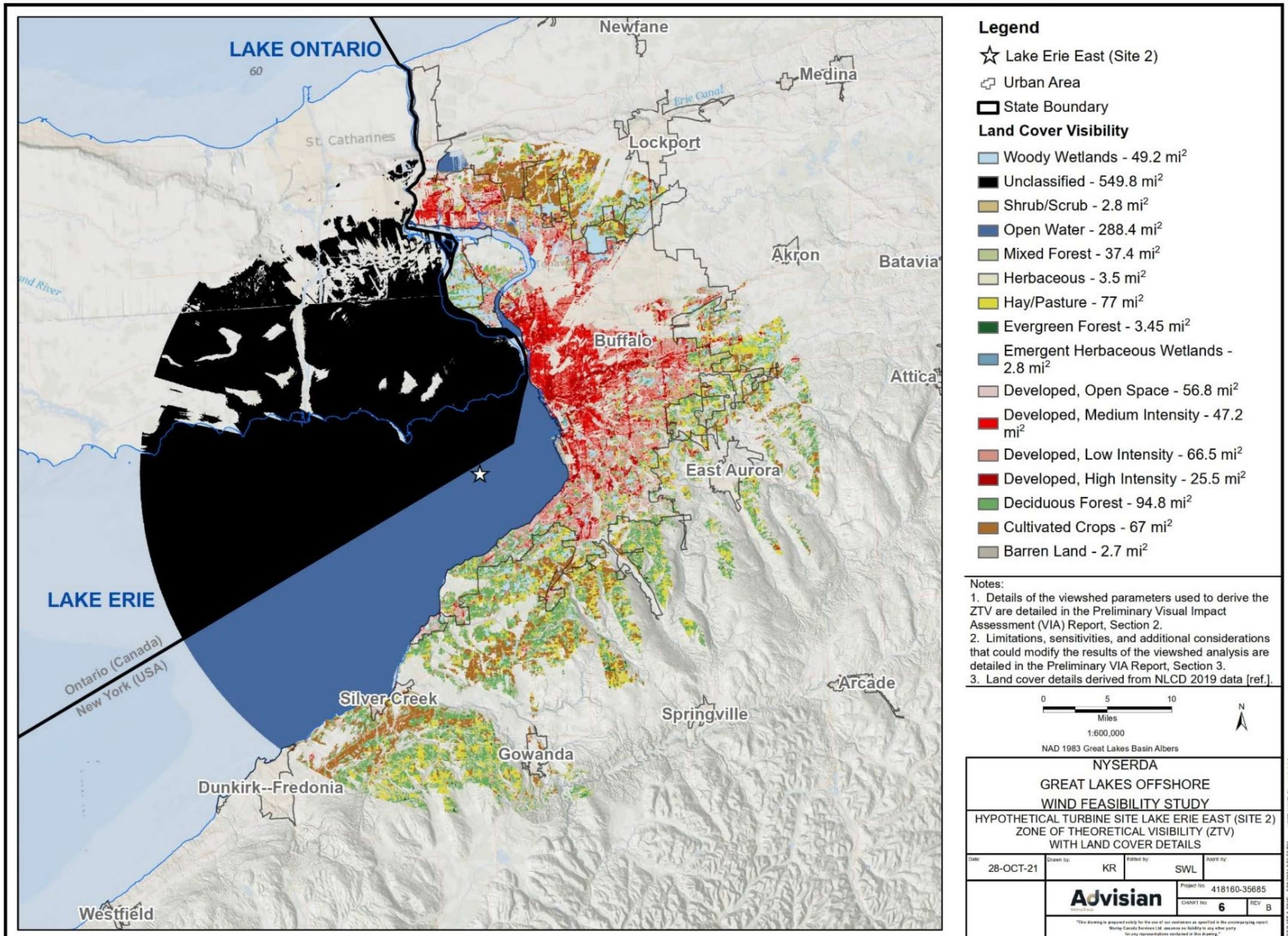
Figure 13. Lake Erie Hypothetical Turbine Placement Site 2 Zone of Theoretical Visibility with Land Cover



Imagery Source: Sources: Esri, GEBCO, NOAA, National Geographic, Garmin, HERE, Geonames.org, and other contributors
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[ref.] Yang, L., Jin, S., Danielson, P., Homer, C., Gass, L., Case, A., Costello, C., Dewitz, J., Fry, J., Funk, M., Grannemann, B., Rigge, M. and G. Xian. 2018. A New Generation of the United States National Land Cover Database: Requirements, Research Priorities, Design, and Implementation Strategies, ISPRS Journal of Photogrammetry and Remote Sensing, 146, pp.108-123.
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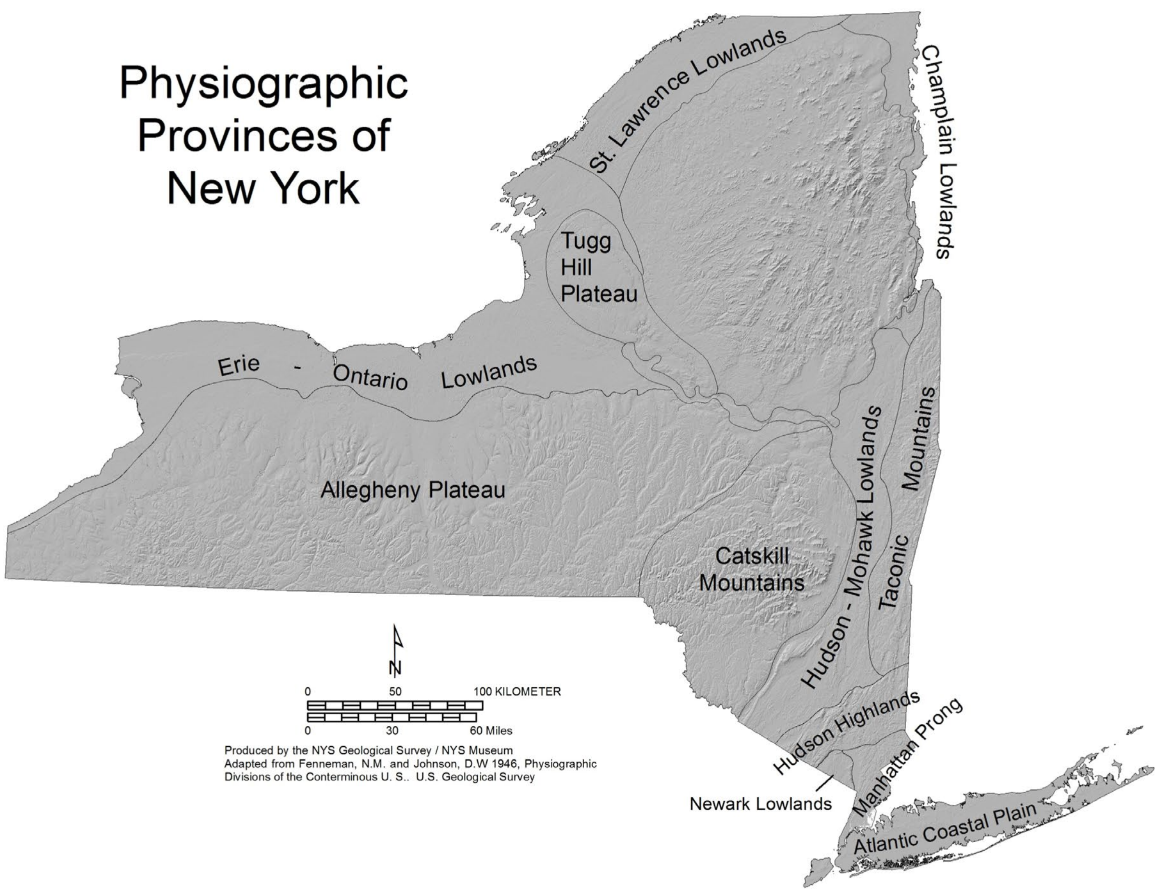
4.1.1 Lake Erie West, Hypothetical Site 1

The area identified with potential for line-of-sight with the hypothetical turbine at site 1 is illustrated in Figure 10. The ZTV extends into parts of Dunkirk—Fredonia and Westfield within New York State, and North East and Erie within Pennsylvania.

Topography associated with the Allegheny Plateau (Figure 14) serves as a distinct obstruction to views with the hypothetical turbine at site 1. From about 4 mi to 11.5 mi (6.4 km to 18.5 km) inland line-of-sight is drastically reduced by the topography associated with the plateau's margin (Figure 10). Further screening is expected if surficial details are incorporated in a DSM for refined viewshed analysis. Topographically, low areas associated with features such as Twentymile Creek and Belson Creek are also shielded from view of the hypothetical turbine at site 1.

Figure 14. Physiographic Provinces of New York State

Source: (USGS 2016)



The ZTV for Lake Erie West (site 1) can be further investigated relative to land cover classifications, as shown in Table 7 and illustrated on Figure 11. The majority of the visible area at hypothetical site 1 is classified as Open Water and Unclassified. Of the land cover areas classified as "Developed," the Low-Intensity regions appear to have the most exposure, about 17 sq mi (43 sq km), or 1.1% of the ZTV. Approximately 2.9% of the total ZTV for hypothetical site 1 is considered "Developed." Cultivated Crop areas and Deciduous Forest regions occupy larger areas of potential visibility, with regions constituting 3.4% and 3.7% of the ZTV, respectively.

Note that the metrics presented are not exclusive to coverage within New York State; however, land cover classification is US-centric, and areas noted as "unclassified" include both open water and land areas associated with Canada.

Table 7. Land Cover Classification of Zone of Theoretical Visibility for Hypothetical Turbine Placement at Lake Erie West (Site 1)

Source: (MRLC 2021b)

Land Cover Class	Approx. Calculated Area of Coverage within ZTV		Approx. % of Total ZTV
	Sq mi	Sq km	
Unclassified	548 sq mi	1,418 sq km	36.8%
Open Water	749 sq mi	1,940 sq km	50.4%
Developed, Open Space	14 sq mi	36 sq km	0.9%
Developed, Low-Intensity	17 sq mi	43 sq km	1.1%
Developed, Medium Intensity	9.6 sq mi	25 sq km	0.6%
Developed High Intensity	4.8 sq mi	13 sq km	0.3%
Barren Land (Rock/Sand/Clay)	0.5 sq mi	1.2 sq km	0.03%
Deciduous Forest	56 sq mi	144 sq km	3.7%
Evergreen Forest	0.8 sq mi	2.0 sq km	0.1%
Mixed Forest	11 sq mi	29 sq km	0.8%
Shrub/Scrub	0.8 sq mi	2.1 sq km	0.1%
Grassland/Herbaceous	1.3 sq mi	3.3 sq km	0.1%
Pasture/Hay	18 sq mi	48 sq km	1.2%
Cultivated Crops	50 sq mi	131 sq km	3.4%
Woody Wetlands	4.2 sq mi	11 sq km	0.3%
Emergent Herbaceous Wetlands	1.3 sq mi	3.3 sq km	0.1%

* Sq km= square kilometers; Sq mi = square miles.

** Row colors correspond with the legend in Figure 11 and Figure 13 above.

4.1.2 Lake Erie East, Hypothetical Site 2

The area identified with potential for line of sight with the hypothetical turbine at site 2 is illustrated in Figure 12. Much of Buffalo, NY and the surrounding area falls within the ZTV for site 2, although a detailed DSM would likely provide significant screening and reduction of the actual ZTV in these developed areas.

The visual barrier associated with topography of the Allegheny Plateau, encountered at site 1, becomes ineffective in obstructing views for sites placed offshore farther east, as the region proximal to the lakes becomes dominated by the Erie-Ontario Lowlands (Figure 14). As such, hypothetical site 2 (and those within Lake Ontario) exhibits increased potential visibility farther inland compared to site 1.

The land cover classifications associated with the ZTV for Lake Erie East (site 2) are described in Table 8 and illustrated on Figure 13. The majority of the visible area at hypothetical site 2 is classified as Open Water and Unclassified. Of the land cover areas classified as "Developed," the Low-Intensity regions appear to have the most exposure, about 67 sq mi (172 sq km), or 4.8% of the ZTV. Approximately 14.2% of the total ZTV for hypothetical site 2 is considered "Developed," which is significantly more than was observed at site 1.

Table 8. Land Cover Classification of Zone of Theoretical Visibility for Hypothetical Turbine Placement at Lake Erie East (Site 2)

Source: (MRLC 2021b)

Land Cover Class	Approx. Calculated Area of Coverage within ZTV		Approx. % of Total ZTV
	Sq mi	Sq km	
Unclassified	550 sq mi	1,424 sq km	40.0%
Open Water	288 sq mi	747 sq km	21.0%
Developed, Open Space	57 sq mi	147 sq km	4.1%
Developed, Low-Intensity	67 sq mi	172 sq km	4.8%
Developed, Medium Intensity	47 sq mi	122 sq km	3.4%
Developed High Intensity	26 sq mi	66 sq km	1.9%
Barren Land (Rock/Sand/Clay)	2.7 sq mi	7.1 sq km	0.2%
Deciduous Forest	95 sq mi	245 sq km	6.9%
Evergreen Forest	3.5 sq mi	9.0 sq km	0.3%
Mixed Forest	37 sq mi	97 sq km	2.7%
Shrub/Scrub	2.8 sq mi	7.2 sq km	0.2%

Table8 continued

Land Cover Class	Approx. Calculated Area of Coverage within ZTV		Approx. % of Total ZTV
	Sq mi	Sq km	
Grassland/Herbaceous	3.5 sq mi	9.1 sq km	0.3%
Pasture/Hay	77 sq mi	200 sq km	5.6%
Cultivated Crops	67 sq mi	174 sq km	4.9%
Woody Wetlands	49 sq mi	127 sq km	3.6%
Emergent Herbaceous Wetlands	2.8 sq mi	7.3 sq km	0.2%

* Sq mi = square mile’ Sq km =square kilometer.
* Row colors correspond with Figure 11 and Figure 13.

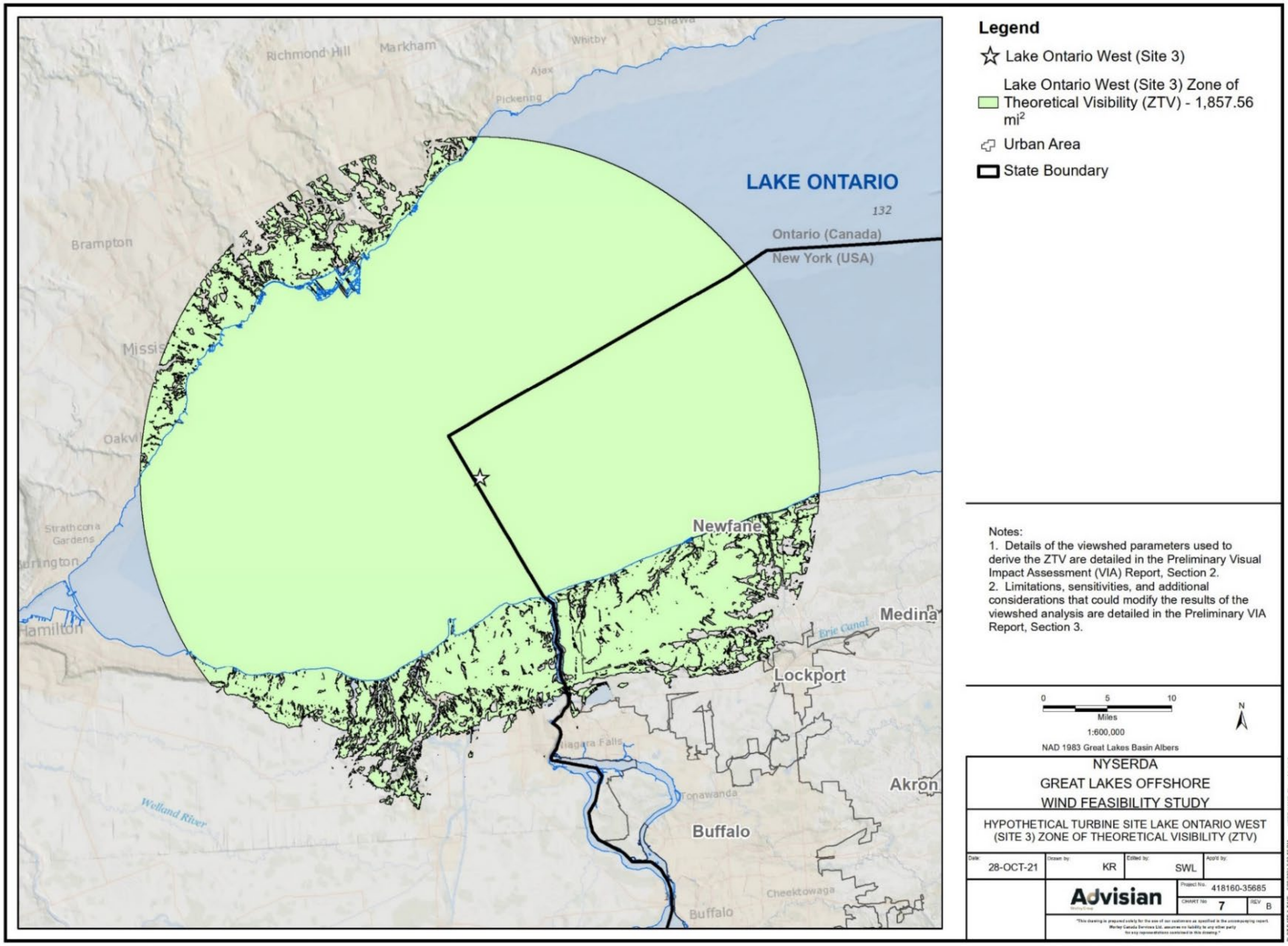
Deciduous Forest regions occupy the next largest areas of potential visibility, 6.9% of the ZTV. These areas are “dominated by trees generally greater than 5 m tall, and greater than 20% of total vegetation cover” (MRLC 2021b), which would provide screening for views if the surface features were incorporated into a detailed DSM. An additional consideration in Deciduous Forests is that “more than 75% of the tree species shed foliage simultaneously in response to seasonal change” (MRLC 2021b), which implies that there may be seasonal affects to the visibility of turbines in the lake from those regions. Additional areas with predicted visibility at site 2 include regions of Pasture/Hay (5.6% of ZTV), Cultivated Crops (4.9% of ZTV), Woody Wetlands (3.6% of ZTV), and Mixed Forests (2.7% of ZTV).

4.2 Lake Ontario

The four hypothetical turbine placement sites within Lake Ontario provide some insight into visibility differences along the lake within NYS waters. All four hypothetical locations are sited at the hypothetical minimum distance from shore, 10 mi (16 km), and yield a kind of “worst case” view for turbine hub-height visibility (Figure 9). Siting a project farther from shore will reduce potential for visibility onshore, as will considering surficial features, structures, and vegetation through use of a refined DSM.

Figure 15 through Figure 22 provide the viewshed results for the Lake Ontario hypothetical sites. Detailed metrics for the calculated ZTV for the four Lake Ontario hypothetical sites are presented in Table 9. The metrics presented are not exclusive to coverage within New York State; however, land cover classification is US-centric, and areas noted as “unclassified” include both open water and land areas associated with Canada.

Figure 15. Lake Ontario Hypothetical Turbine Placement Site 3 Zone of Theoretical Visibility



Imagery Source: Sources: Esri, GEBCO, NOAA, National Geographic, Garmin, HERE, Geonames.org, and other contributors
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors
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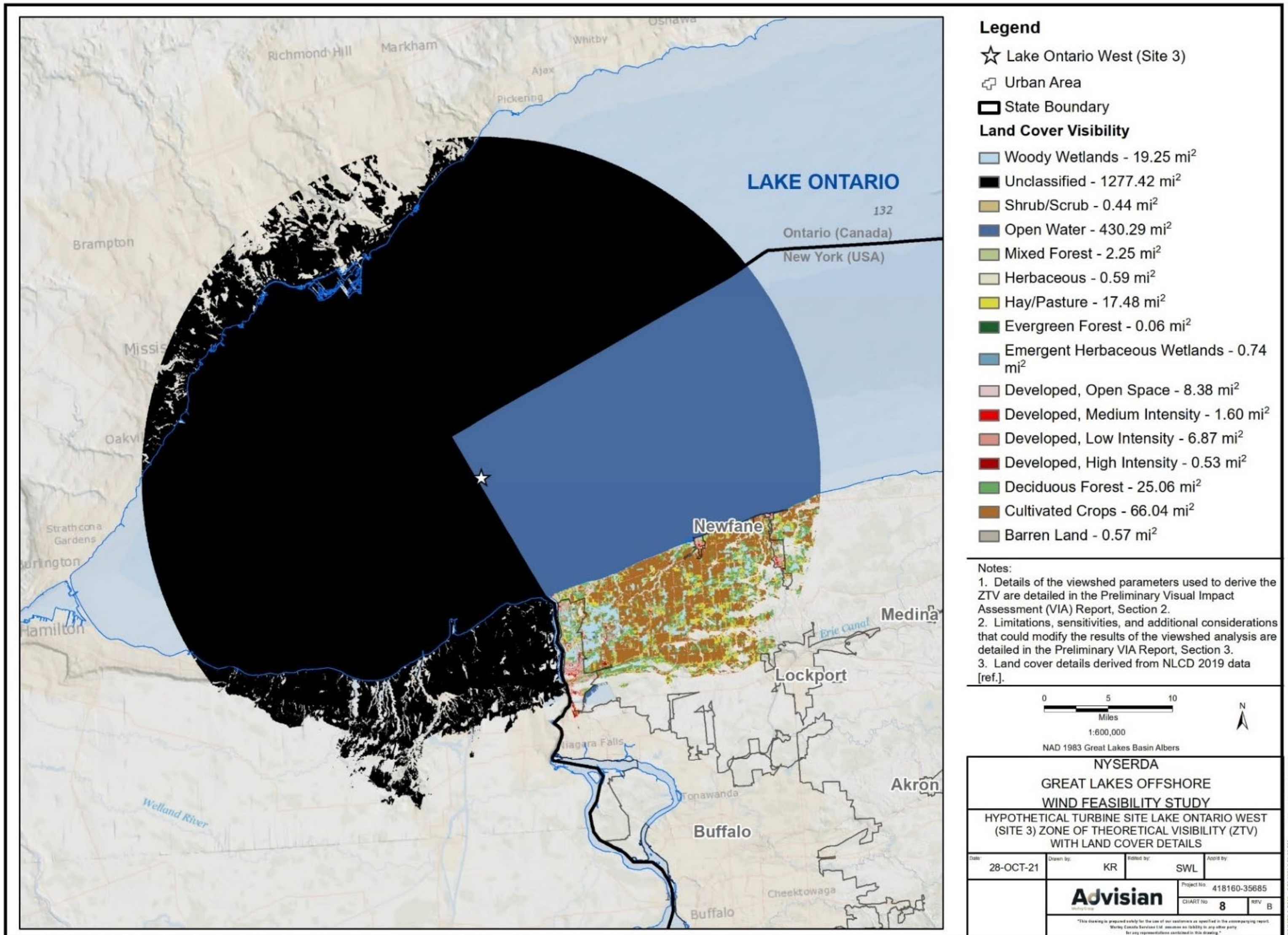
Figure 16. Lake Ontario Hypothetical Turbine Placement Site 3 Zone of Theoretical Visibility with Land Cover



Imagery Source: Sources: Esri, GEBCO, NOAA, National Geographic, Garmin, HERE, Geonames.org, and other contributors
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors
[ref.] Yang, L., Jin, S., Danielson, P., Homer, C., Gass, L., Case, A., Costello, C., Dewitz, J., Fry, J., Funk, M., Grannemann, B., Rigge, M. and G. Xian. 2018. A New Generation of the United States National Land Cover Database: Requirements, Research Priorities, Design, and Implementation Strategies, ISPRS Journal of Photogrammetry and Remote Sensing, 146, pp.108-123.
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Figure 17. Lake Ontario Hypothetical Turbine Placement Site 4 Zone of Theoretical Visibility

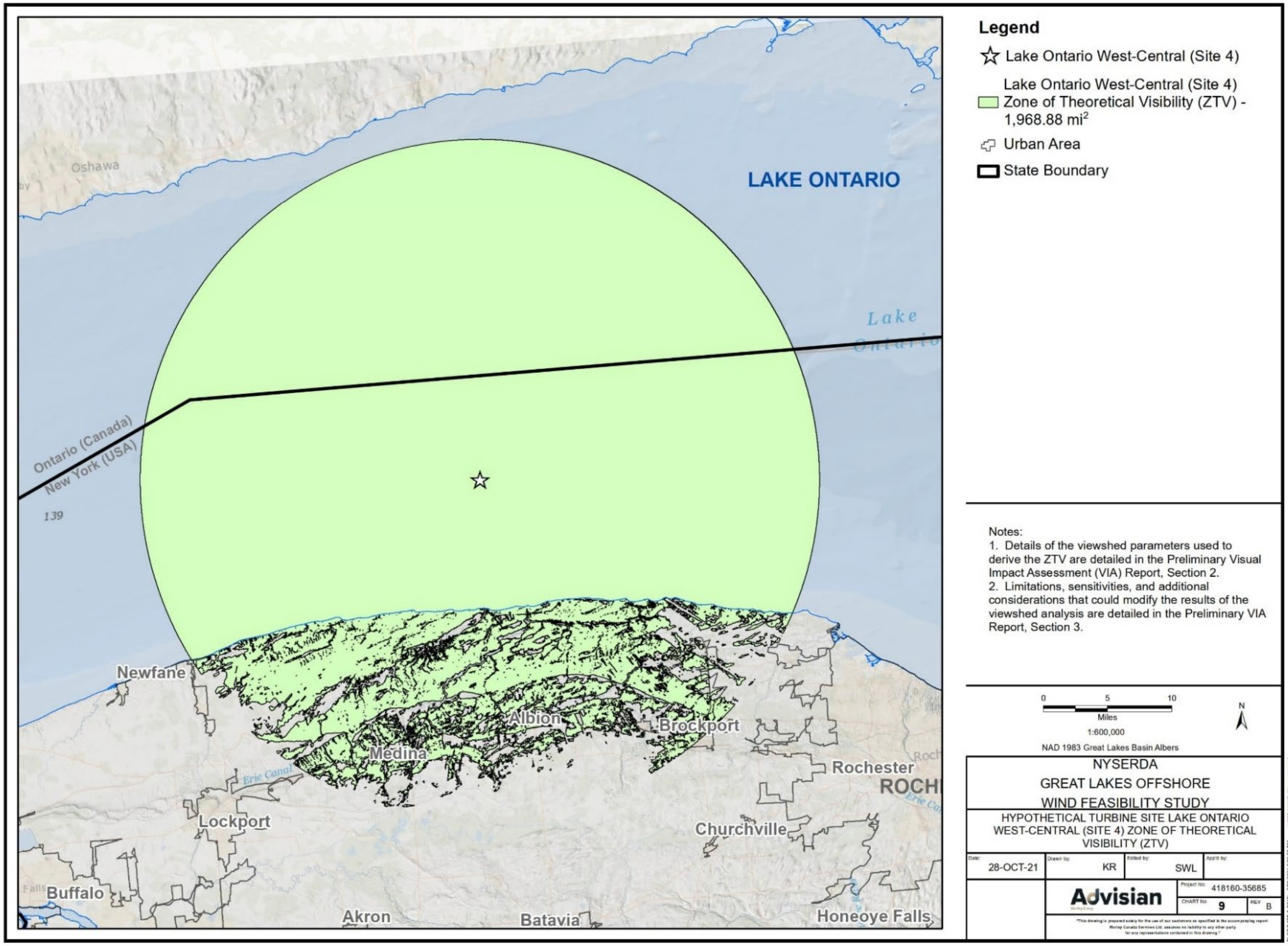

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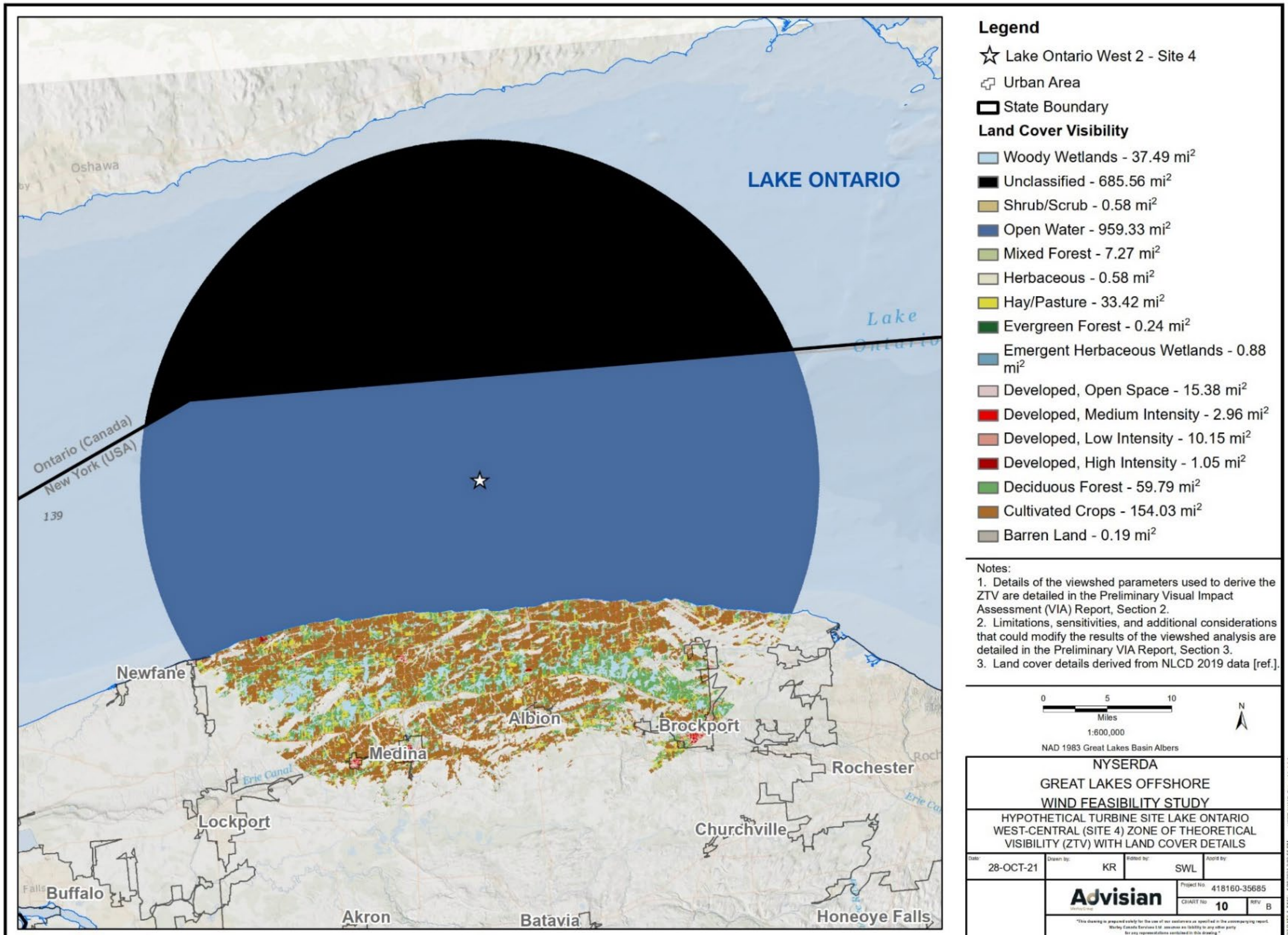
Figure 18. Lake Ontario Hypothetical Turbine Placement Site 4 Zone of Theoretical Visibility with Land Cover



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Imagery Source: Sources: Esri, GEBCO, NOAA, National Geographic, Garmin, HERE, Geonames.org, and other contributors
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors
[ref.] Yang, L., Jin, S., Danielson, P., Homer, C., Gass, L., Case, A., Costello, C., Dewitz, J., Fry, J., Funk, M., Grannemann, B., Rigge, M. and G. Xian. 2018. A New Generation of the United States National Land Cover Database: Requirements, Research Priorities, Design, and Implementation Strategies, ISPRS Journal of Photogrammetry and Remote Sensing, 146, pp.108-123.
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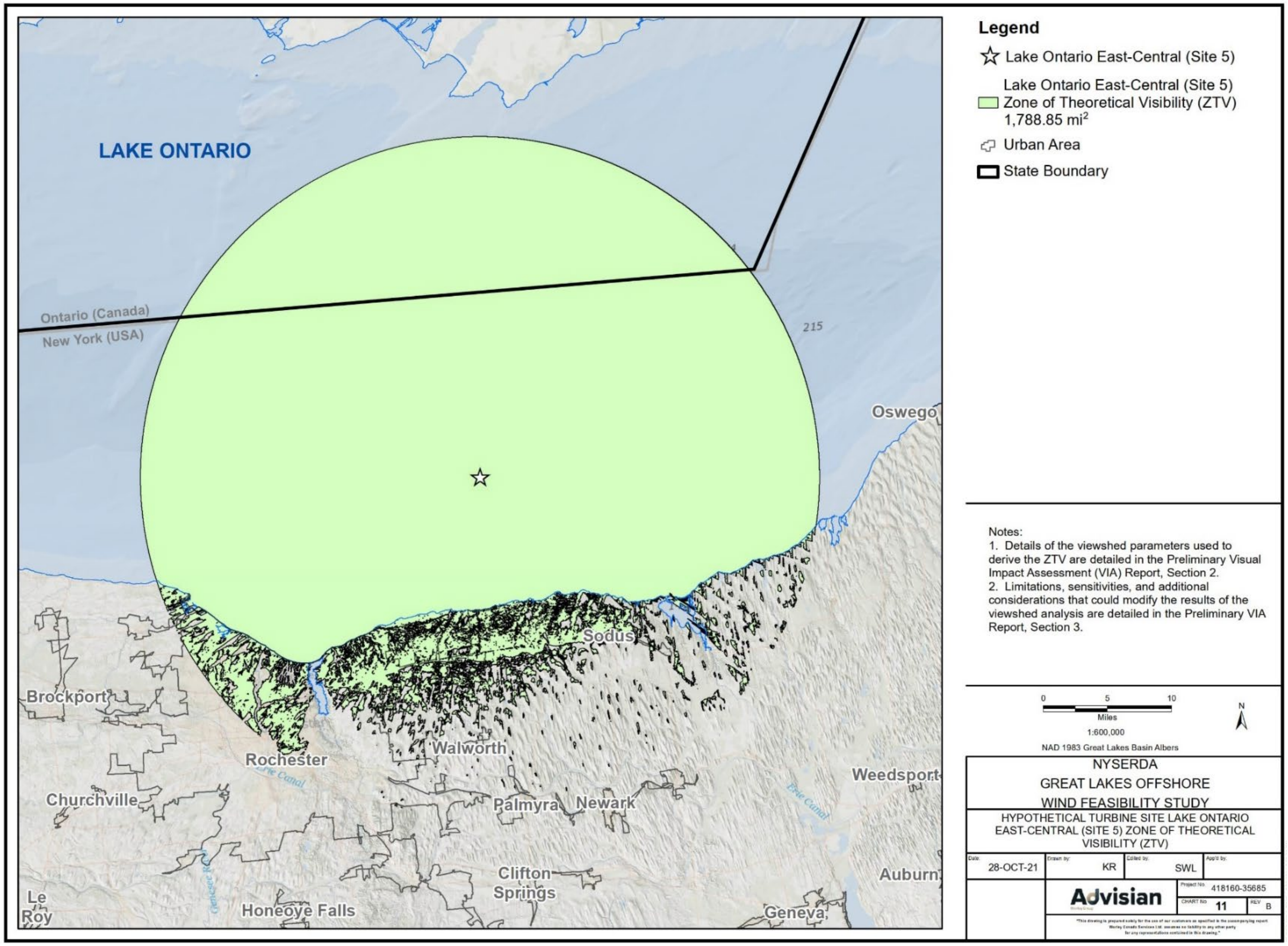
Figure 19. Lake Ontario Hypothetical Turbine Placement Site 5 Zone of Theoretical Visibility



Imagery Source: Sources: Esri, GEBCO, NOAA, National Geographic, Garmin, HERE, Geonames.org, and other contributors
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors
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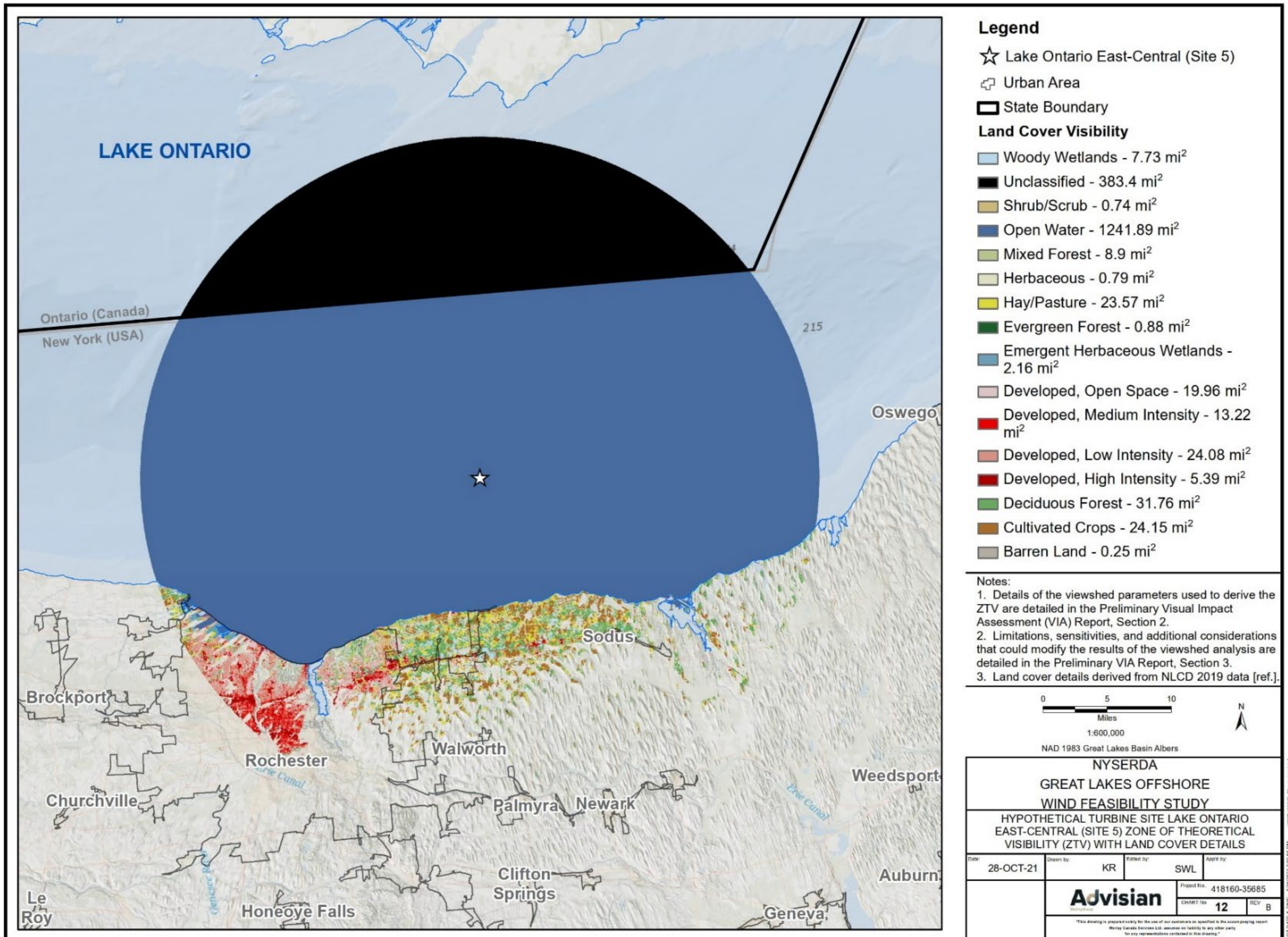
Figure 20. Lake Ontario Hypothetical Turbine Placement Site 5 Zone of Theoretical Visibility with Land Cover



Imagery Source: Sources: Esri, GEBCO, NOAA, National Geographic, Garmin, HERE, Geonames.org, and other contributors
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors
[ref.] Yang, L., Jin, S., Danielson, P., Homer, C., Gass, L., Case, A., Costello, C., Dewitz, J., Fry, J., Funk, M., Grannemann, B., Rigge, M. and G. Xian. 2018. A New Generation of the United States National Land Cover Database: Requirements, Research Priorities, Design, and Implementation Strategies, ISPRS Journal of Photogrammetry and Remote Sensing, 146, pp.108-123.
FILE LOCATION: E:\GIS\Projects\418160-35685\01 MXD\Final Maps\RevB\NYSERDA Hypothetical Turbine Site Lake Ontario East Central Site5 ZTV with Land Cover Details.mxd

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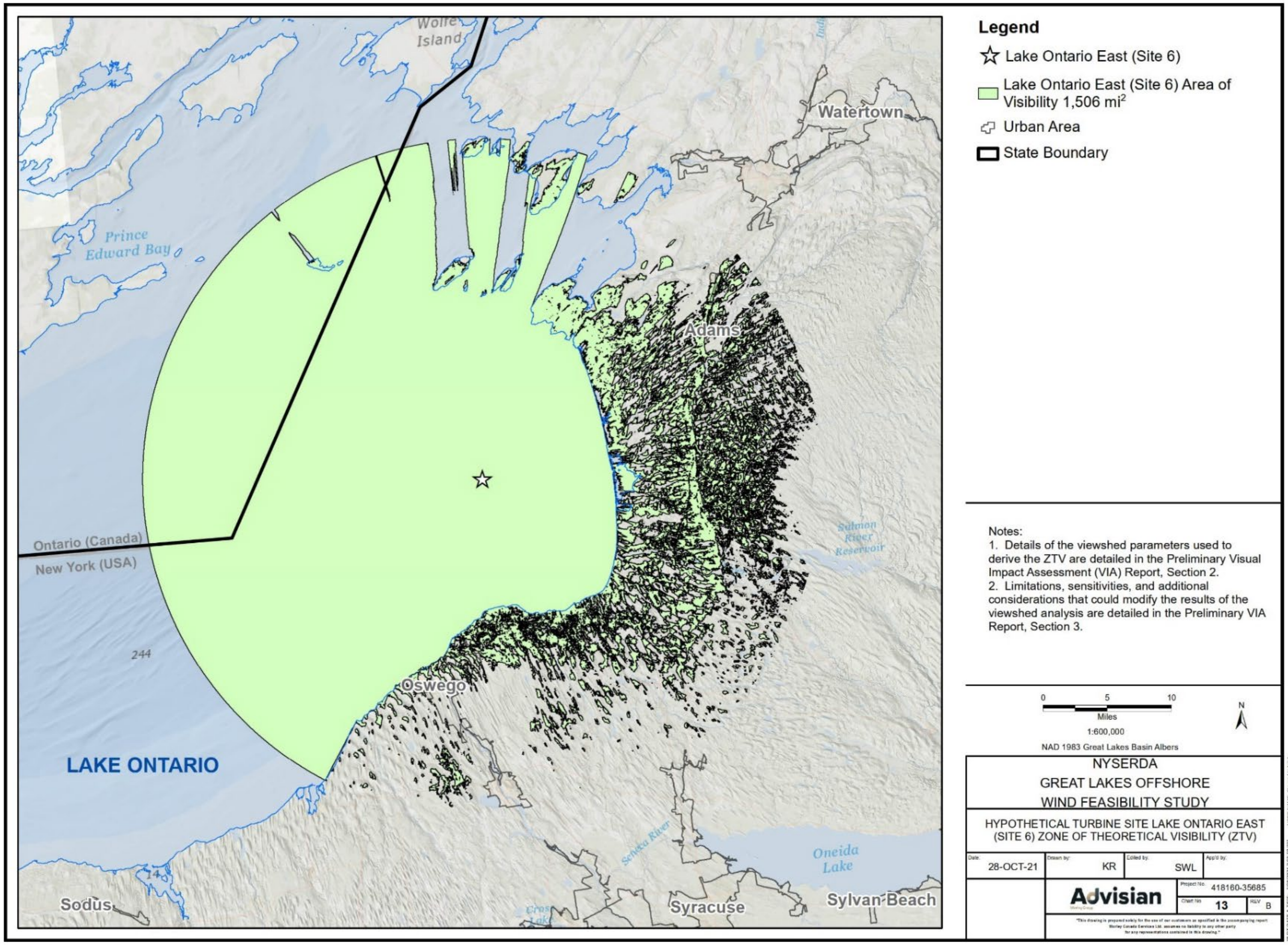
Figure 21. Lake Ontario Hypothetical Turbine Placement Site 6 Zone of Theoretical Visibility



Imagery Source: Sources: Esri, GEBCO, NOAA, National Geographic, Garmin, HERE, Geonames.org, and other contributors
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors
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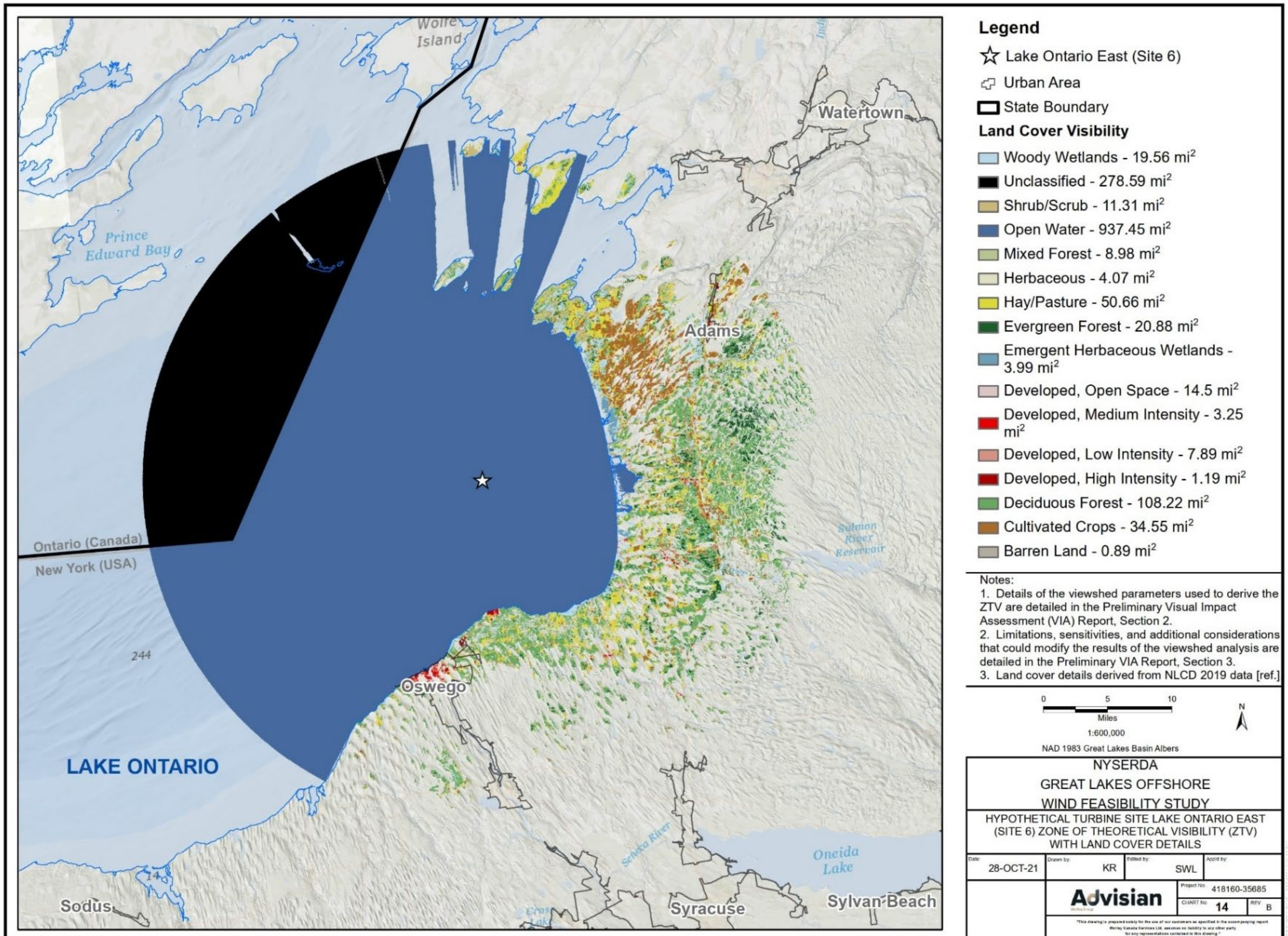
Figure 22. Lake Ontario Hypothetical Turbine Placement Site 6 Zone of Theoretical Visibility with Land Cover



Imagery Source: Sources: Esri, GEBCO, NOAA, National Geographic, Garmin, HERE, Geonames.org, and other contributors
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors
[ref.] Yang, L., Jin, S., Danielson, P., Homer, C., Gass, L., Case, A., Costello, C., Dewitz, J., Fry, J., Funk, M., Grannemann, B., Rigge, M. and G. Xian. 2018. A New Generation of the United States National Land Cover Database: Requirements, Research Priorities, Design, and Implementation Strategies, ISPRS Journal of Photogrammetry and Remote Sensing, 146, pp.108-123.
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Table 9. Coverage Metrics for Zone of Theoretical Visibility Associated with Lake Ontario Hypothetical Sites

Site ID	Calculated Area of ZTV	% of Total Viewshed Coverage Identified as ZTV	Total Areal Extent of ZTV over Open Water	% of ZTV over Open Water	Total Areal Extent of ZTV over Land	% of ZTV over Land
Lake Ontario West (Site 3)	1,858 sq mi (4,812 sq km)	84%	1,462 sq mi (3,786 sq km)	79%	396 sq mi (1,026 sq km)	21%
Lake Ontario West-Central (Site 4)	1,969 sq mi (5,100 sq km)	89%	1,646 sq mi (4,263 sq km)	84%	323 sq mi (837 sq km)	16%
Lake Ontario East-Central (Site 5)	1,789 sq mi (4,633 sq km)	81%	1,624 sq mi (4,205 sq km)	91%	165 sq mi (428 sq km)	9%
Lake Ontario East (Site 6)	1,506 sq mi (3,901 sq km)	68%	1,214 sq mi (3,145 sq km)	81%	292 sq mi (756 sq km)	19%

Sq km= square kilometers; Sq mi = square miles

4.2.1 Lake Ontario West, Hypothetical Site 3

The area identified with potential for line-of-sight with the hypothetical turbine at site 3 is illustrated in Figure 15. From the Lake Ontario West hypothetical location, visibility generally extends inland to the Niagara Escarpment (Figure 23). There are additional portions of the ZTV that extend west into Canada, as well as locations along the northern shoreline of Lake Ontario in Canada that may have visibility of a proposed turbine at the location of site 3.

Figure 23. Map of the Niagara Escarpment

Source: (Wikimedia Commons contributors)

The land cover classifications associated with the ZTV for Lake Ontario West (s3) are described in Table 10 and illustrated on Figure 16. The majority of the visible area at hypothetical site 3 is classified as Open Water and Unclassified. More than half of the area with interpreted visibility, 68.8% of the ZTV, is identified with the location as Canada.

Of the land cover areas classified as "Developed," the Open Space regions appear to have the most exposure, about 8.4 sq mi (22 sq km), or 0.5% of the site 3 ZTV. Approximately 1% of the total ZTV for hypothetical site 3 is considered "Developed," which is less than what was observed at site 1 and site 2 in Lake Erie. Cultivated Crops (3.6% of ZTV), Deciduous Forests (1.3% of ZTV), and Woody Wetlands (1.0%) are the next most prominent land cover types within the site 3 ZTV behind Unclassified and Open Water.

Table 10: Land Cover Classification of Zone of Theoretical Visibility for Hypothetical Turbine Placement at Lake Ontario West (Site 3)

Source: (MRLC 2021b)

Land Cover Class	Approx. Calculated Area of Coverage within ZTV		Approx. % of Total ZTV
	Sq mi	Sq km	
Unclassified	1,277 sq mi	3,309 sq km	68.8%
Open Water	430 sq mi	1,114 sq km	23.2%
Developed, Open Space	8.4 sq mi	22 sq km	0.5%
Developed, Low-Intensity	6.9 sq mi	18 sq km	0.4%
Developed, Medium Intensity	1.6 sq mi	4.2 sq km	0.1%
Developed High Intensity	0.5 sq mi	1.4 sq km	0.03%
Barren Land (Rock/Sand/Clay)	0.6 sq mi	1.5 sq km	0.03%
Deciduous Forest	25 sq mi	65 sq km	1.3%
Evergreen Forest	0.1 sq mi	0.2 sq km	0.003%
Mixed Forest	2.2 sq mi	5.8 sq km	0.1%
Shrub/Scrub	0.4 sq mi	1.1 sq km	0.02%
Grassland/Herbaceous	0.6 sq mi	1.5 sq km	0.03%
Pasture/Hay	17 sq mi	45 sq km	0.9%
Cultivated Crops	66 sq mi	171 sq km	3.6%
Woody Wetlands	19 sq mi	50 sq km	1.0%
Emergent Herbaceous Wetlands	0.7 sq mi	1.9 sq km	0.04%

* Sq km = square kilometers; Sq mi= square miles.

* Row colors correspond with Figure 16, Figure 18, Figure 20, and Figure 22.

4.2.2 Lake Ontario West-Central, Hypothetical Site 4

The area identified with potential for line-of-sight with the hypothetical turbine at site 4 is illustrated in Figure 17. The Niagara Escarpment (Figure 23) does not appear to offer the same screening capacity to this eastern location as was observed at hypothetical site 3. Medina, Albion, and Brockport, NY are a few of the more inland communities that were identified with potential visibility of hypothetical site 4. There are additional portions of the site 4 ZTV that extend north into Canadian waters; however, the viewshed coverage area did not extend far enough north to include land.

The land cover classifications associated with the ZTV for Lake Ontario West-Central (site 4) are described in Table 11 and illustrated on Figure 18. The majority of the visible area at hypothetical site 4 is classified as Open Water and Unclassified.

Table 11. Land Cover Classification of Zone of Theoretical Visibility for Hypothetical Turbine Placement at Lake Ontario West-Central (Site 4)

Source: (MRLC 2021b)

Land Cover Class	Approx. Calculated Area of Coverage within ZTV		Approx. % of Total ZTV
	Sq mi	Sq km	
Unclassified	686 sq mi	1,776 sq km	34.8%
Open Water	959 sq mi	2,485 sq km	48.7%
Developed, Open Space	15 sq mi	40 sq km	0.8%
Developed, Low-Intensity	10 sq mi	26 sq km	0.5%
Developed, Medium Intensity	3.0 sq mi	7.7 sq km	0.2%
Developed High Intensity	1.0 sq mi	2.7 sq km	0.1%
Barren Land (Rock/Sand/Clay)	0.2 sq mi	0.5 sq km	0.01%
Deciduous Forest	60 sq mi	155 sq km	3.0%
Evergreen Forest	0.2 sq mi	0.6 sq km	0.01%
Mixed Forest	7.3 sq mi	19 sq km	0.4%
Shrub/Scrub	0.6 sq mi	1.5 sq km	0.03%
Grassland/Herbaceous	0.6 sq mi	1.5 sq km	0.03%
Pasture/Hay	33 sq mi	87 sq km	1.7%
Cultivated Crops	154 sq mi	399 sq km	7.8%
Woody Wetlands	37 sq mi	97 sq km	1.9%
Emergent Herbaceous Wetlands	0.9 sq mi	2.3 sq km	0.04%

* Sq km = square kilometers; Sq mi = square miles.

* Colors correspond with Figure 16, Figure 18, Figure 20, and Figure 22.

Of the land cover areas classified as "Developed," the Open Space regions appear to have the most exposure, about 15 sq mi (40 sq km), or 0.8% of the site 4 ZTV. Approximately 1.6% of the total ZTV for hypothetical site 4 is considered "Developed," which is similar to what was observed at Lake Ontario West (site 3). Cultivated Crops (7.8% of ZTV), Deciduous Forests (3.0% of ZTV), Woody Wetlands (1.9%), and Pasture/Hay (1.7% of ZTV) are the next most prominent land cover types within the site 4 ZTV behind Open Water and Unclassified.

4.2.3 Lake Ontario East-Central, Hypothetical Site 5

The area identified with potential for line-of-sight with the hypothetical turbine at site 5 is illustrated in Figure 19. The ZTV includes a portion of Rochester, NY. The surface topography east of Rochester exhibits linear glacial features such as drumlins that offer sufficient elevation changes to obstruct the line-of-sight with site 5. As with site 4, there are additional portions of the site 5 ZTV that extend north into Canadian waters; however, the viewshed coverage area does not extend far enough north to include land.

The land cover classifications associated with the ZTV for Lake Ontario East-Central (site 5) are described in Table 12 and illustrated on Figure 20. The majority of the visible area at hypothetical site 5 is classified as Open Water and Unclassified.

Table 12. Land Cover Classification of Zone of Theoretical Visibility for Hypothetical Turbine Placement at Lake Ontario East-Central (Site 5)

Source: (MRLC 2021b)

Land Cover Class	Approx. Calculated Area of Coverage within ZTV		Approx. % of Total ZTV
	Sq mi	Sq km	
Unclassified	383 sq mi	993 sq km	21.4%
Open Water	1,242 sq mi	3,216 sq km	69.4%
Developed, Open Space	20 sq mi	52 sq km	1.1%
Developed, Low-Intensity	24 sq mi	62 sq km	1.3%
Developed, Medium Intensity	13 sq mi	34 sq km	0.7%
Developed High Intensity	5.4 sq mi	14 sq km	0.3%
Barren Land (Rock/Sand/Clay)	0.3 sq mi	0.7 sq km	0.01%
Deciduous Forest	32 sq mi	82 sq km	1.8%
Evergreen Forest	0.9 sq mi	2.3 sq km	0.05%
Mixed Forest	8.9 sq mi	23 sq km	0.5%

Land Cover Class	Approx. Calculated Area of Coverage within ZTV		Approx. % of Total ZTV
	Sq mi	Sq km	
Shrub/Scrub	0.7 sq mi	1.9 sq km	0.04%
Grassland/Herbaceous	0.8 sq mi	2.0 sq km	0.04%
Pasture/Hay	24 sq mi	61 sq km	1.3%
Cultivated Crops	24 sq mi	63 sq km	1.4%
Woody Wetlands	7.7 sq mi	20 sq km	0.4%
Emergent Herbaceous Wetlands	2.2 sq mi	5.6 sq km	0.1%

* Sq km = square kilometers; Sq mi = square miles.
* Row colors correspond with Figure 16, Figure 18, Figure 20, and Figure 22.

Of the land cover areas classified as "Developed," the Low-Intensity regions appear to have the most exposure, about 24 sq mi (62 sq km), or 1.3% of the site 5 ZTV. Approximately 3.4% of the total ZTV for hypothetical site 5 is considered "Developed." Deciduous Forests (1.8% of ZTV), Cultivated Crops (1.4% of ZTV), and Pasture/Hay (1.3% of ZTV) are the next most prominent land cover types within the site 5 ZTV behind Open Water and Unclassified.

4.2.4 Lake Ontario East, Hypothetical Site 6

The area identified with potential for line-of-sight with the hypothetical turbine at site 6 is illustrated in Figure 21. The surface topography exhibits linear glacial features such as drumlins that offer sufficient elevation changes to interrupt and obstruct the line-of-sight, similar to observations noted at site 5. Islands within the lake, such as Galloo Islands, Stony Island, and Calf Island also provide topography that serves to obstruct the view with the hypothetical Lake Ontario East turbine location. A portion of the ZTV for site 6 extends into Canadian waters, with the only potential Canadian land visibility expected to be associated with Main Duck Island and Yorkshire Island within Lake Ontario.

The land cover classifications associated with the ZTV for Lake Ontario East (site 6) are described in Table 13 and illustrated on Figure 22. The majority of the visible area at hypothetical site 6 is classified as Open Water and Unclassified. The ZTV associated with site 6 has the smallest portion of Unclassified land use of all the sites investigated in this assessment, which suggests a potential for reduced impact to Canada.

Table 13. Land Cover Classification of Zone of Theoretical Visibility for Hypothetical Turbine Placement at Lake Ontario East (Site 6)

Source: (MRLC 2021b)

Land Cover Class	Approx. Calculated Area of Coverage within ZTV		Approx. % of Total ZTV
	Sq mi	Sq km	
Unclassified	279 sq mi	722 sq km	18.5%
Open Water	937 sq mi	2,428 sq km	62.2%
Developed, Open Space	15 sq mi	38 sq km	1.0%
Developed, Low-Intensity	7.9 sq mi	20 sq km	0.5%
Developed, Medium Intensity	3.3 sq mi	8.4 sq km	0.2%
Developed High Intensity	1.2 sq mi	3.1 sq km	0.1%
Barren Land (Rock/Sand/Clay)	0.9 sq mi	2.3 sq km	0.1%
Deciduous Forest	108 sq mi	280 sq km	7.2%
Evergreen Forest	21 sq mi	54 sq km	1.4%
Mixed Forest	9.0 sq mi	23 sq km	0.6%
Shrub/Scrub	11 sq mi	29 sq km	0.8%
Grassland/Herbaceous	4.1 sq mi	11 sq km	0.3%
Pasture/Hay	51 sq mi	131 sq km	3.4%
Cultivated Crops	35 sq mi	89 sq km	2.3%
Woody Wetlands	20 sq mi	51 sq km	1.3%
Emergent Herbaceous Wetlands	4.0 sq mi	10 sq km	0.3%

* Sq km = square kilometers; Sq mi = square miles.

* Row colors correspond with Figure 16, Figure 18, Figure 20, and Figure 22.

Of the land cover areas classified as "Developed," the Open Space regions appear to have the most exposure, about 15 sq mi (38 sq km), or 1.0% of the site 6 ZTV. Approximately 1.8% of the total ZTV for hypothetical site 6 is considered "Developed." Deciduous Forests (7.2% of ZTV), Pasture/Hay (3.4% of ZTV), Cultivated Crops (2.3% of ZTV), Evergreen Forests (1.4% of ZTV), and Woody Wetlands (1.3% of ZTV) are the next most prominent land cover types within the site 6 ZTV behind Open Water and Unclassified.

5 Insights from Viewshed Analyses

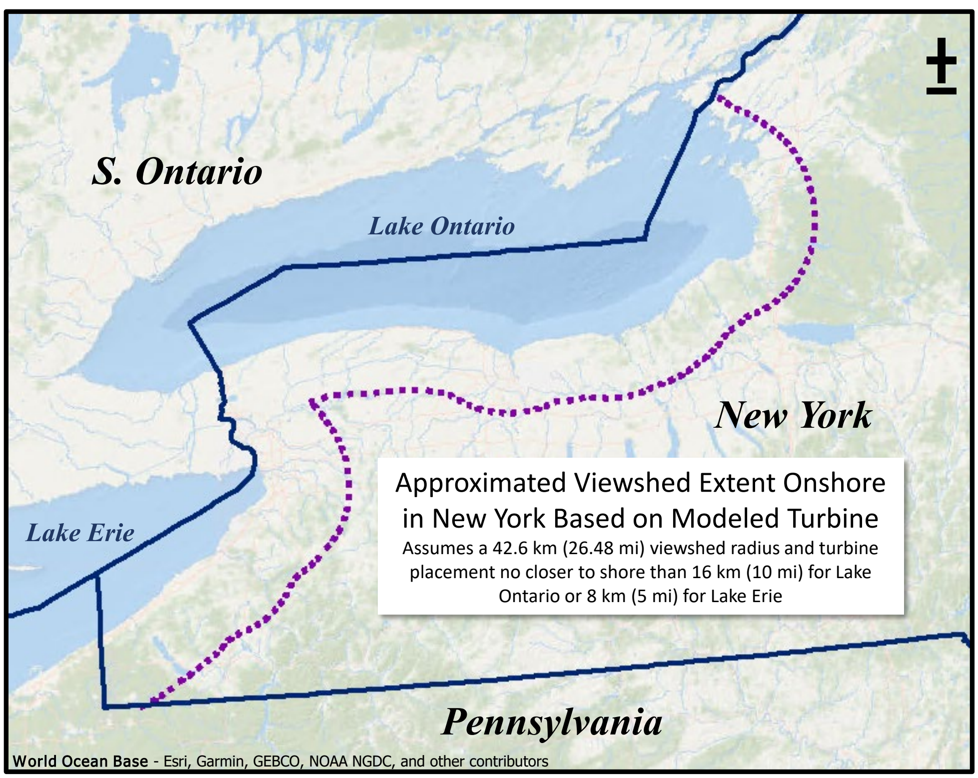
Reviewing the results of the viewshed analyses for the six hypothetical sites described herein provides insights regarding the expected extents of future studies, consideration for areas that may be visually sensitive, and serves as a reminder of important issues faced in other similar projects.

5.1 General Extent of Visibility Investigation

The parameters of the modeled turbine defined in this study yield an estimated viewshed radius of ~26.48 mi (42.6 km). Assuming turbines are placed within Lake Ontario at a minimum distance of 10 mi (16 km) from shore, or a minimum of 5 mi (8 km) in Lake Erie, it is possible to get an idea of the general coverage a VIA might need to investigate for proposed projects. Figure 24 illustrates a generalized approximation of consolidated viewshed limits for turbine placements in both Lakes that meet the minimum standoff from shore.

Figure 24. Approximation of Consolidated Viewshed Extents Onshore into New York State—Based on Modeled Turbine (GE Cypress 6.0-164) and Viewshed Parameters

Assumes turbine placement is minimum of 10 mi (16 km) from shore in Lake Ontario and minimum of 5 mi (8 km) in Lake Erie.



This approximation is not an evaluation of potential visibility, as would be defined by the ZTV resulting from the viewshed calculations. Rather, the dashed line represents a composite of the approximate onshore limit of visual impact investigations based on the defined turbine and viewshed parameters presented herein. If turbines are placed farther into the lake, an increased distance from the shoreline, then the viewshed limits are expected to adjust accordingly thereby reducing the land portion that is covered within the viewshed extents.

5.2 Sensitive Areas within the General Extent of Potential Visibility

Areas that may be visually sensitive to development in the Great Lakes encompass a broad range of sites, from those of historic significance to those of recreational or aesthetic significance. Trails, scenic roads/highways, primary recreational boating areas, overlooks, parks, and other sites may be sensitive to changes in the view. Views from private facilities such as hotels, restaurants, and residential areas may also be important to consider. These sensitive areas may extend beyond the borders of New York State.

Input from the public and relevant stakeholders can be considered when conducting detailed VIA(s) on any proposed development as an aid for identifying the appropriate locally significant and sensitive areas and in selection of key observation points.

5.2.1 National Register of Historic Places

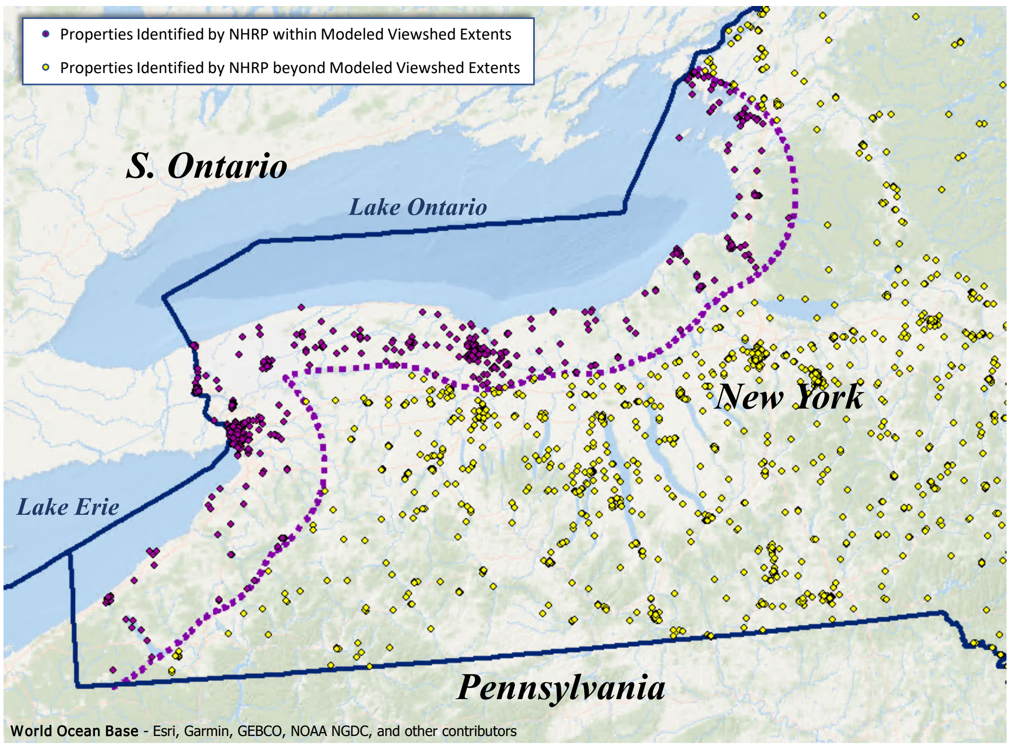
Historic resources within New York State are potential visually sensitive areas that would be investigated in a detailed VIA for a proposed project. Based on the records available from the New York State Historic Preservation Office (SHPO), the National Register of Historic Places (NRHP) has 6,241 resources of historic significance within the entirety of the State (NY SHPO 2021). Of those, 753 appear to fall within the approximated consolidated viewshed extent surrounding Lake Erie and Lake Ontario (Figure 24 and Figure 25). The NRHP records do not include resources that may be eligible for recognition, only those that are already recognized with that status.

NRHP sites found to be of interest for VIA consideration will depend on the proposed Great Lakes Wind development plan and location, as well as the modeling parameters selected for viewshed calculations. Verification of visibility, or obstruction to views, for NRHP resources within the viewshed of a proposed project area can be investigated and considered in the evaluation of visual impact as part of a detailed VIA. Site visits and visual simulations may be conducted if an NRHP resource location is identified as a key observation point within a specified viewshed for a proposed development.

Figure 25. National Register of Historic Properties within New York State Relative to the Approximated Consolidated Viewshed Extent

Based on Modeled Turbine (GE Cypress 6.0-164) and Viewshed Parameters

Source: (NY SHPO 2021)



5.2.2 Potential Visibility Beyond New York State

Visual impact from any selected site, assuming comparable turbine dimensions as modeled, will extend beyond NYS borders, with visibility predicted to extend into the neighboring State of Pennsylvania (as modeled at Lake Erie West site 1) and across the international boundary into the province of South Ontario, Canada (as noted at all modeled sites). Proposed offshore wind development within the Great Lakes may benefit from close collaboration with regulatory agencies and stakeholders from these neighboring regions in order to minimize and appropriately mitigate visual impacts.

5.3 Challenges Noted from Offshore and Great Lakes Wind Projects

As detailed in the New York State Greatlakes Wind Energy Feasibility Study: State and Federal Permitting Roadmap (NYSERDA, 22-12k) Federal, State, and Utility Permitting Roadmap and Study and the Relative Risks, Minimization/Mitigation, and Benefits component of the Great Lakes Wind Feasibility Study (NYSERDA 2022i), previously proposed offshore wind projects faced significant challenges to permitting, including issues related to visual impact. In those cases, the general perception was that the value of properties with visibility of the turbines and the intrinsic value of the proposed site itself would be compromised in the event that turbines were constructed.

The Cape Wind project, for example, located off the coast of Massachusetts in Nantucket Sound faced significant legal challenges from local residents. Despite receiving the necessary State and local pre-construction permits, these lawsuits exhausted Cape Wind's capacity to continue development and the project was cancelled.

The Icebreaker Wind project in Ohio State waters of Lake Erie is currently navigating the legal system. Most recently, two condominium owners with lakeview homes filed a lawsuit to block the construction of the project due to issues including viewshed concerns (Kowalski 2021). For reference, the VIA of the Icebreaker Wind project evaluated six sited turbines with a total height (from the water surface to the rotor hub) of 479 ft (146 m). When considering high-resolution LiDAR elevation data and the screening effects of buildings and vegetation, the study found that the proposed turbines would likely be seen by 92.8% of the 10 mi (16 km) study area, most of which is open water. Approximately 5.4% of the landward study area was predicted to have visibility of the turbine hubs. Where visible, the turbines would be seen near the horizon, sited 8 to 10 mi (12.9 to 16 km) from shore (Environmental Design & Research, Landscape Architecture, Engineering & Environmental Services, D.P.C. (EDR) 2017). The Icebreaker Wind project is currently on hold until the lawsuits are fully settled with the Ohio Supreme Court (Kowalski 2021).

6 Considerations

If the New York State chooses to pursue wind development in the Great Lakes, the following steps should be considered once a site or potential sites are selected:

- Conduct a detailed and site-specific assessment of the viewshed and visual impacts based on the details of the planned development. Such a study could take into consideration the specific turbine model dimensions, the wind farm layout and turbine placement, and utilize high-resolution elevation and surface model data, as well as land-use data specific for the localized area of potential visibility.
- Determine key observation points within the ZTV based on the detailed viewshed assessment conducted for the site-specific development plan. Locations defined as key observation points may affect assessment outcomes.
- Depending on the location and layout of proposed wind projects in Lake Ontario or Lake Erie, additional assessment may be required to address visual impacts to regions beyond New York State, including potential international collaboration with Canada.
- Visual simulations, generated specifically to represent views from key observation points, can be prepared to help visualize how the proposed windfarm may affect the view. Simulations representing typical meteorological conditions for different seasons and times of day are highly recommended. This portion of evaluation will require site visits to select key observation points, possibly over multiple days or during different times of the year, in order to photographically capture the viewing area(s) appropriately.
- The viewshed calculations and visual simulations can be referenced together to gain additional insight for evaluating viewer activities, sensitivity levels, preferences, and concerns. An additional assessment can evaluate who (in a general sense) the potential observers at the various key observation points might be, what activities they engage in at the site where visibility may be possible, what value they place on the view, and what perception they have of offshore wind projects. This type of study requires public outreach and communication to understand the unique visual qualities of key sites and what changes an offshore wind generation facility might introduce to the aesthetic and experiential qualities of the area.
- Proposed wind development in the Great Lakes may require submission of an EA or an Environmental Impact Statement (EIS), per guidelines established in the National Environmental Policy Act. A VIA is typically part of an EIS, particularly for large-scale energy generation and transport facilities (Sullivan and Meyer 2014). Depending on the areas within the proposed project site viewshed(s), it may be also required that a separate visual effects assessment for historical properties be prepared, following the requirements of Section 106 of the National Historic Preservation Act (National Park Service 2012).

- Radar and aviation interference studies may be necessary to evaluate potential interference with radar and air traffic from the installation and operation of wind turbines.
- In its OCS Study BOEM 2021-032, Assessment of Seascape, Landscape, and Visual Impacts of Offshore Wind Energy Developments on the Outer Continental Shelf of the Unites States, BOEM offers guidance on the methodology for conducting detailed VIAs, which could be applied to Great Lakes Wind in the absence of any other superseding regulatory guidance (R. G. Sullivan 2021).

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