



Examining the Effects of a Potential Wind Turbine Facility on the Viewshed of Assateague Island National Seashore

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Photo taken by Andrew Roach



Project Introduction

- A formal proposal to build a wind farm facility off the coast of ASIS* has yet to be accepted or seriously considered. However:
 - Wind farm facilities off the coast of Maryland have been discussed in local government meetings.
 - An off-shore wind farm facility is currently proposed for the coast of Delaware, ~30 miles north of ASIS.
(see <http://www.bluewaterwind.com>)
 - As energy costs continue to increase, so will the interest in wind power. In the mid-Atlantic region, this means off-shore wind power.

* ASIS is the abbreviation of Assateague Island National Seashore.



Project Introduction (cont.)

- As a result, ASIS has taken a pro-active approach in preparing for a wind turbine facility proposal. This approach includes investigating and preparing the following products:
 - Information about off-shore turbine placement
 - Determining average visibility conditions
 - Viewshed analysis
 - Photo simulations/visualizations



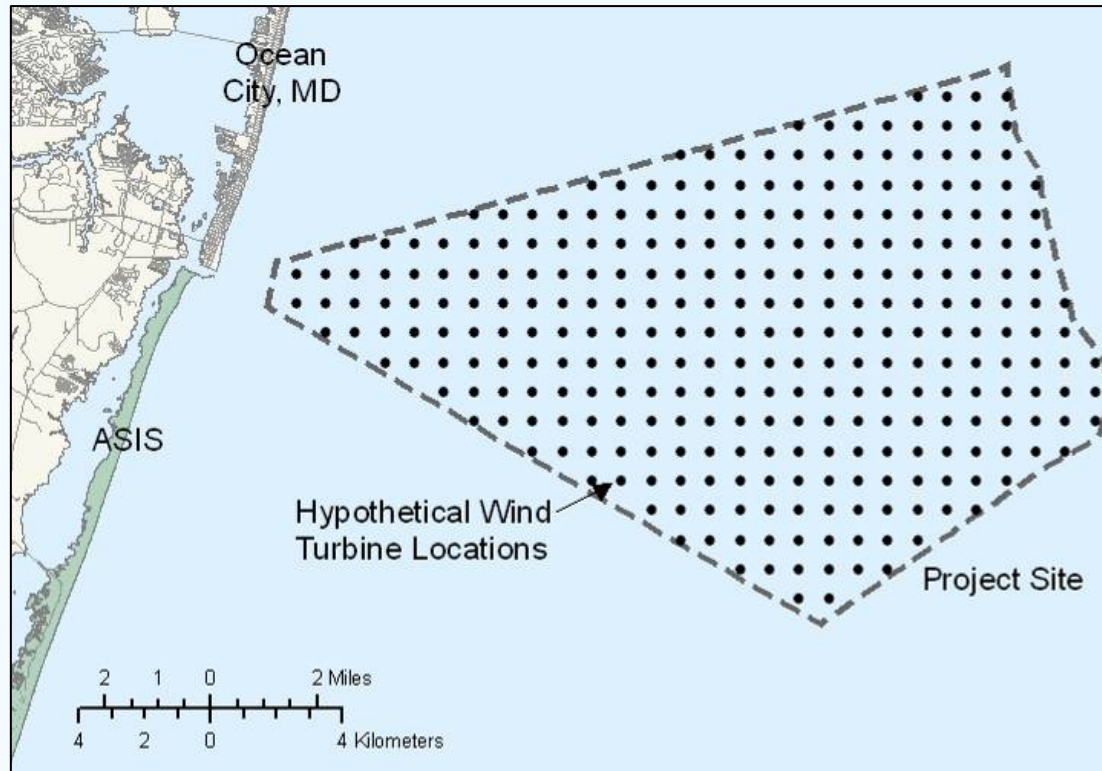
Hypothetical Project Site



Because no formal proposals for this area have been submitted, a hypothetical project site was created in order to test the assembled data and applications.



Hypothetical Project Site (cont.)



The hypothetical project site initiates at 1 mile off-shore of the Ocean City Inlet, and each border extends into the ocean at a 45° angle, terminating at the 20m bathymetric contour line. Turbines were placed within the project extent at 1 kilometer spacing, to accommodate the turbine rotors.



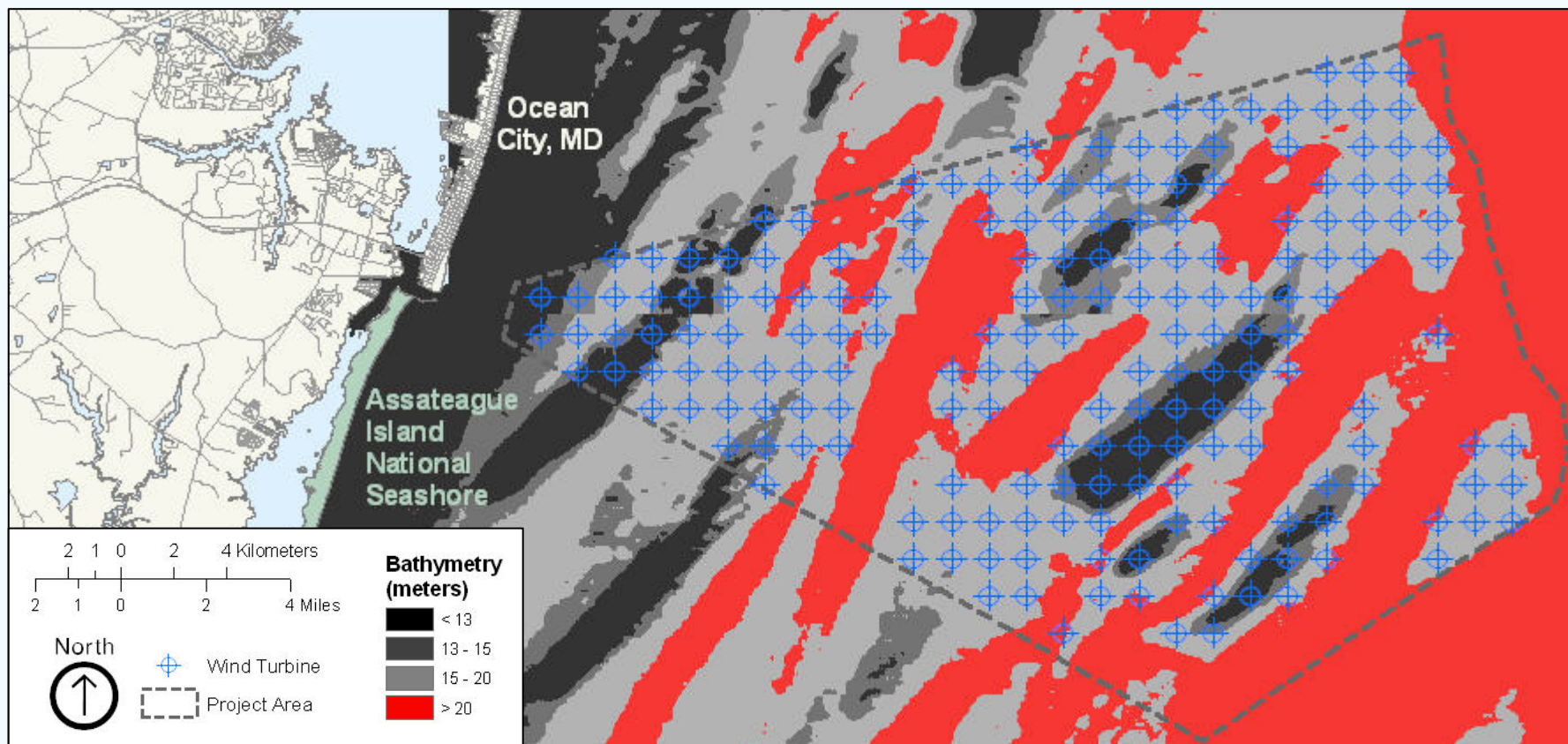
Information about off-shore turbine placement

- Bathymetry
 - According to a working group out of the University of Delaware, most commercial wind turbines cannot be constructed in depths below 20 meters.
 - Depending on the model proposed, bathymetry will play a role in turbine locations.
 - Off-shore bathymetry data is freely available through a NOAA website, but the most recent data available is from the 1970's.



Information about off-shore turbine placement

- Bathymetry (cont.)

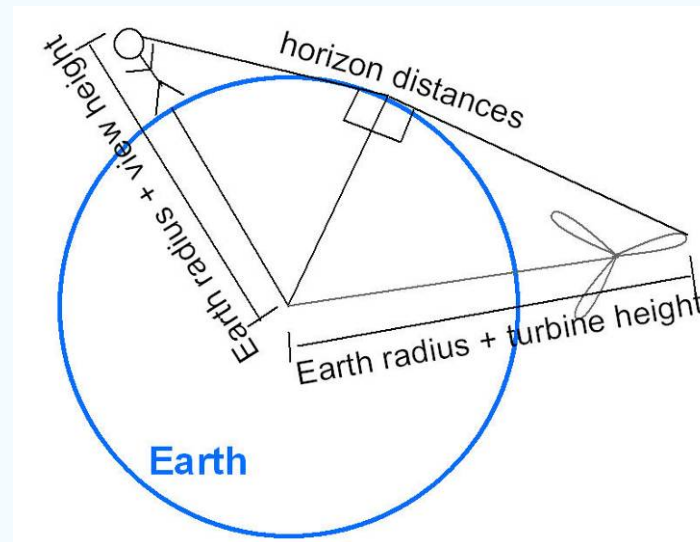


For our hypothetical project area, we limited turbine locations to areas with depths fewer than 20 meters (66 feet).



Information about off-shore turbine placement

- Calculating horizon distances
 - Because there is a finite distance one can see over the ocean, horizon distances were calculated using the Pythagorean Theorem and the radius of the Earth.





Information about off-shore turbine placement

- Calculating horizon distances (cont.)
 - Minimum distances were calculated for wind turbines to be completely out of sight for a visitor standing at beach and dune elevations on Assateague Island.

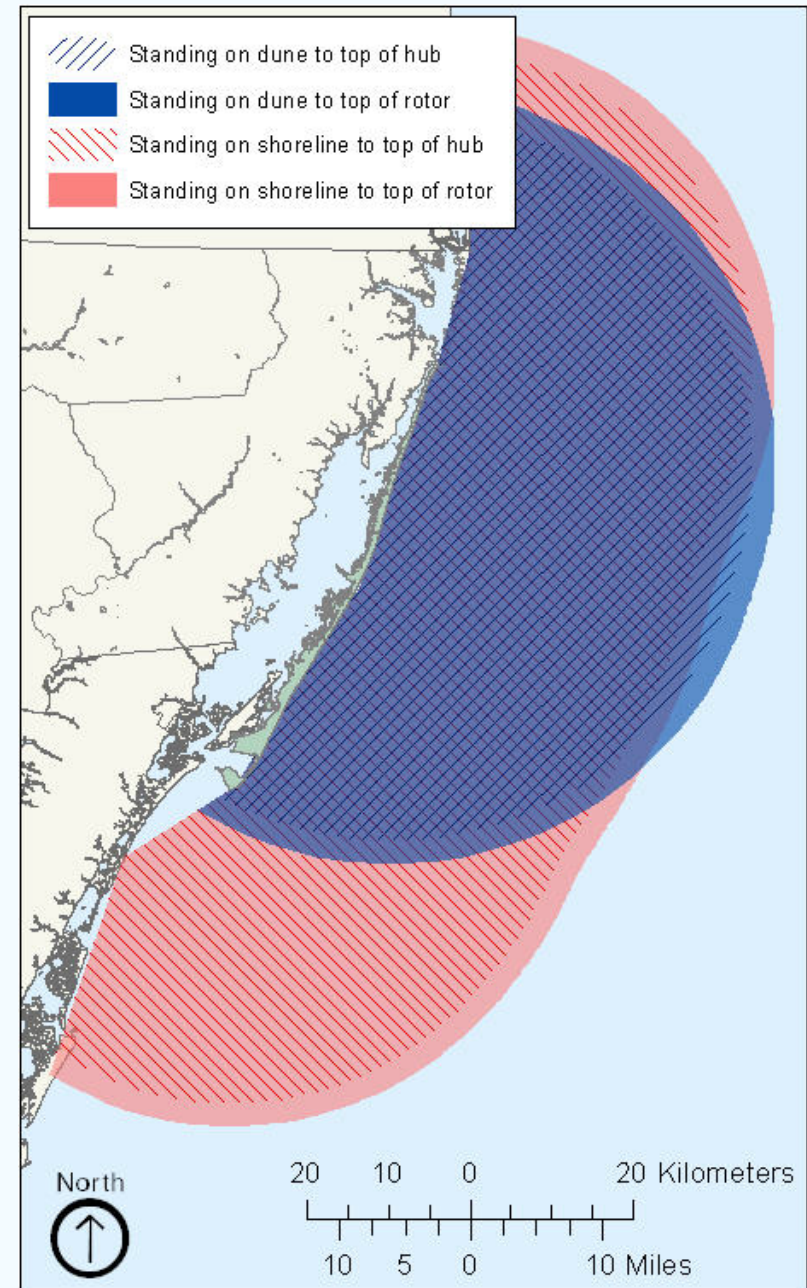


Observer	Turbine hub $h_{\text{turbine}} = 91.4\text{m (300 ft)}$	Turbine rotor $h_{\text{turbine}} = 106.7\text{m (350 ft)}$
5'6" person on beach $h = 1.67$ meters	38.7 km 24.0 miles	41.5 km 25.8 miles
5'6" person on dune $h = 6.92$ meters	43.5 km 27.0 miles	46.3 km 28.8 miles



Information about off-shore turbine placement

- **Calculating horizon distances (cont.)**
 - These distances can be portrayed on a map, and show areas where turbines would be visible from ASIS under ideal visibility conditions.

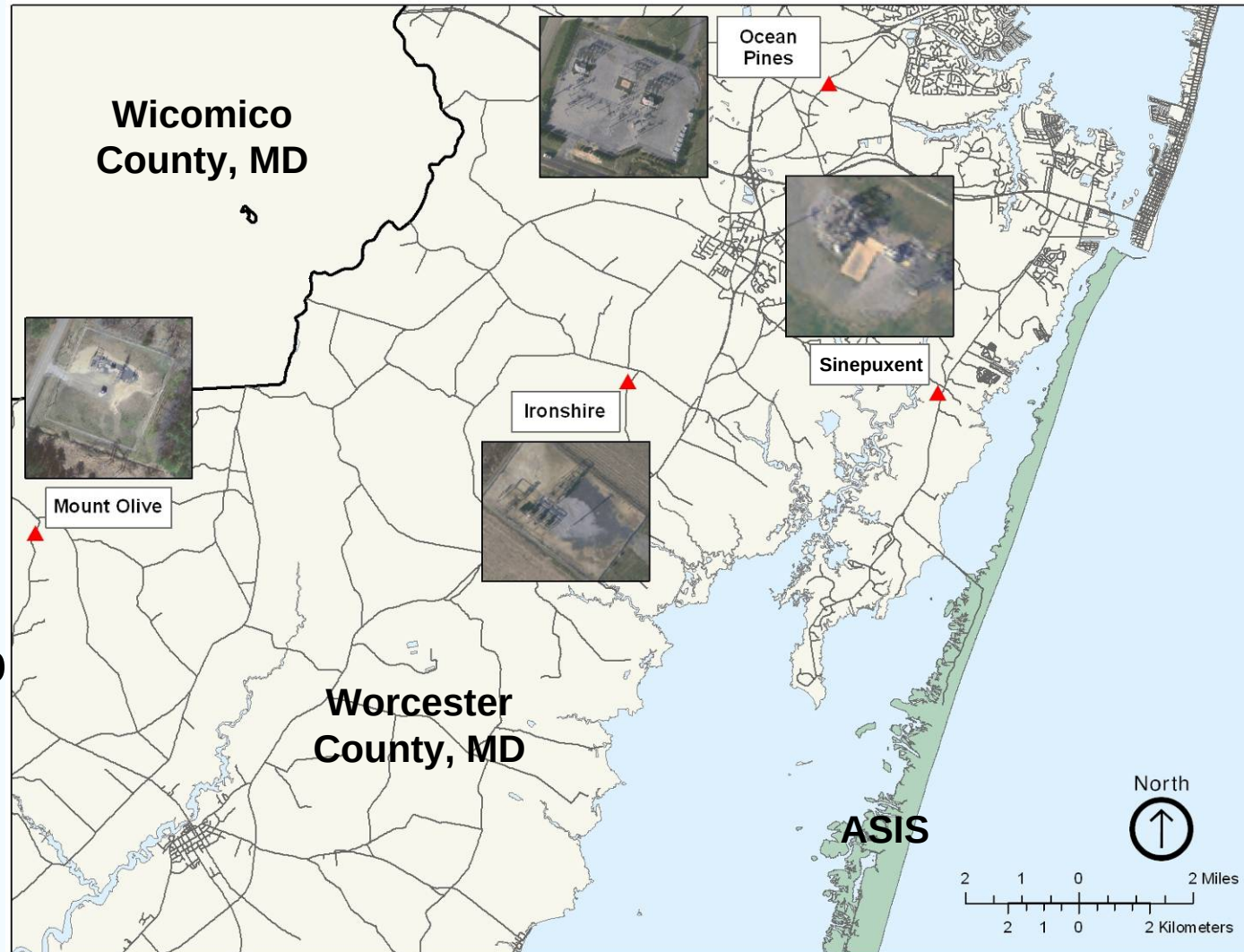




Information about off-shore turbine placement

Electrical sub-station locations

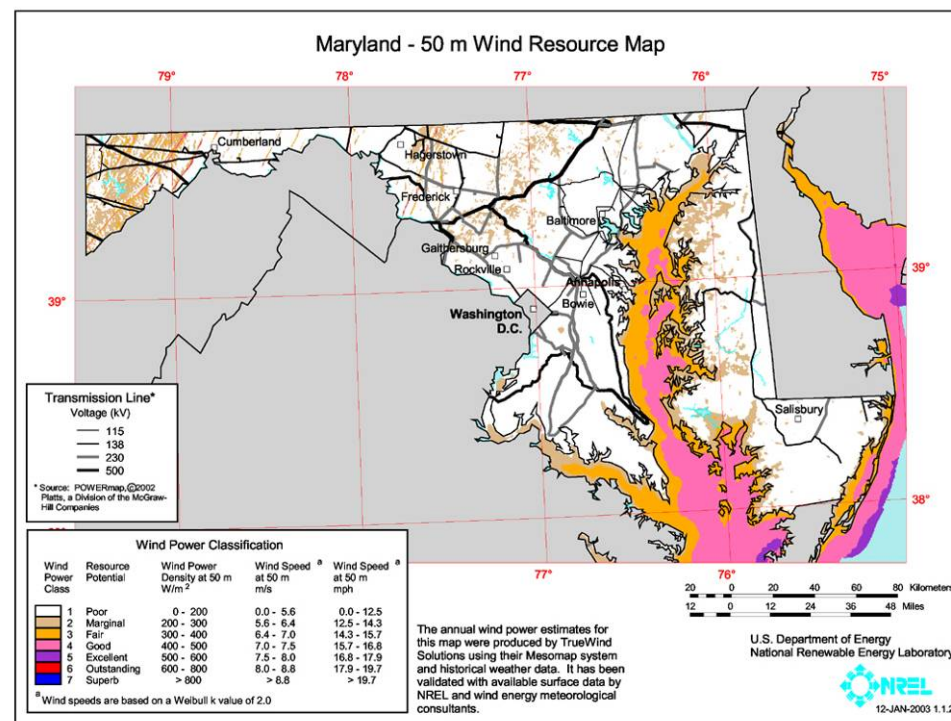
In an effort to reduce costs, wind turbine facility locations may depend on their proximity to electrical sub-stations.





Information about off-shore turbine placement

- Wind speed maps
 - Freely available from National Renewable Energy Laboratory website (www.nrel.gov)
 - Contain poor coverage of off-shore areas.





Determining ASIS Visibility Conditions

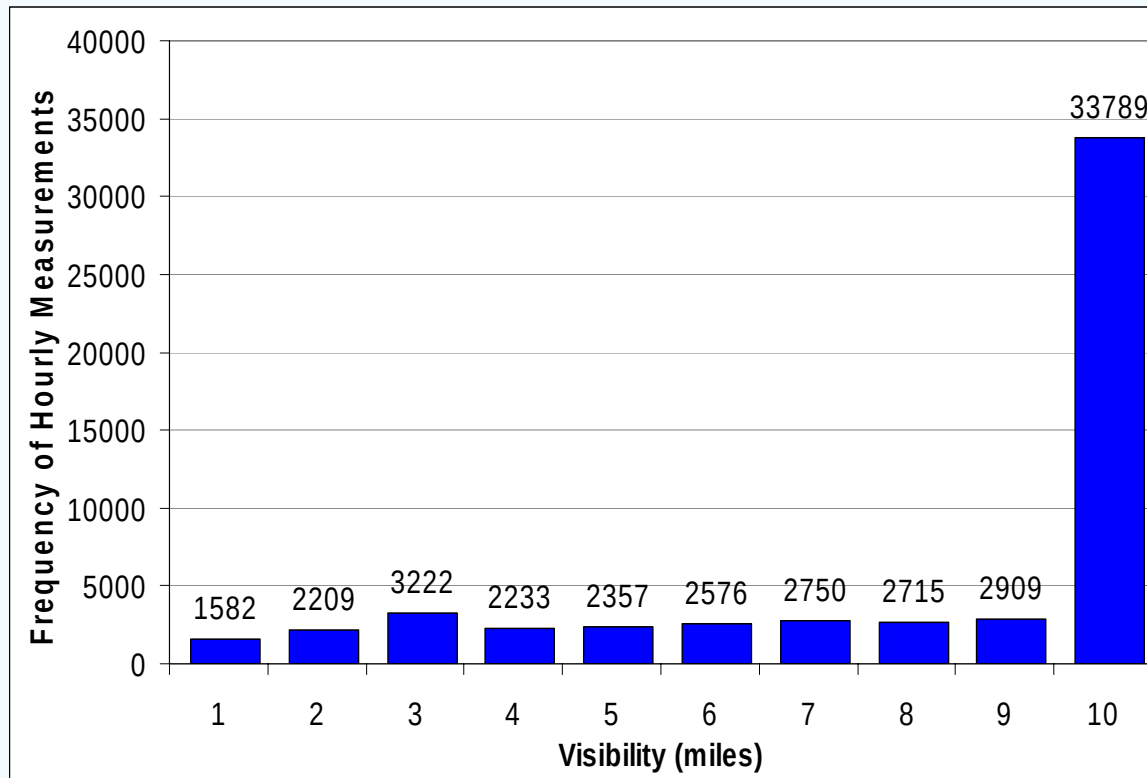
Hourly visibility measurements are recorded at the Ocean City Municipal Airport, (located in close proximity to ASIS).

This data is archived and distributed through the National Climatic Data Center (www.ncdc.noaa.gov), and is freely available by download to federal users.





Frequency of Hourly Visibility Measurements, Collected at Ocean City Airport From Jan. 1, 2001 - Dec. 31, 2006

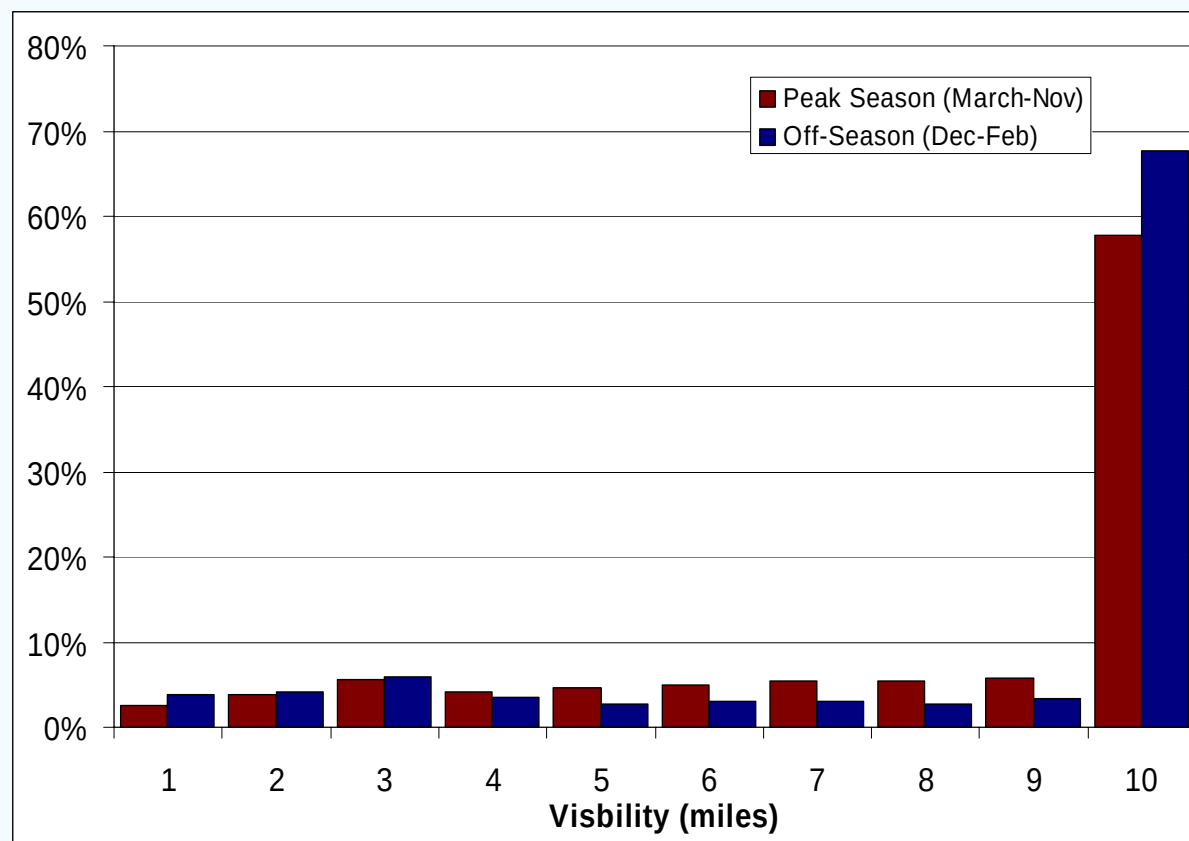


For this project, the wind turbine located closest to the ASIS North Day-Use Beach is about 8 miles away. As a result, **at least one turbine is visible 70% of the time** (visibility within 8-10 miles), and **the turbines would not be visible from this location 30% of the time** (visibility within 0-7 miles).

- Data from National Climatic Data Center (NCDC): Prevailing Surface Visibility is reported in statute miles & fractions, derived from sensors at the Ocean City Municipal Airport. Max reported visibility is 10 statute miles. Reported as variable, as prevailing visibility varies by 1/2 mile or more when the average visibility is less than 3 miles.
- In this graph, each column contains the frequency of measurements equal to or less than the visibility value below each bar and values greater than the previous value. For example, the first bar contains values ranging from 0.0 to 1.0 miles, the next bar contains values ranging from 1.1 to 2.0 miles, etc. (The only exception is for the measurements portrayed at 9 miles, which are made up entirely of a value of 9.1 miles.)



Percentage of Hourly Visibility Measurements, During the Peak and Off Seasons Collected at Ocean City Airport From Jan. 1, 2001 - Dec. 31, 2006

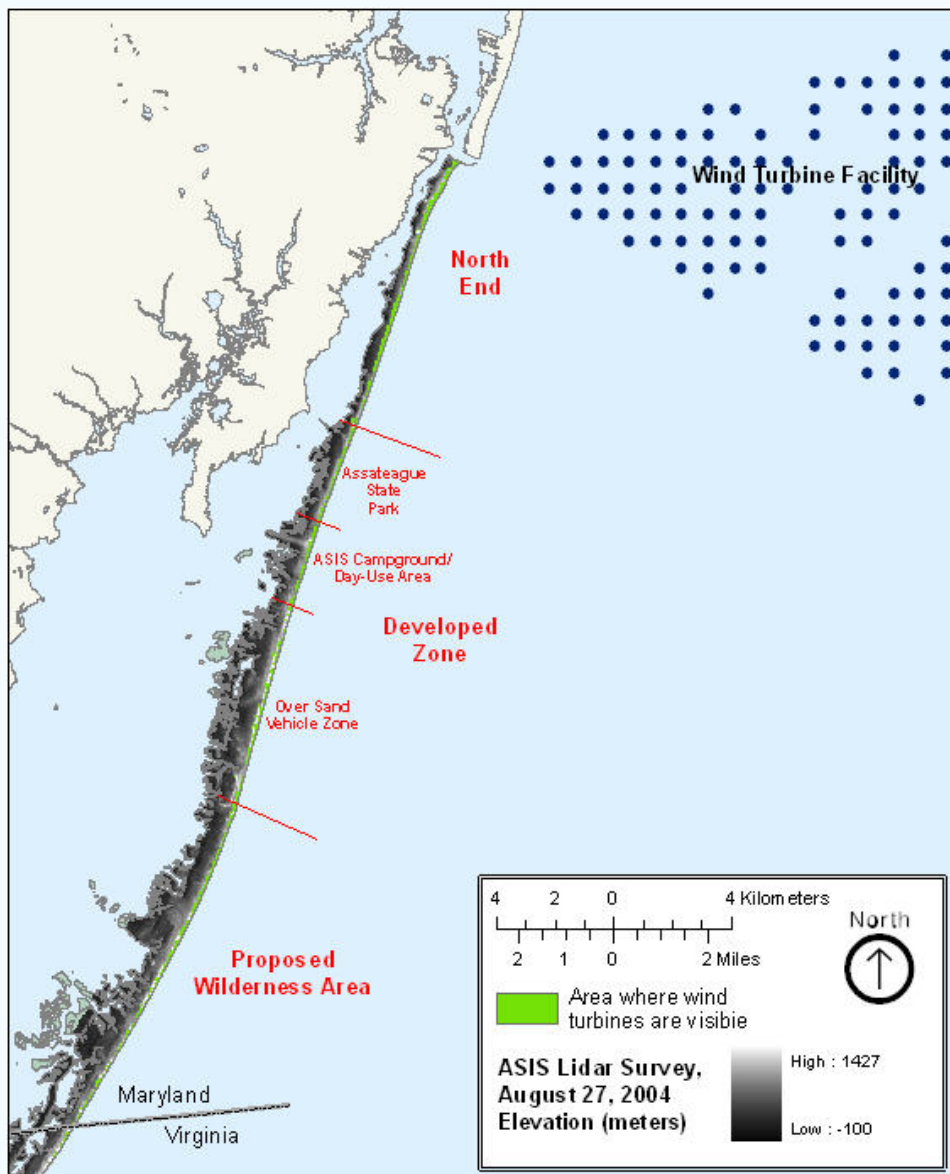


In this example, the wind turbine located closest to the ASIS North Day-Use Beach is about 8 miles away. As a result, at least one turbine is visible 70% of the time (visibility within 8-10 miles) during the peak visitor season and 74% of the time during the off-season.

- Data from National Climatic Data Center (NCDC): Prevailing Surface Visibility is reported in statute miles & fractions, derived from sensors at the Ocean City Municipal Airport. Max reported visibility is 10 statute miles. Reported as variable, as prevailing visibility varies by 1/2 mile or more when the average visibility is less than 3 miles.
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Viewshed Analysis



Using recent lidar elevation data and tools available in ArcGIS Spatial Analyst, specific areas on Assateague Island can be quantified where the wind turbines would be visible.



Photo Simulations/Visualizations

- The software package WindPro* was utilized to create photo simulations of what a visitor would see at various locations along Assateague Island.
- The photomontage module within the WindPro software provides tools to insert wind turbine models into a digital photograph.



Original Photograph



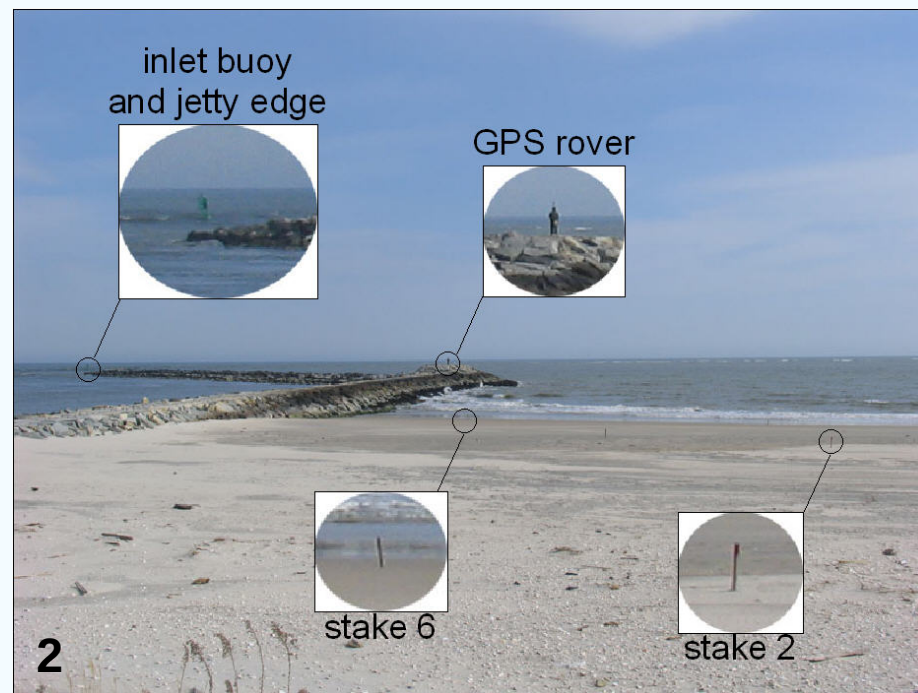
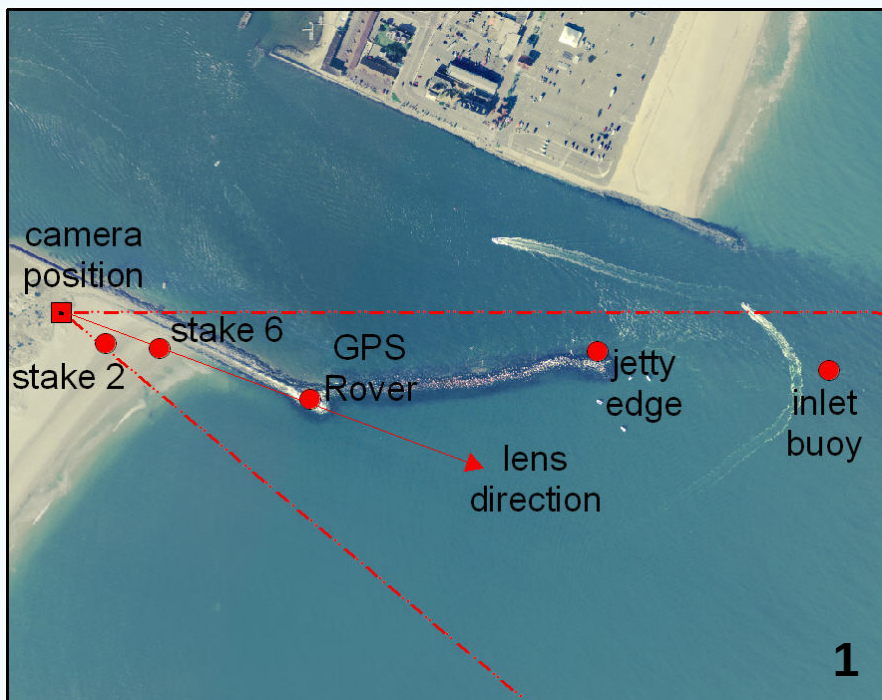
WindPro Visualization

* The WindPro website address is: <http://www.emd.dk/WindPRO/Frontpage>



Photo Simulations/Visualizations

How it works...

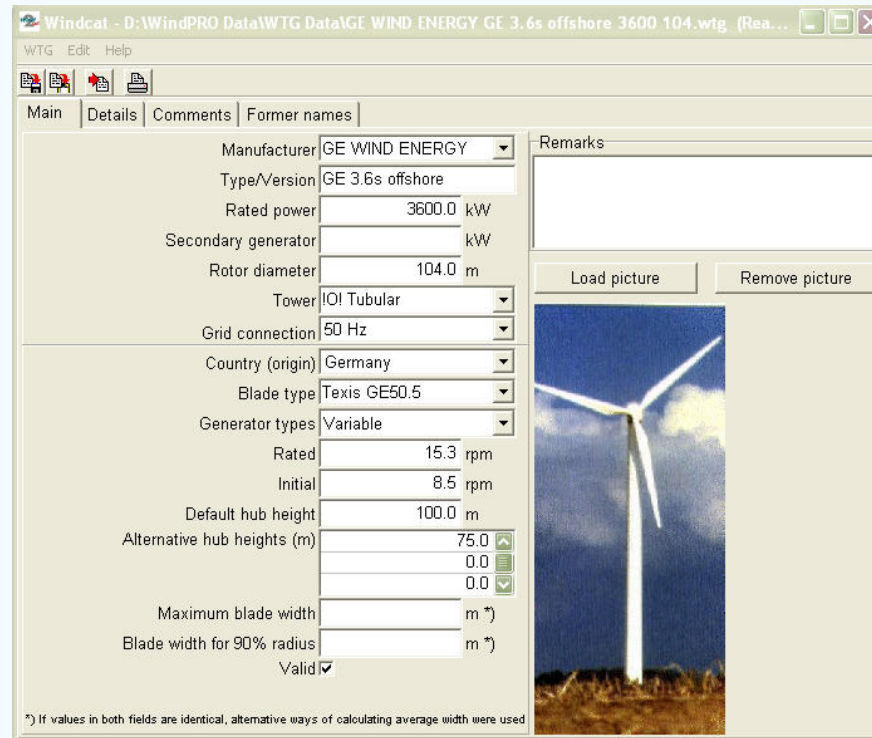


- 1) A digital camera is set up on a leveled tripod and a survey-grade GPS is used to collect the camera position, and features that can be used as ground control in the digital photograph. Information required by the software is also recorded at this time, such as focal length, lens direction, wind direction, weather conditions, and general visibility.
- 2) The image is loaded into the WindPro software, along the camera information and coordinates and elevation measurements for each ground control point.



Photo Simulations/Visualizations

How it works...



3) The coordinates of the proposed wind turbines are loaded into the software, and a specific wind turbine model is chosen. The turbine models are then digitally placed into the digital photograph, using the camera model and control points.



Photo Simulations/Visualizations Results

Pictures were taken at two locations on ASIS:

- 1) Near the Ocean City Inlet, in close proximity to the hypothetical wind turbine facility.

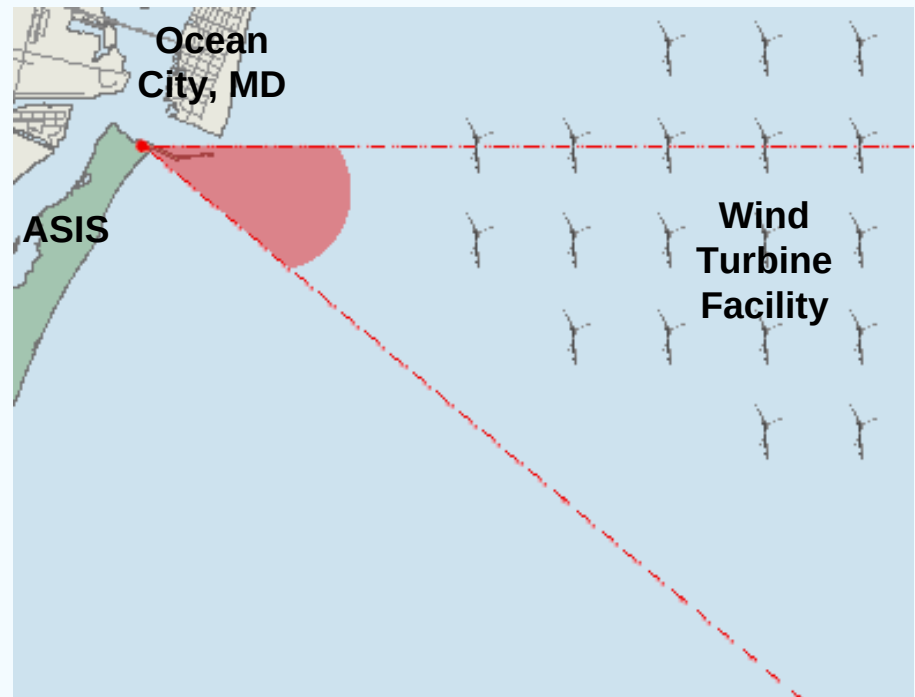




Photo Simulations/Visualizations

Results - Ocean City Inlet Photo Simulation





Photo Simulations/Visualizations Results

Pictures were taken at two locations on ASIS:

- 2) At the ASIS North Day-Use Beach, which is a common destination for visitors.

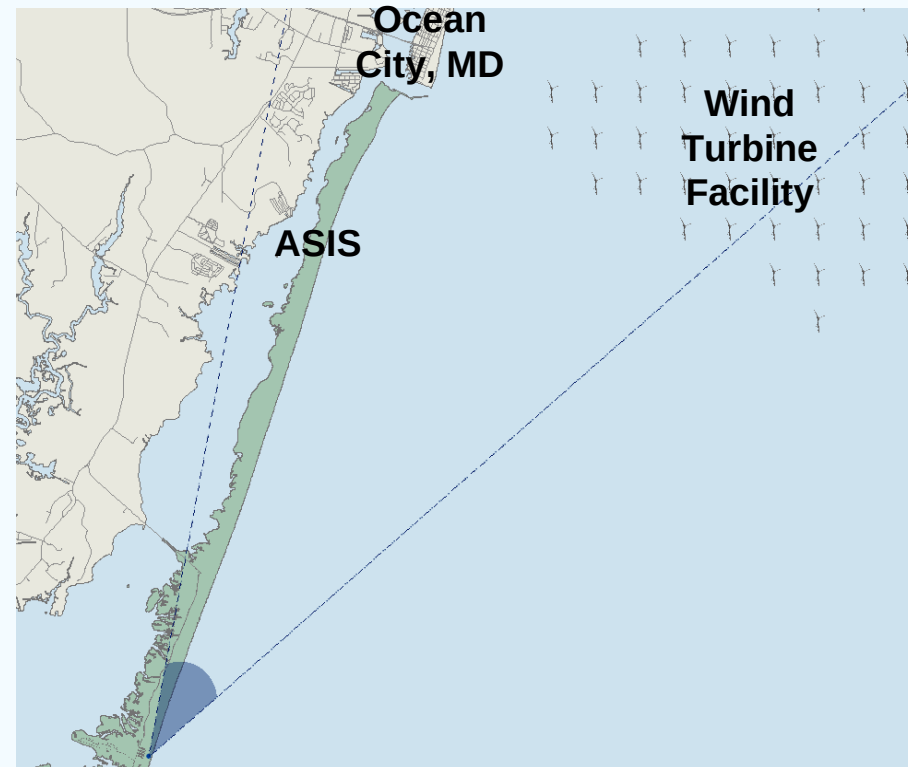




Photo Simulations/Visualizations Results – ASIS North Day-Use Beach





Acknowledgements

- Carl Zimmerman, ASIS Resource Management Division Chief.
 - Andrew Roach, ASIS Resource Management GIS.
- Worcester County, MD electrical sub-station locations were provided by Jon Swann of the Choptank Electric Cooperative.
- Visibility data was obtained from NCDC, with some initial guidance from George Goodrow, the Airport Manager at Ocean City Municipal Airport.
- Lidar data is provided through a partnership between NPS, USGS, and NASA.
 - Information about calculating horizon distances, and a value for the earth's radius, was found on the website of Dr. Steve Sque, of the University of Exeter: <http://newton.ex.ac.uk/research/qsystems/people/sque/physics/horizon/>
- Please contact Arthur Rodriguez, ASIS Resource Management GIS, with any questions or comments –
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