

Appendix II-K3

Radar Impact Evaluation



US WIND OFFSHORE WIND PROJECT
RADAR AND NAVIGATIONAL AID SCREENING STUDY
OCTOBER 9, 2021

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INTRODUCTION

The US Wind Offshore Wind Project consists of 125 proposed wind turbines off the coasts of Delaware and Maryland.¹ This report provides the results of a radar and navigational aid screening study conducted by Westslope Consulting, LLC (Westslope) for the proposed wind turbines and a Lease Area encompassing the proposed wind turbines using blade-tip heights of 817 feet above mean sea level (MSL) and 938 feet MSL.²

This study includes the following:

- An initial analysis using the Department of Defense (DoD) Preliminary Screening Tool (PST);
- Research into other radar sites and Very High Frequency Omnidirectional Range (VOR) navigational aid sites near the proposed wind turbines;
- An Air Route Surveillance Radar (ARSR) and Airport Surveillance Radar (ASR) line-of-sight (LOS) analysis;
- An Advanced Dynamic Aircraft Measurement System (ADAMS) screening analysis;
- A VOR screening analysis;
- A Next Generation Radar (NEXRAD) weather radar screening analysis; and
- A coastal High Frequency (HF) radar LOS analysis.

ANALYSIS

DoD Preliminary Screening Tool

Westslope conducted an initial analysis for Long Range Radar (LRR) and NEXRAD using the DoD PST on the Federal Aviation Administration (FAA) Obstruction Evaluation/Airport Airspace Analysis website.³ This analysis provides a cursory indication of whether wind turbines may be within line-of-sight of one or more radar sites, and likely to affect radar performance.

The PST LRR analysis accounts for ARSR sites and ASR sites used for air defense by the DoD at the North American Aerospace Defense Command and for homeland security by the Customs and Border Protection Air and Marine Operations Center.⁴ Further, the PST NEXRAD analysis accounts for DoD, FAA, and National Oceanic and Atmospheric Administration (NOAA) Weather Surveillance Radar model-88 Doppler (WSR-88D) sites.⁵ The PST does not account for all DoD, Department of Homeland Security (DHS), or FAA ground-based radar sites, including Relocatable Over-the-Horizon Radar sites, tethered aerostat radar sites, or FAA Terminal Doppler Weather Radar sites.

¹ WTG-Locations_20210623.shp.

² MD-Lease-Area_20210623.shp.

³ See <http://oeaaa.faa.gov>.

⁴ For LRR, the PST uses a buffered line-of-sight analysis at a blade-tip height of 750 feet AGL.

⁵ For NEXRAD, the PST uses a blade-tip height of 160 meters AGL (525 feet AGL).

The PST is helpful for identifying potential impacts to LRR and NEXRAD; however, the results are preliminary, as suggested by the title of the PST, and do not provide an official decision as to whether impacts are acceptable to operations.

Please note that the PST NEXRAD analysis does not account for blade-tip heights greater than 525 feet AGL, does not account for WSR-88D sites authorized to scan at elevation angles below 0.5 degrees, and does not reflect the wind farm impact zone scheme updated in 2018 by the NOAA WSR-88D Radar Operations Center (ROC). The updated scheme expands the red area, or “No Build Zone,” from three to four kilometers (km) and to areas where wind turbines penetrate the third elevation angle scanned by a WSR-88D.

Based on the Lease Area, Westslope created a single point and a four-point polygon for PST analysis purposes.

The PST analysis results for LRR show that the single point falls within a green area. A green area indicates no anticipated impacts to air defense and homeland security radar. Please note that blue and grey areas also represent green areas in the PST LRR analysis results. Further, the PST analysis results for the polygon show that the proposed wind turbines fall within green and yellow areas. A yellow area indicates that impacts are likely to air defense and homeland security radar. See Figure 1, where the black rotor represents the single point, the black line represents the polygon, the black dots represent the 125 proposed wind turbines, and the red line represents the Lease Area.

Westslope identified the closest six radar sites in the PST LRR results as the Atlantic City Airport Surveillance Radar model-9 (ASR-9), Dover Air Force Base (AFB) Digital Airport Surveillance Radar (DASR), Gibbsboro Air Route Surveillance Radar model-4 (ARSR-4), Naval Air Station (NAS) Patuxent River Airport Surveillance Radar model-11 (ASR-11), Oceana ARSR-4, and the Wallops Island Airport Surveillance Radar model-8 (ASR-8). In addition to the DoD and DHS using these radar sites for air defense and homeland security, the DoD uses the Dover AFB DASR for air traffic control at the Dover AFB Radar Approach Control facility (RAPCON) and uses the NAS Patuxent River ASR-11 at the NAS Patuxent River Radar Air Traffic Control Facility (RATCF). The FAA uses the Atlantic City ASR-9, Gibbsboro ARSR-4, Oceana ARSR-4, and the Wallops Island ASR-8 for air traffic control at multiple facilities, including the Atlantic City Terminal Radar Approach Control (TRACON), New York Air Route Traffic Control Center (ARTCC), and the Washington ARTCC.

For NEXRAD, the PST analysis results for the single point and the polygon show that the proposed wind turbines fall within a green area. A green area, or “No Impact Zone,” indicates that impacts are not likely to WSR-88D operations. Please note that blue and grey areas also represent green areas in the PST NEXRAD analysis results. See Figure 2. Westslope identified the radar site in the PST NEXRAD analysis as the Dover AFB WSR-88D.

Research conducted by Westslope shows that the lowest elevation angle scanned by the Dover AFB WSR-88D is 0.5 degrees.

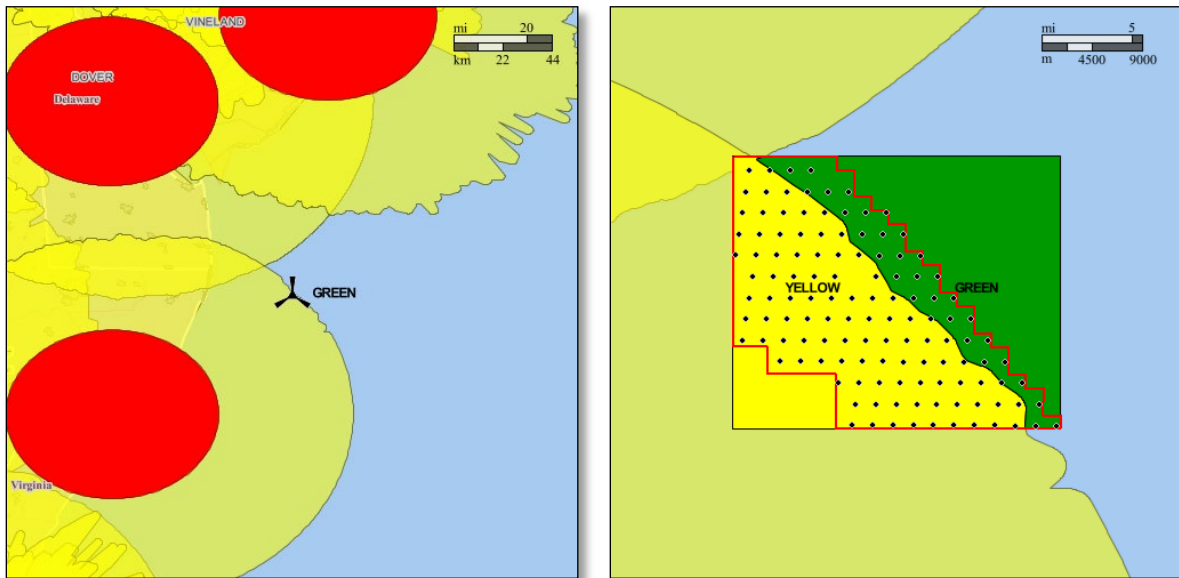


Figure 1 Long Range Radar Results for the Single Point (left) and for the Polygon (right)

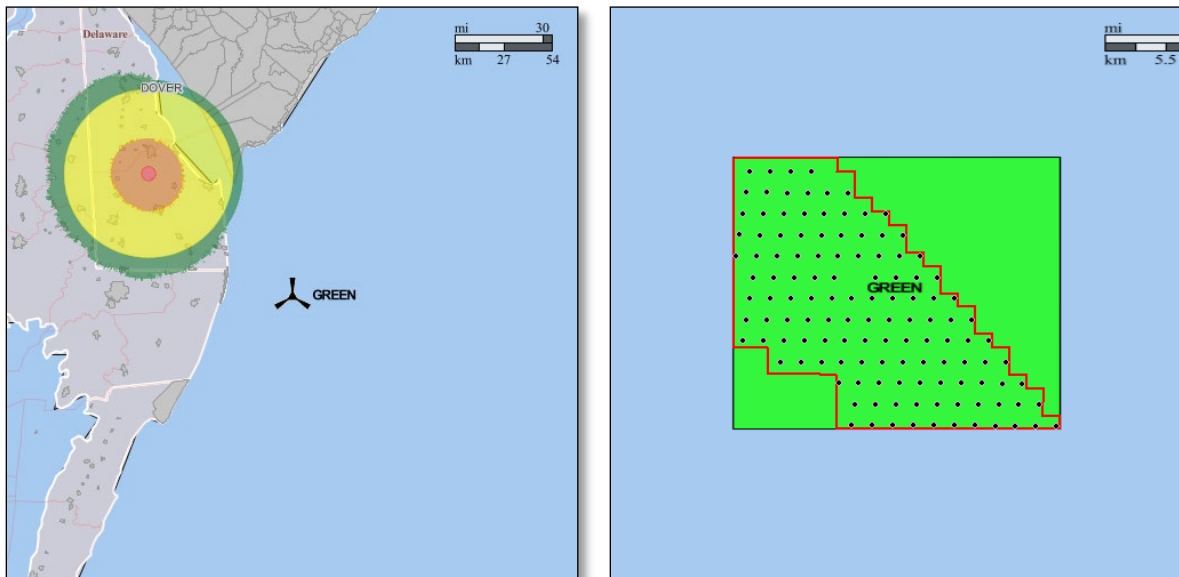


Figure 2 NEXRAD Results for the Single Point (left) and for the Polygon (right)

Other ARSR and ASR Sites

Research conducted by Westslope identified no additional ARSR or ASR sites near the proposed wind turbines.

Co-Located Secondary Surveillance Radar

Research conducted by Westslope identified the following secondary surveillance radar systems co-located with the ARSR and ASR systems:

- An Air Traffic Control Beacon Interrogator model-5 is co-located with the Atlantic City ASR-9;
- An Air Traffic Control Beacon Interrogator model-6 is co-located with the Gibbsboro ARSR-4 and the Oceana ARSR-4;
- An AN/UPX-27 is co-located with the Wallops Island ASR-8; and
- A Monopulse Secondary Surveillance Radar is co-located with the Dover AFB DASR and the NAS Patuxent River ASR-11.

In general, secondary surveillance radar systems are less susceptible to interference from wind turbines than primary surveillance radar systems, such as the ARSR and ASR systems.

ADAMS

Research conducted by Westslope identified the ADAMS radar facility near the proposed wind turbines.

The DoD uses the ADAMS at the Atlantic Test Range on the NAS Patuxent River for radar cross section measurements.

VOR Sites

Research conducted by Westslope identified the following three navigational aid sites near the proposed wind turbines:

- Salisbury VOR and co-located Tactical Air Navigation system (VORTAC);
- Snow Hill VORTAC; and
- Waterloo VOR and co-located Distance Measuring Equipment (VOR/DME).

Correspondence with the FAA indicates that these VORs are conventional VORs. In general, conventional VORs are more susceptible than Doppler VORs to interference from wind turbines.

Other NEXRAD Weather Radar Sites

Research conducted by Westslope identified the following two additional NEXRAD weather radar sites near the proposed wind turbines:

- Norfolk WSR-88D; and
- Philadelphia WSR-88D.

Research conducted by Westslope shows that the lowest elevation angle scanned by the Norfolk WSR-88D and the Philadelphia WSR-88D is 0.5 degrees.

HF Radar Sites

Research conducted by Westslope identified the following nine HF radar sites near the proposed wind turbines:

- Assateague Island HF radar;
- Brigantine Long Range HF radar;
- Cape Henlopen HF radar;
- Cape May Point HF radar;
- Cedar Island HF radar;
- Loveladies HF radar;
- North Wildwood HF radar;
- Strathmere HF radar; and
- Wildwood HF radar.

The Assateague Island HF radar and the Cedar Island HF radar are operated by Old Dominion University. The Brigantine Long Range HF radar, Cape Henlopen HF radar, Cape May Point HF radar, Loveladies HF radar, North Wildwood HF radar, Strathmere HF radar, and the Wildwood HF radar are operated by Rutgers University.

Various federal agencies in partnership with NOAA's Integrated Ocean Observing System (IOOS) use the ocean surface current and wave data provided by these HF radar sites in support of multiple missions.

ARSR and ASR LOS Analysis

Westslope conducted an ARSR and ASR LOS analysis using the United States Geological Survey (USGS) 10-meter National Elevation Dataset (NED). This analysis shows whether wind turbines at blade-tip heights of 817 feet MSL or 938 feet MSL will be within line-of-sight of one or more ARSR and ASR sites.

Westslope conducted the LOS analysis for the following six ARSR and ASR sites:

- Atlantic City ASR-9;
- Dover AFB DASR;
- Gibbsboro ARSR-4;
- NAS Patuxent River ASR-11;
- Oceana ARSR-4; and
- Wallops Island ASR-8.

The proposed wind turbines are beyond the instrumented range of the Atlantic City ASR-9 and the NAS Patuxent River ASR-11. As such, no additional analysis was considered necessary for these radar sites.

Dover AFB DASR

The LOS analysis results show that one of the 125 proposed wind turbines will be within line-of-sight of and will interfere with the Dover AFB DASR at a blade-tip height of 817 feet MSL. At a blade-tip height of 938 feet MSL, 13 of the 125 proposed wind turbines will be within line-of-sight of and will interfere with this radar site. See Figure 3. The radar effects will include unwanted radar returns (clutter) resulting in a partial loss of primary target detection and a number of false primary targets over and in the immediate vicinity of the proposed wind turbines within line-of-sight. Other radar effects include a partial loss of weather detection and false weather indications over and in the immediate vicinity of the proposed wind turbines within line-of-sight.

Gibbsboro ARSR-4

The LOS analysis results show that the 125 proposed wind turbines will not be within line-of-sight of and will not interfere with the Gibbsboro ARSR-4 at blade-tip heights of 817 feet MSL or 938 feet MSL. As a result, Westslope does not expect any radar effects at or below these blade-tip heights.

Oceana ARSR-4

The LOS analysis results show that the 125 proposed wind turbines will not be within line-of-sight of and will not interfere with the Oceana ARSR-4 at blade-tip heights of 817 feet MSL or 938 feet MSL. As a result, Westslope does not expect any radar effects at or below these blade-tip heights.

Wallops Island ASR-8

The LOS analysis results show that 85 of the 125 proposed wind turbines will be within line-of-sight of and will interfere with the Wallops Island ASR-8 at a blade-tip height of 817 feet MSL. At a blade-tip height of 938 feet MSL, all 125 proposed wind turbines will be within line-of-sight of and will interfere with this radar site. See Figure 4. The radar effects will include clutter resulting in a partial loss of primary target detection and a number of false primary targets over and in the immediate vicinity of the proposed wind turbines within line-of-sight. Other possible radar effects include a partial loss of weather detection and false weather indications over and in the immediate vicinity of the proposed wind turbines within line-of-sight.

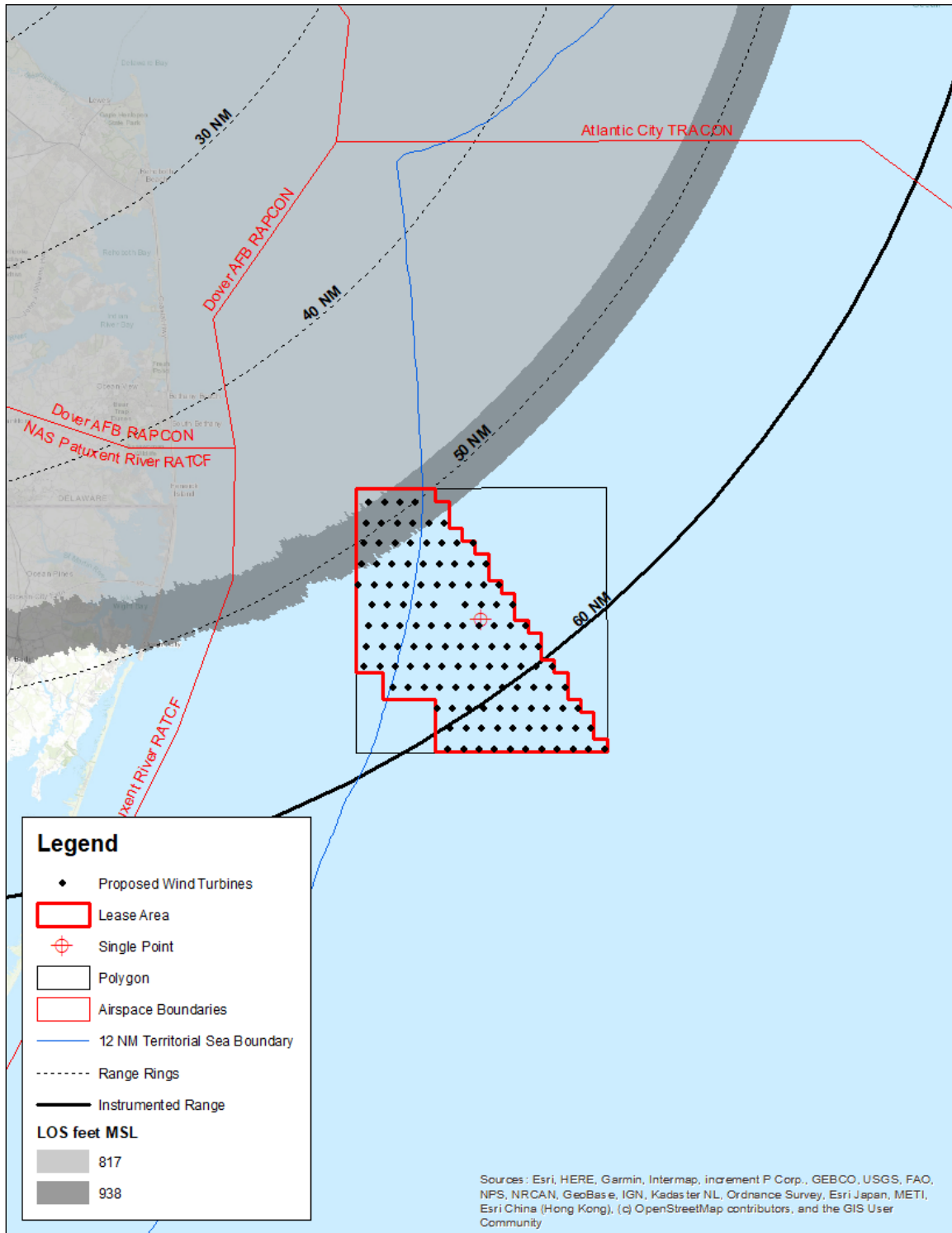


Figure 3 LOS Analysis Results for the Dover AFB DASR using 10-meter NED

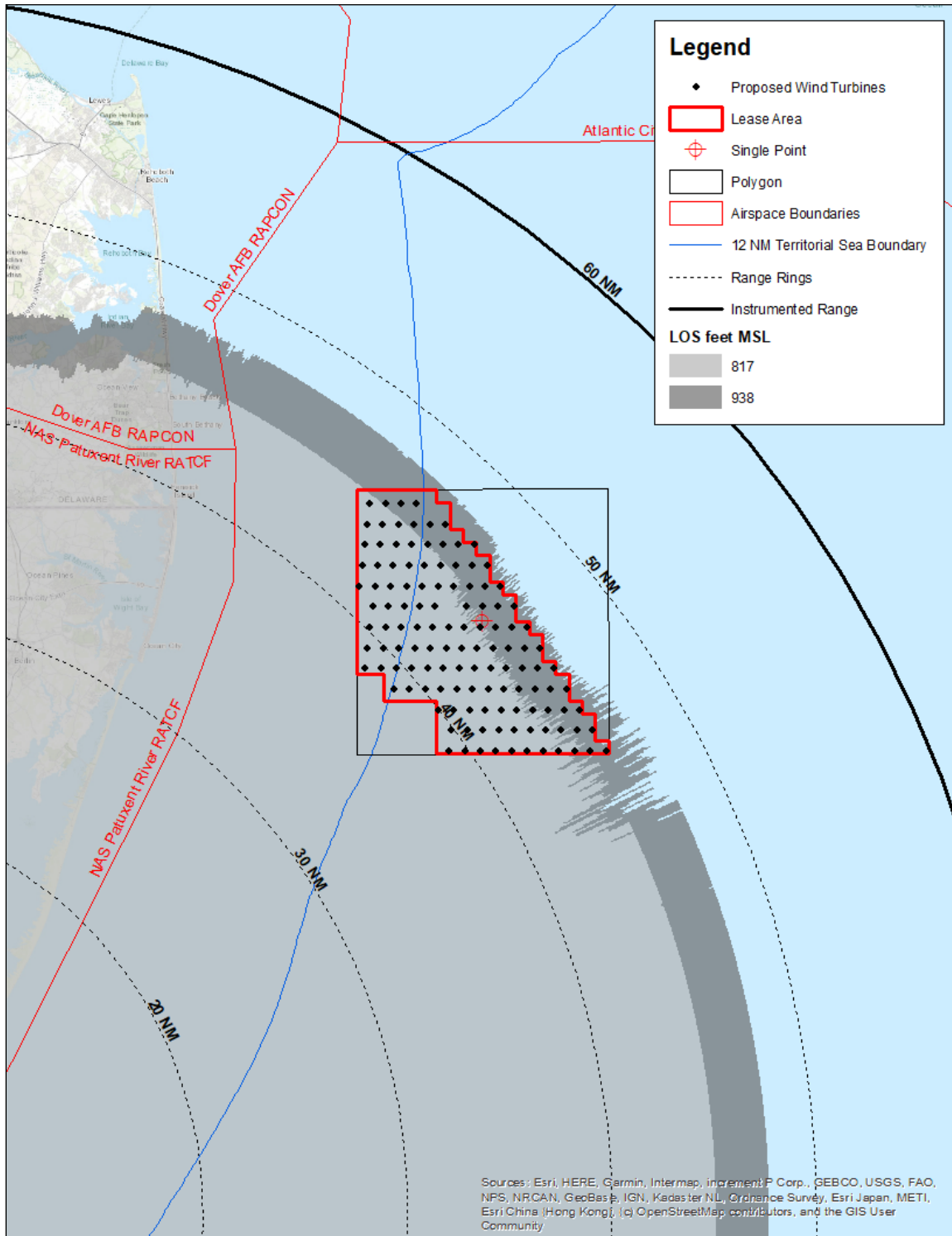


Figure 4 LOS Analysis Results for the Wallops Island ASR-8 using 10-meter NED

ADAMS Screening Analysis

Westslope conducted a screening analysis for the ADAMS using a 4/3 earth's radius model and USGS 10-meter NED. A 4/3 earth's radius model accounts for the refraction of radio waves as these waves propagate through the lowest layer of the atmosphere under standard atmospheric conditions. Westslope's analysis shows whether wind turbines at blade-tip heights of 817 feet MSL or 938 feet MSL will be within line-of-sight of the ADAMS and reviews whether the proposed wind turbines will fall within the proposed NAS Patuxent River Geographic Area of Concern (GAOC). [1][2]

The ADAMS screening analysis results show that the 125 proposed wind turbines will not be within line-of-sight of and will not interfere with the ADAMS at blade-tip heights of 817 feet MSL or 938 feet MSL under standard atmospheric conditions. See Figure 5. The results also show that the 125 proposed wind turbines will not fall within the "ducting impact region" of the GAOC. The ducting impact region represents an area where radio waves can propagate further than line-of-sight under standard atmospheric conditions. See Figures 6 and 7. As a result, Westslope does not expect any radar effects at or below these blade-tip heights.

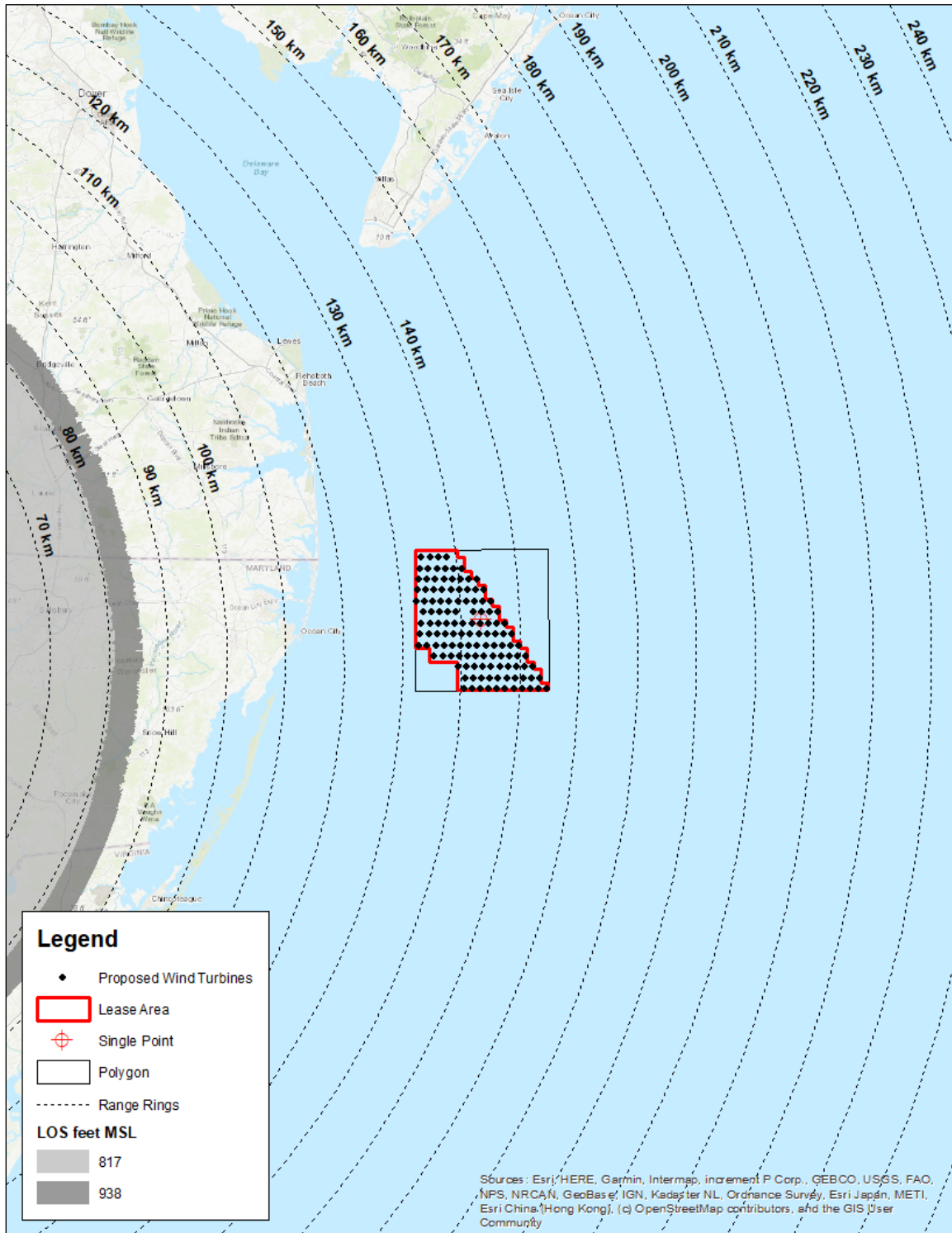


Figure 5 LOS Analysis Results for the ADAMS using 10-meter NED



Figure 6 NAS Patuxent River Area GAOC

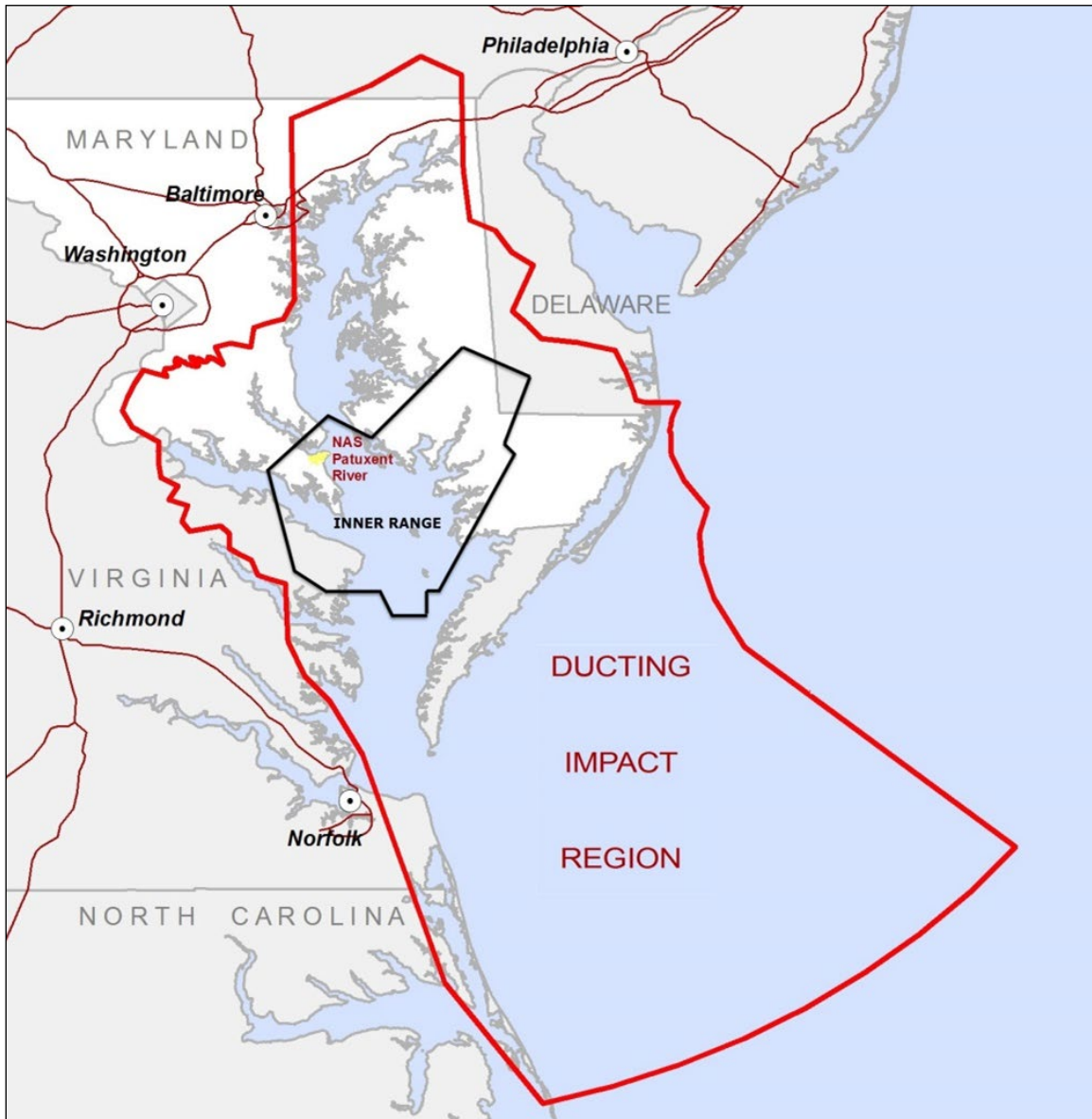


Figure 7 Ducting Impact Region

VOR Screening Analysis

Westslope conducted a VOR screening analysis using USGS 10-meter NED. This analysis shows whether the proposed wind turbines (1) are less than or equal to 8 nautical miles (NM) from a VOR site; (2) will subtend elevation angles greater than 0.60 degrees from the base elevation of a conventional VOR at blade-tip heights of 817 feet MSL or 938 feet MSL, or 0.75 degrees for a Doppler VOR; and (3) will fall within line-of-sight of a VOR site. This screening analysis provides a cursory indication of whether the proposed wind turbines may affect VOR performance and is similar to the FAA's analysis approach for VOR sites. The same criteria will also protect for DMEs and Tactical Air Navigation systems.

Westslope conducted a VOR screening analysis for the following three navigational aid sites:

- Salisbury VORTAC;
- Snow Hill VORTAC; and
- Waterloo VOR/DME.

The proposed wind turbines are greater than 8 NM from the Salisbury VORTAC, Snow Hill VORTAC, and the Waterloo VOR/DME. As such, no additional analysis was considered necessary for these navigational aid sites.

NEXRAD Weather Radar Screening Analysis

The PST NEXRAD analysis does not account for blade-tip heights greater than 525 feet AGL, does not account for WSR-88D sites authorized to scan at elevation angles below 0.5 degrees, and does not reflect the wind farm impact zone scheme updated in 2018 by the NOAA WSR-88D ROC. The updated scheme expands the red area, or “No Build Zone,” from three to four kilometers and to areas where wind turbines penetrate the third elevation angle scanned by a WSR-88D.

Westslope conducted a NEXRAD weather radar screening analysis using USGS 10-meter NED. This analysis shows whether wind turbines at blade-tip heights of 817 feet MSL or 938 feet MSL will be within line-of-sight of one or more WSR-88D sites and incorporates the updated wind farm impact zone scheme.

Westslope conducted the NEXRAD weather radar screening analysis for the following three radar sites:

- Dover AFB WSR-88D;
- Norfolk WSR-88D; and
- Philadelphia WSR-88D.

Research conducted by Westslope shows that the lowest elevation angle scanned by the Dover AFB WSR-88D, Norfolk WSR-88D, and the Philadelphia WSR-88D is 0.5 degrees.

Dover AFB WSR-88D

Westslope’s NEXRAD weather radar screening analysis shows that 104 of the 125 proposed wind turbines will be within line-of-sight of the Dover AFB WSR-88D at a blade-tip height of 817 feet MSL. At a blade-tip height of 938 feet MSL, 121 of the 125 proposed wind turbines will be within line-of-sight of this radar site. See Figure 8. The results also show that the 125 proposed wind turbines at blade-tip heights of 817 feet MSL and 938 feet MSL will fall within a NOAA green area for this radar site. A green area, or “No Impact Zone,” indicates that impacts are not likely to WSR-88D operations. See Figures 9 and 10.

At blade-tip heights of 817 feet MSL and 938 feet MSL, a partial loss of weather detection and false weather indications (Doppler contamination) over and in the immediate vicinity of the proposed wind turbines within line-of-sight are possible due to clutter; however, impacts to Dover AFB WSR-88D operations are not likely.

Norfolk WSR-88D

Westslope's NEXRAD weather radar screening analysis shows that the 125 proposed wind turbines will not be within line-of-sight of and will not interfere with the Norfolk WSR-88D at blade-tip heights of 817 feet MSL or 938 feet MSL. The results also show that the 125 proposed wind turbines at blade-tip heights of 817 feet MSL and 938 feet MSL will fall within a NOAA green No Impact Zone for this radar site. See Figures 11 and 12.

Philadelphia WSR-88D

Westslope's NEXRAD weather radar screening analysis shows that the 125 proposed wind turbines will not be within line-of-sight of and will not interfere with the Philadelphia WSR-88D at blade-tip heights of 817 feet MSL or 938 feet MSL. The results also show that the 125 proposed wind turbines at blade-tip heights of 817 feet MSL and 938 feet MSL will fall within a NOAA green No Impact Zone for this radar site. See Figures 13 and 14.

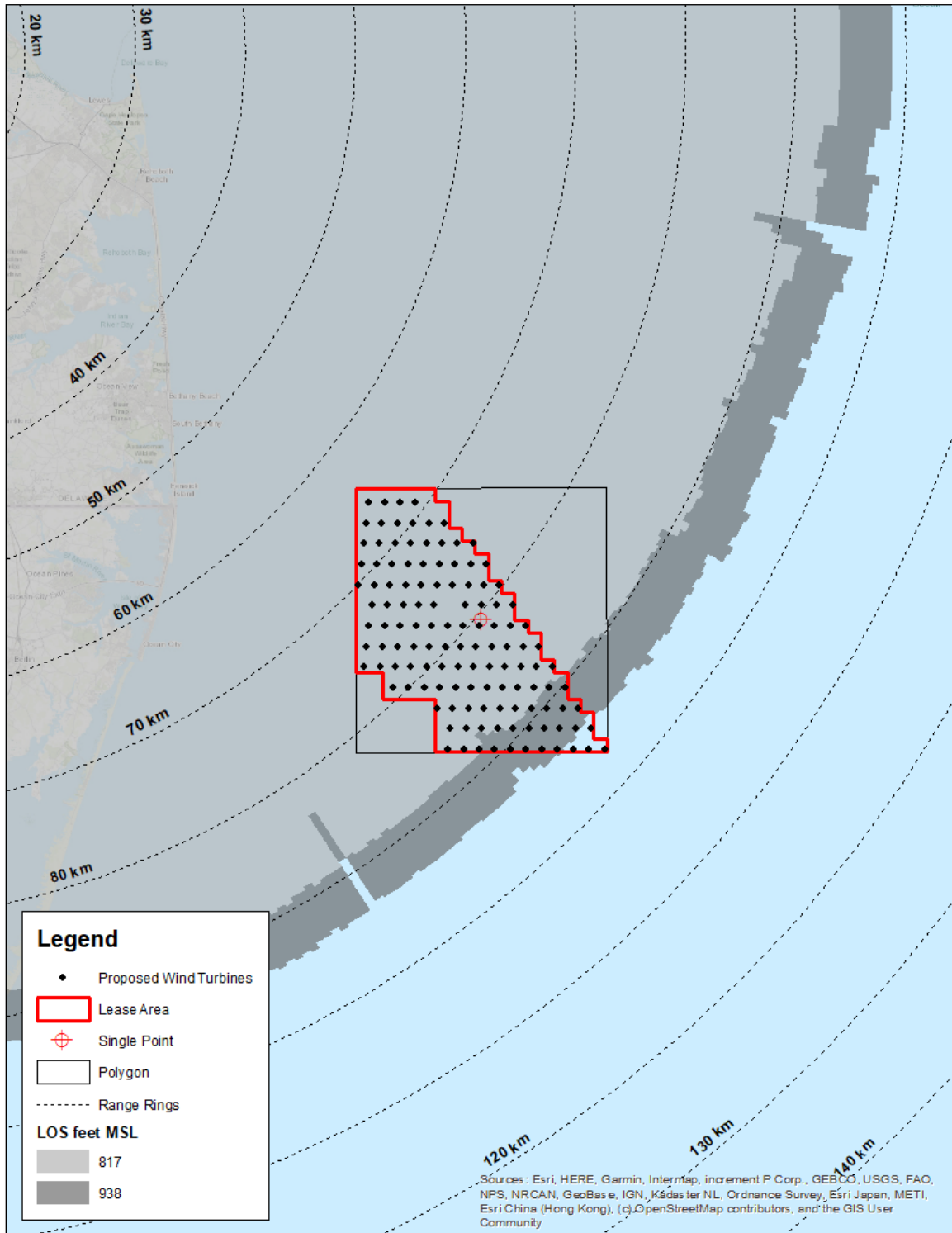


Figure 8 LOS Analysis Results for the Dover AFB WSR-88D using 10-meter NED

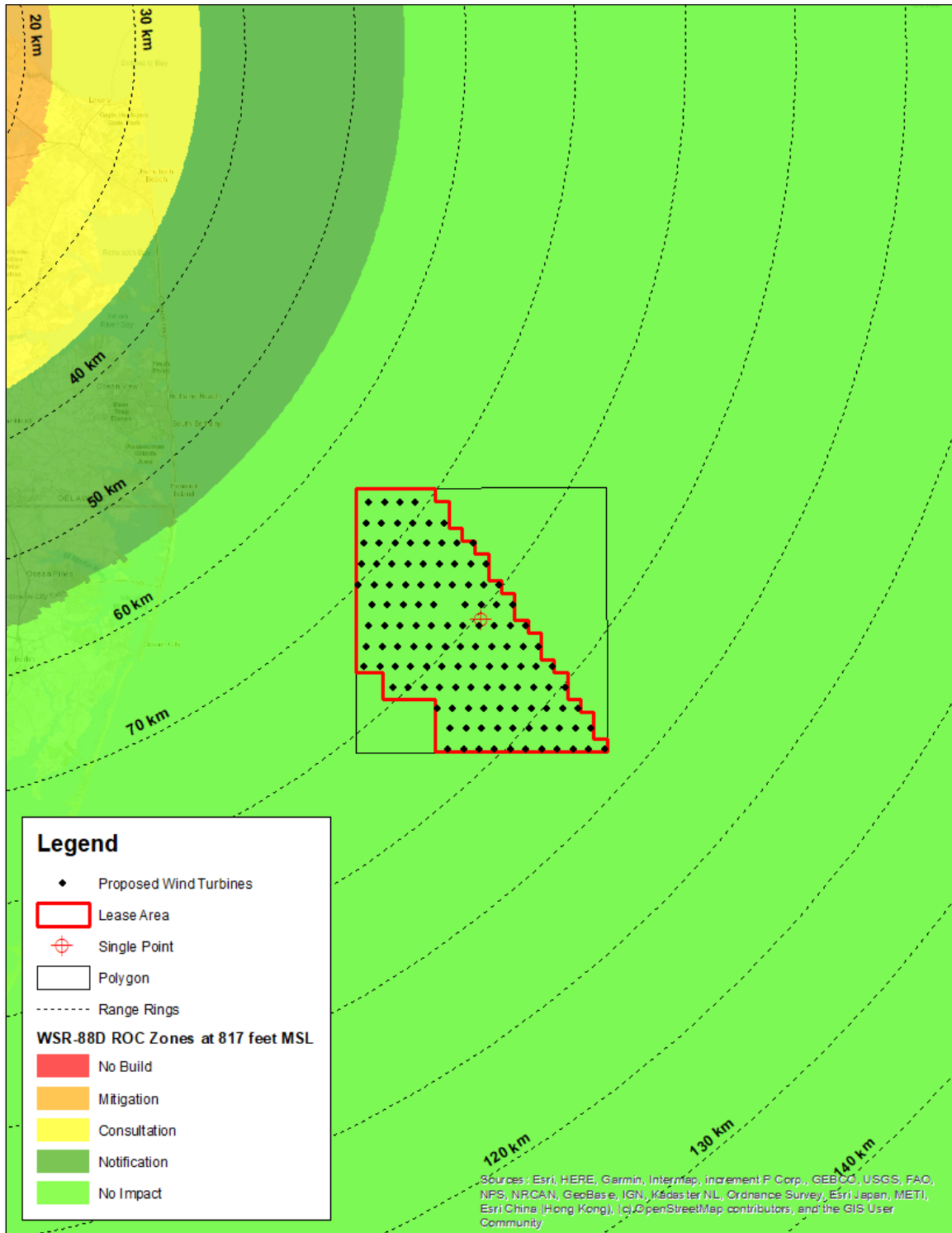


Figure 9 WSR-88D ROC Zone Results at 817 feet MSL for the Dover AFB WSR-88D using 10-meter NED

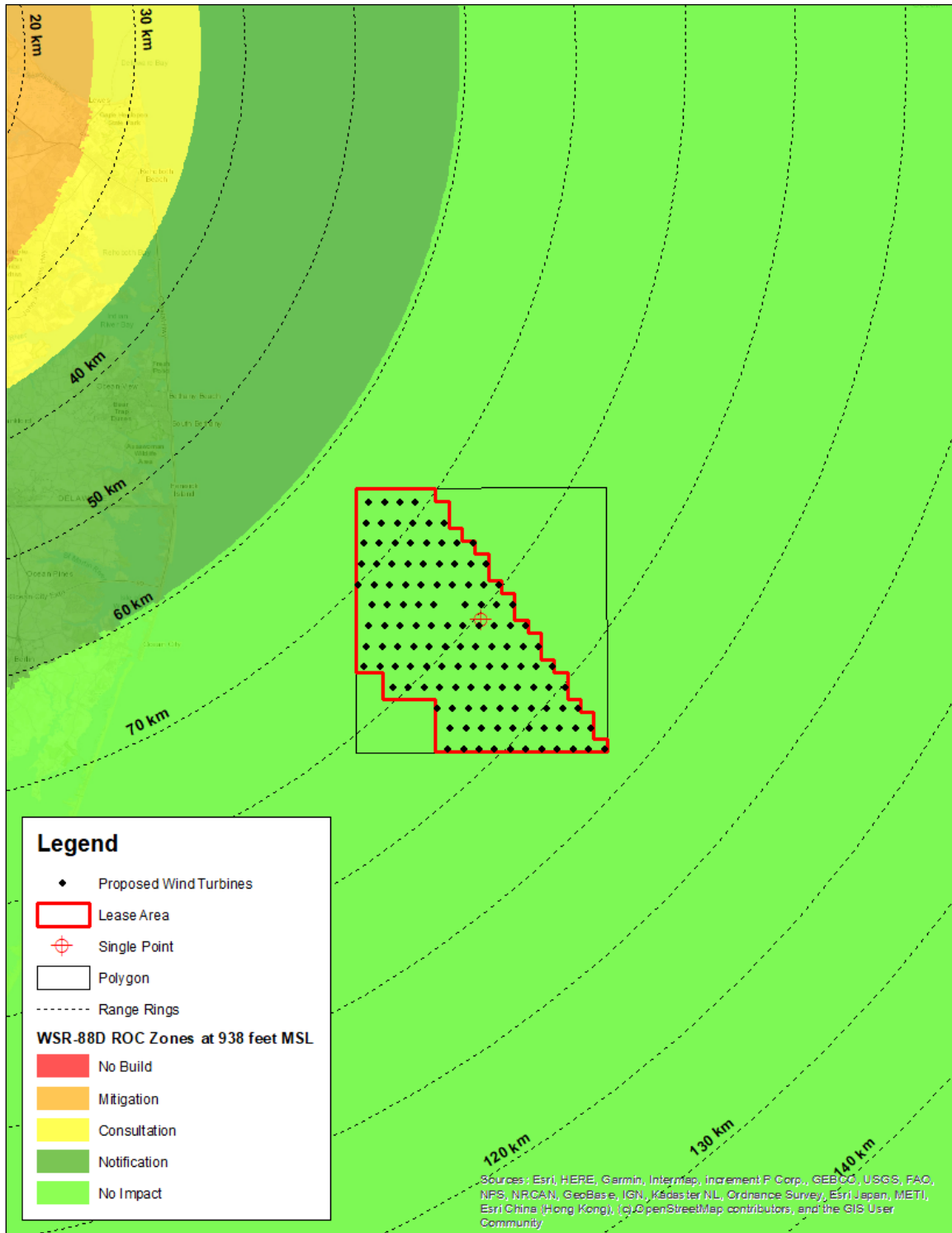


Figure 10 WSR-88D ROC Zone Results at 938 feet MSL for the Dover AFB WSR-88D using 10-meter NED

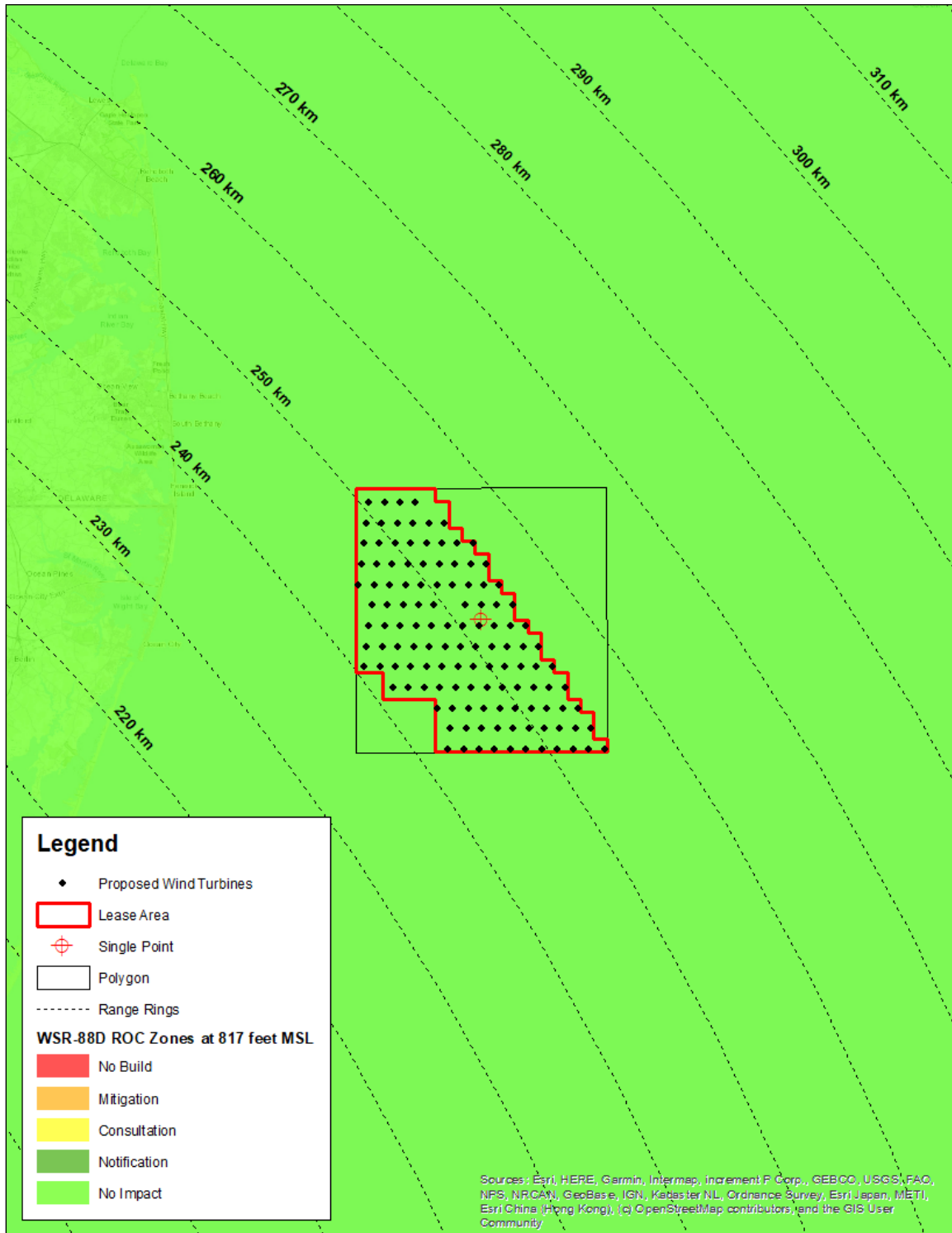


Figure 11 WSR-88D ROC Zone Results at 817 feet MSL for the Norfolk WSR-88D using 10-meter NED

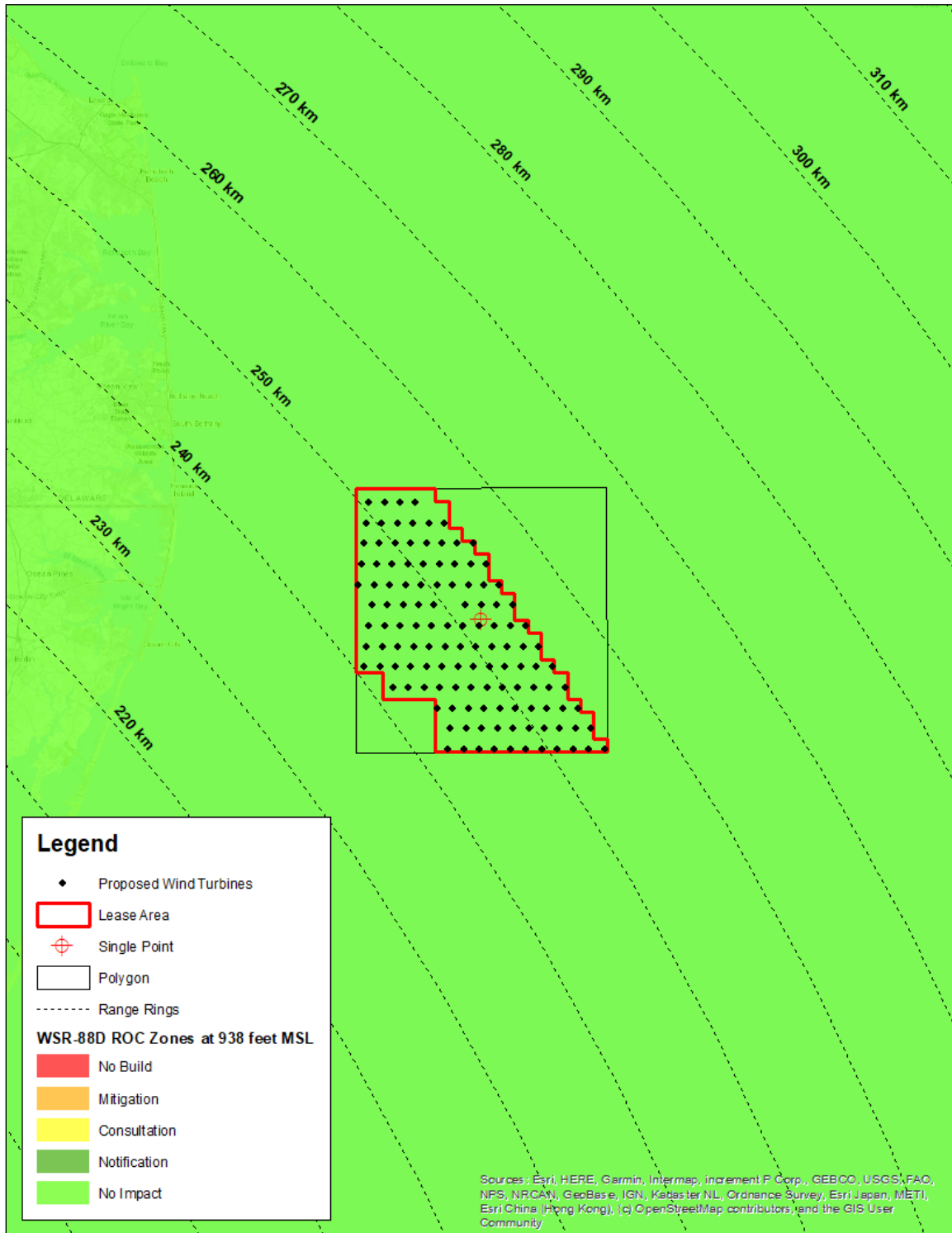


Figure 12 WSR-88D ROC Zone Results at 938 feet MSL for the Norfolk WSR-88D using 10-meter NED

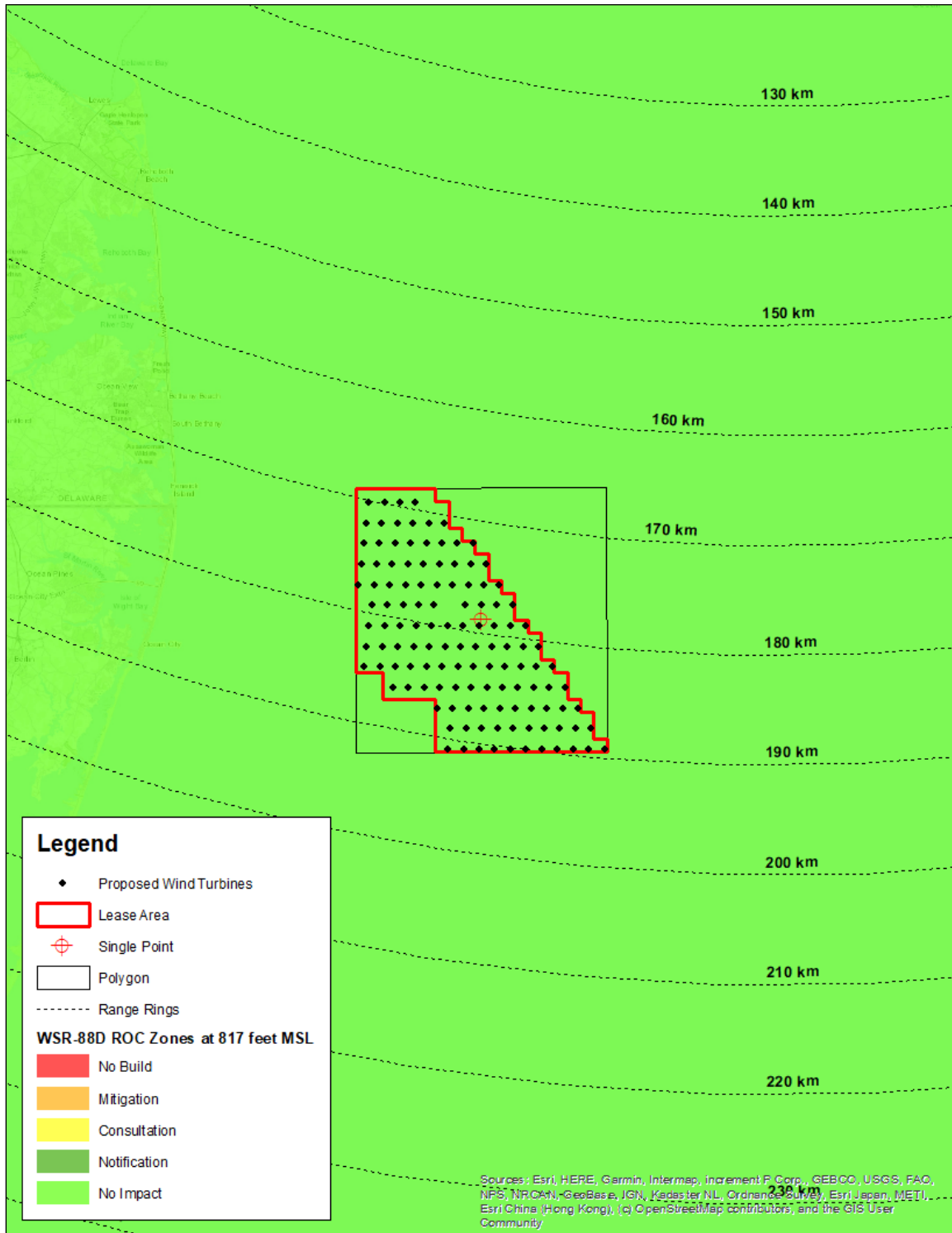


Figure 13 WSR-88D ROC Zone Results at 817 feet MSL for the Philadelphia WSR-888 using 10-meter NED

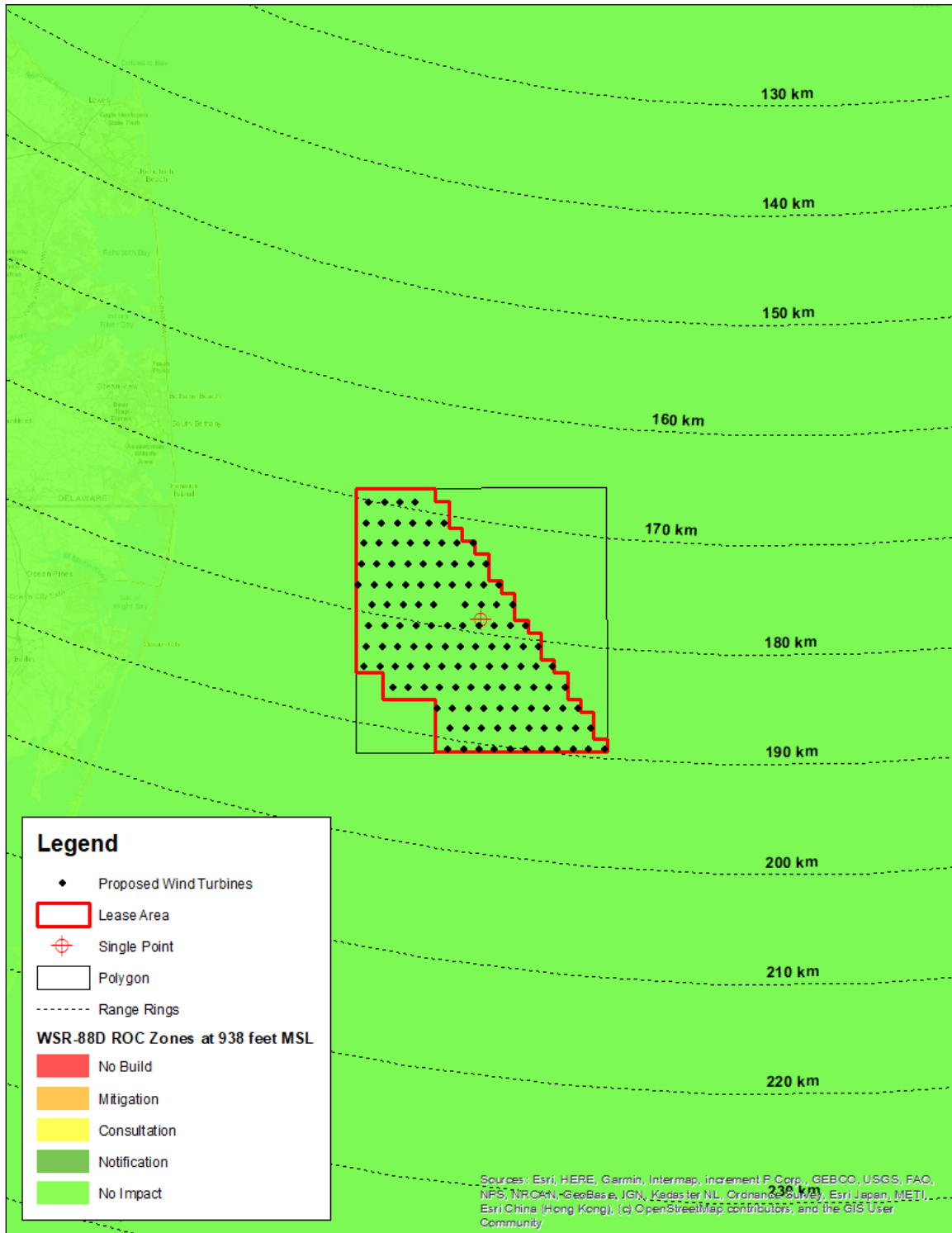


Figure 14 WSR-88D ROC Zone Results at 938 feet MSL for the Philadelphia WSR-888 using 10-meter NED

HF Radar LOS Analysis

Westslope conducted an HF radar LOS analysis using USGS 10-meter NED. This analysis shows whether wind turbines at blade-tip heights of 817 feet MSL or 938 feet MSL will be within line-of-sight of one or more HF radar sites.

Westslope conducted the LOS analysis for the following nine HF radar sites:

- Assateague Island HF radar;
- Brigantine Long Range HF radar;
- Cape Henlopen HF radar;
- Cape May Point HF radar;
- Cedar Island HF radar;
- Loveladies HF radar;
- North Wildwood HF radar;
- Strathmere HF radar; and
- Wildwood HF radar.

Assateague Island HF Radar

The LOS analysis results show that all 125 proposed wind turbines will be within line-of-sight of the Assateague Island HF radar at blade-tip heights of 817 feet MSL and 938 feet MSL. See Figure 15. The radar effects will include clutter in the vicinity of the proposed wind turbines. As a result, impacts to Assateague Island HF radar operations are possible.

Brigantine Long Range HF Radar

The LOS analysis results show that the 125 proposed wind turbines will not be within line-of-sight of the Brigantine Long Range HF radar at blade-tip heights of 817 feet MSL or 938 feet MSL. See Figure 16. Although the proposed wind turbines will not be within line-of-sight of this radar site, radar effects are still possible beyond line-of-sight due to the propagation of HF electromagnetic waves over the ocean surface.

Cape Henlopen HF Radar

The LOS analysis results show that four of the 125 proposed wind turbines will be within line-of-sight of the Cape Henlopen HF radar at blade-tip heights of 817 feet MSL and 938 feet MSL. See Figure 17. The radar effects will include clutter in the vicinity of the proposed wind turbines within line-of-sight. As a result, impacts to Cape Henlopen HF radar operations are possible.

Cape May Point HF Radar

The LOS analysis results show that 111 of the 125 proposed wind turbines will be within line-of-sight of the Cape May Point HF radar at a blade-tip height of 817 feet MSL. At a blade-tip height of 938 feet MSL, all 125 proposed wind turbines will be within line-of-sight of this radar site. See Figure 18. The radar effects will include clutter in the vicinity of the proposed wind turbines within line-of-sight and possibly in the vicinity of the proposed wind turbines beyond line-of-sight due to the propagation of HF electromagnetic waves over the ocean surface. As a result, impacts to Cape May Point HF radar operations are possible.

Cedar Island HF Radar

The LOS analysis results show that the 125 proposed wind turbines will not be within line-of-sight of the Cedar Island HF radar at blade-tip heights of 817 feet MSL or 938 feet MSL. See Figure 19. Although the proposed wind turbines will not be within line-of-sight of this radar site, radar effects are still possible beyond line-of-sight due to the propagation of HF electromagnetic waves over the ocean surface.

Loveladies HF Radar

The LOS analysis results show that the 125 proposed wind turbines will not be within line-of-sight of the Loveladies HF radar at blade-tip heights of 817 feet MSL or 938 feet MSL. See Figure 20. Although the proposed wind turbines will not be within line-of-sight of this radar site, radar effects are still possible beyond line-of-sight due to the propagation of HF electromagnetic waves over the ocean surface.

North Wildwood HF Radar

The LOS analysis results show that 69 of the 125 proposed wind turbines will be within line-of-sight of the North Wildwood HF radar at a blade-tip height of 817 feet MSL. At a blade-tip height of 938 feet MSL, 100 of the 125 proposed wind turbines will be within line-of-sight of this radar site. See Figure 21. The radar effects will include clutter in the vicinity of the proposed wind turbines within line-of-sight and possibly in the vicinity of the proposed wind turbines beyond line-of-sight due to the propagation of HF electromagnetic waves over the ocean surface. As a result, impacts to North Wildwood HF radar operations are possible.

Strathmere HF Radar

The LOS analysis results show that the 125 proposed wind turbines will not be within line-of-sight of the Strathmere HF radar at blade-tip heights of 817 feet MSL or 938 feet MSL. Please note that 99 of the 125 proposed wind turbines are beyond the instrumented range of this radar site. See Figure 22. Although the proposed wind turbines will not be within line-of-sight of this radar site, radar effects are still possible beyond line-of-sight due to the propagation of HF electromagnetic waves over the ocean surface.

Wildwood HF Radar

The LOS analysis results show that 105 of the 125 proposed wind turbines will be within line-of-sight of the Wildwood HF radar at a blade-tip height of 817 feet MSL. At a blade-tip height of 938 feet MSL, 124 of the 125 proposed wind turbines will be within line-of-sight of this radar site. See Figure 23. The radar effects will include clutter in the vicinity of the proposed wind turbines within line-of-sight and possibly in the vicinity of the proposed wind turbines beyond line-of-sight due to the propagation of HF electromagnetic waves over the ocean surface. As a result, impacts to Wildwood radar operations are possible.

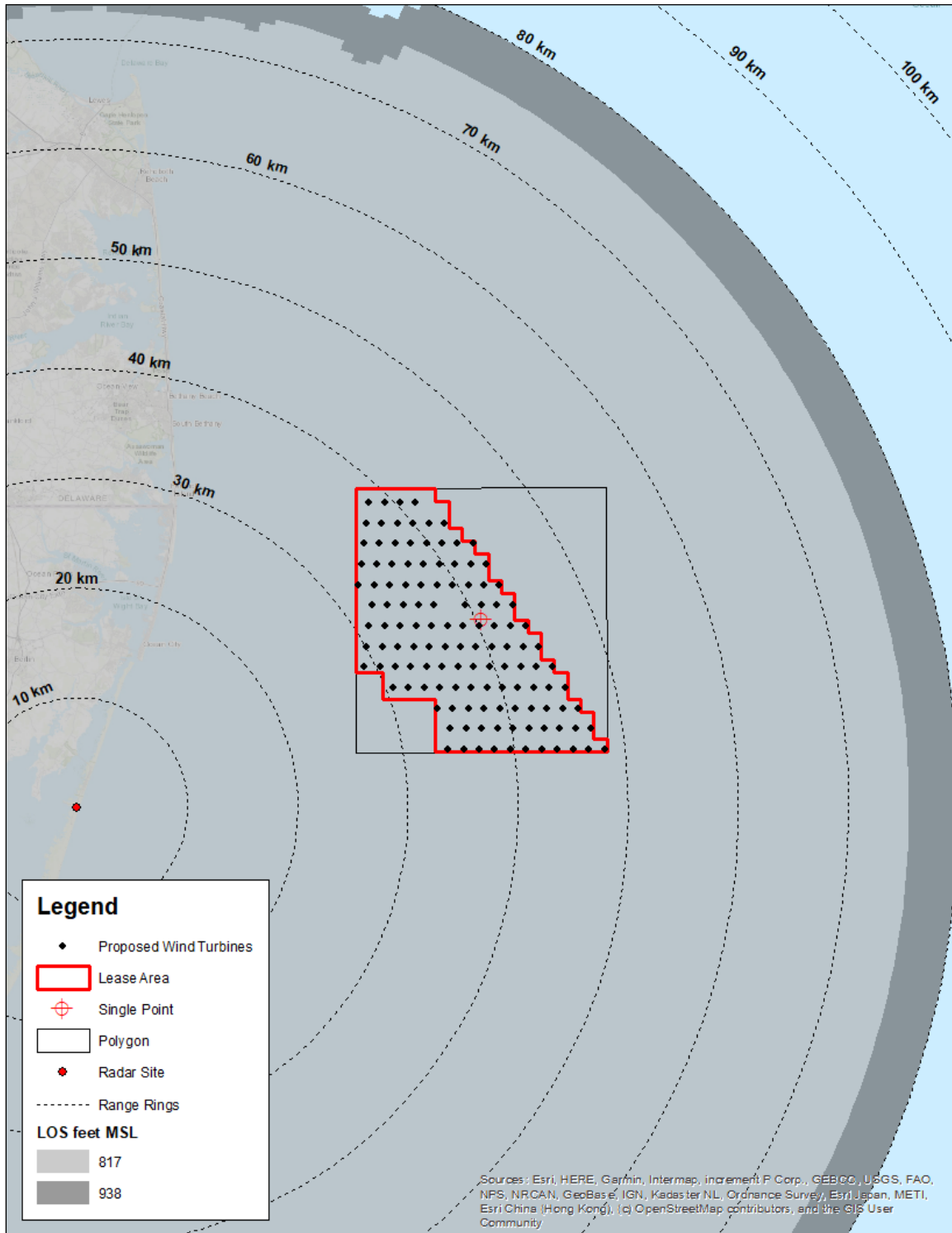


Figure 15 LOS Analysis Results for the Assateague Island HF Radar using 10-meter NED

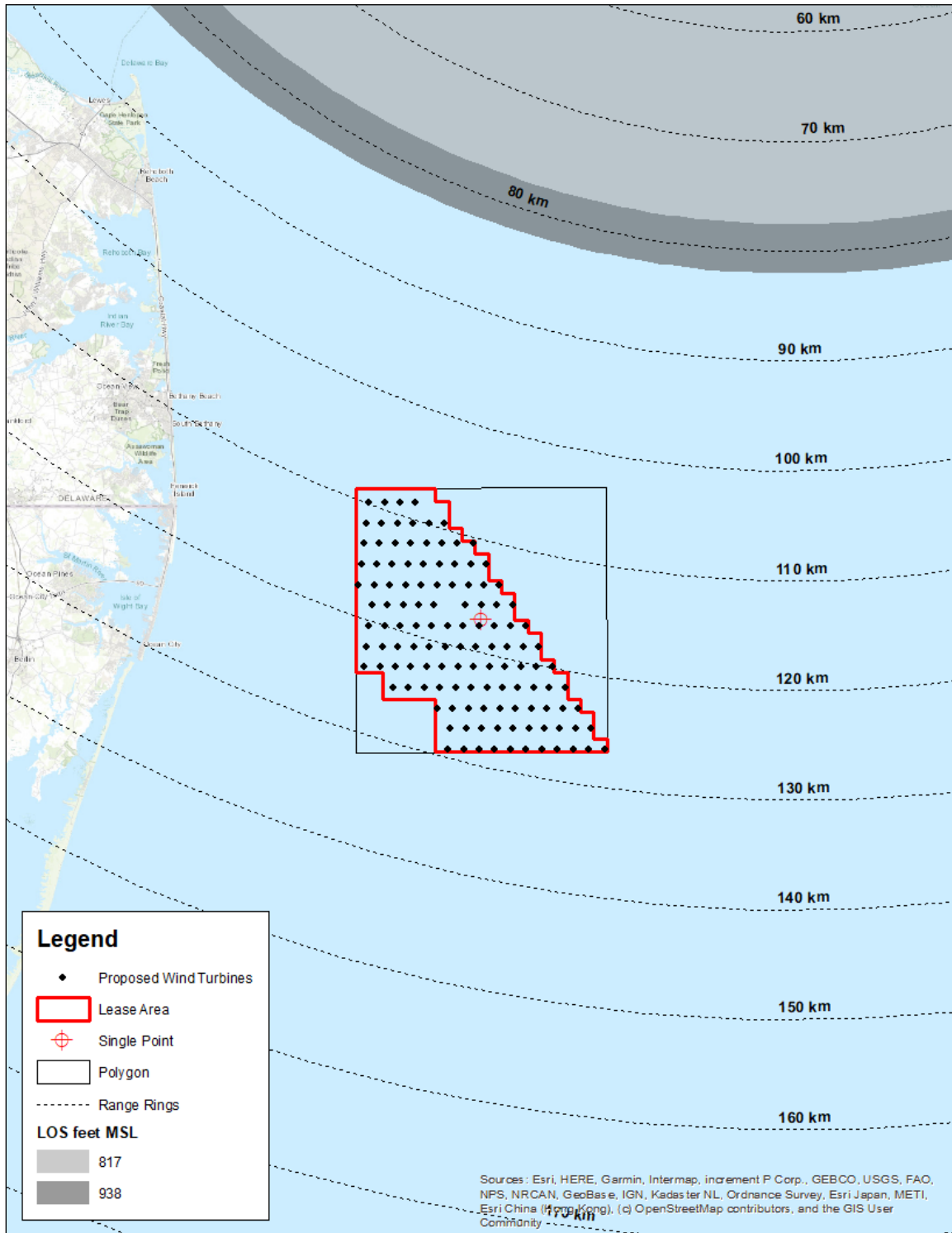


Figure 16 LOS Analysis Results for the Brigantine Long Range HF Radar using 10-meter NED

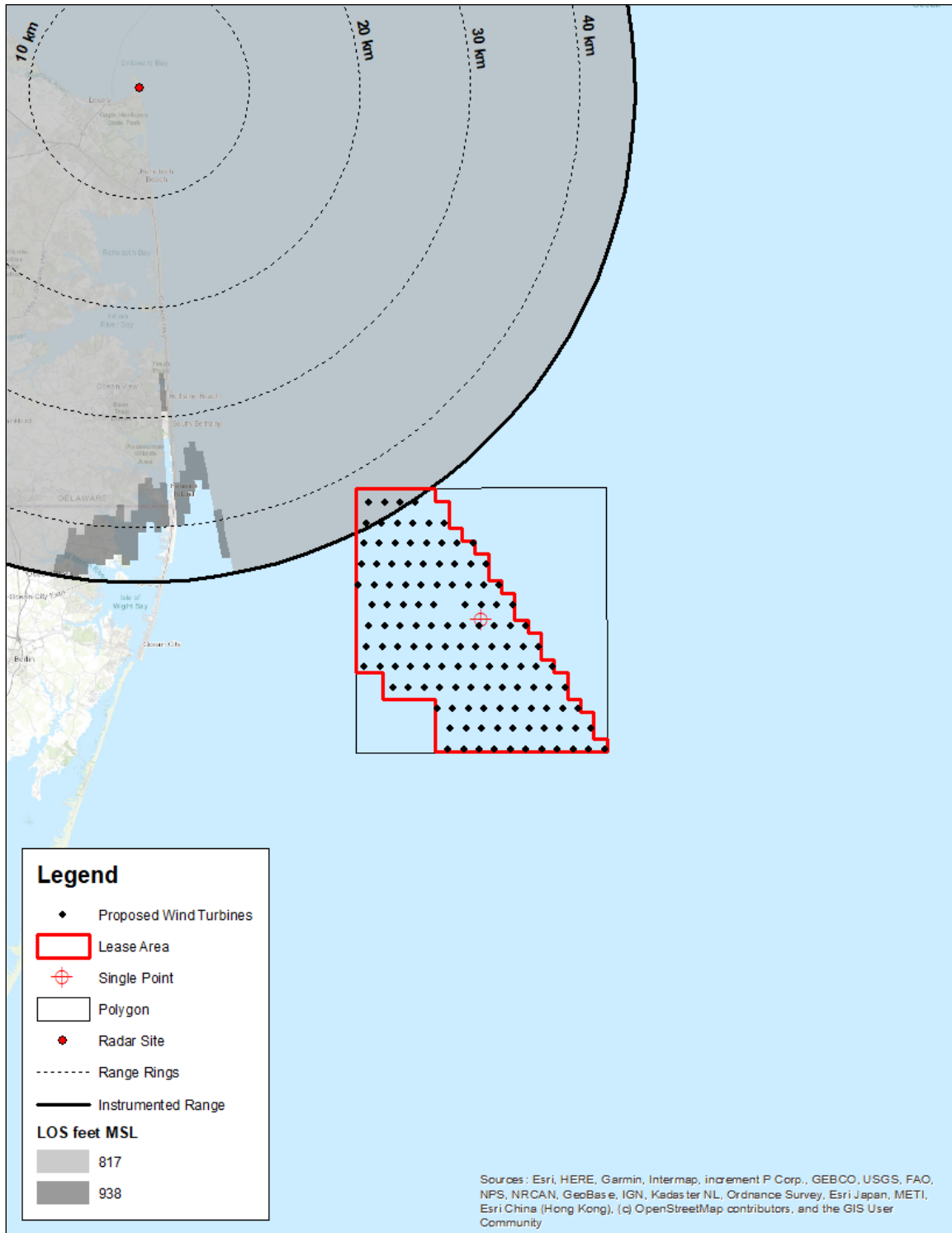


Figure 17 LOS Analysis Results for the Cape Henlopen HF Radar using 10-meter NED

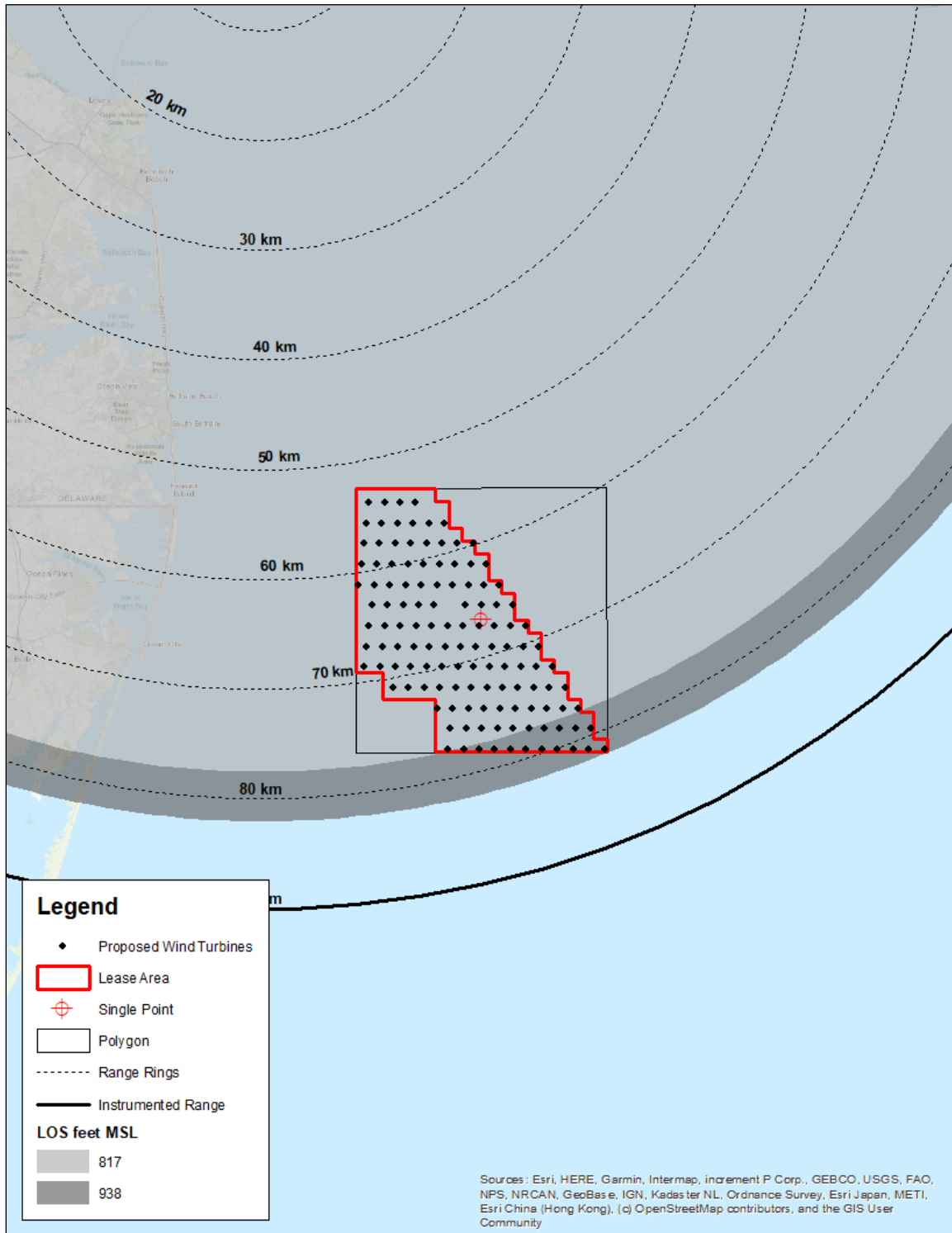


Figure 18 LOS Analysis Results for the Cape May Point HF Radar using 10-meter NED

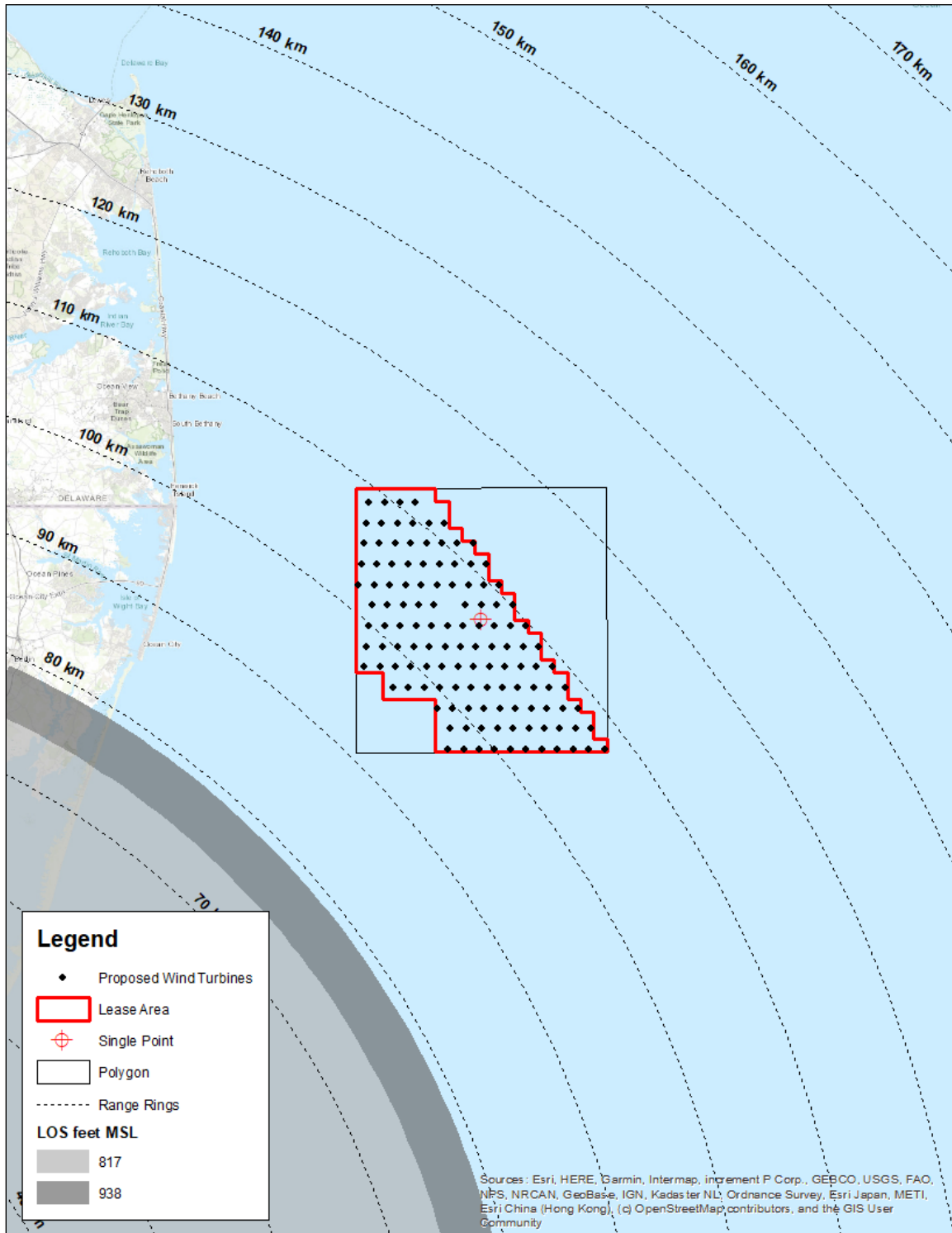


Figure 19 LOS Analysis Results for the Cedar Island HF Radar using 10-meter NED

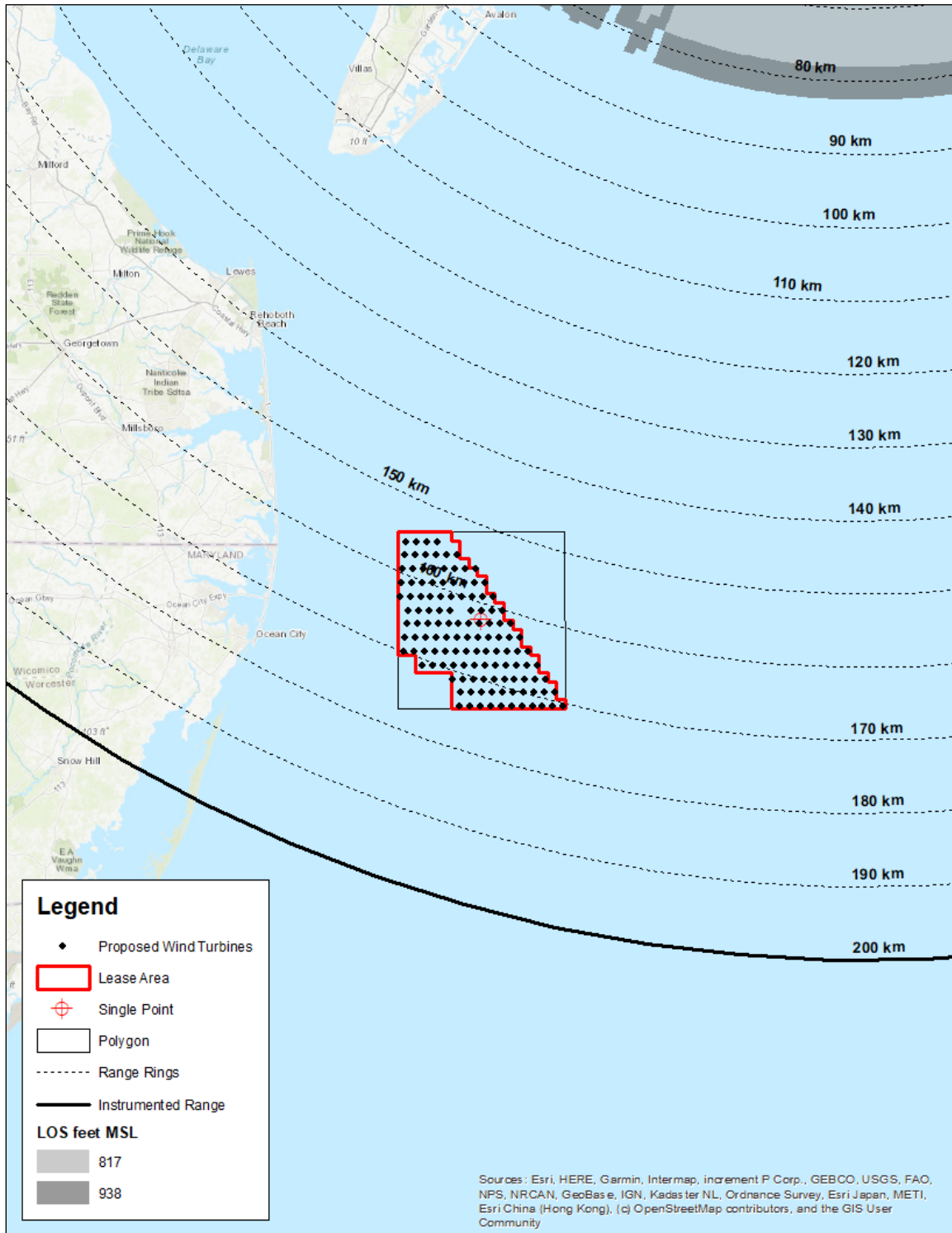


Figure 20 LOS Analysis Results for the Loveladies HF Radar using 10-meter NED

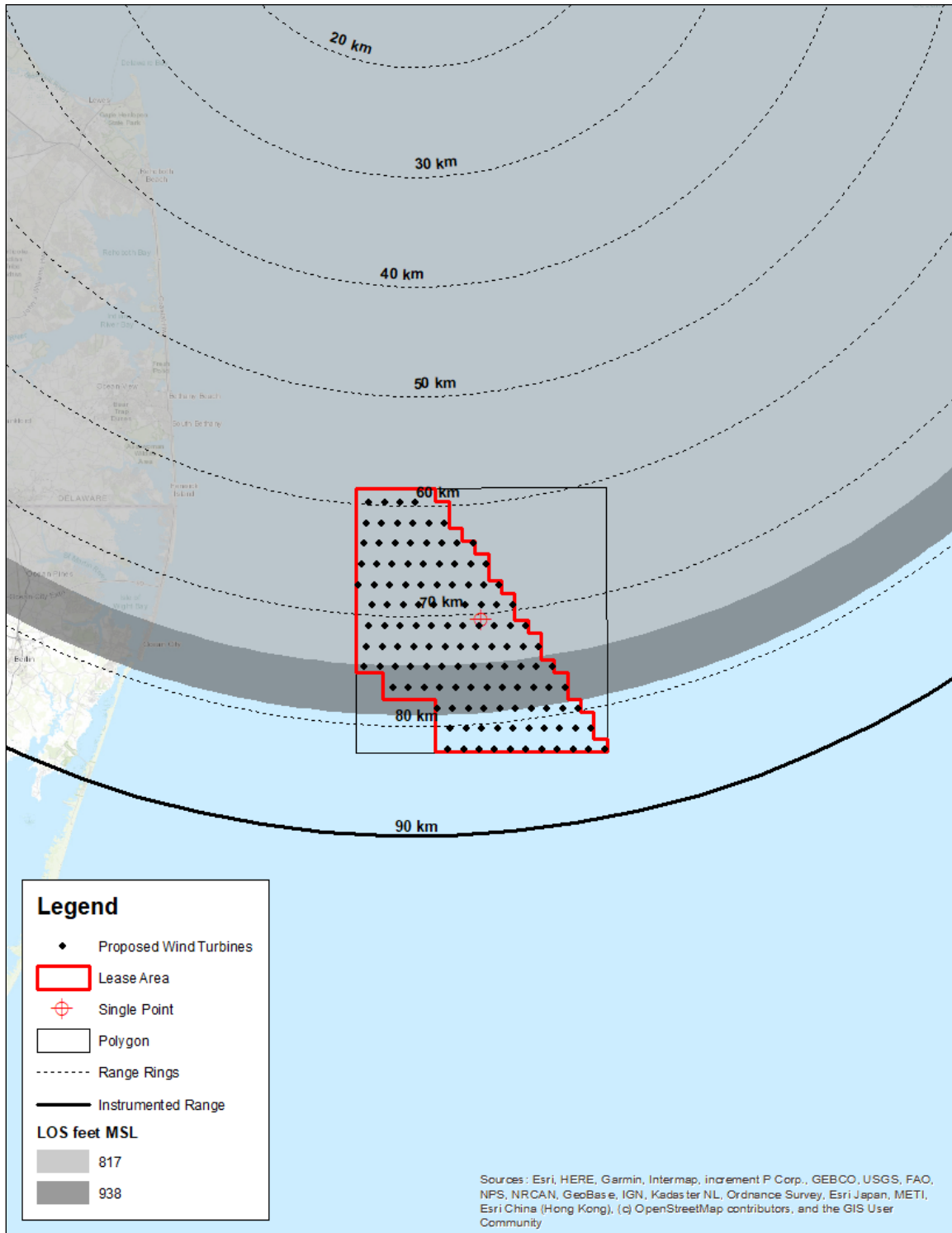


Figure 21 LOS Analysis Results for the North Wildwood HF Radar using 10-meter NED

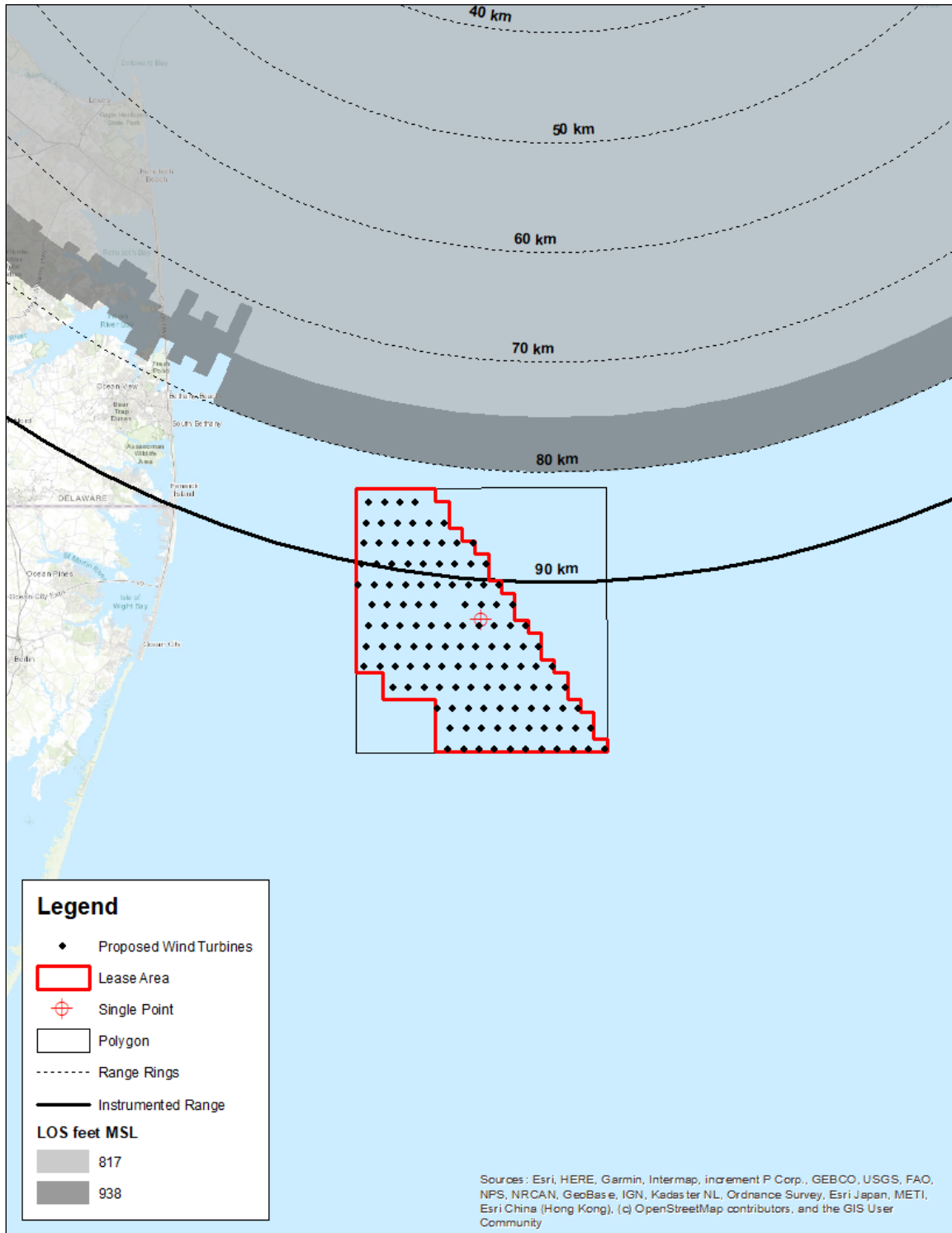


Figure 22 LOS Analysis Results for the Strathmere HF Radar using 10-meter NED

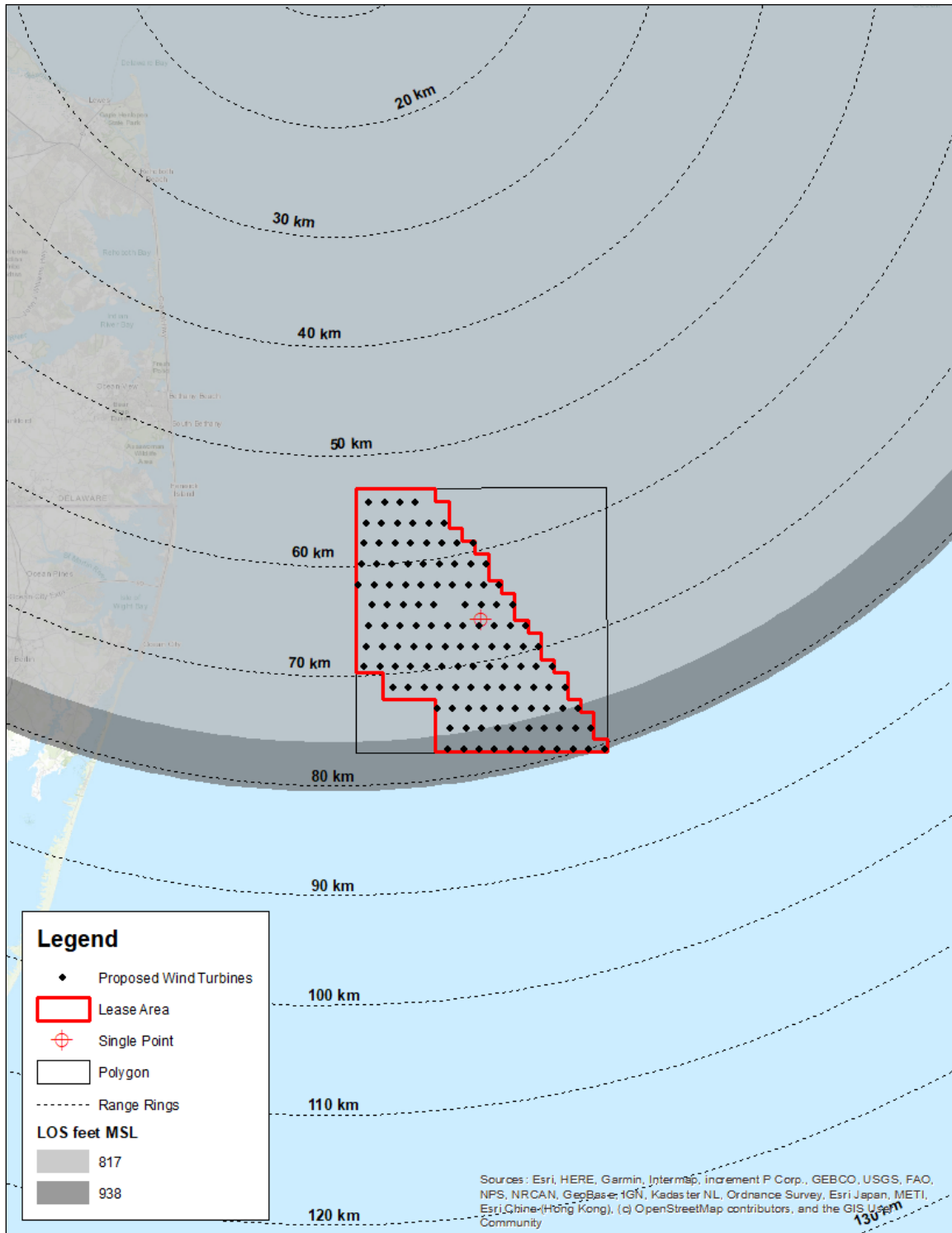


Figure 23 LOS Analysis Results for the Wildwood HF Radar using 10-meter NED

CONCLUSIONS

The DoD PST analysis results for the proposed wind turbines indicate the following:

- Impacts to one air defense and homeland security radar are both likely and not anticipated; and
- Impacts to WSR-88D weather radar are not likely.

Westslope identified the closest six radar sites in the PST analysis results for Long Range Radar as the Atlantic City ASR-9, Dover AFB DASR, Gibbsboro ARSR-4, NAS Patuxent River ASR-11, Oceana ARSR-4, and the Wallops Island ASR-8. Further, Westslope identified the radar site in the PST analysis results for NEXRAD as the Dover AFB WSR-88D.

Research conducted by Westslope identified no additional ARSR or ASR sites near the proposed wind turbines.

Westslope conducted an ARSR and ASR LOS analysis for the following six ARSR and ASR sites:

- Atlantic City ASR-9;
- Dover AFB DASR;
- Gibbsboro ARSR-4;
- NAS Patuxent River ASR-11;
- Oceana ARSR-4; and
- Wallops Island ASR-8.

The proposed wind turbines are beyond the instrumented range of the Atlantic City ASR-9 and the NAS Patuxent River ASR-11. As such, no additional analysis was considered necessary for these radar sites.

The ARSR and ASR LOS analyses conducted by Westslope show the following:

- For the Dover AFB DASR, one of the 125 proposed wind turbines will be within line-of-sight of and will interfere with this radar site at a blade-tip height of 817 feet MSL. At a blade-tip height of 938 feet MSL, 13 of the 125 proposed wind turbines will be within line-of-sight of and will interfere with this radar site.
- For the Wallops Island ASR-8, 85 of the 125 proposed wind turbines will be within line-of-sight of and will interfere with this radar site at a blade-tip height of 817 feet MSL. At a blade-tip height of 938 feet MSL, all 125 proposed wind turbines will be within line-of-sight of and will interfere with this radar site.
- For the Gibbsboro ARSR-4 and the Oceana ARSR-4, the 125 proposed wind turbines will not be within line-of-sight of and will not interfere with these radar sites at blade-tip heights of 817 feet MSL or 938 feet MSL.

For the Dover AFB DASR and the Wallops Island ASR-8, without mitigation, the radar effects due to clutter will include a partial loss of primary target detection and a number of false primary targets over and in the immediate vicinity of the proposed wind turbines within line-of-sight. Other radar effects include a partial loss of weather detection and false weather indications over and in the immediate vicinity of the proposed wind turbines within line-of-sight. Please note that radar effects do not always translate into operational impacts. Because wind turbines will be within line-of-sight of these radar sites, Westslope expects that the DoD and FAA will have concerns with the proposed wind turbines within line-of-sight at blade-tip heights of 817 feet MSL and 938 feet MSL based on electromagnetic interference to air navigation facilities. The FAA's aeronautical study process and the DoD Siting Clearinghouse process will provide an official decision as to whether impacts are acceptable to operations. Although possible, Westslope does not expect that the DHS will have concerns with the proposed wind turbines within line-of-sight at blade-tip heights of 817 feet MSL or 938 feet MSL based on impacts to these radar sites.

Mitigation options for the Dover AFB DASR and the Wallops Island ASR-8 include, but are not limited to, optimization. Optimization is referred to as Radar Adverse-impact Mitigation by the DoD and may be required to the radar settings to minimize primary false targets and maximize primary target detection.

Westslope does not expect that the 125 proposed wind turbines will affect the secondary surveillance radar co-located with the Dover AFB DASR or the Wallops Island ASR-8.

Westslope's ADAMS screening analysis shows that the 125 proposed wind turbines will not be within line-of-sight of and will not interfere with the ADAMS at blade-tip heights of 817 feet MSL or 938 feet MSL under standard atmospheric conditions. The results also show that the 125 proposed wind turbines will not fall within the ducting impact region for the proposed NAS Patuxent River GAOC. As a result, Westslope does not expect any radar effects at or below these blade-tip heights.

Westslope conducted a VOR screening analysis for the following three navigational aid sites:

- Salisbury VORTAC;
- Snow Hill VORTAC; and
- Waterloo VOR/DME.

Westslope's VOR screening analysis for the Salisbury VORTAC, Snow Hill VORTAC, and the Waterloo VOR/DME shows that the proposed wind turbines are greater than 8 NM from these navigational aid sites. Although possible, Westslope does not expect that the FAA will have concerns with the proposed wind turbines at blade-tip heights of 817 feet MSL or 938 feet MSL based on impacts to these navigational aid sites.

Westslope conducted a NEXRAD weather radar screening analysis for the following three radar sites:

- Dover AFB WSR-88D;
- Norfolk WSR-88D; and
- Philadelphia WSR-88D.

Westslope's NEXRAD weather radar screening analysis for the Dover AFB WSR-88D shows that 104 of the 125 proposed wind turbines will be within line-of-sight of this radar site at a blade-tip height of 817 feet MSL. At a blade-tip height of 938 feet MSL, 121 of the 125 proposed wind turbines will be within line-of-sight of this radar site. The results also show that the 125 proposed wind turbines at blade-tip heights of 817 feet MSL or 938 feet MSL will fall within a NOAA green No Impact Zone for this radar site. At blade-tip heights of 817 feet MSL and 938 feet MSL, Doppler contamination over and in the immediate vicinity of the proposed wind turbines within line-of-sight is possible due to clutter; however, impacts to Dover AFB WSR-88D operations are not likely.

Although possible, Westslope does not expect that the DoD will have concerns during the FAA's aeronautical study process with the proposed wind turbines within line-of-sight at blade-tip heights of 817 feet MSL or 938 feet MSL based on impacts to the Dover AFB WSR-88D.

Westslope's NEXRAD weather radar screening analysis for the Norfolk WSR-88D and the Philadelphia WSR-88D shows that the 125 proposed wind turbines will not be within line-of-sight of and will not interfere with these radar sites at blade-tip heights of 817 feet MSL or 938 feet MSL. The results also show that the 125 proposed wind turbines at blade-tip heights of 817 feet MSL or 938 feet MSL will fall within a NOAA green No Impact Zone for these radar sites.

Westslope conducted an HF radar LOS analysis for the following nine radar sites:

- Assateague Island HF radar;
- Brigantine Long Range HF radar;
- Cape Henlopen HF radar;
- Cape May Point HF radar;
- Cedar Island HF radar;
- Loveladies HF radar;
- North Wildwood HF radar;
- Strathmere HF radar; and
- Wildwood HF radar.

The HF radar LOS analyses conducted by Westslope show the following:

- For the Assateague Island HF radar, all 125 proposed wind turbines will be within line-of-sight of this radar site at blade-tip heights of 817 feet MSL and 938 feet MSL.

- For the Cape Henlopen HF radar, four of the 125 proposed wind turbines will be within line-of-sight of this radar site at blade-tip heights of 817 feet MSL and 938 feet MSL.
- For the Cape May Point HF radar, 111 of the 125 proposed wind turbines will be within line-of-sight of this radar site at a blade-tip height of 817 feet MSL. At a blade-tip height of 938 feet MSL, all 125 proposed wind turbines will be within line-of-sight of this radar site.
- For the North Wildwood HF radar, 69 of the 125 proposed wind turbines will be within line-of-sight of this radar site at a blade-tip height of 817 feet MSL. At a blade-tip height of 938 feet MSL, 100 of the 125 proposed wind turbines will be within line-of-sight of this radar site.
- For the Wildwood HF radar, 105 of the 125 proposed wind turbines will be within line-of-sight of this radar site at a blade-tip height of 817 feet MSL. At a blade-tip height of 938 feet MSL, 124 of the 125 proposed wind turbines will be within line-of-sight of this radar site.
- For the Brigantine Long Range HF radar, Cedar Island HF radar, and the Loveladies HF radar, the 125 proposed wind turbines will not be within line-of-sight of these radar sites at blade-tip heights of 817 feet MSL or 938 feet MSL. Although the proposed wind turbines will not be within line-of-sight of these radar sites, radar effects are still possible beyond line-of-sight due to the propagation of HF electromagnetic waves over the ocean surface.
- For the Strathmere HF Radar, the 125 proposed wind turbines will not be within line-of-sight of this radar site at blade-tip heights of 817 feet MSL or 938 feet MSL. Please note that 99 of the 125 proposed wind turbines are beyond the instrumented range of this radar site. Although the proposed wind turbines will not be within line-of-sight of this radar site, radar effects are still possible beyond line-of-sight for the 26 proposed wind turbines within instrumented range of this radar site due to the propagation of HF electromagnetic waves over the ocean surface.

For the Assateague Island HF radar, Cape Henlopen HF radar, Cape May Point HF radar, North Wildwood HF radar, and the Wildwood HF radar, without mitigation, the radar effects will include clutter in the vicinity of the proposed wind turbines within line-of-sight and possibly in the vicinity of the proposed wind turbines beyond line-of-sight due to the propagation of HF electromagnetic waves over the ocean surface. Because wind turbines will be within line-of-sight of these radar sites, Westslope expects that multiple federal agencies in partnership with NOAA's IOOS may have concerns with wind turbines within line-of-sight in the proposed wind turbines at blade-tip heights of 817 feet MSL and 938 feet MSL based on potential interference to these HF radar sites.

Mitigation options for HF radar include, but are not limited, to the following:

- Implementation of a software package to address interference from wind turbines in real-time, which is being researched by CODAR Ocean Sensors, Ltd. under funding from the Bureau of Ocean Energy Management; and
- Installation of other wave and current sensors in the Lease Area.

Westslope recommends that the proposed wind turbines be submitted to the DoD Siting Clearinghouse for an informal review and to the National Telecommunications Information Administration (NTIA) for a detailed review. The NTIA is essentially a clearinghouse for other federal agencies, including the National Oceanic and Atmospheric Administration. Additionally, Westslope recommends consultation with NOAA's IOOS Program Office.

If you have any questions regarding this analysis, please contact Geoff Blackman at (405) 816-2604 or via email at gblackman@westslopeconsulting.com.

REFERENCES

[1] DoD, Office of the Secretary, "*Military Aviation and Installation Assurance Siting Clearinghouse; Notice and Request for Public Comment on Boardman, Oregon, and NAS Patuxent River, Maryland, Geographic Areas of Concern*," August 8, 2018, [\[https://www.federalregister.gov/documents/2018/08/08/2018-16886/military-aviation-and-installation-assurance-siting-clearinghouse-notice-and-request-for-public\]](https://www.federalregister.gov/documents/2018/08/08/2018-16886/military-aviation-and-installation-assurance-siting-clearinghouse-notice-and-request-for-public).

[2] DoD, Department of the Navy, "*Geographic Area of Concern (GAOC): Naval Air Station (NAS) Patuxent River Area, including the Advanced Dynamic Aircraft Measurement System (ADAMS) and the Digital Airport Surveillance Radar (DASR)*," May 14, 2018, [Tab_D_-_INSTALLATION_MANAGEMENT_20180514,_GAOC_for_Pax_River_Final.docx].