AECOM

APPENDIX AA

Radar and Navigational Aid Screening Study

Photo credit: Matt Goldsmith, Equinor

June 2023

Prepared for

Beacon Wind LLC

BEACON WIND PROJECT

RADAR AND NAVIGATIONAL AID SCREENING STUDY

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INTRODUCTION

The proposed Beacon Wind Project (Project) consists of 155 wind turbines and two substations off the coast of Nantucket in Massachusetts.[1] The substations will utilize two of the total 157 proposed locations. This report provides the results of a radar and navigational aid screening study conducted by Westslope Consulting, LLC (Westslope) for the 157 proposed locations and a Lease Area encompassing the proposed locations using blade-tip heights of 850 feet (259 meters) above ground level (AGL) and 1,116 feet (340 meters) AGL.[2] [3]

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 locations;
- An Air Route Surveillance Radar (ARSR) and Airport Surveillance Radar (ASR) line-of-sight (LOS) analysis;
- An Early Warning Radar (EWR) LOS analysis;
- A Terminal Doppler Weather Radar (TDWR) 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.[4] 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.[5] Further, the PST NEXRAD analysis accounts for DoD, FAA, and National Oceanic and Atmospheric Administration (NOAA) Weather Surveillance Radar model-88

[1] WTG_Phase1.shp and WTG_Phase2.shp.
[2] LeaseArea_OCS-A_0520.shp.
[3] This analysis was initiated prior to the Project's project design envelope (PDE) reduction. The current maximum PDE is a 1,083 ft (330 m) AGL wind turbine.
[4] See http://oeaaa.faa.gov.
[5] For LRR, the PST uses a buffered line-of-sight analysis at a blade-tip height of 750 feet AGL.

Doppler (WSR-88D) sites.[6] 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 TDWR sites.

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 yellow area. A yellow area indicates that impacts are likely to air defense and homeland security radar. Further, the PST analysis results for the polygon show that the proposed locations fall within yellow and green areas. 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. See Figure 1, where the black rotor represents the single point, the black line represents the polygon, the black dots represent the 157 proposed locations, and the red line represents the Lease Area.

Westslope identified the four radar sites in the PST LRR results as the Falmouth Airport Surveillance Radar model-8 (ASR-8), Nantucket Airport Surveillance Radar model-9 (ASR-9), North Truro Air Route Surveillance Radar model-4 (ARSR-4), and the Providence ASR-9. In addition to the DoD and DHS using these radar sites for air defense and homeland security, the FAA uses these radar sites for air traffic control at multiple facilities, including the Boston Terminal Radar Approach Control (TRACON), Nantucket Air Traffic Control Tower, Boston Air Route Traffic Control Center (ARTCC), and the Providence TRACON.

For NEXRAD, the PST analysis results for the single point and the polygon show that the proposed locations 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 two radar sites in the PST NEXRAD analysis as the Boston WSR-88D and the Brookhaven WSR-88D.

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

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

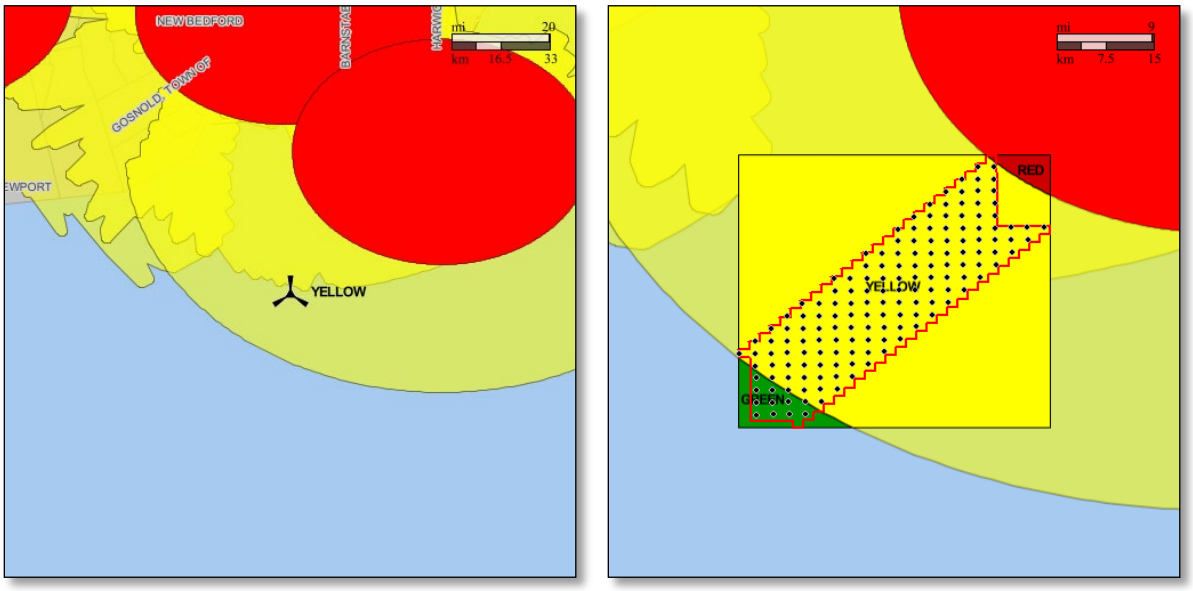

Figure 1 Long Range Radar Results for the Single Point (left) and for the Polygon (right)

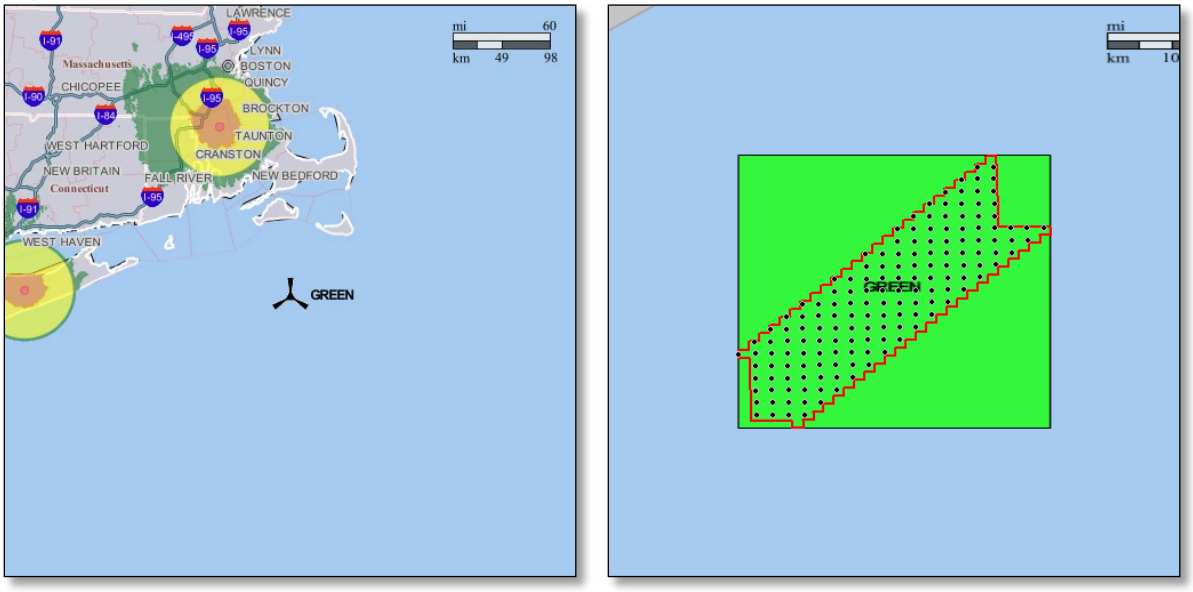

Figure 2 NEXRAD Results for the Single Point (left) and for the Polygon (right)

Other ARSR and ASR Sites

Research conducted by Westslope identified the following two additional ARSR and ASR sites near the proposed locations:

- Boston ASR-9; and
- Riverhead ARSR-4.

The FAA uses these radar sites for air traffic control at multiple facilities, including the Boston TRACON and the New York ARTCC.

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 Falmouth ASR-8;
- An Air Traffic Control Beacon Interrogator model-6 is co-located with the North Truro ARSR-4 and the Riverhead ARSR-4; and
- A Mode S is co-located with the Boston ASR-9, Nantucket ASR-9, and the Providence ASR-9.

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.

EWR Sites

Research conducted by Westslope identified one EWR site near the proposed locations: the Cape Cod Air Force Station (AFS) EWR.

The DoD uses the Cape Cod AFS EWR for ballistic missile defense and space surveillance.

TDWR Sites

Research conducted by Westslope identified one TDWR site near the proposed locations: the Boston TDWR.

The FAA uses this radar site for air traffic control at the Boston TRACON.

VOR Sites

Research conducted by Westslope identified the following two navigational aid sites near the proposed locations:

- Martha's Vineyard VOR and co-located Distance Measuring Equipment (VOR/DME); and
- Nantucket 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.

HF Radar Sites

Research conducted by Westslope identified the following 10 HF radar sites near the proposed locations:

- Amagansett HF radar;
- Block Island Long Range HF radar;
- Horseneck Beach State Reservation HF radar;
- Long Point Wildlife Refuge HF radar;
- Martha's Vineyard HF radar;
- Moriches HF radar;
- Martha's Vineyard Coastal Observatory (MVCO) Meteorological Mast HF radar;
- Nantucket HF radar;
- Nantucket Island HF radar; and
- Nauset HF radar.

The Amagansett HF radar, Block Island Long Range HF radar, Martha's Vineyard HF radar, Moriches HF radar, and the Nantucket Island HF radar are operated by Rutgers University. The Horseneck Beach State Reservation HF radar, Long Point Wildlife Refuge HF radar, MVCO Meteorological Mast HF radar, and the Nantucket HF radar are operated by the Woods Hole Oceanographic Institution. The Nauset HF radar is operated by the University of Massachusetts Dartmouth.

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 850 feet (259 meters) AGL or 1,116 feet (340 meters) AGL 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:

- Boston ASR-9;
- Falmouth ASR-8;
- Nantucket ASR-9;
- North Truro ARSR-4;
- Providence ASR-9; and
- Riverhead ARSR-4.

The proposed locations are beyond the instrumented range of the Boston ASR-9 and the Providence ASR-9. As such, no additional analysis was considered necessary for these radar sites.

Falmouth ASR-8

The LOS analysis results show that 61 of the 157 proposed locations will be within line-of-sight of and may interfere with the Falmouth ASR-8 at a blade-tip height of 850 feet (259 meters) AGL. At a blade-tip height of 1,116 feet (340 meters) AGL, 104 of the 157 proposed locations will be within line-of-sight of and may interfere with this radar site. See Figure 3. The radar effects may 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 locations 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 locations within line-of-sight.

Nantucket ASR-9

The LOS analysis results show that all 157 proposed locations will be within line-of-sight of and may interfere with the Nantucket ASR-9 at blade-tip heights of 850 feet (259 meters) AGL and 1,116 feet (340 meters) AGL. See Figure 4. The radar effects may 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 locations. Other radar effects include a partial loss of weather detection and false weather indications over and in the immediate vicinity of the proposed locations.

North Truro ARSR-4

The LOS analysis results show that the 157 proposed locations will not be within line-of-sight of and will not interfere with the North Truro ARSR-4 at blade-tip heights of 850 feet (259 meters) AGL or 1,116 feet (340 meters) AGL. As a result, Westslope does not expect any radar effects at or below these blade-tip heights.

Riverhead ARSR-4

The LOS analysis results show that the 157 proposed locations will not be within line-of-sight of and will not interfere with the Riverhead ARSR-4 at blade-tip heights of 850 feet (259 meters) AGL or 1,116 feet (340 meters) AGL. As a result, Westslope does not expect any radar effects at or below these blade-tip heights.

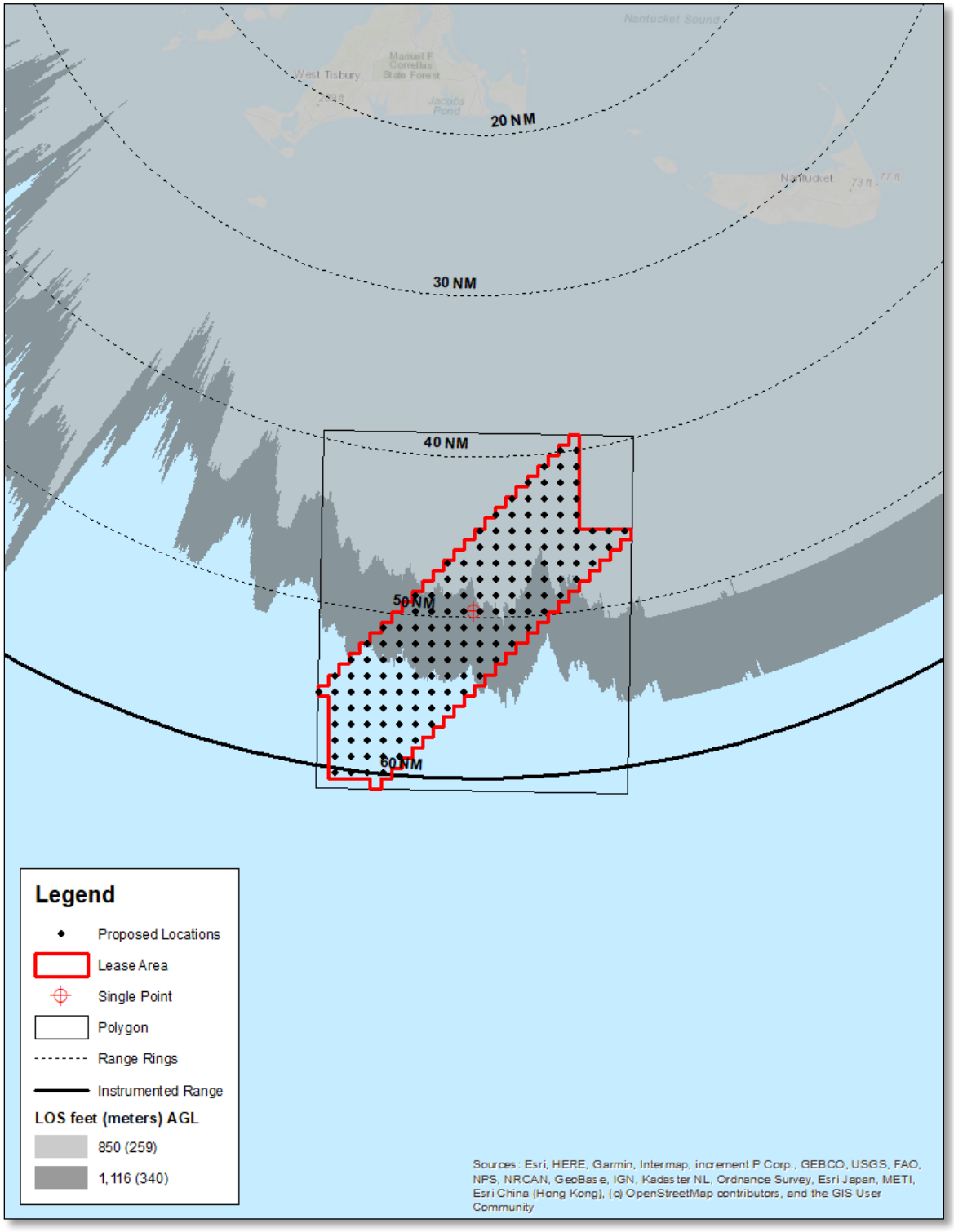

Figure 3 LOS Analysis Results for the Falmouth ASR-8 using 10-meter NED

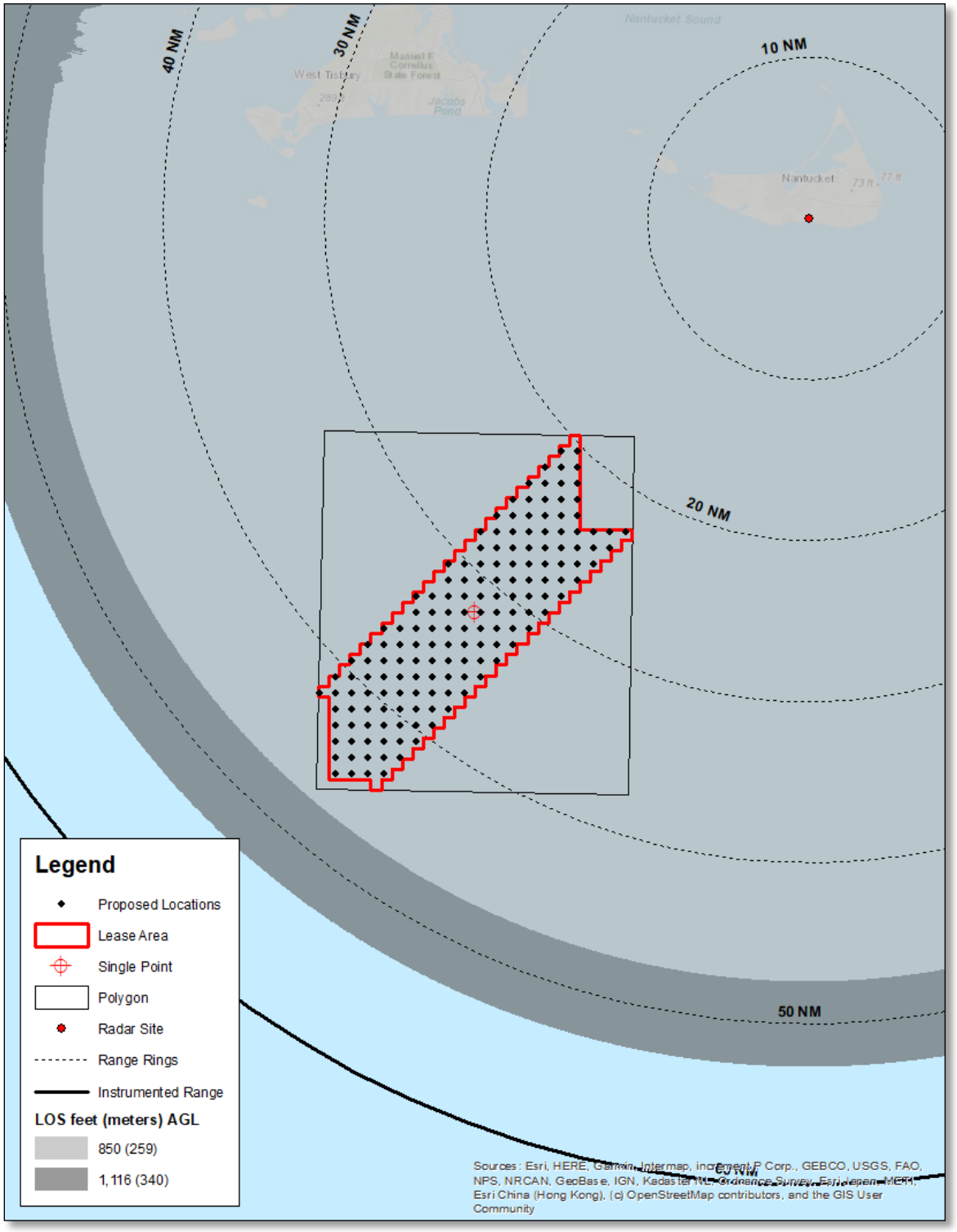

Figure 4 LOS Analysis Results for the Nantucket ASR-9 using 10-meter NED

EWR LOS Analysis

Westslope conducted an EWR LOS analysis for the Cape Cod AFS EWR using USGS 10-meter NED. This analysis shows whether wind turbines at blade-tip heights of 850 feet (259 meters) AGL or 1,116 feet (340 meters) AGL will be within line-of-sight of this EWR site.

Cape Cod AFS EWR

The LOS analysis results show that 71 of the 157 proposed locations will be within line-of-sight of the Cape Cod AFS EWR at a blade-tip height of 850 feet (259 meters) AGL. At a blade-tip height of 1,116 feet (340 meters) AGL, 112 of the 157 proposed locations will be within line-of-sight of this radar site. See Figure 5.

Research conducted by Westslope suggests that the proposed locations within line-of-sight of the Cape Cod AFS EWR could have a significant impact on this early warning radar. [1] As such, Westslope recommends early consultation with the DoD Siting Clearinghouse.

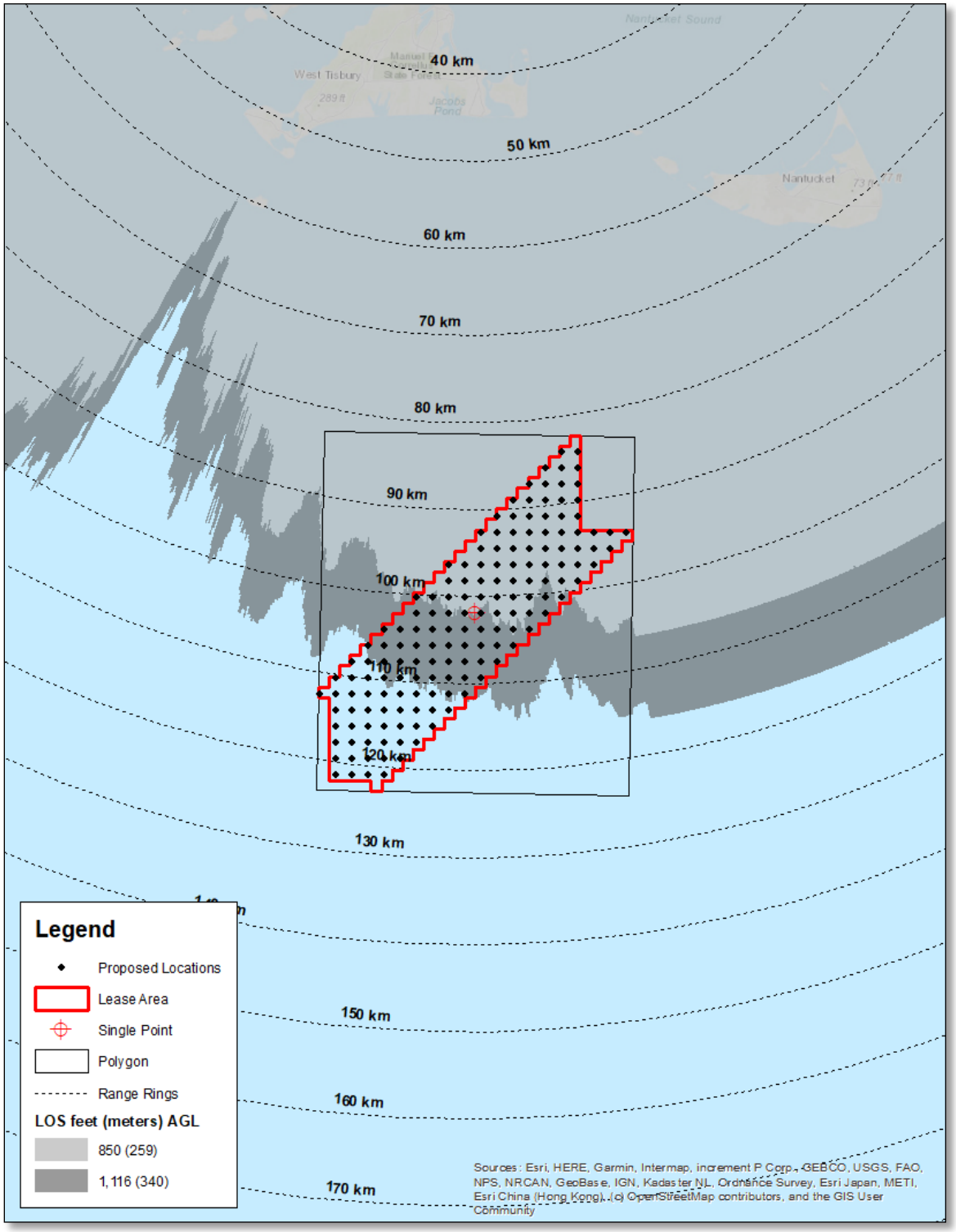

Figure 5 LOS Analysis Results for the Cape Cod AFS EWR using 10-meter NED

TDWR Screening Analysis

Westslope conducted a TDWR screening analysis for the Boston TDWR using USGS 10-meter NED. This analysis shows whether wind turbines at blade-tip heights of 850 feet (259 meters) AGL or 1,116 feet (340 meters) AGL will be within line-of-sight of this TDWR site and determines the number of elevation angles penetrated and potentially affected.

The proposed locations are beyond the instrumented range of the Boston TDWR. As such, no additional analysis was considered necessary for this radar site.

VOR Screening Analysis

Westslope conducted a VOR screening analysis using USGS 10-meter NED. This analysis shows whether the proposed locations (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 850 feet (259 meters) AGL or 1,116 feet (340 meters) AGL, 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 locations may affect VOR performance and is similar to the FAA's analysis approach for VOR sites. The same criteria will also protect for DMEs.

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

- Martha's Vineyard VOR/DME; and
- Nantucket VOR/DME.

The proposed locations are greater than 8 NM from the Martha's Vineyard VOR/DME and the Nantucket 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 850 feet (259 meters) AGL or 1,116 feet (340 meters) AGL 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 two radar sites:

- Boston WSR-88D; and
- Brookhaven WSR-88D.

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

Boston WSR-88D

Westslope's NEXRAD weather radar screening analysis shows that the 157 proposed locations will not be within line-of-sight of and will not interfere with the Boston WSR-88D at blade-tip heights of 850 feet (259 meters) AGL or 1,116 feet (340 meters) AGL. The results also show that the 157 proposed locations at blade-tip heights of 850 feet (259 meters) AGL and 1,116 feet (340 meters) AGL 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 6 and 7.

Brookhaven WSR-88D

Westslope's NEXRAD weather radar screening analysis shows that the 157 proposed locations will not be within line-of-sight of and will not interfere with the Brookhaven WSR-88D at blade-tip heights of 850 feet (259 meters) AGL or 1,116 feet (340 meters) AGL. The results also show that the 157 proposed locations at blade-tip heights of 850 feet (259 meters) AGL and 1,116 feet (340 meters) AGL will fall within a NOAA green No Impact Zone for this radar site. See Figures 8 and 9.

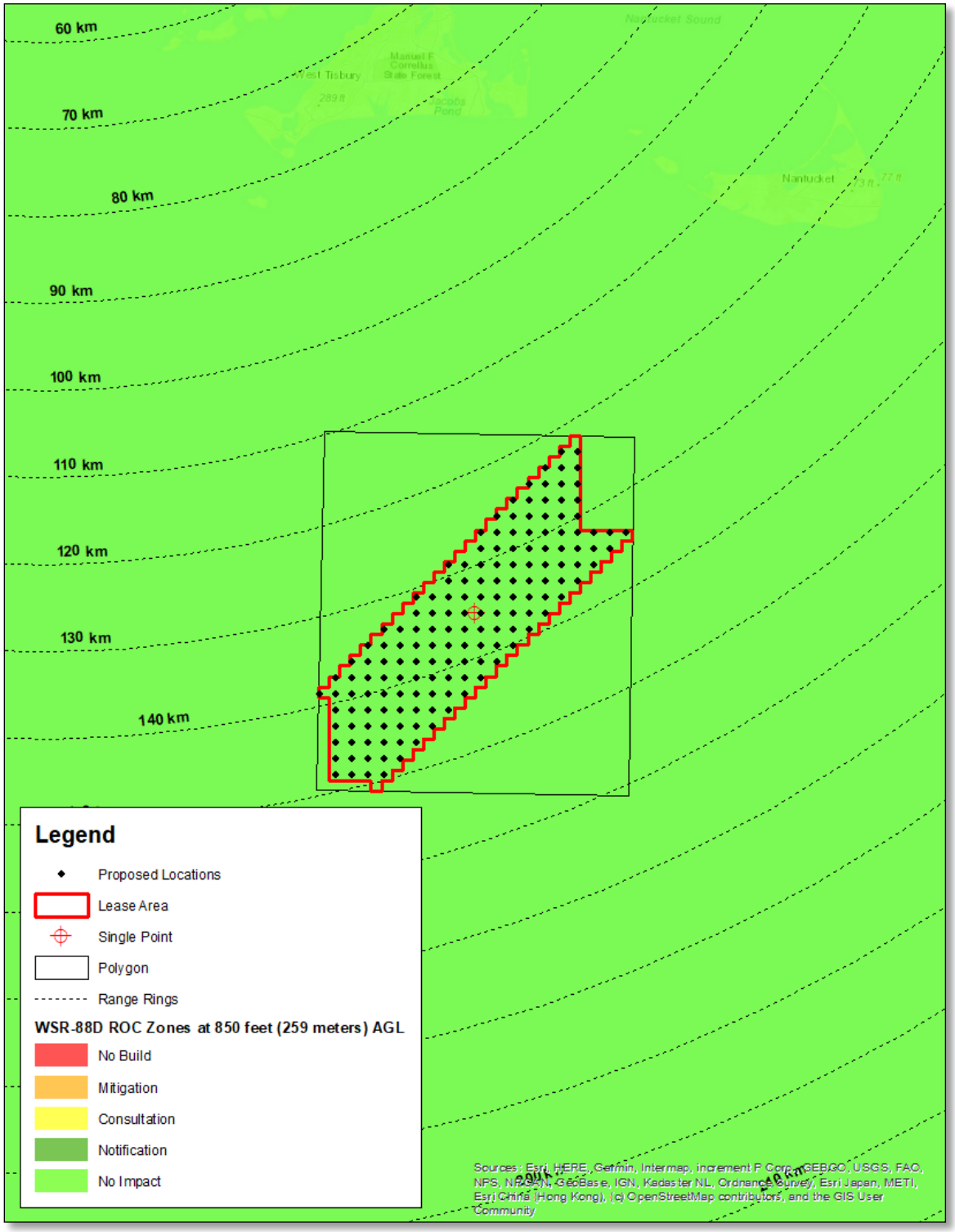

Figure 6 WSR-88D ROC Zone Results at 850 feet (259 meters) AGL for the Boston WSR-88D using 10-meter NED

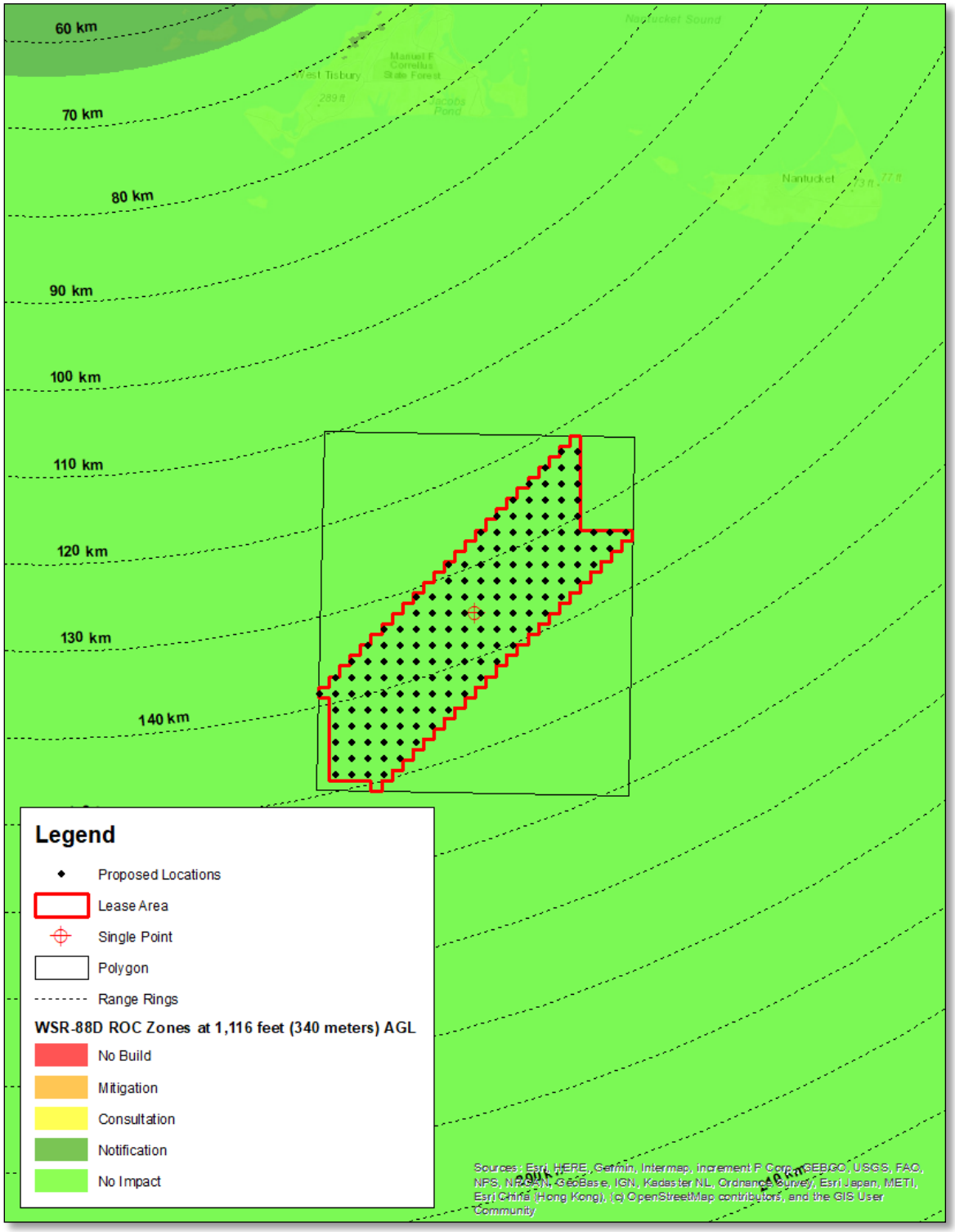

Figure 7 WSR-88D ROC Zone Results at 1,116 feet (340 meters) AGL for the Boston WSR-88D using 10-meter NED

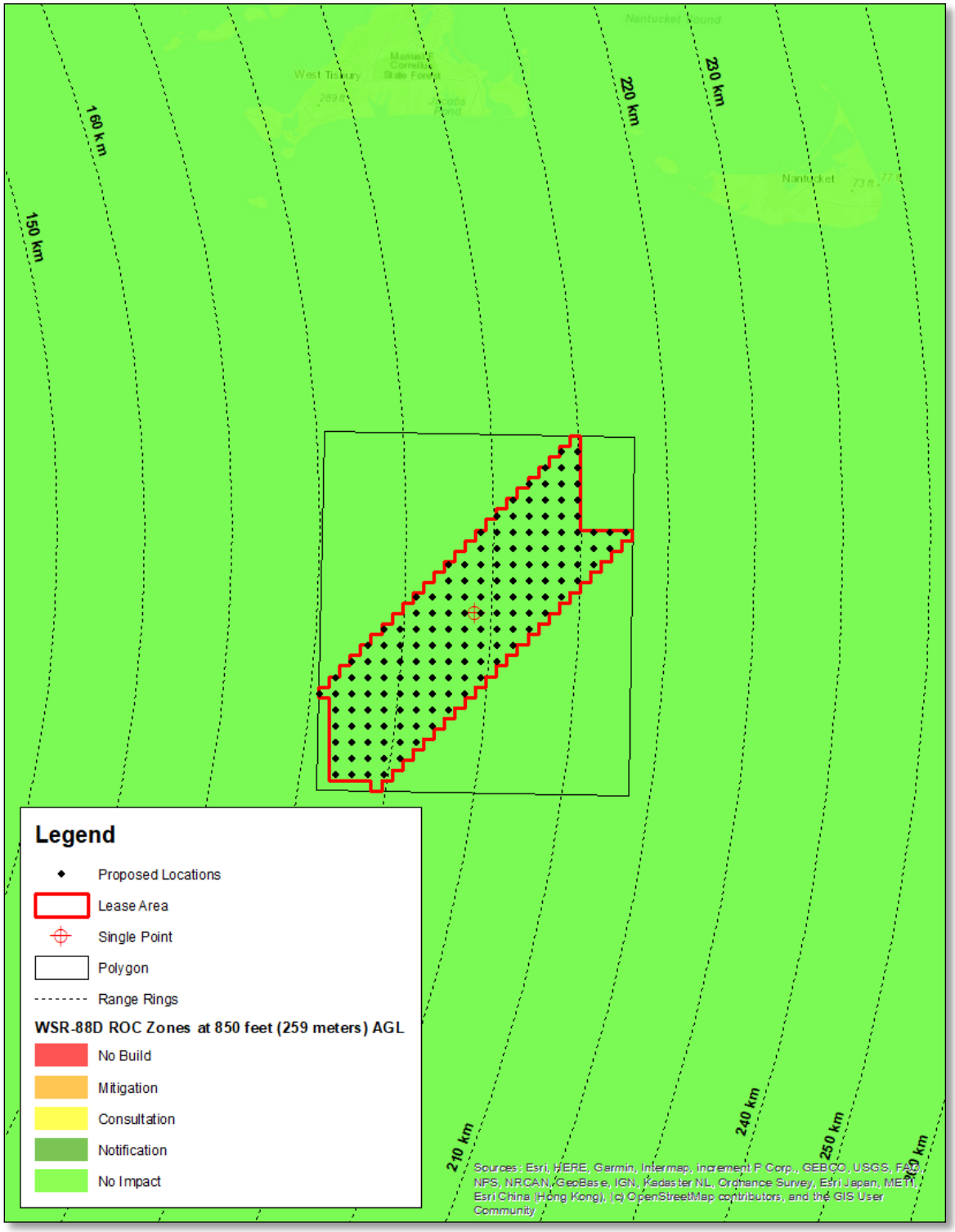

Figure 8 WSR-88D ROC Zone Results at 850 feet (259 meters) AGL for the Brookhaven WSR-88D using 10-meter NED

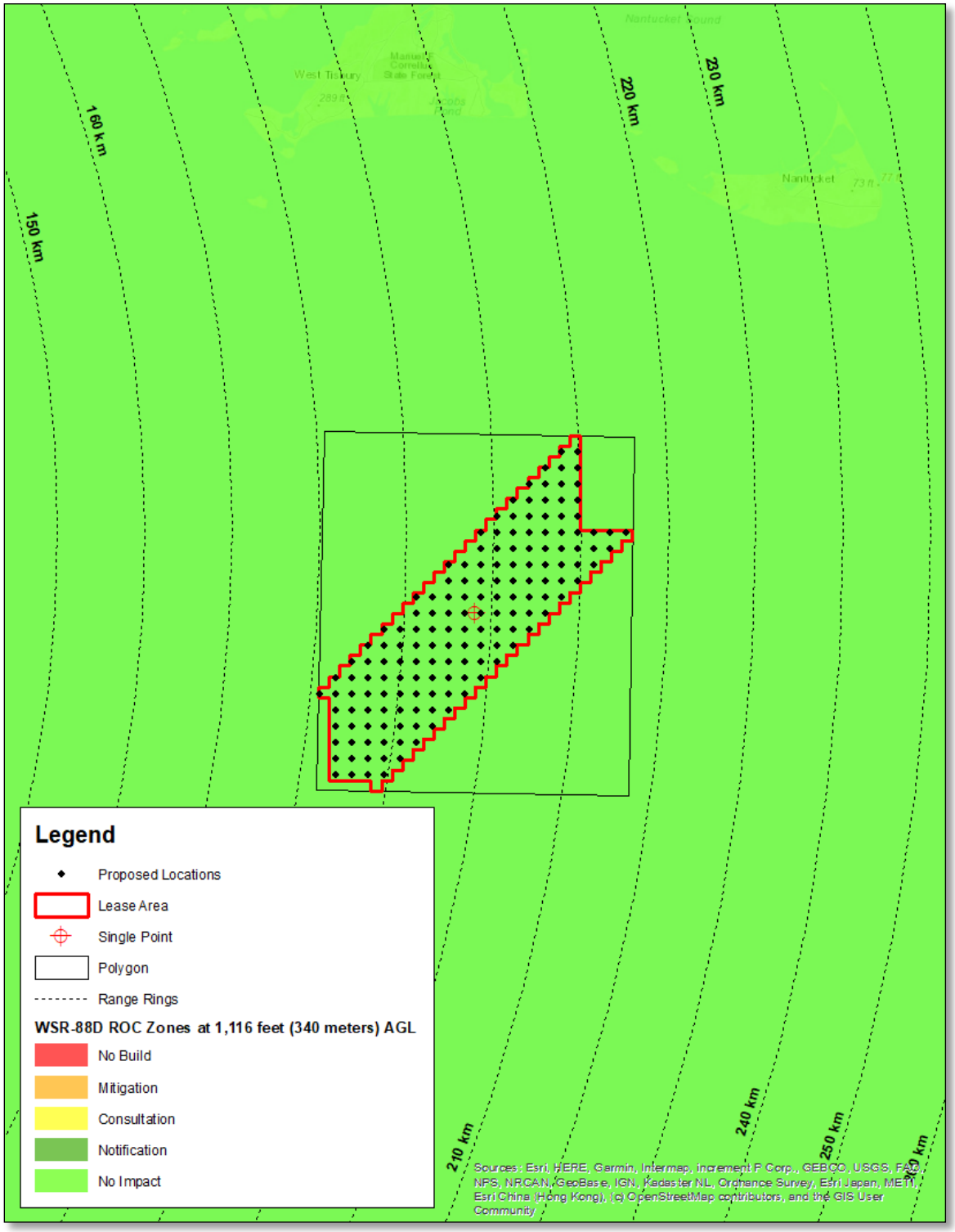

Figure 9 WSR-88D ROC Zone Results at 1,116 feet (340 meters) AGL for the Brookhaven WSR-88D using 10-meter NED

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 850 feet (259 meters) AGL or 1,116 feet (340 meters) AGL will be within line-of-sight of one or more HF radar sites.

Westslope conducted the LOS analysis for the following 10 HF radar sites:

- Amagansett HF radar;
- Block Island Long Range HF radar;
- Horseneck Beach State Reservation HF radar;
- Long Point Wildlife Refuge HF radar;
- Martha's Vineyard HF radar;
- Moriches HF radar;
- MVCO Meteorological Mast HF radar;
- Nantucket HF radar;
- Nantucket Island HF radar; and
- Nauset HF radar.

Amagansett HF Radar

The LOS analysis results show that the 157 proposed locations will not be within line-of-sight of the Amagansett HF radar at blade-tip heights of 850 feet (259 meters) AGL or 1,116 feet (340 meters) AGL. See Figure 10. Although the proposed locations 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.

Block Island Long Range HF Radar

The LOS analysis results show that 75 of the 157 proposed locations will be within line-of-sight of the Block Island Long Range HF radar at a blade-tip height of 850 feet (259 meters) AGL. At a blade-tip height of 1,116 feet (340 meters) AGL, 150 of the 157 proposed locations will be within line-of-sight of this radar site. See Figure 11. The radar effects may include clutter in the vicinity of the proposed locations within line-of-sight and possibly in the vicinity of the proposed locations beyond line-of-sight due to the propagation of HF electromagnetic waves over the ocean surface. As a result, impacts to Block Island Long Range HF radar operations are possible.

Horseneck Beach State Reservation HF Radar

The LOS analysis results show that the 157 proposed locations will not be within line-of-sight of the Horseneck Beach State Reservation HF radar at a blade-tip height of 850 feet (259 meters) AGL. At a blade-tip height of 1,116 feet (340 meters) AGL, 45 of the 157 proposed locations will be within line-of-sight of this radar site. Please note that 74 of the 157 proposed locations are beyond the instrumented range of this radar site. See Figure 12. The radar effects may include clutter in the vicinity of the proposed locations within line-of-sight and possibly in the vicinity of the proposed locations beyond line-of-sight due to the propagation of HF electromagnetic waves over the ocean surface. As a result, impacts to Horseneck Beach State Reservation HF radar operations are possible.

Long Point Wildlife Refuge HF Radar

The LOS analysis results show that all 157 proposed locations will be within line-of-sight of the Long Point Wildlife Refuge HF radar at blade-tip heights of 850 feet (259 meters) AGL and 1,116 feet (340 meters) AGL. See Figure 13. The radar effects may include clutter in the vicinity of the proposed locations. As a result, impacts to Long Point Wildlife Refuge HF radar operations are possible.

Martha's Vineyard HF Radar

The LOS analysis results show that 153 of the 157 proposed locations will be within line-of-sight of the Martha's Vineyard HF radar at a blade-tip height of 850 feet (259 meters) AGL. At a blade-tip height of 1,116 feet (340 meters) AGL, all 157 proposed locations will be within line-of-sight of this radar site. See Figure 14. The radar effects may include clutter in the vicinity of the proposed locations within line-of-sight and possibly in the vicinity of the proposed locations beyond line-of-sight due to the propagation of HF electromagnetic waves over the ocean surface. As a result, impacts to Martha's Vineyard HF radar operations are possible.

Moriches HF Radar

The LOS analysis results show that the 157 proposed locations will not be within line-of-sight of the Moriches HF radar at blade-tip heights of 850 feet (259 meters) AGL or 1,116 feet (340 meters) AGL. See Figure 15. Although the proposed locations 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.

MVCO Meteorological Mast HF Radar

The LOS analysis results show that 12 of the 157 proposed locations will be within line-of-sight of the MVCO Meteorological Mast HF radar at blade-tip heights of 850 feet (259 meters) AGL and 1,116 feet (340 meters) AGL. Please note that 145 of the 157 proposed locations are beyond the instrumented range of this radar site. See Figure 16. The radar effects may include clutter in the vicinity of the proposed locations within line-of-sight and possibly in the vicinity of the proposed locations beyond line-of-sight due to the propagation of HF electromagnetic waves over the ocean surface. As a result, impacts to MVCO Meteorological Mast HF radar operations are possible.

Nantucket HF Radar

The LOS analysis results show that 151 of the 157 proposed locations will be within line-of-sight of the Nantucket HF radar at a blade-tip height of 850 feet (259 meters) AGL. At a blade-tip height of 1,116 feet (340 meters) AGL, all 157 proposed locations will be within line-of-sight of this radar site. See Figure 17. The radar effects may include clutter in the vicinity of the proposed locations within line-of-sight and possibly in the vicinity of the proposed locations beyond line-of-sight due to the propagation of HF electromagnetic waves over the ocean surface. As a result, impacts to Nantucket HF radar operations are possible.

Nantucket Island HF Radar

The LOS analysis results show that 117 of the 157 proposed locations will be within line-of-sight of the Nantucket Island HF radar at a blade-tip height of 850 feet (259 meters) AGL. At a blade-tip height of 1,116 feet (340 meters) AGL, 154 of the 157 proposed locations will be within line-of-sight of this radar site. See Figure 18. The radar effects may include clutter in the vicinity of the proposed locations within line-of-sight and possibly in the vicinity of the proposed locations beyond line-of-sight due to the propagation of HF electromagnetic waves over the ocean surface. As a result, impacts to Nantucket Island HF radar operations are possible.

Nauset HF Radar

The LOS analysis results show that the 157 proposed locations will not be within line-of-sight of the Nauset HF radar at blade-tip heights of 850 feet (259 meters) AGL or 1,116 feet (340 meters) AGL. See Figure 19. Although the proposed locations 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.

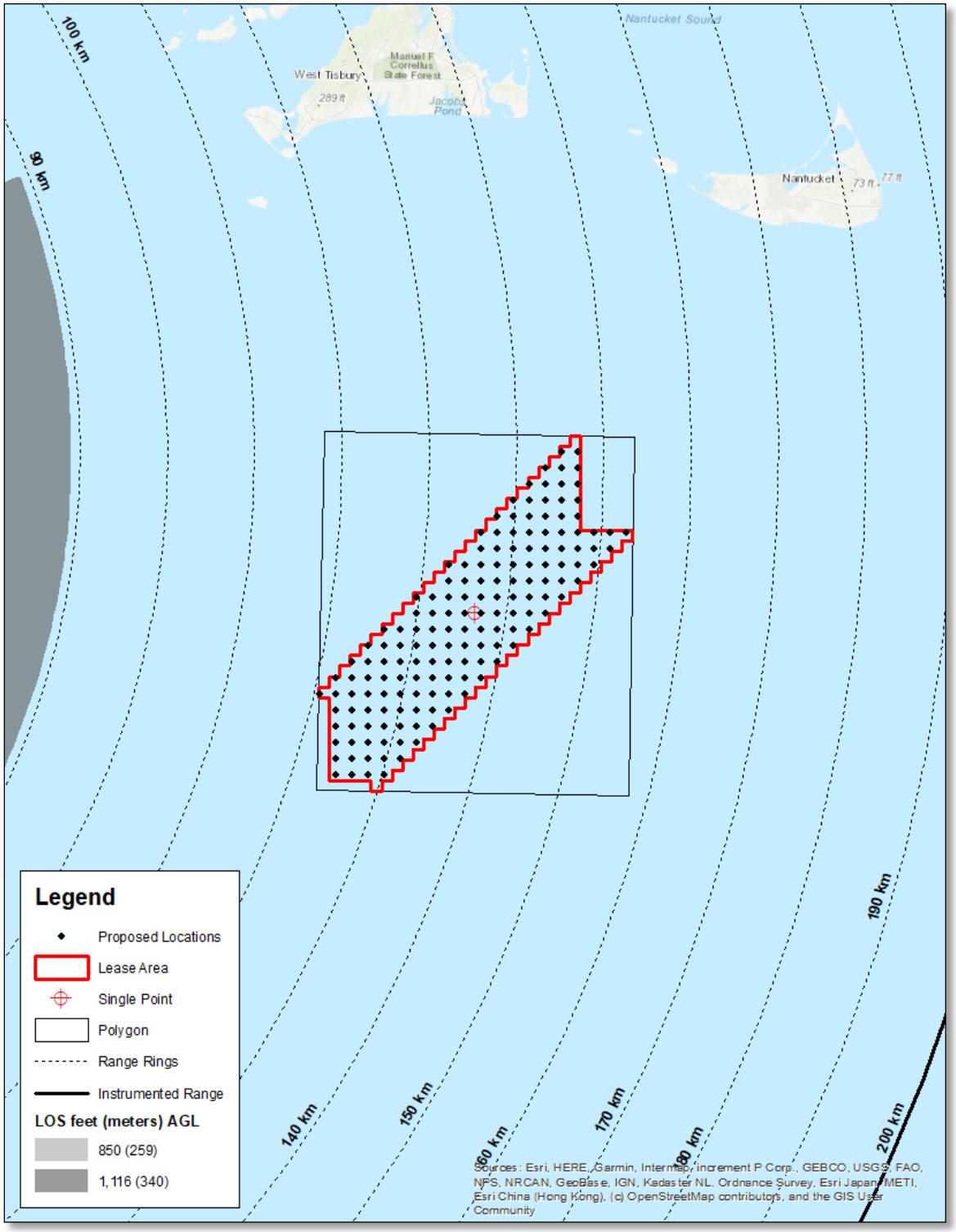

Figure 10 LOS Analysis Results for the Amagansett HF Radar using 10-meter NED

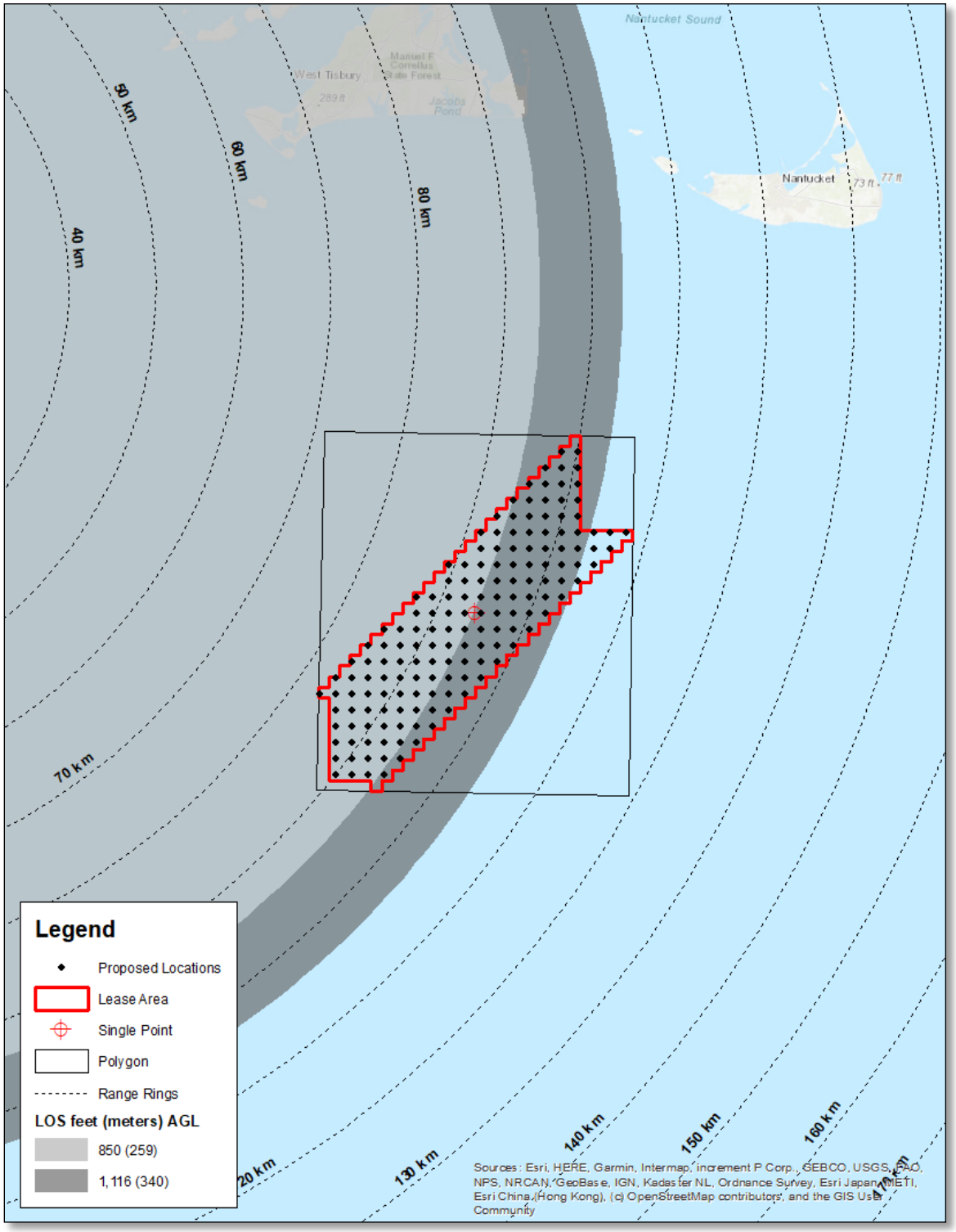

Figure 11 LOS Analysis Results for the Block Island Long Range HF Radar using 10-meter NED

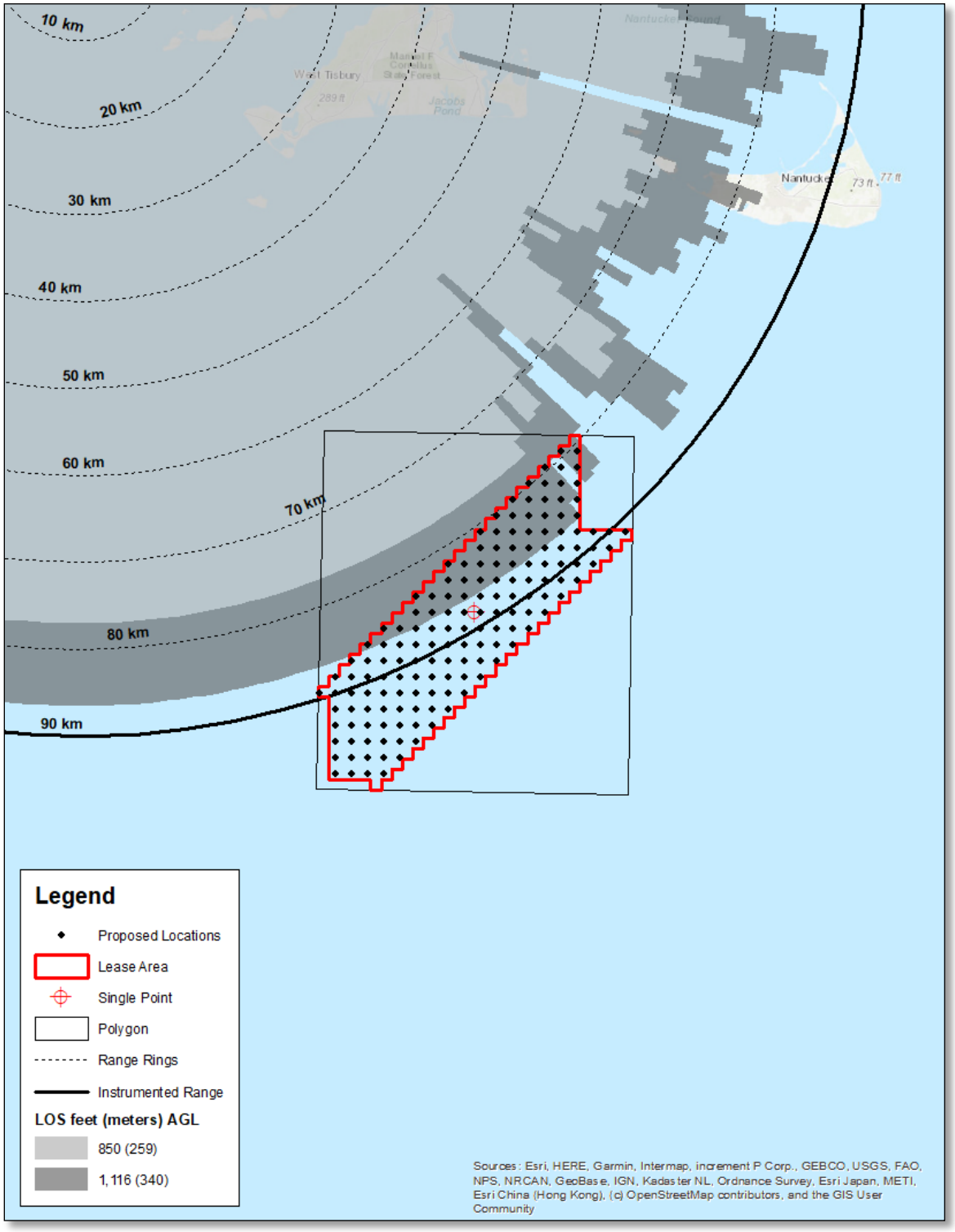

Figure 12 LOS Analysis Results for the Horseneck Beach State Reservation HF Radar using 10-meter NED

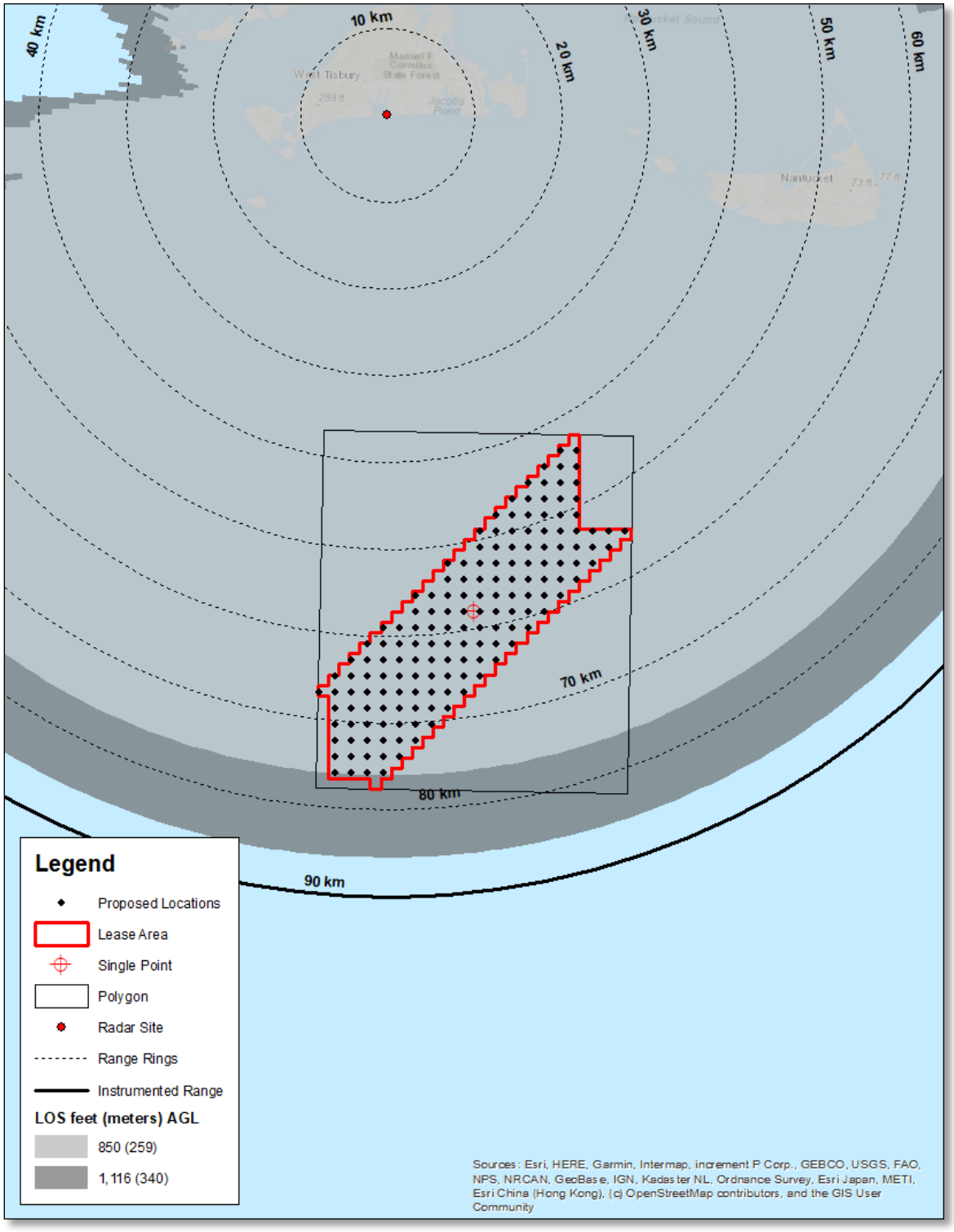

Figure 13 LOS Analysis Results for the Long Point Wildlife Refuge HF Radar using 10-meter NED

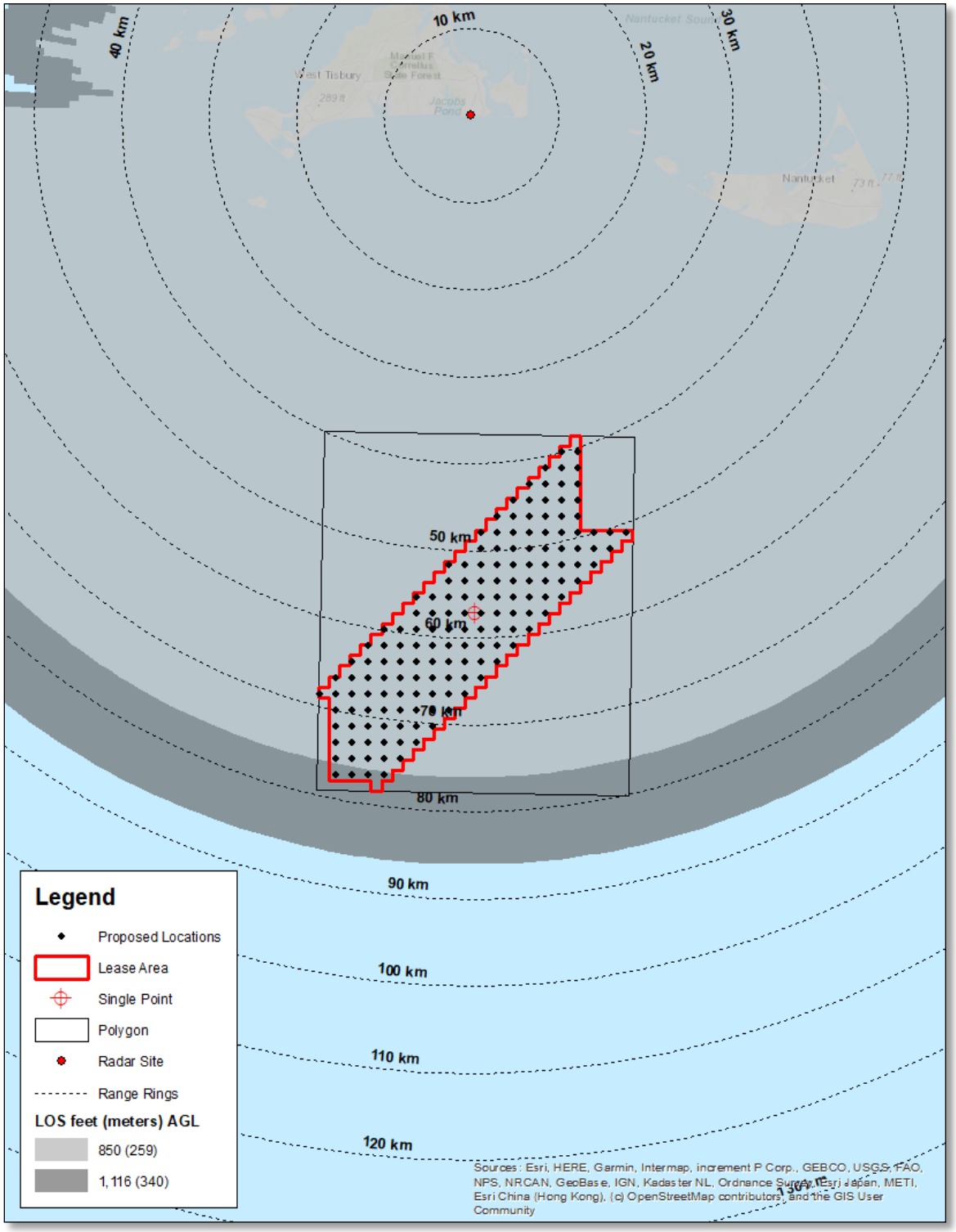

Figure 14 LOS Analysis Results for the Martha's Vineyard HF Radar using 10-meter NED

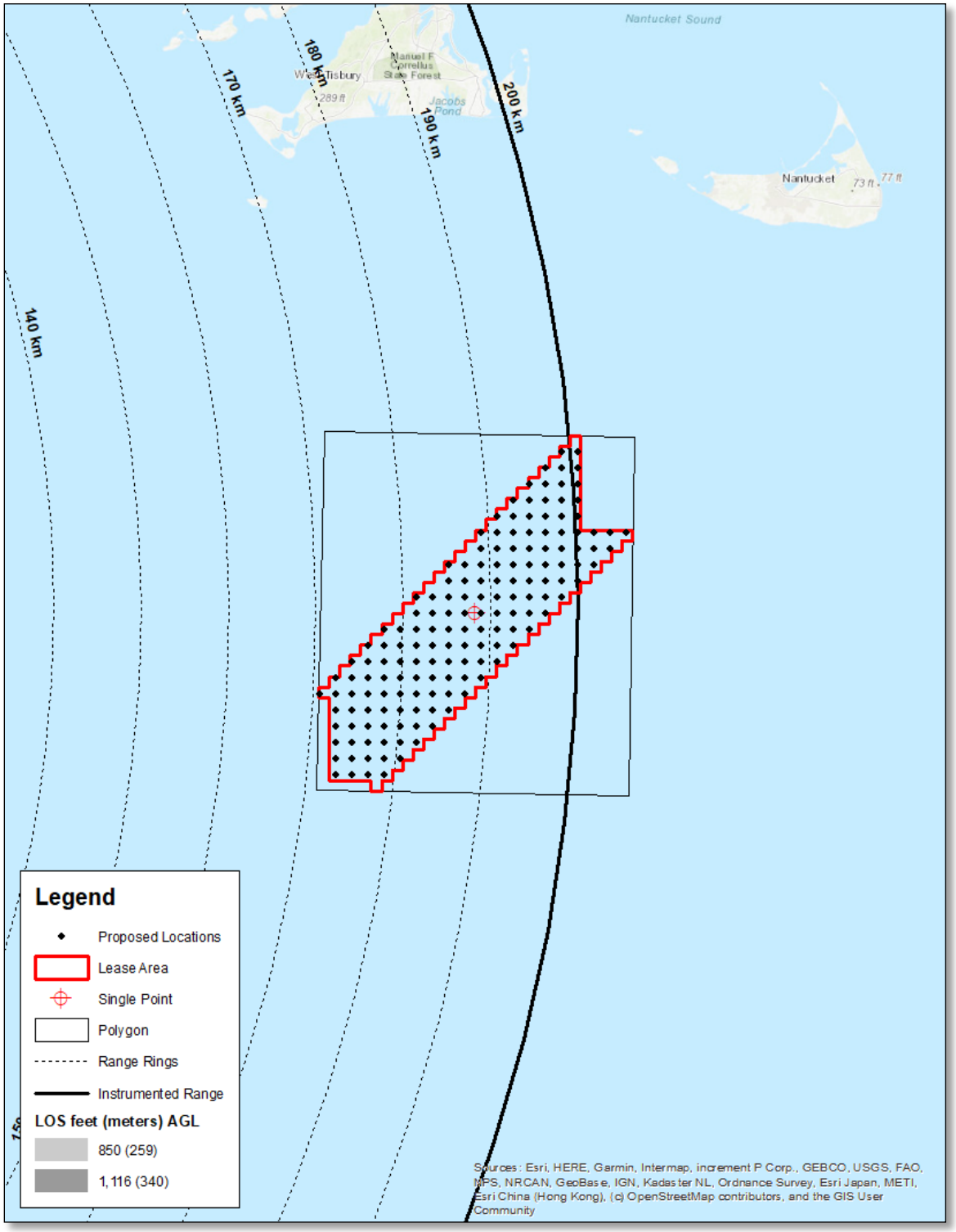

Figure 15 LOS Analysis Results for the Moriches HF Radar using 10-meter NED

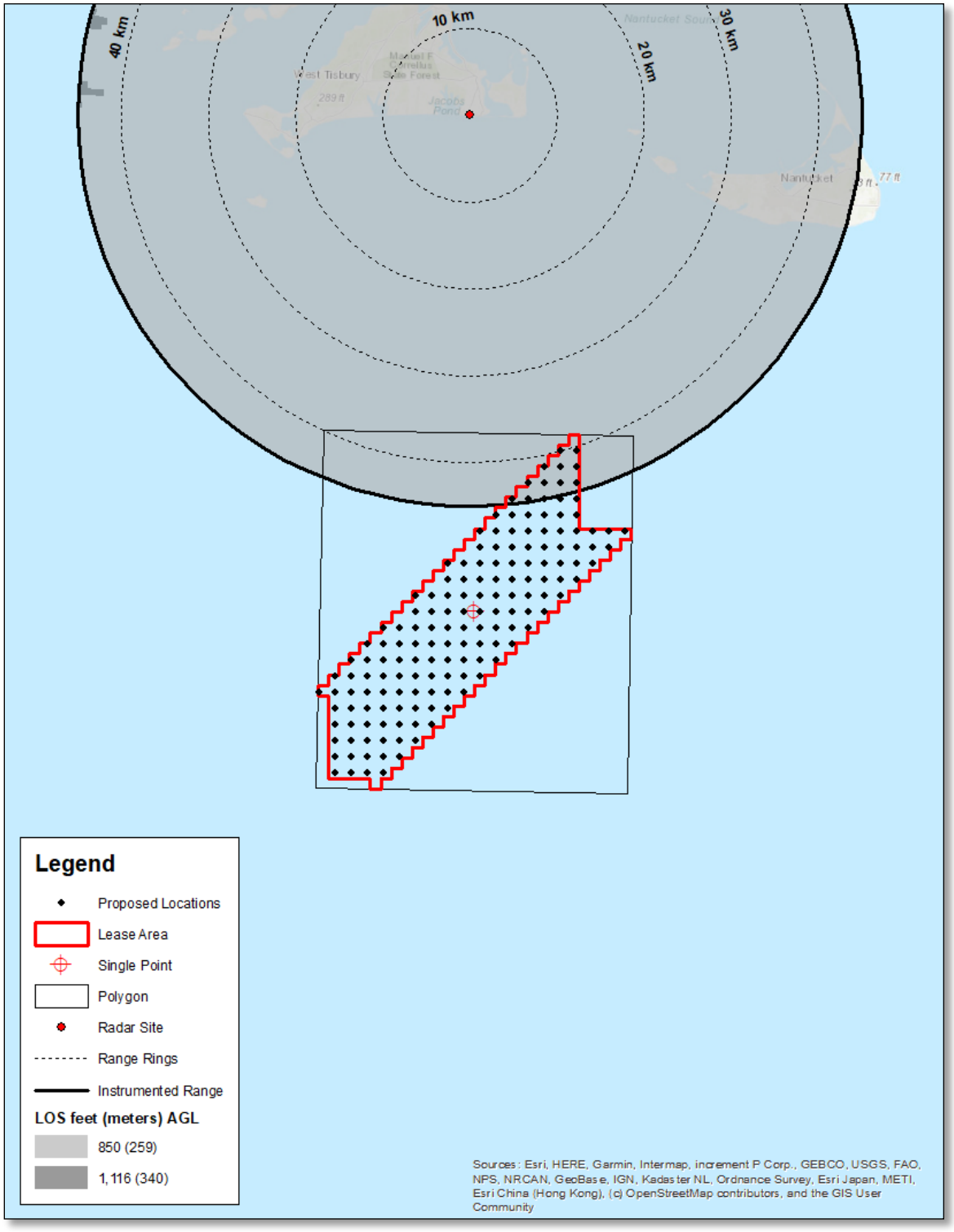

Figure 16 LOS Analysis Results for the MVCO Meteorological Mast HF Radar using 10-meter NED

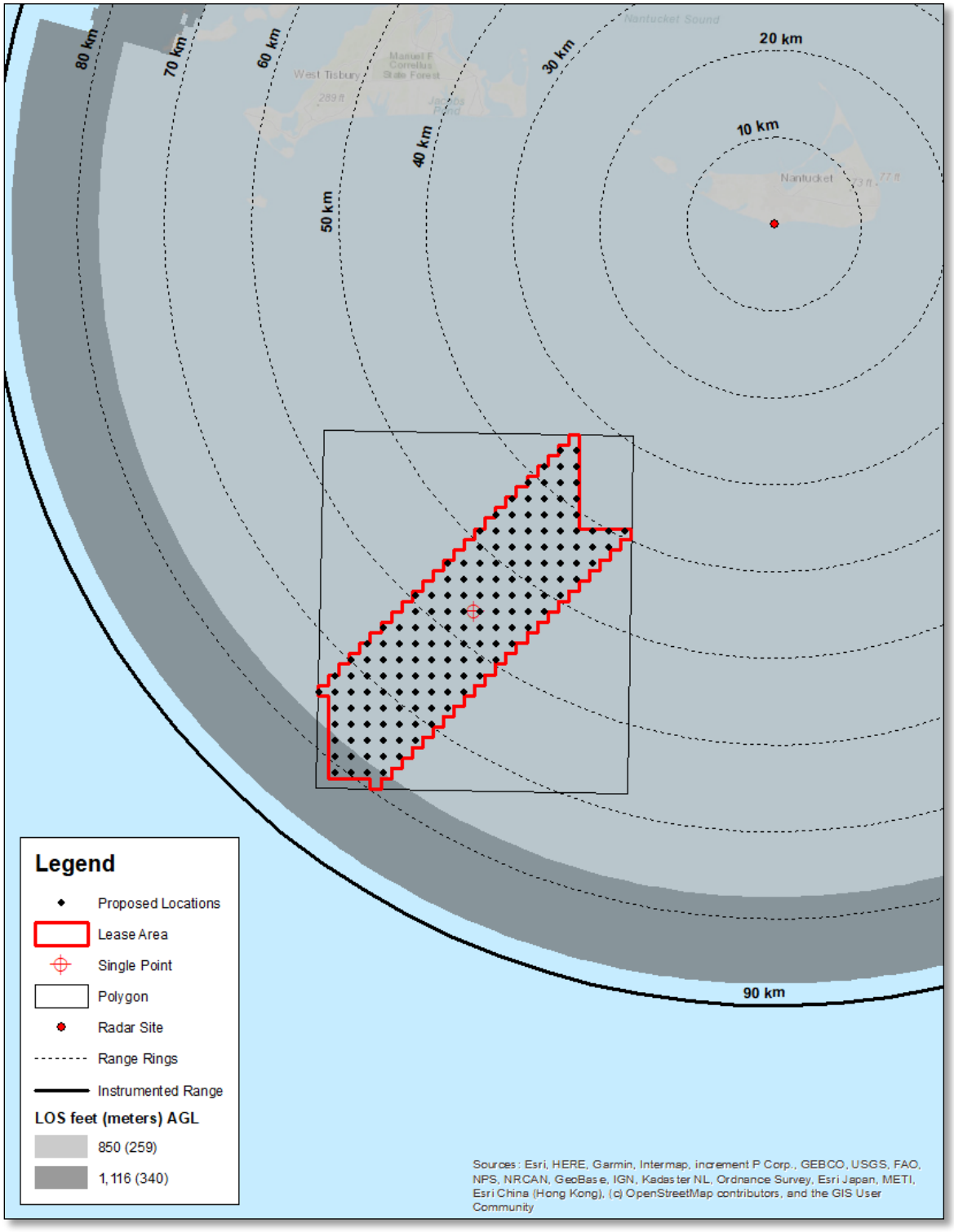

Figure 17 LOS Analysis Results for the Nantucket HF Radar using 10-meter NED

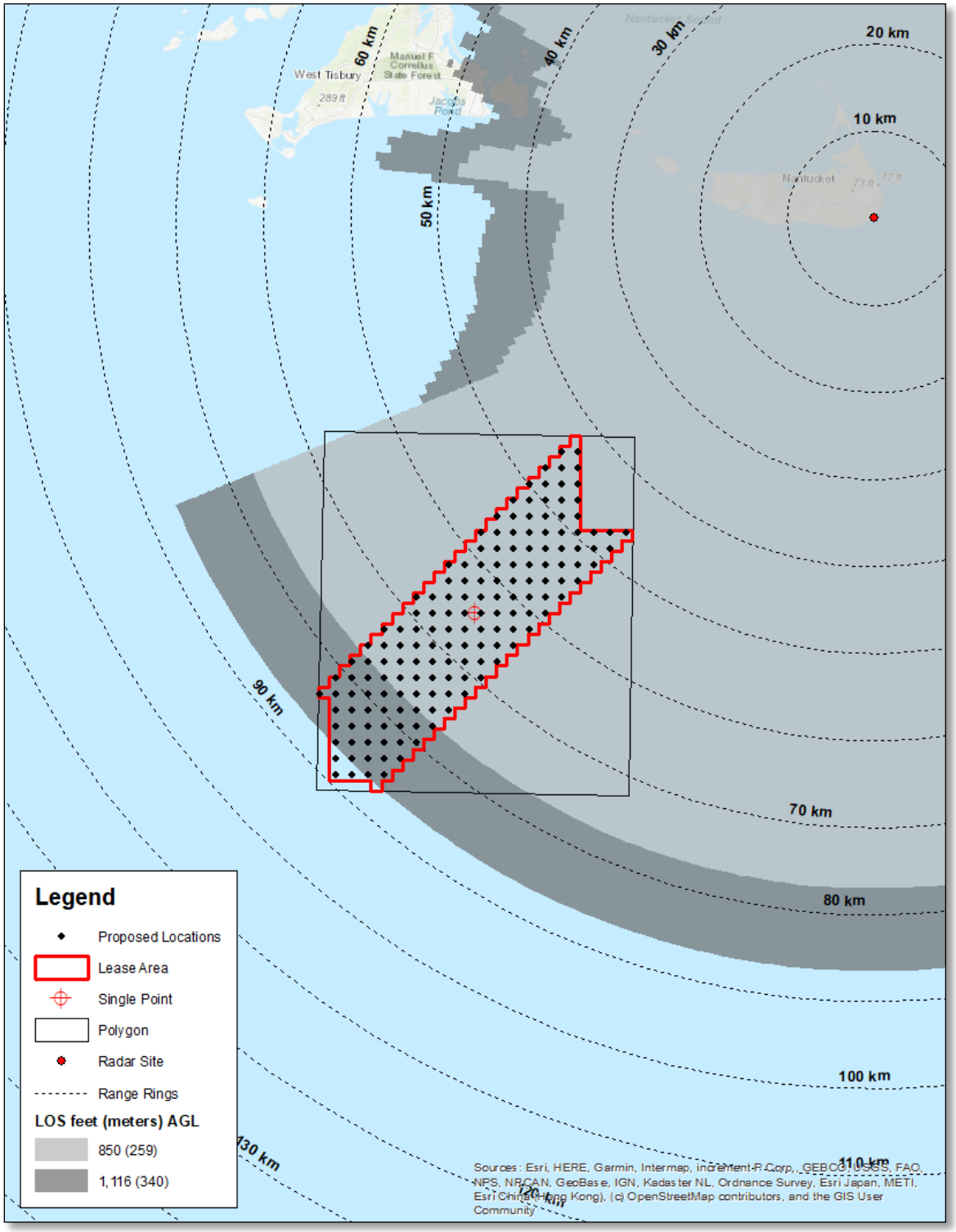

Figure 18 LOS Analysis Results for the Nantucket Island HF Radar using 10-meter NED

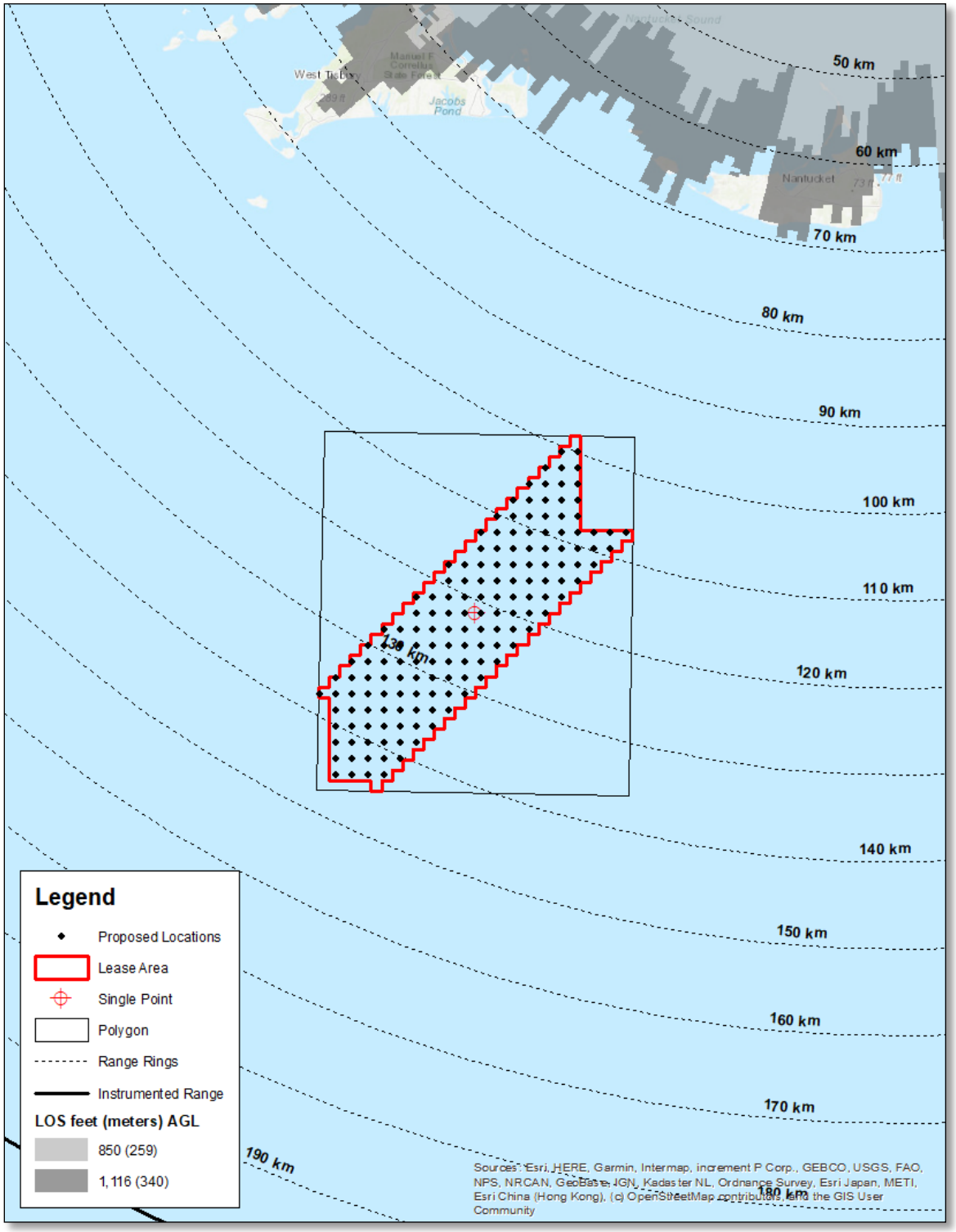

Figure 19 LOS Analysis Results for the Nauset HF Radar using 10-meter NED

CONCLUSIONS

The DoD PST analysis results for the proposed locations indicate the following:

- Impacts to air defense and homeland security radar are likely in the majority of the Lease Area and not anticipated in the southwestern corner; and
- Impacts to WSR-88D weather radar are not likely.

Westslope identified the four radar sites in the PST analysis results for Long Range Radar as the Falmouth ASR-8, Nantucket ASR-9, North Truro ARSR-4, and the Providence ASR-9. Further, Westslope identified the two radar sites in the PST analysis results for NEXRAD as the Boston WSR-88D and the Brookhaven WSR-88D.

Research conducted by Westslope identified two additional ARSR and ASR sites near the proposed locations: the Boston ASR-9 and the Riverhead ARSR-4.

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

- Boston ASR-9;
- Falmouth ASR-8;
- Nantucket ASR-9;
- North Truro ARSR-4;
- Providence ASR-9; and
- Riverhead ARSR-4.

The proposed locations are beyond the instrumented range of the Boston ASR-9 and the Providence ASR-9. 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 Falmouth ASR-8, 61 of the 157 proposed locations will be within line-of-sight of and may interfere with this radar site at a blade-tip height of 850 feet (259 meters) AGL. At a blade-tip height of 1,116 feet (340 meters) AGL, 104 of the 157 proposed locations will be within line-of-sight of and may interfere with this radar site.
- For the Nantucket ASR-9, all 157 proposed locations will be within line-of-sight of and may interfere with this radar site at blade-tip heights of 850 feet (259 meters) AGL and 1,116 feet (340 meters) AGL.
- For the North Truro ARSR-4 and the Riverhead ARSR-4, the 157 proposed locations will not be within line-of-sight of and will not interfere with these radar sites at blade-tip heights of 850 feet (259 meters) AGL or 1,116 feet (340 meters) AGL.

For the Falmouth ASR-8 and the Nantucket ASR-9, without mitigation, the radar effects due to clutter may include a partial loss of primary target detection and a number of false primary targets over and in the immediate vicinity of the proposed locations 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 locations 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 may have concerns with the proposed locations within line-of-sight at blade-tip heights of 850 feet (259 meters) AGL and 1,116 feet (340 meters) AGL based on electromagnetic interference to air navigation facilities. The DoD Siting Clearinghouse process will provide an official decision as to whether impacts are acceptable to operations. The proposed locations are greater than 12 NM off the coast of the United States, therefore, the proposed locations are not within territorial waters where the FAA conducts aeronautical studies. If necessary, the FAA will be consulted. Although possible, Westslope does not expect that the DHS will have concerns with the proposed locations within line-of-sight at blade-tip heights of 850 feet (259 meters) AGL or 1,116 feet (340 meters) AGL based on impacts to these radar sites.

Mitigation options for the Falmouth ASR-8 and the Nantucket ASR-9 include, but are not limited to, the following:

- For the Falmouth ASR-8, optimization, referred to as Radar Adverse-impact Mitigation (RAM) by the DoD, may be required to the radar settings to minimize primary false targets and maximize primary target detection.
- For the Nantucket ASR-9, this radar site uses adaptive processing techniques to self-optimize the radar settings to minimize primary false targets and maximize primary target detection. As such, it is unlikely that intervention will be required by FAA personnel to address primary radar performance. For the partial loss of weather detection and false weather indications, an update to the clear day map to minimize false weather indications may be required.
- Overlapping coverage is provided by the above two radar sites and possibly by the North Truro ARSR-4.

Westslope does not expect that the 157 proposed locations will affect the secondary surveillance radar co-located with the Falmouth ASR-8 or the Nantucket ASR-9.

Westslope's EWR LOS analysis for the Cape Cod AFS EWR shows that 71 of the 157 proposed locations will be within line-of-sight of this radar site and could have a significant impact on this early warning radar at a blade-tip height of 850 feet (259 meters) AGL. At a blade-tip height of 1,116 feet (340 meters) AGL, 112 of the 157 proposed locations will be within line-of-sight of this radar site and could have a significant impact on this early warning radar.

For the Cape Cod AFS EWR, Westslope recommends early consultation with the DoD Siting Clearinghouse. Because wind turbines will be within line-of-sight of this radar site, it is possible that the

DoD may have concerns with the proposed locations within line-of-sight based on electromagnetic interference to a ballistic missile defense and space surveillance facility.

Westslope's TDWR screening analysis for the Boston TDWR shows that the proposed locations are beyond the instrumented range of this radar site. As such, no additional analysis was considered necessary for this radar site.

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

- Martha's Vineyard VOR/DME; and
- Nantucket VOR/DME.

Westslope's VOR screening analysis for the Martha's Vineyard VOR/DME and the Nantucket VOR/DME shows that the proposed locations 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 locations at blade-tip heights of 850 feet (259 meters) AGL or 1,116 feet (340 meters) AGL based on impacts to these navigational aid sites.

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

- Boston WSR-88D; and
- Brookhaven WSR-88D.

Westslope's NEXRAD weather radar screening analysis for the Boston WSR-88D and the Brookhaven WSR-88D shows that the 157 proposed locations will not be within line-of-sight of and will not interfere with these radar sites at blade-tip heights of 850 feet (259 meters) AGL or 1,116 feet (340 meters) AGL. The results also show that the 157 proposed locations at blade-tip heights of 850 feet (259 meters) AGL and 1,116 feet (340 meters) AGL will fall within a NOAA green No Impact Zone for these radar sites.

Westslope conducted an HF radar LOS analysis for the following 10 radar sites:

- Amagansett HF radar;
- Block Island Long Range HF radar;
- Horseneck Beach State Reservation HF radar;
- Long Point Wildlife Refuge HF radar;
- Martha's Vineyard HF radar;
- Moriches HF radar;
- MVCO Meteorological Mast HF radar;
- Nantucket HF radar;
- Nantucket Island HF radar; and
- Nauset HF radar.

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

- For the Block Island Long Range HF radar, 75 of the 157 proposed locations will be within line-of-sight of this radar site at a blade-tip height of 850 feet (259 meters) AGL. At a blade-tip height of 1,116 feet (340 meters) AGL, 150 of the 157 proposed locations will be within line-of-sight of this radar site.
- For the Horseneck Beach State Reservation HF radar, the 157 proposed locations will not be within line-of-sight of this radar site at a blade-tip height of 850 feet (259 meters) AGL. At a blade-tip height of 1,116 feet (340 meters) AGL, 45 of the 157 proposed locations will be within line-of-sight of this radar site. Please note that 74 of the 157 proposed locations are beyond the instrumented range of this radar site.
- For the Long Point Wildlife Refuge HF radar, all 157 proposed locations will be within line-of-sight of this radar site at blade-tip heights of 850 feet (259 meters) AGL and 1,116 feet (340 meters) AGL.
- For the Martha's Vineyard HF radar, 153 of the 157 proposed locations will be within line-of-sight of this radar site at a blade-tip height of 850 feet (259 meters) AGL. At a blade-tip height of 1,116 feet (340 meters) AGL, all 157 proposed locations will be within line-of-sight of this radar site.
- For the MVCO Meteorological Mast HF radar, 12 of the 157 proposed locations will be within line-of-sight of this radar site at blade-tip heights of 850 feet (259 meters) AGL and 1,116 feet (340 meters) AGL. Please note that 145 of the 157 proposed locations are beyond the instrumented range of this radar site.
- For the Nantucket HF radar, 151 of the 157 proposed locations will be within line-of-sight of this radar site at a blade-tip height of 850 feet (259 meters) AGL. At a blade-tip height of 1,116 feet (340 meters) AGL, all 157 proposed locations will be within line-of-sight of this radar site.
- For the Nantucket Island HF radar, 117 of the 157 proposed locations will be within line-of-sight of this radar site at a blade-tip height of 850 feet (259 meters) AGL. At a blade-tip height of 1,116 feet (340 meters) AGL, 154 of the 157 proposed locations will be within line-of-sight of this radar site.
- For the Amagansett HF radar, Moriches HF radar, and the Nauset HF radar, the 157 proposed locations will not be within line-of-sight of these radar sites at blade-tip heights of 850 feet (259 meters) AGL or 1,116 feet (340 meters) AGL. Although the proposed locations 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 Block Island Long Range HF radar, Horseneck Beach State Reservation HF radar, Long Point Wildlife Refuge HF radar, Martha's Vineyard HF radar, MVCO Meteorological Mast HF radar, Nantucket HF radar, and the Nantucket Island HF radar, without mitigation, the radar effects may include clutter in the vicinity of the proposed locations within line-of-sight and possibly in the vicinity of the proposed locations 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 the proposed locations within line-of-sight at blade-tip heights of 850 feet (259 meters) AGL and 1,116 feet (340 meters) AGL 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 locations 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 gnblackman@westslopeconsulting.com.

REFERENCES

[1] DoD, Missile Defense Agency, "*Wind Turbine Analysis for Cape Cod Air Force Station Early Warning Radar and Beale Air Force Base Upgraded Early Warning Radar*," Spring 2007.

Photo credit: Matt Goldsmith, Equinor