TO:	All Interested Parties
FROM:	Jessica Schultz, Deputy Director, Weather Surveillance Radar - Model 1988 Doppler (WSR-88D) Radar Operations Center (ROC)
SUBJECT:	Lowering the Minimum Scan Angle of the KDOX WSR-88D serving the Dover Air Force Base (AFB), DE, area
DATE:	August 23, 2023

JS

In accordance with provisions of the National Environmental Policy Act of 1969, the WSR-88D ROC prepared a Draft Environmental Assessment (EA) analyzing the potential environmental effects of lowering the minimum scan angle of the KDOX WSR-88D serving the Dover AFB, DE, area. The Draft Environmental Assessment is available for public review and comment. The Draft EA may be obtained at:

https://www.roc.noaa.gov/WSR88D/SafetyandEnv/EAReports.aspx

The KDOX WSR-88D is an existing radar facility located about 1.5 miles NW of Ellendale, Sussex County, DE. The KDOX WSR-88D, commissioned in 1993, is one of 159 WSR-88Ds in the nationwide network. The KDOX WSR-88D antenna transmits a narrow focused main beam with a width of 1 degree. In normal operation, the radar antenna rotates horizontally to cover all directions (i.e., azimuths). The radar antenna also varies the scan angle at which it points with respect to the horizon. Currently, the WSR-88D operates at a minimum of scan angle of +0.5 degrees (deg) above the horizon. NWS proposes to reduce the minimum scan angle of the KDOX WSR-88D from the current minimum of +0.5 deg to +0.3 deg (i.e., 0.2 deg lower than existing) to provide enhanced coverage of the lower portions of the atmosphere. No construction activities or physical modification of the KDOX WSR-88D would be required to implement the proposed action; the only change would be to the radar's operating software.

NWS will accept written comments on the Draft EA until September 30, 2023. Please submit comments via either email or regular mail to:

James Manitakos
Sensor Environmental LLC
296 West Arbor Avenue
Sunnyvale, CA 94085-3602

Email: jmanitakos@sensorenvirollc.com

Comments sent by regular mail must be postmarked September 30, 2023. After the end of the Draft EA review period, the ROC will prepare a Final EA containing responses to all comments. NWS will not make any decision on implementing the proposed action until completion of the environmental review. Thank you for your interest in this important project.

SENSOR ENVIRONMENTAL LLC
www.sensorenvirollc.com

Draft Environmental Assessment Report • August 2023

ENVIRONMENTAL ASSESSMENT (EA)

LOWERING THE MINIMUM SCAN ANGLE OF THE WEATHER SURVEILLANCE RADAR - MODEL 1988, DOPPLER (WSR-88D) SERVING THE DOVER AIR FORCE BASE, DELAWARE, AREA

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Executive Summary

The Weather Surveillance Radar, Model 1988 Doppler (WSR-88D) Radar Operations Center (ROC) is composed of representatives from the National Weather Service (NWS) of the Department of Commerce, the Air Weather Service of the Department of Defense, and the Federal Aviation Administration (FAA) of the Department of Transportation. The ROC operates the existing WSR-88D serving the Dover AFB, DE, area. The International Civil Aviation Organization designator for the radar is KDOX and the radar is located at about 1.5 miles northwest of Ellendale, Sussex County, DE. The KDOX WSR-88D was commissioned in January 11, 1993 and has been in continuous operation since 1993. It is one of 159 WSR-88Ds in the nationwide network.

The KDOX WSR-88D is an S-band Doppler, dual polarized weather radar, which ROC uses to collect meteorological data to support weather forecasts and severe weather warnings for the Dover, DE area. The KDOX WSR-88D antenna transmits a narrow focused main beam with a width of 1 degree. In normal operation, the WSR-88D antenna rotates horizontally to cover all directions (i.e., azimuths). The radar antenna also varies the scan angle at which it points with respect to the horizon. The scan angle is measured along the axis of the main beam and can be changed in 0.1 deg increments. Currently, the KDOX WSR-88D operates at a minimum of scan angle of +0.5 degrees (deg) above the horizon. ROC proposes to reduce the minimum scan angle of the KDOX WSR-88D from the current minimum of +0.5 deg to +0.3 deg (the proposed action). Lowering the minimum scan angle would provide enhanced coverage of the lower portions of the atmosphere. No construction activities or physical modification of the KDOX WSR-88D would be required to implement the proposed action; the only change would be to the radar's operating software.

In April 1993, ROC prepared a National Environmental Policy Act (NEPA) document titled, *Supplemental Environmental Assessment (SEA) of the Effects of Electromagnetic Radiation from the WSR-88D Radar.* That document analyzed operating the WSR-88D at a minimum scan angle of +0.5 degree (deg). This Draft EA builds on that prior study by examining the possible effects of operating the KDOX WSR-88D at a minimum scan angle of +0.3 (i.e., 0.2 deg lower than the minimum scan angle examined in the April 1993 SEA). Operating this radar at a lower scan angle would increase the area of radar coverage, providing additional data on atmospheric conditions to ROC forecasters and other data users. The area covered at 2,000 ft above site level (ASL) would increase by 73.4%. Coverage at 2,000 ft elevation over the Atlantic Ocean would extend from the current 40 miles east of the Delaware shoreline to about 61 miles. This radar coverage improvement would be very beneficial to NWS and USAF weather forecasters and others parties (e.g., public safety agencies and emergency responders) using the radar information.

The lower minimum scan angle would not result in the KDOX WSR-88D main beam impinging on the ground within 3 miles of the WSR-88D. The proposed action would slightly increase radiofrequency (RF) exposure levels in the vicinity of the KDOX WSR-88D. As shown in Table

S-1, during normal operation of the radar with rotating antenna, RF exposure would comply with the safety standards developed by the Institute of Electrical and Electronic Engineers (IEEE) and the adopted by the American National Standards Institute (ANSI) for the general public and workers. Federal Communications Commission (FCC) and Occupational safety and Health Administration (OSHA) safety levels would also be met at all locations.

Table S-1: RF Power Density within Main Beam of KDOX WSR-88D at Minimum Scan Angle of +0.3 deg Compared to ANSI/IEEE Safety Standards

Location / Distance from Radar	Time-Averaged Power Density (mW/cm^2)	ANSI/IEEE General Public RF Safety Standard		ANSI/IEEE Occupational RF Safety Standard	
		Safety Standard (mW/cm^2)	Factor Below Std	Safety Standard (mW/cm^2)	Factor Below Std
Surface of Radome	0.603	1.0	1.66	5.0	7.9
Closest Structure -Cell Phone Tower (4,500 ft)	0.00040	1.0	10,000	5.0	50,000
Closest Illuminated Ground (>15,840 ft)	0.000032	1.0	27,000	5.0	135,000

During infrequent stationary antenna operation, RF exposure levels within the WSR-88D main beam would exceed ANSI/IEEE and FCC safety levels for exposure of the general public within 1,740 ft of the WSR-88D antenna. FCC and ANSI/IEEE occupational safety levels would be exceeded within 777 ft. The KDOX WSR-88D operating at +0.3 deg would not impinge on the ground surface or any occupied structures within those distance and risks to human health would not result.

Because the KDOX WSR-88D operates in a frequency band dedicated to government radiolocation services and the main beam would not impinge on the ground surface in the radar vicinity, the proposed action would not cause radio interference with television, radio, cellular telephone, personal communications devices (PCDs), electro-explosive devices, fuel handling, or active implantable medical devices.

WSR-88D RF emissions have the potential to cause electromagnetic interference (EMI) with sensitive equipment used at astronomical observatories. Twenty astronomical observatories are located within 150 miles of the KDOX WSR-88D. A minimum scan angle of +0.3 deg would not result in the WSR-88D main beam impinging on any of those observatories.

Lowering the minimum scan angle of the KDOX WSR-88D would not require physical changes to the radar, vegetation removal, or ground disturbance. The proposed action would not result in significant effects in the following subject areas:

- Land Use and Coastal Zone Management
- Geology, Soils, and Seismic Hazards
- Drainage and Water Quality
- Transportation
- Air Quality
- Flood Hazards
- Wetlands
- Biological Resources / Protected Species
- Cultural and Historic Resources
- Environmental Justice Socioeconomic Impacts
- Farmlands
- Energy Consumption
- Visual Quality/ Light Emissions
- Solid and Hazardous Waste
- Wild and Scenic Rivers

ROC evaluated the benefits and potential impacts of lowering the minimum center of beam scan angle of the KDOX WSR-88D to each angle between +0.4 and +0.0 deg in 0.1 degree increments. Operating the KDOX WSR-88D at alternative minimum scan angle of +0.4 deg would result in similar environmental effects as the proposed action. Like the proposed action, significant environmental effects would not result. A minimum scan angle of +0.4 deg would increase the radar's coverage area, but by less than the proposed action (i.e., minimum scan angle of +0.3) deg. Minimum scan angles lower than +0.3 deg would not increase coverage area and would result in increased ground clutter returns. Thus, a minimum scan angle of +0.3 deg is the most beneficial among those considered by the ROC.

The no action alternative would result in continued operation of the KDOX WSR-88D at the existing minimum scan angle of +0.5 deg. The improvements in radar coverage resulting from the proposed project would not be achieved. The no-action alternative would not change RF exposure levels from existing. Under both the proposed action and the no action alternative, RF exposure during normal WSR-88D operations would conform to safety standards established by ANSI/IEEE, OSHA, and FCC. Similar to the proposed action, the no-action alternative would not cause significant effects to the natural or man-made environment.

The ROC will distribute the Draft EA to interested members of the public and government agencies for review and comment. Comments on the Draft EA will be accepted by ROC during a minimum 30-day comment period which will end on September 1, 2023. The ROC will provide official responses to all pertinent comments received during the Draft EA comment period in a

Final EA report. The ROC will make a decision whether to implement the proposed lowering of the KDOX WSR-88D minimum scan angle after the Final EA report is completed.

CONTENTS

FIGURES

TABLES

ABBREVIATIONS

AAMI	Association for Advancement of Medical Instrumentation
AFB	Air Force Base
AFWA	Air Force Weather Agency
AGL	above ground level
ANSI	American National Standards Institute
ASL	above site level
CHRIS	[Delaware] Cultural and Historical Resources Information System
Deg	degree(s)
DCMP	Delaware Coastal Management Program
DE	Delaware
DoA	Department of Agriculture
E	east
EA	Environmental Assessment
E.O.	Executive Order
EED	electro-explosive device
EMI	electromagnetic interference
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FCC	Federal Communications Commission
FEMA	Federal Emergency Management Agency
FONSI	Finding of No Significant Impact
ft	foot, feet
HERO	Hazards of Electromagnetic Radiation to Ordnance
IEEE	Institute of Electrical and Electronics Engineers
JSPO	Joint System Program Office
KDOX	WSR-88D serving the Dover AFB, DE, area
m	meter(s)
MBTA	Migratory Bird Treaty Act (of 1918)
MHz	megahertz
mi	mile(s)
MPE	maximum permissible exposure
MSL	mean sea level
mW/cm^2	milliwatts per square centimeter
NAO	NOAA Administrative Order
N	north
NEPA	National Environmental Policy Act
NEXRAD	Next Generation Weather Radar (also known as WSR-88D)
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NTIA	National Telecommunications and Information Agency
NW	northeast
NW	northwest
ROC	National Weather Service
PEIS	Programmatic Environmental Impact Statement
RkA	Rockawalkin loamy sand

RF	radiofrequency
S	south
SE	southeast
SW	southwest
SEA	Supplemental Environmental Assessment
SHPO	State Historic Preservation Office
sq mi	square mile(s)
std	standard
U.S.	United States
USAF	U.S. Air Force
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
W	west
WSR-88D	Weather Surveillance Radar – 1988, Doppler

1 BACKGROUND AND SCOPE OF REPORT

1.1 BACKGROUND

The Weather Surveillance Radar, Model 1988 Doppler (WSR-88D) Radar Operations Center (ROC) is composed of representatives from the National Weather Service (NWS) of the National Oceanic and Atmospheric Administration within the Department of Commerce, the Air Force Weather Agency (AFWA) of the Department of Defense, and the Federal Aviation Administration (FAA) of the Department of Transportation. The ROC operates a nationwide network of 159 weather radars that provide critical real-time information on atmospheric conditions to weather forecasters.

The network radars operated by ROC are named Weather Surveillance Radar-Model 1988 Doppler (WSR-88D) after the year they were first put into service and their capabilities to use Doppler shift measurements to determine wind velocities. They are also known as Next Generation Weather Radars (NEXRADs). Like all active radars, the WSR-88D transmits a radio signal, which reflects off targets and returns to the radar. The radar measures the strength of the return signal, its direction of return, and the time between transmission and return, which allows determination of the target characteristics. Because the WSR-88D has the potential to cause electromagnetic effects on the environment, ROC carefully considered these effects and strives to prevent effects, or when effects cannot be avoided, mitigate the significance of those effects. To that end, the NEXRAD Joint System Program Office (JSPO) prepared environmental reports evaluating potential electromagnetic effects of the WSR-88D during planning and implementation of the WSR-88D network. In 1984, the JSPO issued the first environmental document which considered electromagnetic effects (among other effects). That report is titled: *Next Generation Weather Radar Programmatic Environmental Impact Statement (PEIS), Report R400-PE201* [ROC, 1984]. In 1993, JSPO issued a supplemental report updating the analysis contained in the 1984 PEIS to account for changes since 1984 in electromagnetic standards and guidelines and developments in radar design and operational modes. The supplemental report is titled *Final Supplemental Environmental Assessment (SEA) of the Effects of Electromagnetic Radiation from the WSR-88D Radar* [NEXRAD JSPO, 1993]. The 1993 SEA analyzed the potential electromagnetic effects of operating the WSR-88D at a minimum scan angle of +0.5 degree (deg) above horizontal, measured at the center of the WSR-88D main beam. The minimum scan angle of +0.5 deg represented the lowest scan angle used operation of the WSR-88Ds at that time.

The ROC operates the WSR-88D serving the Dover Air Force Base (AFB) AFB, DE, area. The radar identifier is KDOX and the radar is located at about 1.5 miles NW of Ellendale in Sussex County, DE. The KDOX WSR-88D is part of the nationwide WSR-88D network. The ROC proposes to operate the KDOX WSR-88D at a minimum scan angle of +0.3 deg, which is lower than the current minimum scan angle of +0.5 deg above the horizon. Operating the KDOX WSR-88D at this lower scan angle was not analyzed in the 1993 SEA.

The ROC follows procedures established by National Oceanic and Atmospheric Administration (NOAA), the parent agency of NWS, of the potential environmental consequences of proposed actions to comply with the National Environmental Policy Act (NEPA). Procedures to be followed are set forth in NOAA Administrative Order (NAO) 216-6A (NOAA, 2016). Because ROC's proposed action of operating the KDOX WSR-88D at a minimum scan angle below +0.5 deg has the potential to cause environmental effects, there is a need to analyze potential environmental consequences, determine their significance, and develop measures to mitigate adverse impacts if necessary.

1.2 SCOPE OF REPORT

This Draft EA report analyzes the potential effects on persons and activities in the vicinity that could result from implementing the proposed action (i.e., lowering the KDOX WSR-88D minimum scan angle to +0.3 deg). Potential environmental effects of alternative minimum scan angles and the no-action alternative (i.e., continued operation of the KDOX WSR-88D at the current minimum scan angle of +0.5 deg) are also considered for comparison purposes. As part of that analysis, the findings of the 1993 SEA have been updated to account for changes in safety standards and guidelines that have been occurred since 1993 and site -specific conditions at the KDOX WSR-88D site and vicinity. The scope of this EA is limited to analyzing potential effects from lowering the minimum scan angle of the KDOX WSR-88D. Because the types of electromagnetic effects that may result and their significance depends on local conditions, including uses and topography of the local area, the analysis and findings in this EA are specific to the KDOX WSR-88D, and do not apply to other WSR-88Ds or the WSR-88D network as a whole.

2 PURPOSE AND NEED

NWS is the nation's premiere meteorological forecasting organization. The agency's official mission is as follows:

> "The National Weather Service (NWS) provides weather, hydrologic, and climate forecasts and warnings for the United States, its territories, adjacent waters and ocean areas, for the protection of life and property and the enhancement of the national economy. NWS data and products form a national information database and infrastructure which can be used by other governmental agencies, the private sector, the public, and the global community [ROC, 2009]".

NWS, AFWA, and FAA are part of the ROC, which operates a nationwide network of 159 WSR-88Ds. Data from the WSR-88Ds is used to improve the accuracy of forecasts, watches, and warnings. As an example, the WSR-88D generates precipitation estimates allowing prediction of river flooding in hydrological basins of the area. The ROC then disseminates advance flood warnings to local and state public safety, emergency managers, and the public, allowing them to take appropriate actions to minimize hazards to life and property. Because the meteorological phenomena of greatest interest occur with a few thousand feet (ft) of the ground surface, radar coverage of lower portions of the atmosphere is of great value to forecasters.

However, the elevation above the ground at which the WSR-88D can collect atmospheric data rises with distance from the radar due to earth curvature and the upward tilt of the radar beam, which is currently +0.5 deg or greater. The proposed action of lowering the KDOX WSR-88D minimum scan angle to +0.3 deg would expand the geographic area with radar coverage below 10,000 ft AGL, a substantial benefit to forecasters and other users of WSR-88D data. This EA report describes the improvements in radar coverage that would result if the ROC operates the KDOX WSR-88D serving the Dover AFB, DE, area at a minimum scan angle of +0.3 deg and the environmental effects that may result.

The National Oceanic and Atmospheric Administration (NOAA) is the parent agency of the NWS and the ROC follows NOAA requirements for complying with the National Environmental Policy Act (NEPA) are contained in NOAA Administrative Order (NAO) 216-6A, *Compliance with the National Environmental Policy Act, Executive Orders 12114, Environmental Effects Abroad of Major Federal Actions; 11988 and 13690, Floodplain Management; and 11990 Protection of Wetlands* (NOAA, 2016)], and the Companion Manual for NOAA Administrative Order 216-6A; Policies and Procedures for Compliance with the National Environmental Policy Act and Related Authorities (NOAA, 2017). ROC is subject to those requirements. Appendix E of the NOAA Companion Manual specifies the proper level of NEPA review for actions proposed by NOAA components and lists types of actions that are categorically excluded from the need to prepare a NEPA analysis document (e.g., an EA or environmental impact statement [EIS]). Categorical Exclusion G6, which addresses NEXRAD Radar Coverage, states that

"Actions that change the NEXRAD radar coverage patterns that do not lower the lowest scan angle and do not result in direct scanning of previously non-scanned terrain by the NEXRAD main beam" are categorically excluded from NEPA (NOAA, 2017). The proposed action would not meet these specifications and does not qualify for categorical exclusion treatment. Therefore, NEPA analysis is required for the proposed lowering of the KDOX WSR-88D minimum scan angle to +0.3 deg; this EA report satisfies that requirement.

3 DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

3.1 PROPOSED ACTION

3.1.1 DESCRIPTION OF KDOX WSR-88D

The WSR-88D collects data on weather conditions and provides critical inputs to forecasters. The network is composed of 159 radars, most of which were installed in the late 1980s and 1990s. Each radar includes a roughly 28-ft diameter dish antenna mounted on a steel lattice tower of varying height (depending on local conditions), and shelters housing electronic equipment, a standby power generator and fuel tank, and a transitional power maintenance system. The dish antenna rotates 360 deg and is covered by a fiberglass radome to protect it from the elements.

Figure 1 is a photograph of the KDOX WSR-88D, which was commissioned on January 11, 1993 and has been in continuous operations since being commissioned. The KDOX WSR-88D serves the Dover Air Force Base (AFB), DE, area and is operated by the ROC. The KDOX WSR-88D is located is located about 1.5 miles NW of Ellendale, Sussex County, DE (see Figure 2). The radar antenna, radome, and steel-lattice tower are standard. Table 1 provides information on the KDOX WSR-88D.

Table 1: Information on KDOX WSR-88D serving the Dover AFB, DE, area

Elevation, ground surface at tower base (mean sea level, MSL)	50 ft
Elevation, center of antenna (MSL)	164 ft
Tower Height (m)	30 m (98 ft)
Latitude (WGS84)	38°49’32” N
Longitude (WGS84)	75˚26’23” W
Operating Frequency	2,875 megaHertz (MHz)
Spot Blanking or Sector Blanking used	No

Figure 1: Photograph of KDOX WSR-88D serving Dover AFB, DE, area

Figure 2: Location of KDOX WSR-88D

3.1.2 Proposed Change in Minimum Scan Angle

The WSR-88D is designed to detect and track weather phenomena within a roughly 230 mi distance of the radar. It accomplishes this task by emitting a narrow main beam from a rotating dish antenna. The antenna rotates continuously around a vertical axis to cover the surrounding area. The main beam scan angle is the number of degrees above or below horizontal at the center of the main beam. The upward tilt of the antenna (and therefore the scan angle of the main beam) can be changed, allowing the radar to scan the sky at angles up to + 60.0 deg and down to -1.0 deg; however, in current operation, the maximum scan angle is +19.5 deg and the minimum scan angle is +0.5 deg.

The WSR-88D main beam has a total width of 1 deg in the horizontal and vertical directions (i.e., beam edge is ½ deg from the center of the beam), as shown in Figure 3. The power density of the WSR-88D is greatest at the center of the beam and decreases towards the edge of the beam. At the edge of the main beam, the power density is one half of the center of beam power density. In current operation, the minimum scan angle of the main beam is +0.5 deg (i.e., 0.5 deg above horizontal at the center of the main beam) and the lower edge of the main beam (i.e., lower half-power point) is at 0.0 deg or horizontal. ROC proposes to reduce the minimum center of beam scan angle to +0.3 deg, which is 0.2 deg lower than the current minimum scan angle.

Figure 4 is a schematic drawing showing the change in coverage that would result from lowering the KDOX WSR-88D minimum scan angle. The floor of coverage would decrease slightly, but at a scan angle of +0.3 deg would not impinge on the ground surface within 3 miles of the radar. Because the lowered radar main beam would not be significantly obstructed by nearby terrain, buildings, or trees, the radar would cover portions of the atmosphere which are currently not covered. Table 2 shows the improvement in radar coverage that would be achieved, which ranges from 73.4% increase in coverage area at 2,000 ft above site level (ASL) to 29.4% increase at 10,000 ft ASL. Coverage at 2,000 ft elevation over the Atlantic Ocean would extend from the current 40 miles east of the Delaware shoreline to about 61 miles. Figures 5, 6, and 7 show the improvement in radar coverage that would be achieved at 2,000 ft, 5,000 ft, and 10,000 ft ASL, respectively. The improvement in WSR-88D coverage would be beneficial to NWS and AWS forecasters and other users of radar data (e.g., emergency response mangers, water managers, farmers, transportation officials).

Table 2: Existing and Proposed Radar Coverage Areas for KDOX WSR-88D

Minimum Center of Beam Scan Angle (deg)	Coverage Floor (deg)	Area Covered (sq. mi.)		
		2,000 ft ASL	5,000 ft ASL	10,000 ft ASL
+0.5 (existing)	0.0	10,465	27,119	54,885
+0.3 (proposed)	-0.2	18,147 (+73.4%)	36,668 (35.2%)	71,006 (+29.4%)

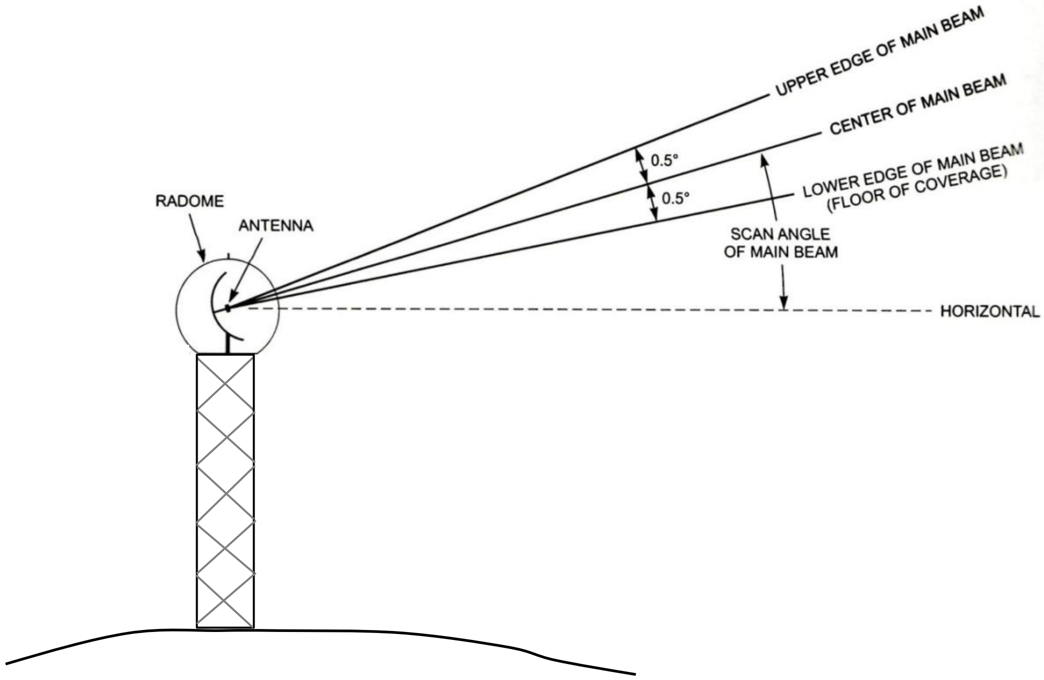

Figure 3: Schematic of WSR-88D Main beam

(Not to scale, width of main beam exaggerated)

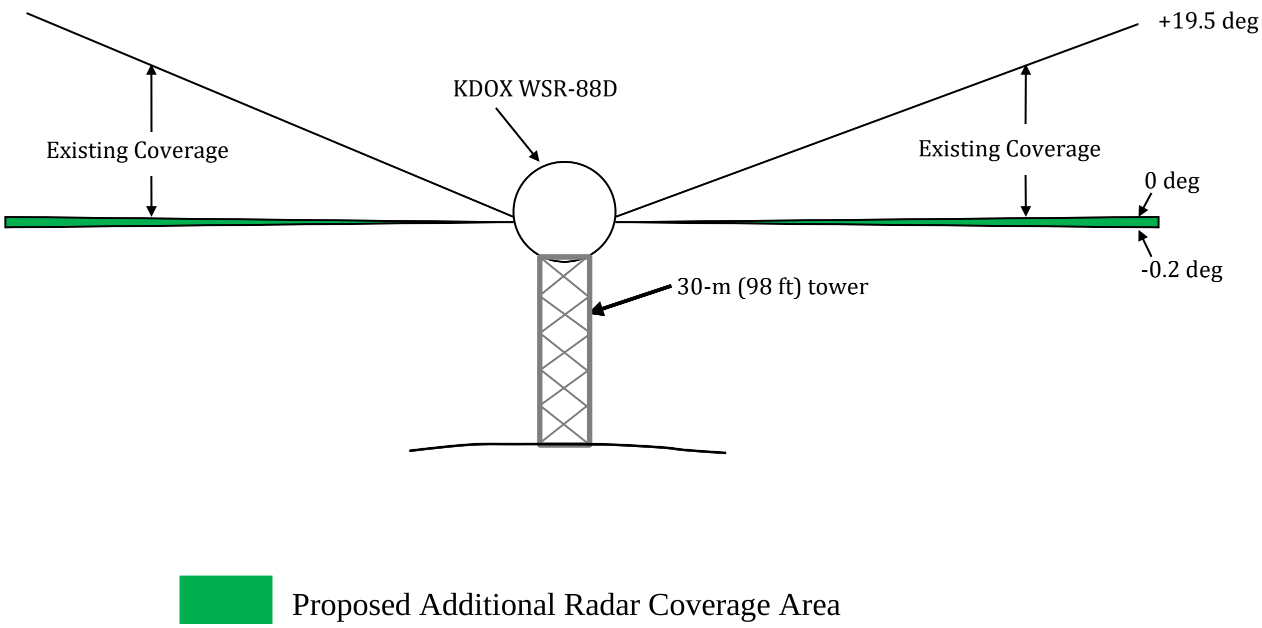

Figure 4: Drawing of Proposed Additional Radar Coverage

Figure 5: Existing and Proposed KDOX WSR-88D Coverage at 2,000 ft ASL

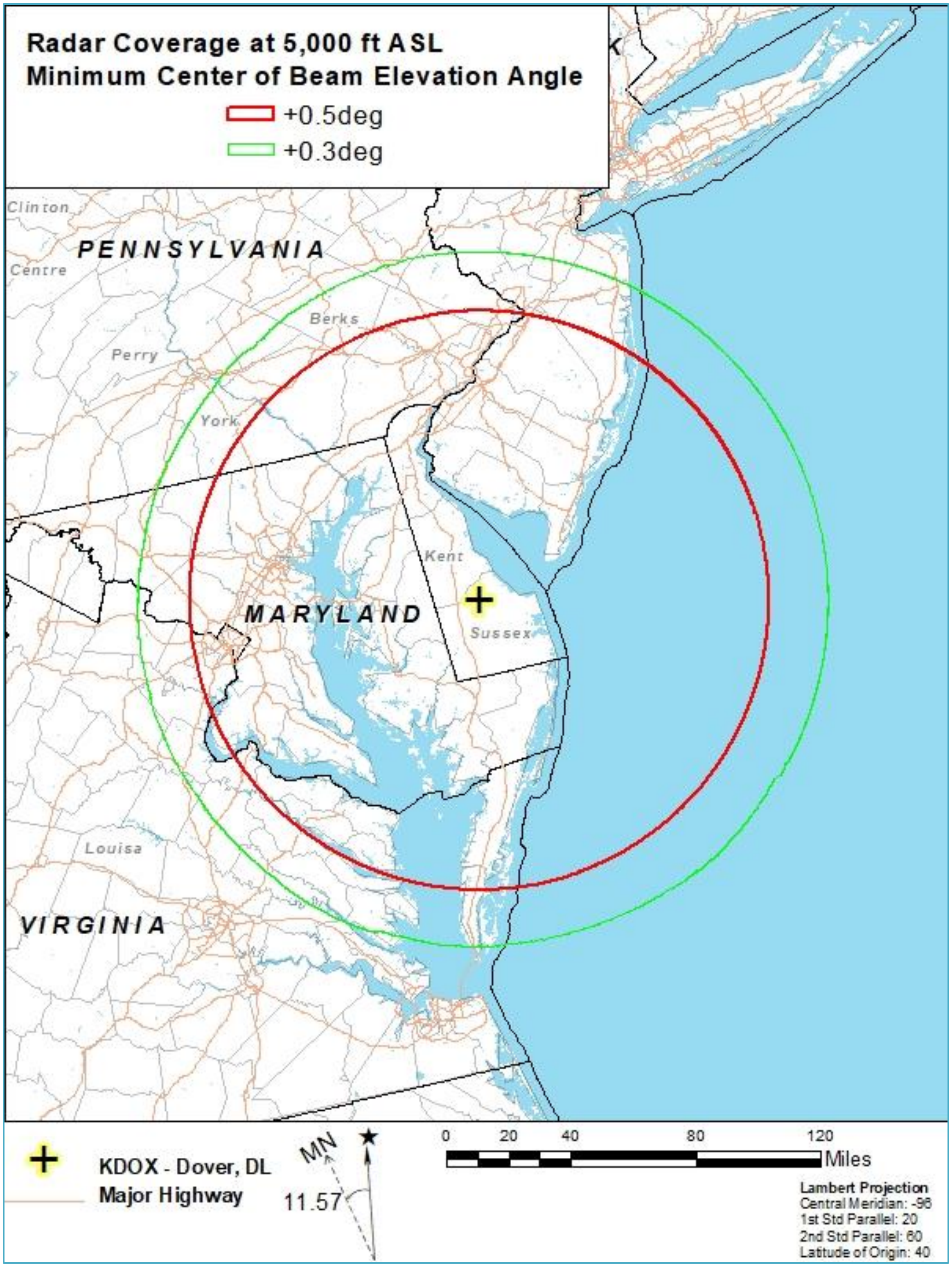

Figure 6: Existing and Proposed KDOX WSR-88D Coverage at 5,000 ft ASL

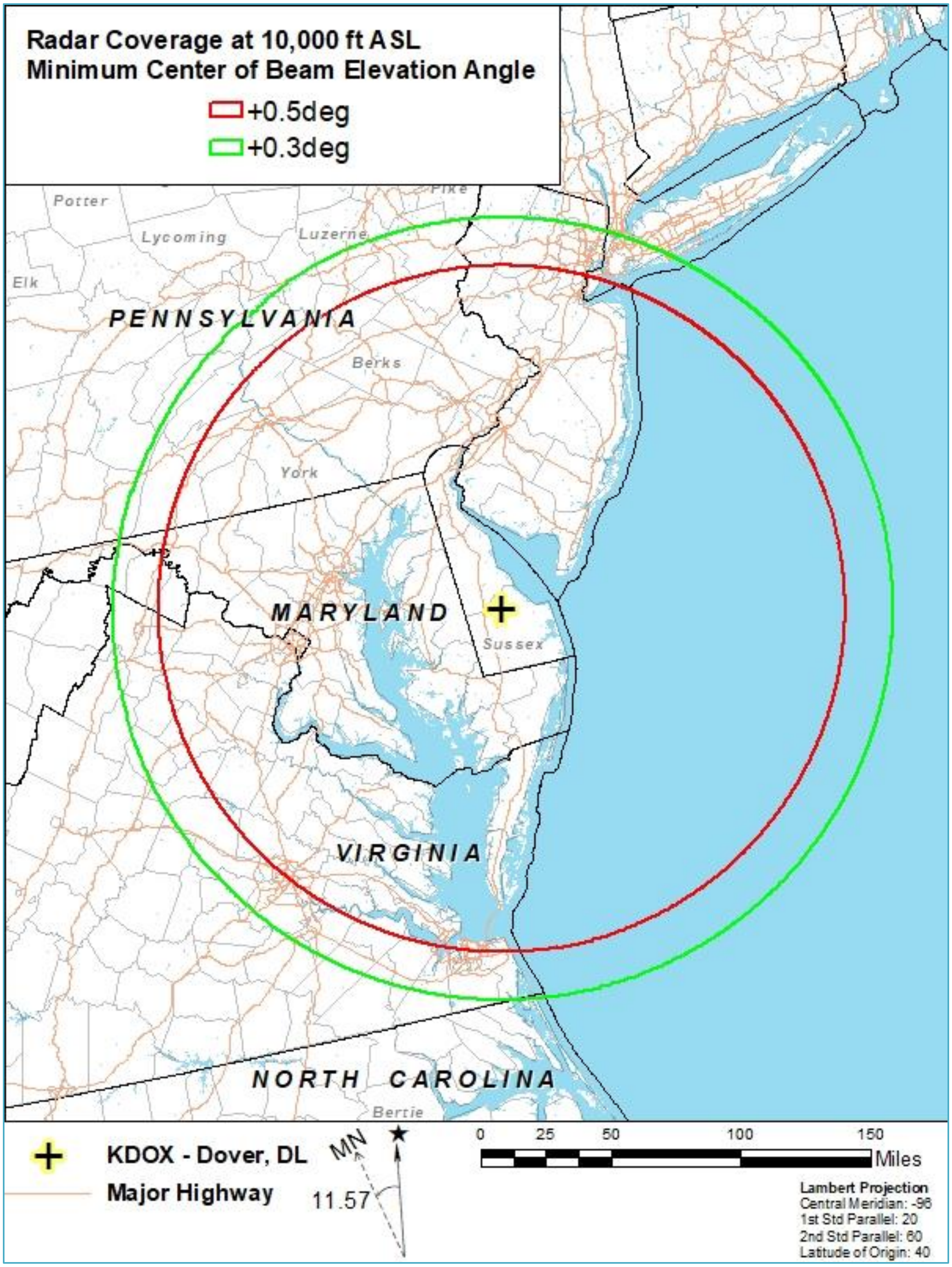

Figure 7: Existing and Proposed KDOX WSR-88D Coverage at 10,000 ft ASL

The existing WSR-88D transmitter and antenna are physically equipped to operate at the proposed minimum scan angle. The only change required to implement the proposed change would be modifications to the software that controls radar operations and processes data collected by the radar. No construction activities or ground disturbance would be required to implement the proposed action. The transmit power of the radar would also be unchanged.

3.2 ALTERNATIVES

NAO 216-6A requires analysis of the no-action alternative in EAs. For purposes of this EA report, the no-action alternative is defined as continuing to operate the KDOX WSR-88D serving the Dover AFB, DE, area with the current minimum center of main beam scan angle of +0.5 deg. This is the same minimum scan angle used by most other WSR-88Ds in the nationwide network. The no-action alternative and alternative minimum scan angles between +0.4 and -0.0 deg are analyzed in Section 5 of this EA.

4 ENVIRONMENTAL SETTING, CONSEQUENCES, AND MITIGATION

4.1 EXPOSURE OF PERSONS TO RADIOFREQUENCY RADIATION

4.1.1 SAFETY STANDARDS

The electromagnetic environment at a specific location and time is composed of the all the electromagnetic fields from various sources (natural and manmade) that arrive there. The electromagnetic spectrum in an area is a continuously usable resource whose dimensions are amplitude, time, frequency, and space. In areas large enough to permit adequate spatial separation of users, the electromagnetic spectrum can simultaneously accommodate many users if they are sufficiently separated in frequency. The electromagnetic environment at any point can change nearly instantaneously and will vary spatially, even at locations in proximity; therefore, it is convenient to measure and characterize electromagnetic phenomena using averages over time and space.

Manmade contributions to the electromagnetic environment are both intentional and unintentional. Radio and television broadcasts, cellular telephone transmissions, and radar signals are examples of intentional contributions. Electromagnetic noise generated by power lines, fluorescent lights, and motors of all sorts are examples of unintentional human contributions. The KDOX WSR-88D transmits a radio signal at a frequency of 2,875 MHz, which is within the radiofrequency (RF) or microwave portion of the electromagnetic spectrum. Although microwaves can add heat to objects, they do not contain enough energy to remove electrons from biological tissue, and are a form of non-ionizing radiation. In this regard, microwaves are fundamentally different from ionizing radiations (e.g., X-rays, ultraviolet rays) which occur at higher frequency portions of the electromagnetic spectrum. Ionizing radiation occurs only at frequencies greater than 10^9 MHz. RF or microwave fields are non-ionizing radiation. Due to the fundamental differences between ionizing and non-ionizing radiation, safety standards and guidelines vary greatly for the two types of electromagnetic radiation. In this section only standards for non-ionizing radiation are addressed because KDOX WSR-88D RF emissions are non-ionizing.

The Institute of Electrical and Electronics Engineers (IEEE) developed safety guidelines for human exposure to RFR, and those standards have been adopted by the American National Standards Institute (ANSI) [ANSI/IEEE, 2019 and 2020]. The ANSI/IEEE safety standard is designed to protect all persons (including infants, elderly persons, and pregnant women) from adverse health effects from exposure to radiofrequency (RF), even if exposure should last over an entire lifetime. These guidelines set safety levels for maximum permissible exposure (MPE) to RF signals, which include a 10- to 50-fold safety margin and are intended to protect all members of the population.

MPEs are specified in power density of the radio signal in milliwatts per square centimeter (mW/cm^2) and vary with operating frequency. Separate MPEs have been established for exposure of the general public and workers and for time-averaged exposure and peak exposure.

Occupational safety standards are higher than those for the general public because workers are trained in RF safety practices and have greater ability to use that knowledge to protect themselves from potentially harmful RF exposure. The KDOX WSR-88D operating frequency is 2,875 MHz. The IEEE/ANSI safety standards for those frequencies are 1.0 mW/cm^2 for the general public (averaged over 30 minutes) and 5.0 mW/cm^2 for workers (averaged over 6 minutes). Federal Communications Commission (FCC) RF exposure standards for RF exposure of the general public and occupational exposure are the same as the ANSI/IEEE safety standards. The Occupational Health and Safety Administration (OSHA) regulates occupational exposure to RF emissions; the OSHA safety standard is 10.0 mW/cm^2 (averaged over 6 minutes) (OSHA, 2021).

4.1.2 RF Exposure Levels

The KDOX WSR-88D is mounted on a 30 m tall steel-lattice tower. Ground surface elevation is 50 ft MSL. The center of the antenna is at 164 ft MSL and the lower edge of the antenna is at 150 ft MSL or 100 ft above ground level (AGL). When operating at the current minimum scan angle of +0.5 deg, the lower edge of the beam is at 0.0 deg (i.e., horizontal) and the radar's main beam does not impinge on the ground surface or any occupied structures close to the radar (see Appendix C). Operating at the proposed minimum scan angle of +0.3 deg would not change that situation; the main beam would not impinge on the ground surface within 15,840 feet (3 miles) of the WSR-88D. The closest structure within the main bean is a cell phone tower located 4,500 ft south (S). RF power density levels at the tower are shown in Table 3.

Compared to the existing minimum scan angle of +0.5 deg, lowering the minimum scan angle to +0.3 deg would result in a slight increase in RF exposure levels at air space in the vicinity of the radar. Appendix A includes calculations of the existing time-averaged RF exposure levels in the vicinity of the KDOX WSR-88D, and the RF exposure that would result if ROC lowers the minimum scan angle to +0.3 deg. Table 3 summarizes the results from Appendix A.

Table 3: RF Power Densities of KDOX WSR-88D Main Beam Compared to Safety Levels

Location / Distance from KDOX WSR-88D	Time-Averaged Power Density (mW/cm^2)	ANSI/IEEE General Public RF Safety Standard		ANSI/IEEE and FCC Occupational RF Safety Standard	
		Safety Standard (mW/cm^2)	Factor Below Std	Safety Standard (mW/cm^2)	Factor Below Std
Surface of Radome	0.603	1.0	1.66	5.0	7.9
Closest Structure: Cell Phone Tower 4,500 ft S	0.00029	1.0	3,400	5.0	17,200
Closest Terrain: >15,840 ft	0.000023	1.0	43,400	5.0	217,300

During normal operation of the WSR-88D with a rotating antenna, RF exposure levels at all locations would comply with safety standards for exposure of both workers (i.e., occupational exposure) and the general public.

During infrequent stationary antenna operation, RF exposure levels within the WSR-88D main beam would exceed ANSI/IEEE and FCC safety levels for exposure of the general public within 1,740 ft of the WSR-88D antenna. FCC occupational safety levels would be exceeded within 777 ft. No structures or terrain are within those distances and no RF safety hazards would result.

4.1.3 RF Electro-stimulation

The ANSI/IEEE safety guidelines also cover possible induction of currents within the bodies of persons and the potential for electro-stimulation of persons who make contact with conductive objects in the RFR field. The result is potentially harmful sensation of shock and/or burn. These effects only occur for RF fields at frequencies below 110 MHz (ANSI/IEEE, 2006). The KDOX WSR-88D would continue to operate at 2,875 MHz, outside the frequency range where induced currents or electro-simulation occur, and would not cause these effects.

4.1.4 Cumulative RF Exposure

As shown in Table 3, the power density of RF transmissions decreases exponentially with distance from the antenna. At all locations in the vicinity, RF emitted by the WSR-88D during normal operation would be at substantially below the safety standard for RF exposure of the general public. It is improbable that radio emissions from an external source would add to the WSR-88D RF emissions during normal operation to cause cumulative RF exposure levels exceeding safety standards.

4.2 RF EXPOSURE OF EQUIPMENT AND ACTIVITIES

4.2.1 Television, Radio, Cellular Telephone, and Personal Communications Devices (PCDs)

High-power radar, such as the WSR-88D, can interfere with operation of radio, television, cellular telephone, and PCDs in close vicinity to the radar antenna. However, these devices operate at different frequencies from the WSR-88D, reducing the potential for radio interference. NTIA regulations reserve the 2,700 to 3,000 MHz band for government radiolocation users (e.g., meteorological and aircraft surveillance radars) [NTIA, 2009]. The WSR-88D operates outside the frequencies used by television and radio broadcasts, cellular telephones, and personal communication devices. Lowering the minimum scan angle to +0.3 deg would not result in the main beam impinging on the ground surface within 2.8 miles of the radar and the potential for radio interference would be low. No mitigation is necessary.

4.2.2 Electro-explosive Devices (EEDs)

Electro-explosive devices are used to detonate explosives, separate missiles from aircraft, and propel ejection seats from aircraft. Under extreme circumstances, electromagnetic radiation can cause unintended firing of EEDs. Calculations based on a U.S. Air Force (USAF) standard indicate that using electric blasting caps at distances beyond approximately 900 ft from the WSR-88D is a safe practice, even in the main beam of the radar, where the power density of the WSR-88D radio signal is greatest [USAF, 1982]. The U.S. Navy Hazards of Electromagnetic Radiation to Ordnance (HERO) regulations classify EEDs as safe, susceptible, or unsafe and unreliable, based on compliance with MIL-STD 664 (series). HERO safe EEDs are considered safe in all RFR environments. HERO susceptible EEDs may be detonated by RF energy under certain circumstances. HERO unsafe or unreliable EEDs have not been evaluated for compliance with MILSTD 664 or is being assembled, dissembled, or subject to unauthorized conditions, which can increase its sensitivity to RF emissions. Safe separation distances vary for susceptible and unsafe or unreliable ordnance [Naval Sea Systems Command, 2008]. For HERO susceptible ordnance, the safe separation distance (D) in ft is calculated as follows:

$$D = (781)\,(f)^{-1}(\text{average power x antenna gain})^{½}$$

Where f is operating frequency in MHz and average power = maximum transmitted power × duty cycle. Inserting these values gives:

$$D = (781)\,(2{,}875)^{-1}\,(475{,}000\text{ W} \times 0.0021 \times 35{,}500)^{½}\text{ ft}$$
$$D = 1{,}617\text{ ft}$$

For HERO unsafe or unreliable ordnance, the safe separation distance (D) in ft is calculated as follows:

$$D = (2{,}873)\,(f)^{-1}(\text{average power x antenna gain})^{½}$$
$$D = (2{,}873)\,(2{,}875)^{-1}\,(475{,}000\text{ W} \times 0.0021 \times 35{,}500)^{½}\text{ ft}$$
$$D = 5{,}947\text{ ft}$$

HERO concerns are only applicable in locations illuminated by the main beam of the radar. When operating at a minimum scan angle of +0.3 deg, the KDOX WSR-88D main beam would not illuminate the ground or structures within the safe setback distance for HERO safe EEDs. The uppermost portion of the cell phone tower 4,500 S of the WSR-88D may be within the main beam but it is improbable that HERO unsafe EEDS would be in use at the upper portions of the tower.

4.2.4 FUEL HANDLING

Electromagnetic fields can induce currents in conductive materials and those currents can generate sparks when contacts between conductive materials are made or broken. Sparks can ignite liquid fuels, such as gasoline. This phenomenon is rare, but can result in hazards to human health and property. This potential hazard arises during the transfer of fuel from container to another (e.g., fueling an automobile, boat, or airplane). The U.S. Navy developed a Technical Manual identifying the circumstances where this hazard may occur and providing direction on how to prevent it. The Technical Manual identifies a safe standoff distance based on radar operating characteristics [Naval Sea Systems Command, 2003]. Using formula contained in the Technical Manual, the distance from the WSR-88D at which RFR hazards to fuel may occur is

537 ft. This hazard only exists in areas directly illuminated by the main beam. The WSR-88D main beam operating at a minimum center of antenna scan angle of +0.3 deg would not illuminate the ground or any occupied structures within 537 ft of the radar. The existing fuel tank for the standby generator at the base of the WSR-88D tower would not be illuminated by the WSR-88D main beam and hazards to fuel handling activities would not result. No mitigation is required.

4.2.5 Active Implantable Medical Devices

ANSI and the Association for Advancement of Medical Instrumentation (AAMI) developed the PC69:2007 standard to prevent external electromagnetic sources from causing electromagnetic interference with active implantable medical devices, including cardiac pacemakers and implantable cardiac defibrillators [ANSI/AAMI, 2007]. This standard specifies that cardiac pacemakers and ICDs must be tested by exposing them to a specified magnetic field and that the device must operate without malfunction or harm to the device. The specified field strength varies with frequency. For the WSR-88D operating frequency of 2,875 MHz, the field strength is 3 A/m. This is converted to power density (S) in units of W/m^2 by assuming free air impedance of 377 ohms:

$$S = 377\,|3|^2 \quad W/m^2$$
$$S = 3{,}393\ W/m^2$$

To convert to mW/cm^2, we multiply the numerator by 1,000 mW/W and the divisor by 10,000 $cm^2/\ m^2$ which gives a value of 339.3 mW/cm^2. The peak pulse power of the WSR-88D is given by the following formula (see Appendix A):

$$U_1 = 1.44 \text{ X } 10^9/R^2\ mW/cm^2$$

Inserting R = 2,060 ft gives a value of 339.3 mW/cm^2, which equals the threshold established by PC69:2007 standard. At distances of 2,060 ft or greater, the main beam of the WSR-88D would not adversely affect implantable medical devices. There would also be no hazards to implantable medical devices at locations outside the main beam. Operating at the minimum potential center of beam scan angle of +0.3 deg, the main beam of the KDOX WSR-88D would not illuminate the ground or structures within 2,060 ft of the radar.

Theoretically, persons in aircraft flying within 2,060 ft of the radar could be exposed to RF levels above the device susceptibility threshold set by ANSI/AAMI, but the likelihood of significant harm is extremely low. For persons in aircraft, the airframe would attenuate the RF level and the duration of exposure would be far less than the averaging time (6 to 30 minutes) specified in the RF safety standards, reducing the amount of RF exposure. Additionally, device susceptibility threshold in the PC69:2007 standard is based on coupling of the RFR directly into the device leads (which is the test protocol); the WSR-88D signal would be incident upon the surface of the body and would decrease considerably in strength at the location of the device leads within the body. Third, even in the unlikely event that the WSR-88D RFR couples into the device at levels above the susceptibility threshold, the device would revert to safe mode of operation that would prevent significant harm to the wearer or damage to the device [ANSI/AAMI, 2007].

FCC regulations at 47 CFR Part 95.1221 require that MedRadio medical implant devices and medical body-worn transmitters be able to withstand exposure to RF at the MPEs specified in FCC regulations at 47 CFR 1.1310 (FCC, 2017). As described in Section 4.1 above, RF exposure levels in the vicinity of the KDOX WSR-88D would comply with the FCC safety standards. Exposure of persons wearing implantable medical devices to the KDOX WSR-88D radio emissions would not result in adverse effects.

4.2.6 Astronomical Observatories

The WSR-88D can cause harmful electromagnetic interference (EMI) with charge-couple devices (CCDs) which electronically record data collected by astronomical telescopes (NEXRAD JSPO 1993). The potential for harmful EMI would arise if the WSR-88D's main beam would directly impinge on an astronomical observatory during low angle scanning. Twenty observatories are within 150 miles of the KDOX WSR-88D but lowering the minimum scan angle of KDOX WSR-88D main beam to +0.3 deg would not result in the main beam impinging on any of the observatories (see Appendix C). No adverse effects on astronomical observatories would result.

4.2.7 Summary of RF Exposure Effects

Table 5 summarizes impacts to potentially RF-sensitive equipment and activities. The potential for the proposed action to cause radio interference with other radio users would be very low.

Table 4: Potential Effects of KDOX WSR-88D on Equipment and Activities

Equipment / Activity	Applicable Standard	Setback Distance	Would Main Beam Impinge Within Setback Distance?	Potential for Significant Effects
TV, Radio, Cellular Telephone, and Personal Communications Devices (PCDs)	NTIA Frequency Allocations	n/a	n/a	Very Low
EEDs	U.S. Navy HERO Safe/Unsafe	1,617 ft / 5,947 ft	No	Very Low
Fuel Handling	U.S. Navy Hazards to Personnel, Fuel, and Other Flammable Material	537 ft	No	Very Low
Active Implantable Medical Devices	AAMI PC69:2007, FCC 47 CFR Part 95.1221	2,060 ft	No	Very Low
Astronomical Observatories	Direct Exposure to WSR-88D Main Beam	n/a	n/a	None

4.3 LAND USE AND COASTAL ZONE MANAGEMENT

Delaware is a coastal state and has a Coastal Zone Management Program administered by the Delaware Coastal Management Program (DCMP) within the Department of Natural Resources and Environmental Control (NOAA, 2022). The entire state is within the Coastal Management Area. The Program has adopted policies to balance coastal resource uses, economic development, and conservation (Delaware Coastal Management Program, 2023).

Operating the KDOX WSR-88D at a lower scan angle would not result in ground disturbance or emissions of air or water pollutants. No impacts to land or water resources of the Coastal Management Area would result. Similarly, no impacts to habitats for sensitive species would result. The proposed action would be consistent with policies to protect and conserve natural resources of the Coastal Management Area. Similar to current operations, RF emissions from the proposed lower scan angle operations would conform with RF safety standards for exposure of persons and potentially RF sensitive activities. No visual or acoustic noise impacts would result. The increased radar data collected by KDOX WSR-88D could benefit residents, businesses, and visitors to the coastal zone by improving the quality of weather forecasts and warnings of severe weather. Improved forecasts and warnings would assist in reducing the threats to life and safety and property from coastal storms and severe weather events.

Federal agencies proposing activities and development projects must submit a consistency determination to the DCMP if the proposed action is likely to affect Delaware's coastal resources (DCMP, 2018). For covered actions and projects, no federal license or permit may be issued until the DCMP has concurred, filed to act within a specified time, or DCMP objection has been overruled by the Secretary of Commerce. The proposed action would not physically impact land, water, or other natural resources of the coastal area. Improved weather forecasts and severe weather event alerts could indirectly benefit persons and economic activities of the coastal area, which is consistent with Coastal Management Plan Policies on coastal hazard reduction. Since the proposed action would not adversely affect coastal resources, filing a consistency determination with DCMP is not required.

The proposed action would not change land uses at the KDOX WSR-88D site or vicinity and would not affect nearby land uses.

4.4 GEOLOGY, SOILS, AND SEISMIC HAZARDS

The WSR-88D site is underlain by Pleistocene-age (<1.8 million years old) sedimentary deposits of the Columbia Formation (Delaware Geological Survey, 2010). Soil is Rockawalkin loamy sand (RkA) on 0 to 2% slope. RkA soil is deep and moderately well drained. The water table is 20 to 40 inches below the ground surface and this soil is not hydric. RkA soil is considered prime farmland if irrigated. The frequency or flooding or ponding is "none" (Natural Resources Conservation Service, 2023).

U.S. Geological Survey (USGS) considers Sussex County to have a low risk of seismic hazards (USGS, 2014). The proposed action would not affect the WSR-88D tower structure or change its seismic risk level.

Lowering the minimum scan angle of the KDOX WSR-88D would not require physical changes to the radar or result in ground disturbance. The proposed action would have no effect on geology, soils, or seismicity. No mitigation measures are required.

4.5 DRAINAGE AND WATER QUALITY

The KDOX WSR-88D site drains via overland flow to an unnamed branch of Cedar Creek which discharges to Delaware Bay, about 11 miles NE of the WSR-88D site (USGS, 2023). Lowering the minimum scan angle of the KDOX WSR-88D would not result in ground disturbance. The proposed action would not affect the amount of impervious surface area at the radar site, the rate of storm runoff flowing from the site during or after precipitation events, or generate water pollutants. The proposed action would have no effect on drainage or water quality. No mitigation measures are required.

4.6 TRANSPORTATION

The KDOX WSR-88D is in a rural area. Vehicle access is via US. Highway 113 (a.k.a Dupont Boulevard), a paved four-lane divided highway, and Staytonville Road, a two-lane paved public road with low traffic volumes. The proposed action requires modification of the WSR-88D software to be able to scan at angles below +0.5 deg. To implement the change in scan angle, ROC technicians and engineers would travel to the KDOX WSR-88D site to perform initial testing and ensure that the modified software is operating properly. Travel to the site would be minimal and would not result in significant congestion on local roads. Transportation effects would not be significant. No mitigation measures are required.

4.7 AIR QUALITY

The KDOX WSR-88D is equipped with a standby generator that is used if primary power is interrupted and periodically for testing. The proposed action would not change the power consumption of the WSR-88D or affect the hours of operation of the standby generator, and no change in air emissions would result. A Clean Air Act Federal Conformity Determination is not required. No mitigation measures are required.

4.8 FLOOD HAZARDS

Executive Order (E.O.) 11988, *Floodplain Management*, requires the Federal Government to avoid adverse impacts to the 100-year or base floodplain (that is, the area subject to a 1 percent annual chance of flooding), unless there is no practicable alternative [President, 1977a]. The KDOX WSR-88D site is within Zone X, an area outside the 500-year floodplain (FEMA, 2005). The proposed action of lowering the minimum would not affect floodplains or flood hazards. No mitigation measures are required.

4.9 WETLANDS

E.O. 11990, *Protection of Wetlands*, requires the Federal Government avoid funding or implementing projects which would adversely impact wetlands unless there is no practicable alternative [President, 1977b]. Based on National Wetland Inventory maps prepared by the U.S. Fish and Wildlife Service (USFWS), the WSR-88D site does not contain federal jurisdictional wetlands. The nearest wetlands are palustrine forested broad-leaved deciduous seasonally flooded/saturated (PFO1E), located 300 ft N and riverine intermittent streambed seasonally flooded (R4SBC) located 300 ft NE (USFWS, 2023). The proposed action would not result in ground disturbance or changes to drainage and would not affect federal jurisdictional wetlands; no mitigation is required.

4.10 BIOLOGICAL RESOURCES / PROTECTED SPECIES

The USFWS administers the Endangered Species Act (ESA) and Migratory Bird Treaty Act. The KDOX WSR-88D is located within the area served by the U.S. Fish and Wildlife Service (USFWS) Chesapeake Bay Ecological Services Field Office in Annapolis, MD. The EA preparers obtained a protected species list from that office (see Appendix B). One candidate species for listing as threatened or endangered could potentially occur in the local area: Monarch Butterfly (*Danaus plexippus*). The KDOX WSR-88D is not located within designated monarch butterfly critical habitat. Monarch butterflies are brightly colored and lay eggs on milkweed host plants, and larvae emerge in two to five days and feed on milkweed. Adults live two to five weeks, except when overwintering when they enter suspended reproduction and may live up to nine months. In temperate climates, monarchs seasonally migrate up to 1,800 miles (USFWS, 2021b). The proposed action would not result in ground disturbance or removal of vegetation and would not impact monarch butterfly habitat.

In addition to threatened, endangered, and candidate species USFWS is responsible for protecting migratory birds under the Migratory Bird Treaty Act and Executive Order 13186 *Responsibilities of Federal Agencies to Protect Migratory Birds* and bald and golden eagles under the *Bald and golden Eagle Protection Act*.

Lowering the minimum scan angle to +0.3 deg from the current +0.5 deg would result in a thin sliver of the atmosphere, which is currently below the main beam overage area, being exposed to the main beam of the WSR-88D (see Figure 4). The portion of this atmosphere above the newly exposed sliver of atmosphere is currently within the main beam and RF exposure levels would not change. The sliver of the atmosphere where new main beam coverage would result in increased RF exposure levels would be very small near the WSR-88D - 5 ft thick at 900 ft from the WSR-88D and increasing in thickness with distance from the radar. At 1 mile it would be 28 ft thick and at five miles it would be 138 ft thick. Birds, bats, or insects flying within the newly covered sliver of the atmosphere would be exposed to RF emissions from the WSR-88D. The RF levels in the sliver of airspace would be no greater than in RF levels in the existing covered airspace, which occurs just above the newly exposed air space. At distances of several miles or greater where the volume of newly covered airspace would be substantial, RF levels would be very low. At 900 ft, RF exposure levels would be 100 times less than safety standards for human exposure. Based on the extremely low RF levels at distance from the WSR-88D, RF exposure of birds or insects flying within the newly covered airspace would not be harmful.

Increased RF exposure could result if a bird or butterfly flies in a path that keeps it within the WSR-88D main beam for extended periods of time. However, during normal operation the WSR-88D main beam is continuously moving. At 1,000 ft the WSR-88D main beam is moving at an effective speed of about 89 miles per hour and it is very unlikely that a bird or insect could remain within the WSR-88D main beam for any length of time.

No impacts would result to threatened or endangered species, designated monarch butterfly critical habitat, migratory birds, or bald and golden eagles. No mitigation measures are required.

4.11 CULTURAL AND HISTORIC RESOURCES

Section 106 of the National Historic Preservation Act of 1966 (as amended) requires that federal agencies consider the effects of their actions on historic places and, if effects may result, provide the State Historic Preservation Officer (SHPO) with an opportunity to comment on their actions. Section 106 regulations are set forth in 36 CFR Part 800, *Protection of Historic Properties* (Advisory Council on Historic Preservation, 2010).

Because the proposed action would not involve ground disturbance, no impacts to archaeological or paleontological resources would result. The proposed action's area of potential effect (APE) is defined as area within 1,740 ft of the KDOX WSR-88Ds where RF exposure of persons within the WSR-88D main beam could potentially exceed safety levels (see Appendix A). The State of Delaware Cultural and Historical Resources Information System (CHRIS) was searched to identify places listed or eligible for listing on the National Register of Historic Places (NRHP) within the APE. The nearest listed place is Teddy's Tavern (CR Survey No. S08384), located 4,500 S of the WSR-88D and outside the APE. No places listed on NHRP are in the APE. The potentially eligible Maringola House and Farmstand (CR Survey No. 08570), located 2,700 ft N of the WSR-88D, is also outside the APE (State of Delaware Division of Historical and Cultural Affairs, 2023).

Seven structures within the APE have been evaluated for NRHP eligibility. This includes State Bridge S-901 (CR Survey No. S08331), crossing an unnamed branch of Cedar Creek about 400 ft E of the WSR-88D; four dwellings located 900 to 1,600 ft N on the east side of U.S. Highway 113 (a.k.a. Dupont Boulevard) (CR Survey Nos. S10440, S10441, S08572, and S11896); a dwelling in Fleaburg, DE located 1,700 ft E (CR Survey No. S11905), and the Appenzellar Tract, located 1,200 ft SE (CR Survey No. S12177). All of these places were found to be ineligible for NRHP (State of Delaware Division of Historical and Cultural Affairs, 2023).

No places listed or eligible for listing on NRHP are located within the APE. Additionally, no National Historic Landmarks, National Register Districts, historic cemeteries, or Sussex County

Mill locations are within the APE. The proposed action does not have the potential to affect historic or cultural resources. Under Section 106 Regulations 36 CFR Section 800.4 (d)(1), *No Historic Properties Affected*, if the proposed action does not have the potential to affect historic properties, the ROC shall provide notification of this determination to the SHPO. If the SHPO does not object to the determination within 30 days, ROC's section 106 responsibilities are fulfilled. [ecfr, 2023).

4.12 ENVIRONMENTAL JUSTICE AND SOCIOECONOMIC IMPACTS

E.O. 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations*, requires federal agencies to identify and address, as appropriate, disproportionately high and adverse environmental or human health effects on minority populations and low income populations (President, 1994).

The KDOX WSR-88D is in a rural/agricultural area in Sussex County, DE. Nearby land uses are agriculture and low-density rural residences. The proposed action would not generate air or water pollutants or hazardous waste. The project would modify the operation of the KDOX WSR-88D by reducing the minimum scan angle from +0.5 deg to +0.3 deg. The lowered WSR-88D main beam would not impinge on the ground in proximity to the radar and would comply with safety standards for human exposure to RF energy and setbacks for activities (e.g., fuel handling and EED use) that are potentially sensitive to RF exposure. No disproportionately high and adverse effects would result to any persons, including minority or low income populations. No mitigation is required.

4.13 FARMLANDS

The Farmland Protection Policy Act sets forth federal policies to prevent the unnecessary conversion of agricultural land to non-agricultural use. NRCS regulations at 7 CFR Part 658, *Farmland Protection Policy Act*, are designed to implement those policies. Completion of Form AD-1006 and submission to the U.S. Department of Agriculture (DoA) is required if a federal agency proposes to convert land designated as prime farmland, farmland of statewide importance, or unique farmland to non-agricultural use. Soil at the KDOX WSR-88D site is classified as prime farmland (NRCS, 2021). However, the WSR-88D site is committed to non-agricultural government use. The proposed action would not convert farmland to non-farm use. No mitigation is necessary.

4.14 ENERGY CONSUMPTION

The proposed action would not change electric use by the WSR-88D and would have no effect on energy consumption. No mitigation is necessary.

4.15 VISUAL QUALITY/ LIGHT EMISSIONS

The proposed action would not change the appearance of the KDOX WSR-88D or result in new emissions of visible light. The proposed action would have no effect on visual quality. No mitigation is necessary.

4.16 SOLID AND HAZARDOUS WASTE

The proposed action would result in no changes to solid or hazardous waste generation. No mitigation is necessary.

4.17 WILD AND SCENIC RIVERS

The Wild and Scenic Rivers Act of 1968 protects free-flowing rivers of the U.S. These rivers are protected under the Act by prohibiting water resource projects from adversely impacting values of the river: protecting outstanding scenic, geologic, fish and wildlife, historic, cultural, or recreational values; maintaining water quality; and implementing river management plans for these specific rivers. The wild and scenic rivers closest to the KDOX WSR-88D is the Maurice River in southern New Jersey, about 35 miles NE of the WSR-88D. (National Park Service, 2023). The proposed action would not affect that wild and scenic river. No mitigation is necessary.

5 ALTERNATIVES TO THE PROPOSED ACTION

5.1 MINIMUM SCAN ANGLES BETWEEN +0.4 AND 0.0 DEG

ROC evaluated the benefits and potential impacts of lowering the minimum center of beam scan angle of the KDOX WSR-88D to each angle between +0.4 and 0.0 deg in 0.1 degree increments (see Appendix C). That analysis found that the proposed action of lowering the minimum scan angle to +0.3 deg would result in the significant improvement in radar coverage.

A minimum scan angle of +0.4 deg would increase the radar's coverage area, but by less than the proposed action (i.e., minimum scan angle of +0.3) deg. A minimum scan angle lower than +0.3 deg would not increase coverage area and would have the drawback of increasing ground clutter returns.

Because a minimum scan angle of +0.3 deg would result in significant improvement in radar coverage area while avoiding significant environmental impacts, ROC selected +0.3 deg as the proposed minimum scan angle for the KDOX WSR-88D.

5.2 NO ACTION

The no action alternative consists of continued operation of the KDOX WSR-88D at the existing minimum scan angle of +0.5 deg. The improvements in radar coverage summarized in Section 3 would not be achieved and the project objectives would not be met.

The proposed action would result in increased RF exposure compared to existing WSR-88D operations as described in section 4.1; the no-action alternative would not change RF exposure levels from existing. Under both the proposed action and the no action alternative, RF exposure during normal WSR-88D operations would conform to safety standards established by ANSI/IEEE, OSHA, and FCC.

Similar to the proposed action, the no-action alternative would not result in adverse effects in the following topic areas:

- Land Use and Coastal Zone Management
- Geology, Soils, and Seismic Hazards
- Drainage and Water Quality
- Transportation
- Air Quality
- Flood Hazards
- Wetlands
- Biological Resources / Protected Species
- Cultural and Historic Resources
- Environmental Justice and Socioeconomic Impacts
- Farmlands

- Energy Consumption
- Visual Quality/ Light Emissions
- Solid and Hazardous Waste
- Wild and Scenic Rivers

6 FINDING

The proposed action of lowering the scan angle of the KDOX WSR-88D from the current minimum of +0.5 deg to +0.3 deg would not result in significant changes in the quality of the human environment. Lowering the minimum scan angle would also not add to the environmental effects of past, present, and reasonably foreseeable future actions to cause cumulatively significant effects

The proposed action would improve the quality of meteorological radar data available to ROC forecasters and others users of the data. This may indirectly benefit the residents and businesses of the Dover AFB, DE area, improving the accuracy of forecast and severe weather alerts, which could result in environmental benefits if weather dependent economic activities (e.g., agriculture, construction, outdoor recreation, transportation, water management) become more efficient or safer as a result of improved weather services. The resulting environmental benefits are difficult to quantify, but are unlikely to be significant.

Implementation of the proposed action would not have the potential to cause significant changes in the environmental. A Finding of No Significant Impact is warranted for the proposed action.

7 DOCUMENT PREPARERS

This Draft EA was prepared by Sensor Environmental LLC under contract to Centuria Corporation. Centuria Corporation provides support to the ROC Radar Operations Center (ROC) in Norman, OK.

Mr. James Manitakos, CEO, served as Sensor's Project Manager. Huntington Ingalls Industries (HII)/Alion Science and Technology Corporation prepared radar coverage maps and calculated coverage areas under subcontract to Sensor. Mr. Andre Tarpinian, Radio Frequency Engineer, served as HII Alion's Project Manager. Ms. Jessica Schultz, Deputy Director of the ROC Radar Operations Center, and Mr. Ryan Groce, Program Manager, from the ROC assisted in preparation of this EA.

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9 EA DISTRIBUTION

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SENSOR ENVIRONMENTAL LLC
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Environmental Assessment Report

ENVIRONMENTAL ASSESSMENT (EA)

LOWERING THE MINIMUM SCAN ANGLE OF THE WEATHER SURVEILLANCE RADAR - MODEL 1988, DOPPLER (WSR-88D) SERVING THE DOVER AIR FORCE BASE, DE, AREA

APPENDICES

APPENDIX A

RADIOFREQUENCY RADIATION POWER DENSITY CALCULATIONS

1. OBJECTIVE

This appendix quantifies the power densities of the radiofrequency radiation (RFR) emitted by the Weather Surveillance Radar, Model 1988 Doppler (WSR-88D) during operations that include minimum scan angles lower than +0.5 degrees (deg). The calculated power densities will be used to analyze the potential for effects to result from exposure of humans, equipment, and activities to the WSR-88D radio signal, and the significance of any identified potential effects.

2. METHODOLOGY

This memorandum builds upon the analysis included in the 1993 *Supplemental Environmental Assessment (SEA) of the Effects of Electromagnetic Radiation from the WSR-88D Radar* [NEXRAD Joint System program Office, 1993]. The 1993 analysis analyzed the potential electromagnetic effects of the WSR-88D signal when the radar operates at a minimum center of beam scan angle of +0.5 deg. This memorandum builds on that analysis by considering operation at a lower minimum scan angle of -0.2 deg. The parameters of the WSR-88D are shown in Table A-1 and are not changed from the 1993 analysis:

TABLE A-1: Operating Characteristics of WSR-88D Serving the Dover AFB, DE Area (KDOX)

Parameter	**Value**
Operating Frequency	2,875 megahertz (MHz)
Wavelength at center frequency (2,850 MHz)	0.342 ft, 10.4 cm
Maximum pulse power	475 kiloWatts (kW)
Maximum duty cycle	0.21%
Antenna diameter	28 ft, 853 cm
Antenna gain	35,500:1, 45.5 dB
Beam width to half-power points	1.0 deg
First sidelobe relative power density, maximum	0.00325, -25 dB
Other sidelobe maximum power density, relative to main beam	0.0004, -34 dB

The ROC proposes to modify the minimum center of beam scan angle used during operation of the KDOX WSR-88D below the +0.5 angle currently used. This would not require changes to the antenna, other hardware which composes the WSR-88D, or the radiated pulse power of the WSR-88D. However, incorporating scans at angles below +0.5 deg could affect the amount of RFR exposure experienced by persons, equipment, and activities at or near ground level in the vicinity of the radar. This memorandum quantifies that change.

3. MODIFIED VOLUME SCAN PATTERN 31

The WSR-88D uses a number of complex volume scan patterns to maximize the quality and usefulness of the meteorological data it collects. The 1993 report analyzed volume scan pattern 31, which results in the highest levels of ground-level RFR exposure. Volume Scan Pattern

(VCP) 31 consists of eight 360 deg rotations of the antenna at various scan angles. ROC proposed to add two additional antenna rotations at a scan angle between +0.5 and 0.0 deg to this scan pattern to increase the range at which the radar can detect and track meteorological phenomena, especially at low elevations within the atmosphere. This memorandum assumes that the two added scans would be at +0.3 deg (i.e., lower half power point of -0.3 deg), the lowest scan angles under consideration by ROC. Adding two +0.3 degree scans would result in the greatest possible increase in ground level RFR exposure. The modified VCP 31 would be as follows:

- Two complete rotations at +0.3 deg
- Two complete rotations at +0.5 deg
- Two complete rotations at +1.5 deg
- Two complete rotations at +2.5 deg
- One complete rotation at +3.5 deg
- One complete rotation at +4.5 deg

The complete pattern would include 10 rotations of the antenna at a speed of 0.8 revolutions per minute (rpm), the pattern would take about 12 minutes and 22 seconds to complete [Turner, 2011].

4. CALCULATION OF RF POWER DENSITIES

Appendix A of the 1993 SEA includes detailed calculations of the RFR power density and exposure levels resulting from volume scan pattern 31. The proposed scan change would not affect the distance of the transition from the near field to the far field, calculated at 640 to 800 ft in section A.3 of the 1993 Appendix A.

4.1 Far Field

For VCP 31 operation of the WSR-88D, the values of U_1, U_2, U_3, U_4 and U_5 are unchanged from the values derived in 1993 Appendix A. The RF human exposure standards are based on time-averaged RF exposure for six minutes (occupational exposure) or 30 minutes (general public exposure) [American National Standards Institute/Institute of Electrical and Electronic Engineers, 2019]and 2020. We use six minutes as the averaging time as a worst-case analysis. The time-averaged power density for VCP 31, considering the contributions from both the main beam and the first five sidelobes is given by U_5, below:

$$U_{5,\ VCP\ 31} = 5{,}804 / R^2 \text{ mW/cm}^2$$

At this point the analysis must consider the proposed modifications to VCP 31, which will change the values of U_4 and U_5. The modified VCP 31 would have two additional +0.3 deg scans. Within our six minute averaging time, these two added scans would replace the RFR contribution from one +1.5 deg and one +2.5 deg scan. As described in the 1993 appendix, U_4 sums the RFR contributions at center of antenna level from each of the scans performed during the six minute period of interest. The coefficients for the +0.3 deg scans are 2.4/6 reflecting the proportion of the 6 minutes and 1.0 because the center of beam will essentially be at antenna level (i.e., +0.2 deg which equates to 2.8 ft, or one-tenth of the beam width at the far field transition distance of 800 ft). The corresponding coefficients for the two +0.5 deg scans within the six minutes are 2.4/6 and 0.5, and for the one +1.5 deg scan within the six minutes are 1.2/6 and 0.012. The modified U_4 calculation is given below

$$U_{4,\ mod} = [(2.4/6)\ (1.0) + (2.4/6)\ (0.5) + (1.2/6)\ (0.012)]\ U_3$$

$$U_{4,\ mod} = (0.602)\ U_3$$

Inserting the U_3 value of 1.35 x $10^4/R^2$ milliwatts/cm^2 (mw/ cm^2), yields:

$$U_{4,\ mod} = 8{,}130\ /\ R^2 \quad mW/cm^2$$

U_4 is the 6-minute time-averaged power density at locations in the far field directly illuminated by the main beam and at the same elevation as the WSR-88D antenna, considering the RFR contributed from the main beam and the first five sidelobes. According to the WSR-88D specification, sidelobes of higher order than the first five will contain less than 5% of the eradiated energy. The 1993 SEA calculated the average power density of these higher order sidelobes at $4/R^2$ mW/cm^2. We add this to U_4 to obtain U_5, the total time-averaged power density at an elevation even with the center of antenna elevation and distances greater than 800 ft from the antenna:

$$U_{5,\ mod} = 8{,}130 \text{ x } 10^3/R^2 + 4/R^2 = 8{,}134/R^2 \quad mW/cm^2$$

4.2 Near Field

Appendix A of the 1993 SEA contains the following formula for power density in the WSR-88D main beam during VCP 31 operation:

$$U_{6,\ VCP\ 31} = 9800/\ (R^2 + 800R)\ mW/cm^2$$

Which is based on calculation of the height Y of the mathematical cylinder illuminated by all scans during the six-minute period using the formula Y = 28 + R Tan (2 deg) + 0.035R. Since the modified scan pattern of interest includes scans of +0.3. +0.5, and +1.5 degs, the angular range is 1.2 deg, and we recalculate Y as follows:

$$Y = 28 + R \text{ x } Tan\ (1.2\ deg) = 28 + 0.021R$$

The circumference of the illumination cylinder is $2\pi RY$ and the total area A is

$$A = 2\pi RY = 176R + 0.13R^2$$

The average power radiated is less than or equal to 1 kW, and the average power over the cylindrical surface cannot exceed this value divided by the area. At the mid-height of the cylinder, the local power density will exceed the average value by a factor of 2 (unchanged from the 1993 analysis). We introduce this factor, multiply by 10^6 to convert from kW to mW, and divide by 929 to convert from sq ft to square centimeters (sq cm):

$$U_{6, mod} = 2 \times 10^6 / (929)(176R + 0.13R^2) = 16{,}556 / (R^2 + 1{,}353 R) \text{ mW/cm}^2$$

$U_{6, mod}$ is the time-averaged RFR exposure within the area illuminated by the WSR-88D main beam up to distances of 640 ft where the beam begins to spread.

4.3 RF Exposure Levels near KDOX WSR-88D

Table A-2 shows the time-averaged RF power densities that would result at locations directly illuminated by the main beam of the KDOX WSR-88D when operating in modified VCP 31. The near field is within 640 ft of the radar and the U_6 formula is used to calculate these near field values. At greater distances, the far field formula for U_5 is used. For comparison purposes, corresponding values for the original VCP 31 are also shown. As can be seen from Table A-1, use of modified scan pattern 31 would lower the elevation at which the main beam occurs and would also slightly increase the time-averaged power densities in both the near and far fields.

Table A-2: Comparison of RF Power Densities within the WSR-88D Directly Illuminated Area Using VCP 31 and Modified VCP 31

Place	Distance (ft)	Original VCP 31 Lowest Elev (ft MSL)	Original VCP 31 Time-Avg Power Density (mW/cm2)	Modified VCP 31 Lowest Elev (ft MSL)	Modified VCP 31 Time-Avg Power Density (mW/cm^2)
Surface of Radome	20	150*	0.598	n/a	0.603
Closest Structure: Cell Phone Tower	4,500	150	0.00029	134	0.00040
Closest Illuminated Ground	>15,840	150	0.000023	95	0.000032

*****Elevation of bottom edge of KDOX WSR-88D antenna

ROC may infrequently operate the KDOX WSR-88D with a stationary antenna, resulting in the main beam being continuously pointed at the same location for a period of time. The RF exposure level within the main beam can be calculated using equation U_1 multiplied by the radar duty cycle

$$U_7 = (1.44 \times 10^9/R^2)\ 0.0021 = 3.024 \times 10^6/R^2 \qquad (\text{mW/cm}^2)$$

When operating in stationary antenna mode, the KAH WSR-88D would exceed the American National Standards Institute / Institute of Electrical and Electronic Engineers (ANSI/IEEE) safety levels within the following distances:

- ANSI/IEEE and FCC General Public Safety Level (1.0 mW/cm^2): 1,740 ft

- Federal communications commission (FCC) and ANSI Occupational Safety Level (5.0 mW/cm^2): 777 ft

5. REFERENCES

ANSI/IEEE. *IEEE Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 3 kHz to 300 GHz*. IEEE Std C95.1-2019 (February 8, 2019).

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Next Generation Weather Radar Joint System Program Office (JSPO), *Final Supplemental Environmental Assessment (SEA) of the Effects of Electromagnetic Radiation from the WSR-88D Radar* (April 1993).

APPENDIX B

PROTECTED SPECIES LIST

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Chesapeake Bay Ecological Services Field Office
177 Admiral Cochrane Drive
Annapolis, MD 21401-7307
Phone: (410) 573-4599 Fax: (410) 266-9127

In Reply Refer To: July 22, 2023
Project Code: 2023-0107803
Project Name: KDOX WSR-88D Lower Scan Angle

Subject: List of threatened and endangered species that may occur in your proposed project location or may be affected by your proposed project

To Whom It May Concern:

The enclosed species list identifies threatened, endangered, proposed and candidate species, as well as proposed and final designated critical habitat, that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the U.S. Fish and Wildlife Service (Service) under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 *et seq.*).

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. Please feel free to contact us if you need more current information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally as desired. The Service recommends that verification be completed by visiting the ECOS-IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the ECOS-IPaC system by completing the same process used to receive the enclosed list.

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2) of the Act and its implementing regulations (50 CFR 402 *et seq.*), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species and to determine whether projects may affect threatened and endangered species and/or designated critical habitat.

A Biological Assessment is required for construction projects (or other undertakings having similar physical impacts) that are major Federal actions significantly affecting the quality of the human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2)(c)). For projects other than major construction activities, the Service suggests that a biological evaluation similar to a Biological Assessment be prepared to determine whether the project may affect listed or proposed species and/or designated or proposed critical habitat. Recommended contents of a Biological Assessment are described at 50 CFR 402.12.

If a Federal agency determines, based on the Biological Assessment or biological evaluation, that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Service recommends that candidate species, proposed species and proposed critical habitat be addressed within the consultation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at:

http://www.fws.gov/endangered/esa-library/pdf/TOC-GLOS.PDF

Migratory Birds: In addition to responsibilities to protect threatened and endangered species under the Endangered Species Act (ESA), there are additional responsibilities under the Migratory Bird Treaty Act (MBTA) and the Bald and Golden Eagle Protection Act (BGEPA) to protect native birds from project-related impacts. Any activity, intentional or unintentional, resulting in take of migratory birds, including eagles, is prohibited unless otherwise permitted by the U.S. Fish and Wildlife Service (50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)). For more information regarding these Acts see https://www.fws.gov/birds/policies-and-regulations.php.

The MBTA has no provision for allowing take of migratory birds that may be unintentionally killed or injured by otherwise lawful activities. It is the responsibility of the project proponent to comply with these Acts by identifying potential impacts to migratory birds and eagles within applicable NEPA documents (when there is a federal nexus) or a Bird/Eagle Conservation Plan (when there is no federal nexus). Proponents should implement conservation measures to avoid or minimize the production of project-related stressors or minimize the exposure of birds and their resources to the project-related stressors. For more information on avian stressors and recommended conservation measures see https://www.fws.gov/birds/bird-enthusiasts/threats-to-birds.php.

In addition to MBTA and BGEPA, Executive Order 13186: *Responsibilities of Federal Agencies to Protect Migratory Birds*, obligates all Federal agencies that engage in or authorize activities that might affect migratory birds, to minimize those effects and encourage conservation measures that will improve bird populations. Executive Order 13186 provides for the protection of both migratory birds and migratory bird habitat. For information regarding the implementation of Executive Order 13186, please visit https://www.fws.gov/birds/policies-and-regulations/executive-orders/e0-13186.php.

We appreciate your concern for threatened and endangered species. The Service encourages Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. Please include the Consultation Code in the header of this letter with any request for consultation or correspondence about your project that you submit to our office.

Attachment(s):

- Official Species List

OFFICIAL SPECIES LIST

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

Chesapeake Bay Ecological Services Field Office
177 Admiral Cochrane Drive
Annapolis, MD 21401-7307
(410) 573-4599

PROJECT SUMMARY

Project Code: 2023-0107803
Project Name: KDOX WSR-88D Lower Scan Angle
Project Type: Maintenance/Modification of Communication Tower
Project Description: Reducing the minimum scan angle of existing KDOX WSR-88D to 0.3 deg
Project Location:

The approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/@38.825742149999996,-75.44004028205521,14z

Counties: Sussex County, Delaware

ENDANGERED SPECIES ACT SPECIES

There is a total of 1 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species. Note that 1 of these species should be considered only under certain conditions.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries[1], as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

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1. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

INSECTS

NAME	STATUS
Monarch Butterfly *Danaus plexippus*	Candidate

No critical habitat has been designated for this species.

This species only needs to be considered under the following conditions:

- The monarch is a candidate species and not yet listed or proposed for listing. There are generally no section 7 requirements for candidate species (FAQ found here: https://www.fws.gov/savethemonarch/FAQ-Section7.html).

Species profile: https://ecos.fws.gov/ecp/species/9743

CRITICAL HABITATS

THERE ARE NO CRITICAL HABITATS WITHIN YOUR PROJECT AREA UNDER THIS OFFICE'S JURISDICTION.

YOU ARE STILL REQUIRED TO DETERMINE IF YOUR PROJECT(S) MAY HAVE EFFECTS ON ALL ABOVE LISTED SPECIES.

IPAC USER CONTACT INFORMATION

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APPENDIX C

TECHNICAL MEMORANDUM AND TRIP REPORT

SENSOR ENVIRONMENTAL LLC
www.sensorenvirollc.com

TECHNICAL MEMORANDUM

TO: Ryan Groce, Program Manager, Centuria Corporation	**FROM:** James Manitakos, CEO, Sensor Environmental LLC
CC: Jessica Schultz, Deputy Director, National Weather Service Radar Operations center Andre Tarpinian, Senior RF Engineer, Huntington Ingalls Industries Mission Technologies Group (formerly Alion Science and Technology Corp.)	**SUBJECT:** Analysis of Lower Scan Angles for Weather Surveillance Radar, Model 1988 Doppler (WSR-88D) Serving Dover Air Force Base, DE, Area
DATE: July 7, 2023	

1. BACKGROUND AND NEED

The National Weather Service (NWS) proposes to reduce the minimum vertical scan angles used during normal operation of the WSR-88D serving Dover Air Force Base, area. Information on this radar is shown in Table 1. This WSR-88D was commissioned on January 11, 1993 and has been in operation at its current location since then.

TABLE 1: Information on WSR-88D Serving the Dover AFB, DE, Area	
Location	1.5 mi NW of Ellendale, Sussex County, DE
Commissioning Date	January 11, 1993
International Civil Aviation Organization designator	KDOX
Elevation, ground surface at tower base (mean sea level, MSL)	50 feet (ft)
Elevation, center of antenna (MSL)	164 ft
Tower Height (m)	30 m (98 ft)
Latitude (WGS84)	38˚49’32” N
Longitude (WGS84)	75˚26’23” W
Operating Frequency	2,875 megaHertz (MHz)
Spot Blanking or Sector Blanking used	No

The U.S. Air Force (USAF) currently operates the KDOX WSR-88D at a minimum center-of-beam scan angle of + 0.5 degree (deg). The WSR-88D main beam has a width of 1 deg to the half power points. Half of the beam (i.e., 0.5 deg) is below the axis, resulting in an essentially horizontal floor for existing radar coverage. As a result, the WSR-88D cannot provide radar coverage of the atmosphere below the elevation of the WSR-88D antenna. At considerable distance from the radar, earth curvature increases the height above the ground surface of the uncovered area. To increase the amount of radar coverage provided by the KEVX WSR-88D, The WSR-88D Radar Operations Center (ROC) proposes to operate the radar with a lower center-of-beam minimum scan angle and is considering angles between 0.4 and 0.0 deg. This would result in the lower half power point of the main beam at -0.1 to -0.5 deg, depending on the minimum scan angle selected.

2. INVESTIGATIONS PERFORMED

To analyze the benefits and potential impacts of lowering the minimum scan angle of the KDOX WSR-88D, Sensor Environmental LLC and our subcontractor Alion Science and Technology Corporation performed the following tasks:

1. Visited the KDOX WSR-88D to ascertain site conditions and activities in the vicinity (see Attachment A, Trip Report).
2. Obtained 360-degree calibrated panoramic photograph taken at 25-m level of the KDOX WSR-88D tower, which is about 30 ft lower than the center of antenna height.
3. Prepared maps showing the extent of WSR-88D coverage at 2,000 ft above site level for each (center of beam) scan angle from the current minimum of +0.5 degree to 0.0 degree (See Attachment B).
4. Identified areas of terrain and activities that are potentially sensitive to radiofrequency (RF) radiation exposure in proximity to the WSR-88D that would be directly illuminated by the main beam at each lower scan angle under consideration (see Attachment C).
5. Identified astronomical observatories within 150 miles and analyzed the potential for a lowered WSR-88D main beam to directly impinge on each observatory.
6. Identified wind turbines within 50 miles and analyzed the potential for a lowered WSR-88D main beam to directly impinge on each observatory.

3. WSR-88D COVERAGE

KDOX WSR-88D is located on nearly level ground in a rural portion of Sussex County, Delaware about 21 miles south (S) of Dover Air Force Base and 1.5 miles northwest (NW) of Ellendale, DE. The Project team used Alion Integrated Target Acquisition System (ITAS) terrain-based computer model with GIS-based interface to project the terrain-dependent radar coverage for the KDOX WSR-88D at 2,000 ft above site level (ASL). The radar coverages shown in Attachment B are based on Digital Terrain Elevation Data (DTED) Level 2 topographic data and 4/3 earth radius to account for atmospheric refraction of the WSR-88D main beam. The lower half-power point of the unobstructed WSR-88D main beam is considered the minimum elevation (i.e., floor) of WSR-88D coverage. Table 2 shows KDOX WSR-88D coverage areas at 2,000 ft above site level (ASL) for the range of minimum scan angles under consideration by NWS.

TABLE 2: KDOX WSR-88D Radar Coverage Areas for Minimum Scan Angles				
Coverage Altitude (ft ASL)	**Minimum Center of Beam Scan Angle (deg)**	**Lower Half-power Point (deg)**	**Area in Lambert Projection (sq. mi.)**	**Change from Existing Minimum Scan Angle**
2,000	+0.5 (existing)	0.0	10,465	n/a
2,000	+0.4	-0.1	14,114	+34.9%
2,000	+0.3	-0.2	18,147	+73.4%
2,000	+0.2, +0.1, 0.0	-0.3, -0.4, -0.5	18,268	+74.6%

When operating at the current minimum center of beam minimum scan angle of +0.5 deg, the KDOX WSR-88D is not subject to terrain blockage (see Attachment B). At lower scan angles of +0.4 or + 0.3 deg, radar coverage would improve in all directions. Compared to a minimum scan angle of +0.3, a scan angle of + 0.2 deg would result in minor additional coverage to the east (E) and northeast (NE) but no increase in coverage in other directions. No additional coverage improvement would result at minimum scan angles below +0.2 deg.

Low altitude radar coverage over the Atlantic Ocean is a concern. Under current operations, 2,000-ft radar coverage extends about 57 miles east of the WSR-88D or about 40 miles E of the Delaware shoreline. Lowering the WSR-88D minimum scan angle to +0.3 or +0.2 deg would extend the area of 2,000 ft coverage to about 78 miles E of the WSR-88D.or about 61 miles E of the Delaware shoreline.

4. HUMAN EXPOSURE AND POTENTIALLY RF-SENSITIVE ACTIVITIES

Exposure to radiofrequency (RF) radiation can potentially be harmful to humans and RF-sensitive activities. Table 3 presents the safe setback distances from the WSR-88D for human exposure, implantable medical devices, fuel handling, and EEDs (Sensor Environmental LLC, 2011). Safety standards for implantable medical devices, fuel handling, and EEDs are based on instantaneous exposure. Safety standards for human exposure are based on time-averaged exposure; therefore, exposure during both rotating antenna and stationary antenna operations are considered.

TABLE 3: Safe Setback Distances for Human Exposure and Potentially RF-Sensitive Activities Directly Illuminated by the WSR-88D Main Beam			
Activity	**Safe Setback Distance (ft)**		**Source**
Human Exposure	Rotating Antenna	20	American National Standards Institute/Institute of Electrical and Electronic Engineers (ANSI/IEEE)
	Stationary Antenna	1,740	
Implantable Medical devices	2,060		ANSI/Association for the Advancement of Medical Instrumentation (AAMI)
EEDs (Safe/Unsafe)	1,617 / 5,947		Naval Sea Systems Command
Fuel Handling	537		Naval Sea Systems Command

5. DIRECTLY ILLUMINATED TERRAIN AND STRUCTURES

The safe setback distances from the WSR-88D for human exposure, implantable medical devices, fuel handling, and electro-explosive devices (EEDs), are given in section 4 of this memorandum. The greatest safe setback distance for human exposure or any of these activities for exposure of EEDs, which include blasting caps, some types of ordnance, and equipment used in aviation systems (e.g., ejection seats and separation systems for air-launched missiles). Hazard of Radiation to Ordnance (HERO) regulations characterize EEDs as either unsafe or safe with differing setback distances. HERO unsafe or unreliable EEDs have not been evaluated for compliance with MILSTD 664 or are being assembled, dissembled, or subject to unauthorized conditions, which can increase its sensitivity to RF emissions. HERO safe EEDs have been evaluated for compliance with MILSTD 664 and are not being assembled or dissembled (Naval Sea Systems command, 2008). Based on the U.S. Navy HERO regulations, the safety setback distances for HERO unsafe and safe EED, respectively are 5,947 ft and 1,617 ft respectively. U.S. Air Force safety regulations consider a 900 ft setback distance from radars such as the WSR-88D safe for all types of blasting caps (U.S. Air Force, 1982).

Photographs 2A through 2D in Attachment A Trip Report are panoramic photographs taken from the 20-m level of the KDOX WSR-88D tower and show a 360 deg view of the horizon. As shown in these figures, no nearby structures rise above WSR-88D antenna elevation. A search of the Federal Communications Commission (FCC) Antenna Structure Registration site identified two existing towers. Towers owned by SBA Towers LLC (File Number A0836269) and CTI Towers Assets II, LLC (File Number A1011489) are located about 2.7 miles NE and 3 miles NW of the KDOX WSR-88D, respectively (FCC, 2023). Both those towers meet all safe setback distances from the WSR-88D. Additionally, an unregistered cellular telephone tower owned by American Tower is located about 4,500 ft S of the WSR-88D.at ground elevation about 10 ft lower [U.S. Geological Survey (USGS), 2019]. The height of that tower is not known but appears to be similar to that of the WSR-88D. The American tower structure meets all safe setback distances from the WSR-88D except for unsafe EEDs, it is improbable that unsafe EEDs would be used at the upper portion of a commercial communications tower and no hazard would result.

Attachment C contains maps showing terrain directly illuminated by the KDOX WSR-88D main beam at minimum center of beam scan angles of +0.5 seg (current operation) through -0.2 deg. At the current minimum scan angle of +0.5 deg or a minimum scan angle of +0.4 deg, +0.3 deg, or 0.2 deg, the main beam would not impinge on the ground within 3 miles. At scan angles of 0.1 deg, the main beam would impinge on the ground within three miles in many directions. At 0.0 deg, the main beam would impinge on the ground within three miles in almost all directions.

6. ASTRONOMICAL OBSERVATORIES

The WSR-88D can potentially cause adverse electromagnetic interference (EMI) with charge-couple devices (CCDs) which electronically record data collected by astronomical telescopes (NEXRAD JSPO), 1993). Due to the sensitivity of astronomical equipment which is designed to detect very faint signals from space, this equipment is vulnerable to EMI. The potential for harmful EMI would arise if the WSR-88D main beam would directly impinge on an astronomical observatory during low angle scanning. The area of potential impact to observatories is within 150 miles of the WSR-88D. Portions of the states of Delaware, New Jersey, New York, Pennsylvania, Maryland, and Virginia and Washington D.C. are within 150 miles of the KDOX WSR-88D and were evaluated to identify observatories. Twenty observatories are within 150 miles (www.go-astronomy.com, 2023). Table 4 list these observatories and whether the WSR-88D beam at a scan angle of 0.3 deg would impinge on them. Lowering the minimum scan angle of KDOX WSR-88D main beam to +0.3 deg would not result in the main beam impinging on any of the observatories.

TABLE 4: Astronomical Observatories within 150 miles of KDOX WSR-88D

Observatory	Location	Distance and Direction	Elevation (ft MSL)	Would WSR-88D main beam impinge at lower scan angle of +0.3 deg?
Mt. Cuba	Greeneville, DE	69 mi N	315	No, earth curvature places beam 900 ft above observatory

TABLE 4: Astronomical Observatories within 150 miles of KDOX WSR-88D				
Harold E. Taylor (Stockton Univ)	Galloway, NJ	66 mi NE	75	No, earth curvature places beam 1,000 ft above observatory
Paul Robinson	High Bridge, NJ	133 mi NNE	866	No, earth curvature places beam 5,600 ft above observatory
Peyton (Princeton Univ)	Princeton, NJK	117 mi NNE	200	No, earth curvature places beam 4,600 ft above observatory
Robert A, Schommer (Rutgers Univ)	Rutgers, NJ	127 mi NNE	800	No, earth curvature places beam 5,000 ft above observatory
Astrophysical Observatory Staten	Staten Island, NY	142 mi NNE	65	No, earth curvature places beam 7,500 ft above observatory
Widener Univ	Chester, PA	72 mi N	130	No, earth curvature places beam 1,300 ft above observatory
Naylor	Lewisberry, PA	120 mi NW	605	No, earth curvature places beam 4,500 ft above observatory
Joel Bloom	Philadelphia, PA	81 mi N	120	No, earth curvature places beam 1,800 ft above observatory
Univ of Pennsylvania	Philadelphia, PA	79 mi N	100	No, earth curvature places beam 1,700 ft above observatory
Bradstreet	St. Davids, PA	84 mi N	425	No, earth curvature places beam 1,700 ft above observatory
Sproul (Swarthmore College)	Swarthmore	75 mi N	255	No, earth curvature places beam 1,300 ft above observatory
Villanova University	Villanova	84 mi N	510	No, earth curvature places beam 1,600 ft above observatory

TABLE 4: Astronomical Observatories within 150 miles of KDOX WSR-88D				
Crosby Ramsey Memorial	Baltimore, MD	69 mi NW	75	No, earth curvature places beam 1,200 ft above observatory
Maryland Space Grant	Baltimore	73 mi NW	280	No, earth curvature places beam 1,200 ft above observatory
Univ of Maryland	College Park	83 mi west	200	No, earth curvature places beam 1,800 ft above observatory
Keeble	Ashland, VA	135 mi SW	240	No, earth curvature places beam 6,500 ft above observatory
George Mason Univ	Fairfax, VA	101 mi W	490	No, earth curvature places beam 3,900 ft above observatory
Georgetown Univ	Washington DC	88 mi W	320	No, earth curvature places beam 2,100 ft above observatory
U.S. Naval	Washington DC	89 mi W	200	No, earth curvature places beam 2,200 ft above observatory

7. WIND TURBINES

Wind turbines are a special concern because they produce Doppler radar returns that can mask meteorological returns. The U.S. Wind turbine Database (USGS, 2023) was searched and identified two wind turbines facilities within 50 miles of the KDOX WSR-88D. The University of Delaware operates a single wind turbine at Lewes about 15 miles E of the KDOX WSR-88D. The turbine has a height of about 110 meters and is at ground elevation of 12 ft MSL, resulting in a peak structural elevation of about 373 ft MSL. Given its height and distance, that turbine is within the main beam of the KDOX WSR-88D during current operations. Lowering the minimum WSR-88D scan angle below +0.5 deg would result in a larger portion of the main beam impinging on the wind turbine.

Talbot County (Maryland) Department of Public Works operates a facility with three wind turbines about 34 miles W of the KDOX WSR-88D at ground elevation of about 50 ft MSL. The turbines have heights of 80 meters (262 ft) resulting in a peak structural elevation of about 312 ft MSL. These turbines are currently below the WSR-88D coverage floor. The wind turbines would continue to be below the coverage floor at a minimum scan angle of +0.4 deg. However, at a minimum scan angle of +0.3 deg or lower the WSR-88D main beam would impinge on Talbot County DPW wind turbines.

The U.S. Department of Interior Bureau of Ocean Energy Management (BOEM) is responsible for leasing offshore waters within U.S Exclusive Economic Zone for renewable energy projects, including wind turbines. And environmental review of proposed leases and projects. BOEM's list of existing leases and applications was searched and identified two proposed projects near the Delaware coastline. The Atlantic Shores Offshore Wind South Project is proposed E of Atlantic City, NJ., about 66 miles NE of the KDOX WSR-88D. The project, currently under environmental review by BOEM, would include wind turbines with heights up to 1046.6 feet (tip of the vertical rotor) (BOEM, 2023). A minimum scan angle of +0.3 deg would place the radar coverage floor at roughly elevation 1,100 ft over the Atlantic Shores Offshore Wind South Project area, about 50 ft above the proposed wind turbines. A minimum scan angle of +0.2 deg would result in the KDOX WSR-88D main beam impinging on the upper portions of the proposed wind turbines.

The Maryland Offshore Wind Project is proposed E of Maryland's Atlantic shoreline, about 41 miles SE of the KDOX WSR-88D. The project, currently under environmental review by BOEM, would include wind turbines with heights up to 938 feet (tip of the vertical rotor) (BOEM, 2023). A minimum scan angle of +0.3 deg or 0.2 deg would result in the KDOX WSR-88D main beam impinging on the upper portions of the proposed wind turbines.

8. SUMMARY AND RECOMMENDATION

Compared to the current minimum scan angle of +0.5 deg, lowering the minimum scan angle of the KDOX WSR-88D to +0.3 deg would increase coverage area at 2,000 ft above site level by 73.4% and would extend the range of 2,000 ft coverage over the Atlantic Ocean by an additional 21 miles. Lowering the minimum scan angle to +0.2 deg would result in a minor additional 1.2% increase in coverage area.

No activities or structures are within safe setback distances for human exposure, implantable medical devices, safe EEDs, or fuel handling. A cellular telephone tower about 4,500 ft south of the WSR-88D is within the setback distance for unsafe EEDs, but it is improbable that those types of EEDs would be used at the uppermost portion of the tower (which could be within the WSR-88D main beam).

Twenty astronomical observatories are within 150 miles of the KDOX WSR-88DD, however the main beam at +0.3 deg would not directly impinge on any of these observatories. Lowering the WSR-88D minimum scan angle would not result in adverse effects to astronomical observatories.

Wind turbine facilities operated by the University of Delaware and Talbot County (MD) DPW are 15 miles east and 34 miles west of the WSR-88D, respectively. Under current operations, the WSR-88D main beam impinges on the University of Delaware wind turbine; lowering the minimum scan angle would increase the amount of impingement. The Talbot County DPW wind turbines are currently below the WSR-88D main beam. Lowering the minimum scan angle to +0.3 deg or lower would result in the beam impinging on the Talbot County DPW wind turbines. Offshore wind turbine projects have been proposed off the New Jersey cand Maryland coasts, about 66 miles NE and 41 miles SE, respectively, from the WSR-88D. Those two projects are currently under environmental review by BOEM. A minimum scan angle of +0.3 deg would result in the WSR-88D main beam impinging on the wind turbines proposed for offshore Maryland but not the wind turbines proposed for offshore New Jersey. A minimum scan angle of +0.2 deg would result in the WSR-88D main beam impinging on wind turbines proposed at both areas.

A minimum scan angle of +0.3 deg would provide significantly increased coverage area, including over the Atlantic Ocean. A minimum scan angle lower than +0.3 deg would provide little additional increase in radar coverage area and would have the drawbacks of increase ground clutter returns and increased potential for unwanted Doppler returns from wind turbines. Therefore, a minimum center of beam scan angle of +0.3 deg is recommended for the KDOX WSR-88D.

9. MEMORANDUM AUTHORS

This memorandum was prepared by Sensor Environmental LLC under contract to Centuria Corporation, which is a support contractor to the National Weather Radar Operations Center. Mr. James Manitakos, CEO, served as Sensor’s Project Manager. Huntington Ingalls Industries Mission Technologies Group prepared radar coverage maps and calculated coverage areas under subcontract to Sensor. Mr. Andre Tarpinian, Radio Frequency Engineer, served as Huntington’s Project Manager.

10. REFERENCES

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ATTACHMENT A

TRIP REPORT, KDOX WSR-88D

TRIP REPORT

Traveler: James Manitakos, Sensor Environmental LLC

Destination: KDOX Weather Surveillance Radar, Model 1988 Doppler (WSR-88D) serving the Dover Air Force Base (AFB), DE, area

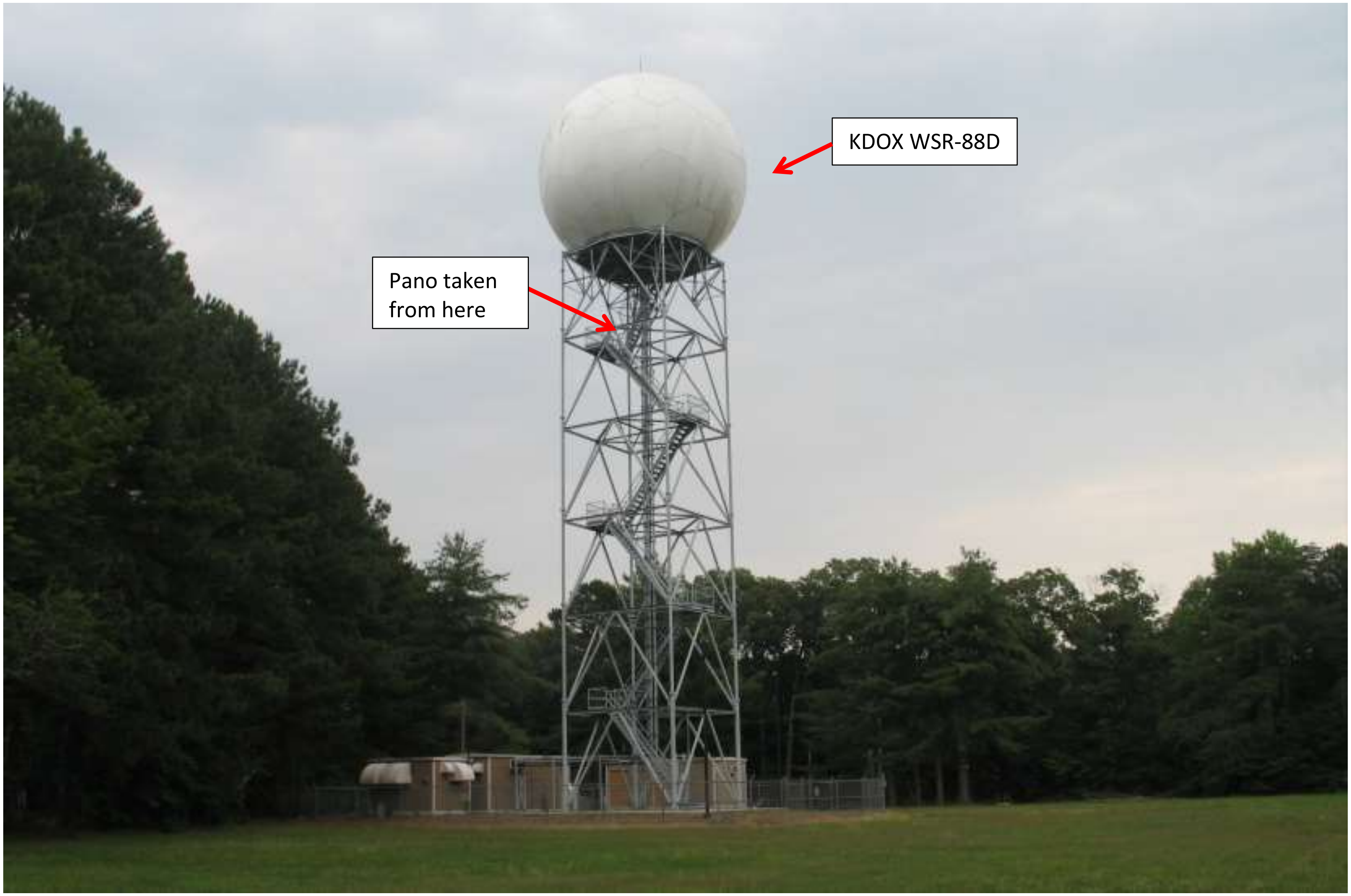
Dates: June 25-27, 2023

Purpose: Field Inspection of radar and vicinity and obtaining 360-degree panoramic photographs from of KDOX WSR-88D tower.

Summary: June 25: Mr. Manitakos flew from San Francisco, CA, to Philadelphia, PA, and drove to Dover, DE.

June 26: Weather: 83° F, overcast. Mr. Manitakos took pictures of the KDOX WSR-88D and investigated land uses in the vicinity of the radar. Mr. Manitakos took a photograph of the KDOX WSR-88D and Sign (Photograph 1) and panoramic photographs (Photograph 2) from the 20-m level of the KDOX WSR-88D, which is about 30 ft below the center of the WSR-88D antenna.

June 27: Mr. Manitakos flew to Tallahassee, FL to collect data at the KEVX (Eglin AFB) WSR-88D site.



Photograph 1: KDOX WSR-88D serving Dover AFB, DE, area viewed from SW

Photograph 2A: Panoramic photograph from KDOX WSR-88D tower [— 0 deg]

Photograph 2B: Panoramic photograph from KDOX WSR-88D tower [— 0 deg]

Photograph 2C: Panoramic photograph from KDOX WSR-88D tower [— 0 deg]

Photograph 2D: Panoramic photograph from KDOX WSR-88D tower [— 0 deg]

ATTACHMENT B

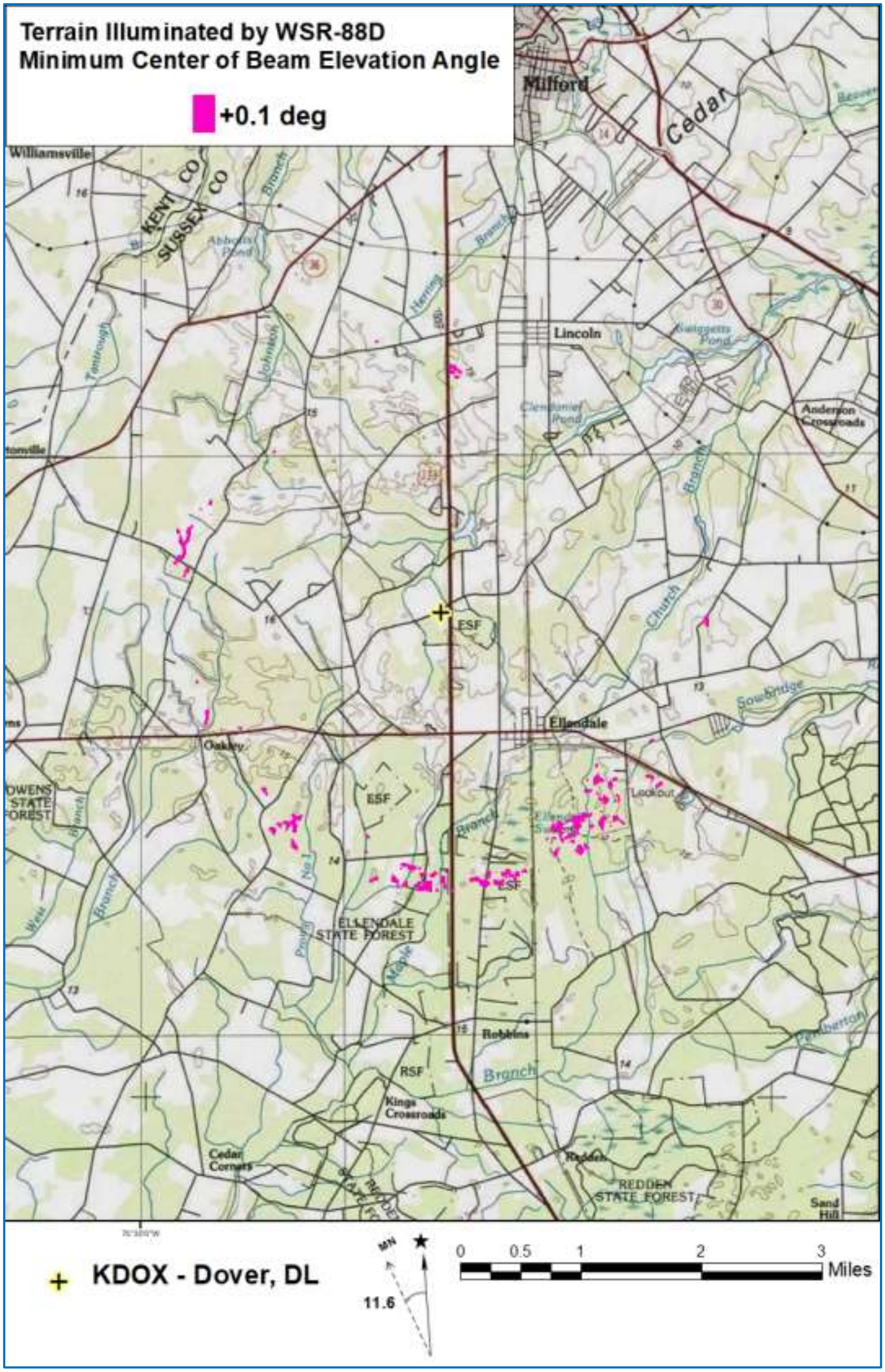
KDOX WSR-88D COVERAGE MAP
MINIMUM SCAN ANGLES +0.5 deg to 0.0 deg

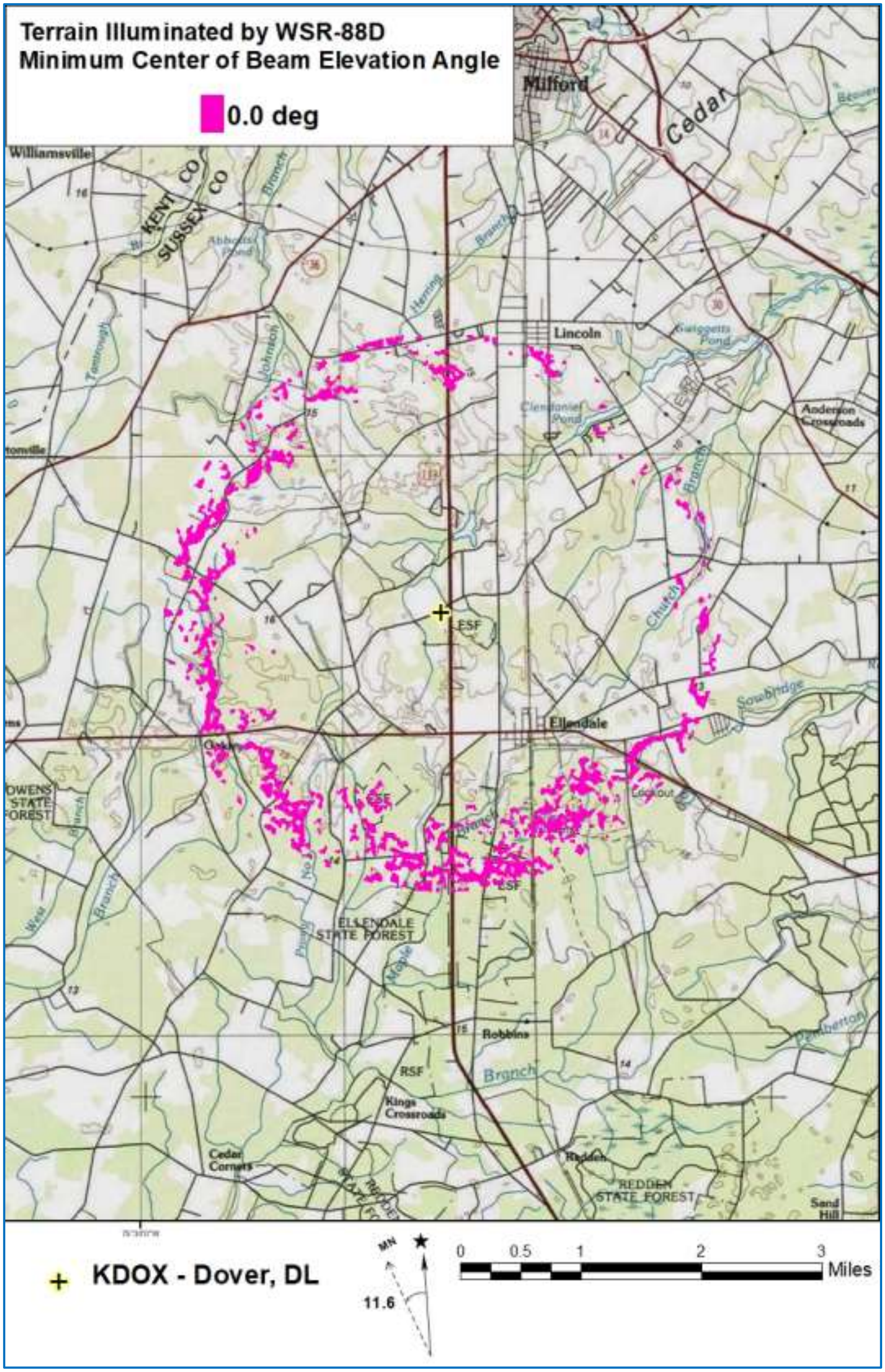

Radar Coverage at 2,000 ft ASL
Minimum Center of Beam Elevation Angle
+0.5deg
+0.2, +0.1, 0.0 deg
+0.4deg
+0.3deg
Suffolk
Carbon
Union
Schuylkill
Lehigh
Snyder
Bucks
Berks
Perry
Burlington
Ocean
Chester
Lancaster
York
Salem
Adams
Carroll
Frederick
Kent
Existing:
40 miles
Montgomery
Sussex
Loudoun
+0.3 deg:
61 miles
Wicomico
Caroline
Louisa
Amelia
Surry
Dinwiddie
KDOX - Dover, DL
Major Highway
MN
11.6
0 12.5 25 50 75 100
Miles
Lambert Projection
Central Meridian: -96
1st Std Parallel: 20
2nd Std Parallel: 60
Latitude of Origin: 40

ATTACHMENT C

KDOX WSR-88D NEARBY DIRECTLY ILLUMINATED TERRAIN AT SCAN ANGLES OF +0.1 to 0.-0 Deg

NOTE: No terrain within 3 miles is directly illuminated by the WSR-88D main beam at scan angles of +0.5, +0.4 deg, +0.3, or +0.2 deg.


Terrain Illuminated by WSR-88D
Minimum Center of Beam Elevation Angle
+0.1 deg
Milford
Cedar
Williamsville
KENT CO
SUSSEX CO
Lincoln
Anderson Crossroads
ESF
Ellendale
Oakley
Lookout
ELLENDALE STATE FOREST
Robbins
RSF
Kings Crossroads
Cedar Corners
REDDEN STATE FOREST
Sand Hill
KDOX - Dover, DL
MN
11.6
0 0.5 1 2 3
Miles


Terrain Illuminated by WSR-88D
Minimum Center of Beam Elevation Angle
0.0 deg
Milford
Cedar
Williamsville
KENT CO
SUSSEX CO
Lincoln
Ellendale
ELLENDALE STATE FOREST
Robbins
Kings Crossroads
Cedar Corners
Redden
REDDEN STATE FOREST
Anderson Crossroads
KDOX - Dover, DL
11.6
MN
0
0.5
1
2
3
Miles