TO: All Interested Parties

FROM: Jessica Schultz, Radar Focal Point, National Weather Service (NWS)

SUBJECT: Lowering the Minimum Scan Angle of the KMBX Weather Surveillance Radar - Model 1988 Doppler (WSR-88D) serving Minot, ND, area

DATE: February 4, 2019

In accordance with provisions of the National Environmental Policy Act of 1969, the National Weather Service (NWS) prepared a Draft Environmental Assessment (EA) analyzing the potential environmental effects of lowering the minimum scan angle of the KMBX WSR-88D serving the Minot, ND, 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 KMBX WSR-88D is an existing radar facility located at an agricultural field in McHenry County about 24 miles east of Minot, ND. The KMBX WSR-88D was commissioned in October 1994 and is one of 159 WSR-88Ds in the nationwide network. The KMBX 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 KMBX 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 KMBX 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 March 11, 2019. Please submit comments via either email or regular mail to:

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Comments sent by regular mail must be postmarked by March 11, 2019. After the end of the review period, NWS 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 • February 2019

ENVIRONMENTAL ASSESSMENT (EA)

LOWERING THE MINIMUM SCAN ANGLE OF THE WEATHER SURVEILLANCE RADAR - MODEL 1988, DOPPLER (WSR-88D) SERVING THE MINOT, NORTH DAKOTA, AREA

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EXECUTIVE SUMMARY

The National Weather Service (NWS) owns and operates the existing Weather Surveillance Radar, Model 1988 Doppler (WSR-88D) serving the Minot, ND, area. The U.S. Air Force (USAF) assists in maintaining the radar. The radio call letters of the radar are KMBX and the radar is located at an agricultural field about 24 miles east of Minot, ND. The KMBX WSR-88D was commissioned in October 1994 and is one of 159 WSR-88Ds in the nationwide network. The U.S. Air Force assists NWS in maintaining the KMBX WSR-88D.

The KMBX WSR-88D is an S-band Doppler, dual polarized weather radar, which NWS uses to collect meteorological data to support weather forecasts and severe weather warnings for central and western North Dakota. The KMBX 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 KMBX radar 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 KMBX 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 KMBX WSR-88D would be required to implement the proposed action; the only change would be to the radar's operating software.

In April 1993, NWS 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 KMBX 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 NWS forecasters and other data users. The area covered at 2,000 ft above site level (ASL) would increase by 33.3%. The radar coverage improvements would be very beneficial to NWS 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 KMBX WSR-88D main beam impinging on the ground or any structures within three miles of the WSR-88D site. The proposed action would slightly increase radiofrequency (RF) exposure levels in the vicinity of the KMBX 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

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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 KMBX 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	1.65	9.65	16
900 ft	0.0100	1.0	100	9.65	965
1 mile	0.00029	1.0	3,450	9.65	33,300
5 miles	0.000013	1.0	76,900	9.65	742,000

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 within 1,740 ft of the WSR-88D antenna. FCC occupational safety levels would be exceeded within 780 ft and ANSI//IEEE occupational safety levels within 560 ft. The KMBX WSR-88D operating at +0.3 deg would not impinge on the ground surface or any structures within those distance and hazards to human health would not result.

Because the KMBX 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. The only astronomical observatory within 150 miles of the KMBX WSR-88D is at Minot State University, 22.4 miles west-southwest of the radar. A minimum scan angle of +0.3 deg would result in the WSR-88D main beam impinging on the observatory if no structural blockage were present. However, the terminal building at Minot International Airport and multi-story commercial buildings are located directly between the WSR-88D and the observatory and provide substantial structural blockage. Given this structural blockage, it is unlikely that the lowered WSR-88D main beam would cause electromagnetic interference with the observatory.

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Lowering the minimum scan angle of the KMBX 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

NWS evaluated the benefits and potential impacts of lowering the minimum center of beam scan angle of the KMBX WSR-88D to each angle between +0.4 and -0.2 deg in 0.1 degree increments (see Appendix B). Operating the KMBX WSR-88D at alternative minimum scan angles between +0.4 deg and -0.1 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 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 of +0.2 deg or lower would not increase radar coverage compared to the proposed action and would increase undesirable ground clutter returns.

The no action alternative would result in continued operation of the KMBX 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 NWS 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 NWS during

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a minimum 30-day comment period which will end on March 11, 2019. The NWS will provide official responses to all pertinent comments received during the Draft EA comment period in a Final EA report. The NWS will make a decision whether to implement the proposed lowering of the KMBX WSR-88D minimum scan angle after the Final EA report is completed.

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ABBREVIATIONS

AGL	above ground level
AAMI	Association for Advancement of Medical Instrumentation
ANSI	American National Standards Institute
ASL	above site level
deg	degree(s)
DoA	Department of Agriculture
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
KMBX	WSR-88D serving the Minot, ND, 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
NEPA	National Environmental Policy Act
NEXRAD	Next Generation Weather Radar (also known as WSR-88D)

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NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NTIA	National Telecommunications and Information Agency
NWS	National Weather Service
PEIS	Programmatic Environmental Impact Statement
RF	radiofrequency
SEA	Supplemental Environmental Assessment
SHPO	State Historic Preservation Officer
sq mi	square mile(s)
SEA	Supplemental Environmental Assessment
U.S.	United States
USAF	U.S. Air Force
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WSR-88D	Weather Surveillance Radar – 1988, Doppler

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1 BACKGROUND AND SCOPE OF REPORT

1.1 BACKGROUND

The National Weather Service (NWS) operates a nationwide network of weather radars that provide critical real-time information on atmospheric conditions to weather forecasters. Additional similar weather radars located in Alaska, Hawaii and Puerto Rico are operated by the Department of Transportation Federal Aviation Administration (FAA). The Department of Defense Air Weather Service also operates weather radars located at United States (U.S.) military installations in the U.S. and abroad. The weather radars operated by these three agencies are part of 159 WSR-88Ds in the nationwide network.

The network radars operated by NWS 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) or Weather Service Radars. 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 targets characteristics. Because the WSR-88D has the potential to cause electromagnetic effects on the environment, NWS 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* [NWS, 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 National Weather Service (NWS) owns and operates the WSR-88D serving the Minot, ND, area. The U.S. Air Force (USAF) assists in maintaining the radar. The radar identifier is KMBX and the radar is located in an agricultural field about 9 miles north of Granville, McHenry County, ND and about 22 miles northeast of Minot, ND. The KMBX WSR-88D is part of the

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nationwide WSR-88D network. The NWS proposes operate the KMBX radar 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 KMBX WSR-88D at this lower scan angle was not analyzed in the 1993 SEA.

The National Oceanic and Atmospheric Administration (NOAA), the parent agency of NWS, require analysis 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 NWS's proposed action of operating the KMBX 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 KMBX WSR-88D minimum scan angle to +0.3 deg). Potential environmental effects of alternative minimum scan angles between +0.4 deg and -0.2 deg and the no-action alternative (i.e. continued operation of the KMBX 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 KMBX WSR-88D site and vicinity. The scope of this EA is limited to analyzing potential effects from lowering the minimum scan angle of the KMBX 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 conclusions contained in this EA are specific to the KMBX WSR-88D, and are not applicable to other WSR-88Ds or the WSR-88D network as a whole.

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2 PURPOSE AND NEED

The 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 [NWS, 2009]".

The nationwide network of 159 WSR-88Ds plays a crucial role in meeting the NWS mission. Data from the WSR-88Ds is used by the NWS 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 NWS 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 occurs 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 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 NWS operates the KMBX WSR-88D serving the Minot, ND, 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. 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). NWS 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 KMBX WSR-88D minimum scan angle to +0.3 deg; this EA report satisfies that requirement.

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3 DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

3.1 PROPOSED ACTION

3.1.1 Description of KMBX WSR-88D

The NWS of the Department of Commerce, Air Force of the Department of Defense, and FAA of the Department of Transportation operate a nationwide network of Doppler meteorological radars, known as NEXRAD or 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 KMBX WSR-88D, which was commissioned in August 1994 and has been in continuous operations since being commissioned. The KMBX WSR-88D serves the Minot, ND, area and is operated and maintained by the NWS and the U.S. Air Force. The Bismarck, ND, Weather Forecast Office (WFO) is the primary recipient of data from the KMBX WSR-88D and serves central and western North Dakota. The KMBX WSR-88D is located in an agricultural field in McHenry County, about 9 miles north of Granville, ND, and 22 miles northeast of Minot, ND (see Figure 2). The radar antenna, radome, and steel-lattice tower are standard. Table 1 provides information on the KMBX WSR-88D.

Table 1: Information on the KMBX WSR-88D Serving the Minot, ND, Area	
Elevation, ground surface at tower base (mean sea level, MSL)	1,492 ft
Elevation, center of antenna (MSL)	1,589 ft
Tower Height (m)	25 m (82 ft)
Latitude (WGS84)	48°23’35” N
Longitude (WGS84)	100°51’52” W
Operating Frequency	2,895 megaHertz (MHz)
Spot Blanking or Sector Blanking used	No

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Figure 1: Photograph of KMBX WSR-88D serving Minot, ND, Area

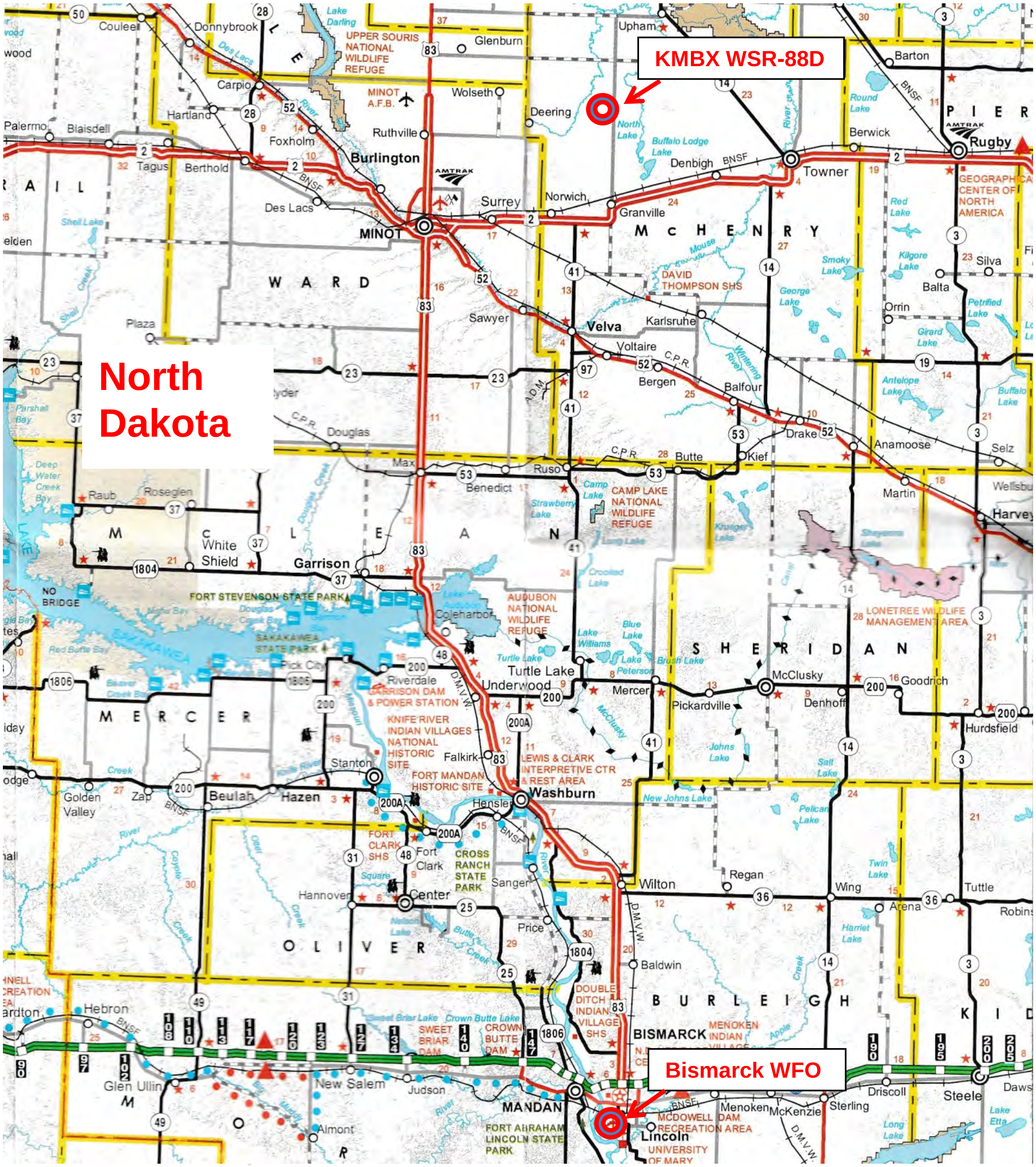

Figure 2: Location of KMBX WSR-88D serving the Minot, ND, area

North

Scale: 0 15 30 miles

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. NWS proposes to reduce the minimum center of beam scan angle +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 KMBX 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 in the vicinity 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 1 shows the improvement in radar coverage that would be achieved, which ranges from 33.3% increase in coverage area at 2,000 ft above site level (ASL) to 14.6% increase at 10,000 ft above site level. Figures 5, 6, and 7 show the improvement in radar coverage at 2,000 ft, 5,000 ft, and 10,000 ft ASL, respectively.

Table 2. Coverage Area for KMBX WSR-88D at Minimum Scan Angle of +0.3 deg

Center of Beam Scan Angle (deg)	Coverage Floor (deg)	Area Covered at 2,000 ft ASL (sq mi)	Area Covered at 5,000 ft ASL (sq mi)	Area Covered at 10,000 ft ASL (sq mi)
+0.5 (existing)	0.0	10,712	27,630	55,830
+0.3 (proposed)	-0.2	14,281 (+33.3%)	33,236 (+20.3%)	64,004 (+14.6%)

Watford City, ND, located about 119 miles west-southwest of the KMBX WSR-88D, is an area of interest. Lowering the minimum scan angle of the KMBX WSR-88D would reduce the altitude of the radar coverage floor over Watford City from the current 6,600 ft above the ground to an estimated 5,500 ft.

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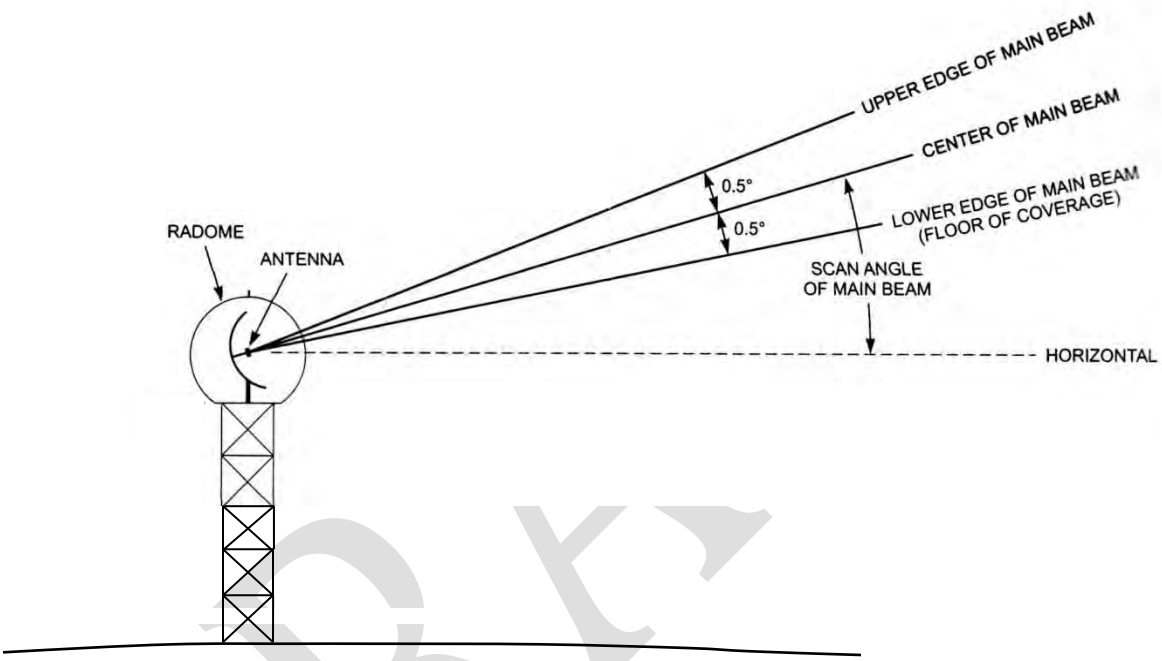

Figure 3: Schematic of WSR-88D Main Beam

(Not to scale, width of main beam exaggerated)

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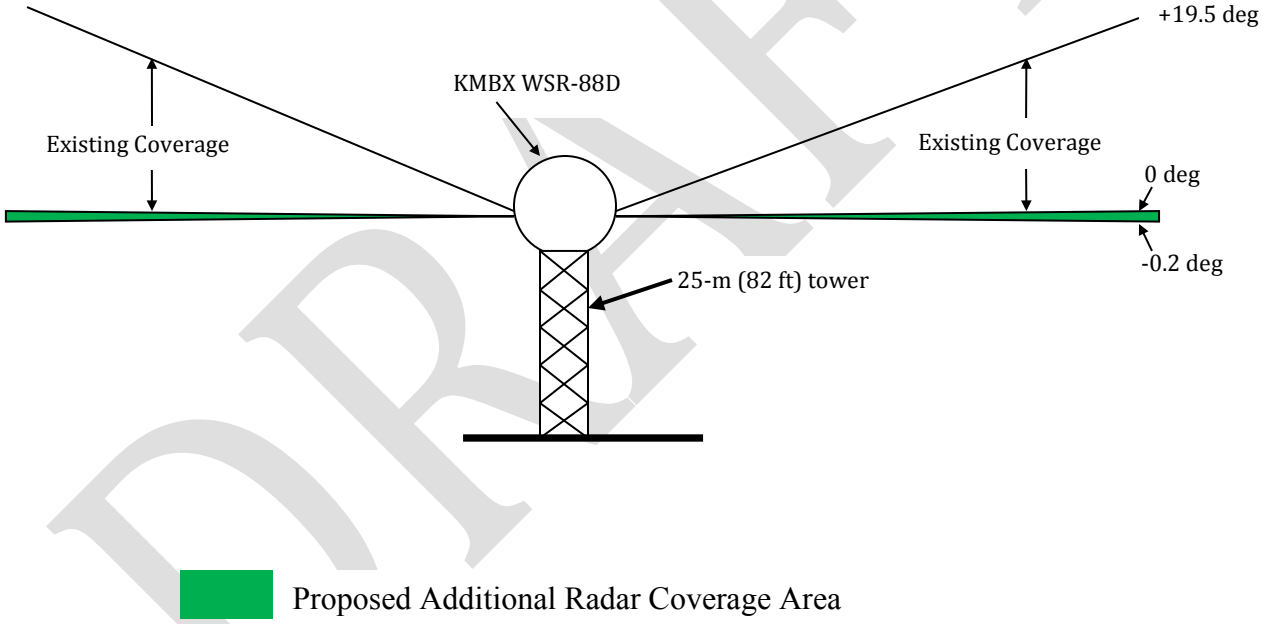

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Figure 4: Drawing Showing Proposed Additional Radar Coverage

Figure 5: Existing and Proposed KMBX WSR-88D Coverage at 2,000 ft above Site Level

Figure 6: Existing and Proposed KMBX WSR-88D Coverage at 5,000 ft above Site Level

Figure 7: Existing and Proposed KMBX WSR-88D Coverage at 10,000 ft above Site Level

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 KMBX WSR-88D serving the Minot, ND, 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 -0.2 deg are analyzed in Section 5 of this EA.

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4 ENVIRONMENTAL SETTING, CONSEQUENCES, AND MITIGATION

4.1 EXPOSURE OF PERSONS TO RADIOFREQUENCY RADIATION

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 close 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 KMBX WSR-88D transmits a radio signal at a frequency of 2,895 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 the KMBX 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, 2006]. 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.

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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 KMBX WSR-88D operating frequency is and 2,895 MHz. The IEEE/ANSI safety standards for those frequencies are 1.0 mW/cm^2 for the general public (averaged over 30 minutes) and 9.65 mW/cm^2 for workers (averaged over 6 minutes).

The Occupational Health and Safety Administration (OSHA) regulates occupational exposure to RF emissions. The OSH safety standard is similar to the ANSI/IEEE occupational safety standard: 10.0 mW/cm^2 (averaged over 6 minutes) (OSHA, 2015). Federal Communications Commission (FCC) RF exposure standards for RF exposure of the general public are the same as the ANSI/IEEE: 1.0 mW/cm^2 averaged over 30 minutes). FCC RF exposure standards for occupational exposure are somewhat lower that the ANSI/IEEE safety levels: 5.0 mW/cm^2 (averaged over 6 minutes).

RF Exposure Levels

The KMBX WSR-88D is mounted on a 25 m tall steel-lattice tower. Ground elevation is ft 1,492 ft MSL. The center of the antenna is 1,589 ft MSL and the lower edge of the antenna is at 1,575 ft MSL, which is 83 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 in proximity to the radar. Operating at the proposed minimum scan angle of +0.3 deg would not change that situation; the main beam would still not impinge on the ground surface within 3 miles of the WSR-88D. There are also no elevated structures within 3 miles of the WSR-88D and the main beam would not impinge on nearby structures.

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 KMBX WSR-88D, and the RF exposure that would result if NWS lowers the minimum scan angle to +0.3 deg. Table 3 summarizes the results from Appendix A. 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 within 1,740 ft of the WSR-88D antenna. FCC occupational safety levels would be exceeded within 780 ft and ANSI//IEEE occupational safety levels within 560 ft. The KMBX WSR-88D operating at +0.3 deg would not impinge on the ground surface or any structures within those distance and risks to human health would not result.

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Table 3: RF Power Density within Main Beam of KMBX 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	1.65	9.65	16
900 ft	0.0100	1.0	100	9.65	965
1 mile	0.00029	1.0	3,450	9.65	33,300
5 miles	0.000013	1.0	76,900	9.65	742,000

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 KMBX WSR-88D would continue to operate at 2,895 MHz, outside the frequency range where induced currents or electro-simulation occur, and would not cause these effects.

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. NWS has not received any reports of the KMBX WSR-88D interfering with operation of other radio uses (Schultz, 2018). Lowering the minimum scan angle to +0.3 deg would not result in the main beam impinging on the ground surface within 3 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 ordnance as safe, susceptible, or unsafe and unreliable, based on compliance with MIL-STD 664 (series). HERO safe ordnance is considered safe in all RFR environments. HERO susceptible ordnance may be detonated by RF energy under certain circumstances. HERO unsafe or unreliable ordnance has 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:

$$D = (781)\ (2{,}895)^{-1}\ (475{,}000\ \text{W} \times 0.0021 \times 35{,}500)^{½}\ \text{ft}$$

$$D = 1{,}605\ \text{ft}$$

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

$$D = (2{,}873)\ (f)^{-1}(\text{average power x antenna gain})^{½}$$

$$D = (2{,}873)\ (2{,}895)^{-1}\ (475{,}000\ \text{W} \times 0.0021 \times 35{,}500)^{½}\ \text{ft}$$

$$D = 5{,}906\ \text{ft}$$

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 KMBX WSR-88D main beam would not illuminate the ground within either 1,605 or 5,906 ft of the radar. The WSR-88D would not be a hazard to EEDs use in the vicinity. No mitigation is necessary.

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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 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 within 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 2,895 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:

$$S = 377\ |3|^2\ \ W/m^2$$

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

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):

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

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 KMBX WSR-88D would not illuminate the ground or publicly accessible structures within 2,060 ft of the radar and no hazards would results to persons with implanted devices.

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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 KMBX WSR-88D would comply with the FCC safety standards. Exposure of persons wearing implantable medical devices to the KMBX 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. Table 4 lists four astronomical observatories located within 150 miles of the KMBX WSR-88D. The elevation of the KMBX WSR-88D main beam at each observatory was calculated based on a minimum center of beam scan angle of +0.3 deg (i.e. lower half-power point of -0.2 deg) and factors in earth curvature, beam spreading, and terrain blockage. However, the terminal building at Minot International Airport and multi-story commercial buildings are located directly between the WSR-88D and the observatory and provides substantial structural blockage. Given this structural blockage, it is unlikely that the lowered WSR-88D main beam would cause electromagnetic interference with the observatory.

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

Observatory	Location	Distance from WSR-88D (mi)	Within Main beam at +0.3 deg?	Structural Blockage Present?
Minot State University	Minot, ND	22.4	Yes	Yes

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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 low.

Table 5: RF Effects of KMBX WSR-88D on Equipment and Activities

Equipment / Activity	Applicable Standard	Setback Distance	Would Main Beam Impinge on Ground Within Setback Distance?	Potential for Significant Effects
Television, Radio, and Cellular Telephone, and Personal Communications Devices (PCDs)	NTIA Frequency Allocations	n/a	n/a	Very Low
EEDs	U.S. Navy HERO	5,906 ft	No	Very Low
Fuel Handling	U.S. Navy Hazards to Personnel, Fuel, and Other Flammable Material	537	No	Very Low
Active Implantable Medical Devices	AAMI PC69:2007, FCC 47 CFR Part 95.1221	2,060	No	Very Low
Astronomical Observatories	Exposure to WSR-88D Main Beam	n/a	n/a	Low

4.3 LAND USE AND COASTAL ZONE MANAGEMENT

North Dakota is not a coastal state and does not have a Coastal Zone Management Program (NOAA Office of Coastal Management, 2018). The proposed action would not affect the coastal zone.

The KMBX WSR-88D is located in a rural area. Land use in the vicinity is agricultural and includes widely spaced residences. The nearest community is the town of Granville (population 241 per the 2010 census), about 9 miles to the south (North Dakota Department of Transportation, undated). The proposed action would not change land uses at the KMBX WSR-88D site or vicinity and would not adversely affect nearby land uses.

4.4 GEOLOGY, SOILS, AND SEISMIC HAZARDS

The geologic substrate at the KMBX WSR-88D site is Quaternary period (less than 1.8 million years old) sand and gravel associated with glacial outwash deposits (American Association of

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Petroleum Geologists, 1984). Soil at the site is Wyndmere fine sandy loam on 0 to 2% slope. The site is somewhat poorly drained with a water table at 18 to 42 inches below the round surface. This soil is not hydric. Wyndmere soils are classified as prime farmland. (Soil Survey Staff, Natural Resources Conservation Service, U.S. Department of Agriculture, 2018). The proposed action would not convert farmland to non-agricultural use or adversely affect continued farming in the vicinity.

The risk of an earthquake is low. U.S. Geological Survey (USGS) estimates the potential for an earthquake strong enough to cause minor damage or greater at less than 1% per year (USGS, 2019).

Lowering the minimum scan angle of the KMBX 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, farmland, or seismicity. No mitigation measures are required.

4.5 DRAINAGE AND WATER QUALITY

The KMBX WSR-88D is generally located within the Little Deep Creek watershed, but the drainage network is discontinuous and storm runoff flows to local depressions. The nearest depression is about ¼ mile south of the WSR-88D site (USGS, 1949). Lowering the minimum scan angle of the KMBX 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 KMBX WSR-88D is accessed from Minot via 20 miles on U.S. Highway 2 to Granville, 9 miles north on 12th Avenue North, 1 mile west on 68th Street N, and ½ mile south on 13th Avenue north. U.S. Highway 2 and 12th Avenue North are paved roads; the other roads are gravel surfaced. Except for U.S. Highway 2, traffic volumes are very light on all these roads.

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, NWS and USAF technicians and engineers would travel to the KMBX 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 KMBX WSR-88D is equipped with a standby generator that is used if primary power is interrupted and also 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

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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 KMBX WSR-88D site is mapped by the Federal Emergency Management Agency in Zone D, an area of possible but undetermined flood hazards (FEMA, 2019). The proposed action of lowering KMBX WSR-88D minimum scan angle deg would not increase storm runoff, change drainage patterns, or place new structures in areas of potential flood hazard. No impacts to the floodplain would result. 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 emergent wetlands (PEM1A) located 250 ft southwest of the WSR-88D (USFWS, 2019). The proposed action would not involve ground disturbance 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 KMBX WSR-88D is located within the area served by the USFWS North Dakota Field Office in Bismarck, ND. The State of North Dakota does not have a state endangered species act. Twelve species listed as threatened or endangered under the federal ESA may occur in portions of North Dakota. McHenry County is within the range of seven listed species as shown in Table 6 (North Dakota Game and Fish Department, 2019).

Dakota skipper is a butterfly that inhabits high quality mixed and tallgrass prairie Critical habitat for the Dakota skipper occurs in McHenry County, but the WSR-88D site is not part of that critical habitat (North Dakota Game and Fish Department, 2019).

The gray wolf inhabits forests and prairie but rarely occurs in North Dakota. There are no breeding populations in the state. The WSR-88D site is not in critical habitat (North Dakota Game and Fish Department, 2019).

Northern long-eared bat occurs widely throughout the eastern and central U.S. but has declined in population due to white-nose syndrome. Northern long-eared bat hibernates in caves, mines, and culverts and migrates to wooded areas to raise young. The WSR-88D site is not in critical habitat (North Dakota Game and Fish Department, 2019).

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The piping plover is a small shorebird that inhabits sparsely vegetated shorelines and shallow alkali lakes. It has declined in population due to habitat loss. The WSR-88D site is not in critical habitat (North Dakota Game and Fish Department, 2019).

Table 6: Endangered and Threatened Species Potentially Occurring in McHenry County, North Dakota

Species (scientific name)	Type	Status	Is WSR-88D site in Critical Habitat?
Dakota skipper (*Hesperia dacotae*)	insect	Threatened	No
Gray wolf (*Canis lupus*)	mammal	Endangered	No
Northern long-eared bat (*Myotis septentrionalis*)	mammal	Threatened	No
Piping plover (*Charadrius melodus circumcintus*)	bird	Threatened	No
Red knot (*Calidris canutus rufa*)	bird	Threatened	No
Western prairie fringed orchid (*Platanthera praeclara*)	plant	Threatened	No
Whooping crane (*Grus Americana*)	bird	Endangered	No

The red knot is a shorebird that migrates annually from southern Chile and Argentina to North America and may migrate though North Dakota. It has declined due to reduction in horseshoe crabs populations (a primary food source) at its breeding grounds on the Atlantic shoreline. The WSR-88D site is not in critical habitat (North Dakota Game and Fish Department, 2019).

Western prairie fringed orchid is a smooth stemmed flowering plant with showy white flowers that appear on individual stems in summer. It grows in native prairies and sedge meadows. The WSR-88D site is not in critical habitat (North Dakota Game and Fish Department, 2019).

Whooping crane is a large wading bird that inhabits wetlands and cropland ponds. McHenry County is within its migratory range, but it does not nest in North Dakota. The WSR-88D site is not in critical habitat (North Dakota Game and Fish Department, 2019).

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The proposed action does not include construction activities and would not result in ground disturbance or vegetation removal. No physical disturbance of habitats for listed species would result. 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 in close proximity to the WSR-88D: 3 ft thick at 900 ft from the WSR-88D and increasing in thickness with distance from the radar. At 1 mile it would be 18 ft thick and at five miles it would be 89 ft thick. Migratory birds or bats 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 a distances of several miles or greater where the volume of newly covered airspace would be substantial, RF levels would be very low. At a distance of 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 listed migratory birds flying within the newly covered airspace would not be harmful.

Elevated RF exposure could result if birds fly 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 a distance of 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 bat could fly within the WSR-88D main beam for any length of time.

The proposed action would not result in significant impacts to protected species, critical habitat, or migratory birds. 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 WSR-88D where RF levels within the WSR-88D main beam could exceed safety standards hazards during infrequent stationary antenna operation (see section 4.1). The National Register of Historic Places (NRHP) was searched for listings within the APE. There are 12 NRHP listings in McHenry County, but none are within the APE

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(Historical Society of North Dakota, 2019). No historic places are within the APE and none would be affected by the proposed action. No mitigation measure is necessary.

Under Section 106 Regulations 36 CFR Section 800.2 (a)(1), *Protection of Historic Properties*, if the proposed action doesn't have the potential to affect historic properties, NWS "has no further obligations under section 106" and consultation with North Dakota SHPO regarding possible impacts on historic properties is not required [Advisory Council on Historic Preservation, 2010].

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 KMBX WSR-88D is located in a rural agricultural area about 9 miles north of Granville, ND. The proposed action would not generate air or water pollutants or hazardous waste. The project would modify the operation of the 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, such as 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. The KMBX WSR-88D site is classified as prime farmland but 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 WSR-88D or result in new emissions of visible light. The proposed action would have no effect on visual quality. No mitigation is necessary.

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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. There are no designated wild and scenic rivers in North Dakota (National Park Service, 2019). The proposed action would not affect wild and scenic rivers. No mitigation is necessary.

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5 ALTERNATIVES TO THE PROPOSED ACTION

5.1 MINIMUM SCAN ANGLES BETWEEN +0.4 AND -0.1 DEG

NWS evaluated the benefits and potential impacts of lowering the minimum center of beam scan angle of the KMBX WSR-88D to each angle between +0.4 and -0.2 deg in 0.1 degree increments (see Appendix B). That analysis found that the proposed action of lowering the minimum scan angle to +0.3 deg would result in the maximum feasible improvement in radar coverage.

Operating the KMBX WSR-88D at alternative minimum scan angles between +0.4 deg and -0.2 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 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 of +0.2 deg or lower would not increase radar coverage compared to the proposed action and would increase undesirable ground clutter returns. Because a minimum scan angle of +0.3 deg would result in the greatest improvement in radar coverage area while avoiding potentially detrimental increases in ground clutter returns, NWS rejected the alternatives of operating the KMBX WSR-88D at a minimum scan angle of +0.4, +0.2, +0.1, 0.0, -0.1, or -0.2 deg.

5.2 NO ACTION

The no action alternative consists of continued operation of the KMBX 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 have no effect 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

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- Environmental Justice and Socioeconomic Impacts
- Farmlands
- Energy Consumption
- Visual Quality/ Light Emissions
- Solid and Hazardous Waste
- Wild and Scenic Rivers

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6 FINDING

The proposed action of lowering the scan angle of the KMBX 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 NWS forecasters and others users of the data. This may indirectly benefit the residents and businesses of central and western ND by 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.

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7 DOCUMENT PREPARERS

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

Mr. James Manitakos, CEO, served as Sensor's Project Manager. 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 Alion's Project Manager. Ms. Jessica Schultz, NWS Radar Focal Point, and Mr. Edward Ciardi, Program Manager, EVP Weather Systems, from the ROC assisted in preparation of this EA. Mr. Jeffery Savadel, Meteorologist-in-Charge, and staff from the Minot, ND, WFO, also assisted in preparation of this EA.

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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 MINOT, NORTH DAKOTA, AREA

APPENDICES

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APPENDIX A

RADIOFREQUENCY RADIATION POWER DENSITY CALCULATIONS

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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 of +0.5 to +0.3 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 +0.3 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 Minot, ND, area (KMBX)

Parameter	**Value**
Operating Frequency	2,895 megahertz (MHz)
Wavelength at WSR-88D center frequency (2,850 MHz)	0.345 ft, 10.5 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 NWS proposes to modify the minimum center of beam scan angle used during operation of the KMBX 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. NWS

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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 -0.2 deg), the minimum scan angle selected by NWS for the KMBX WSR-88D. 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

The values of U_1, U_2, and U_3 would be unchanged from the values derived in 1993 Appendix A. The maximum pulse power density within the main beam (U_1) is given by the formula:

$$U_1 = 1.44 \times 10^9/R^2 \text{ milliWatts per square centimeter (mW/cm}^2\text{)}$$

where R is the distance from the antenna in ft. The maximum pulse power density at locations greater than 6 deg off the main beam axis (i.e. outside the area illuminated by the main beam and first five sidelobes is U_2 (unchanged from 1993 Appendix A), given below:

$$U_2 = 5.76 \times 10^5/R^2 \text{ mW/cm}^2$$

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, 2005]. We use six minutes as the averaging time as a worst-case analysis. The time-averaged power density for the main beam rotating continuously at +0.5 deg, considering the contributions from both the main beam and the first five sidelobes is given by U_3 (unchanged from 1993 Appendix A), below:

$$U_3 = 1.35 \times 10^4/R^2 \text{ mW/cm}^2$$

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At this point the analysis must consider the proposed modifications to VCP 31. 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. +0.3 deg which equates to 4.2 ft, or one-seventh 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

$$U_4 = [(2.4/6)\ (1.0) + (2.4/6)\ (0.5) + (1.2/6)\ (0.012)]\ U_3$$

$$U_4 = (0.6024)U_3$$

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

$$U_4 = 8.132 \times 10^3/R^2 \quad mW/cm^2$$

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:

$$U_5 = 8.13 \times 10^3/R^2 + 4/R^2 = 8.136 \times 10^3/R^2 \quad mW/cm^2$$

4.2 Near Field

Appendix A of the 1993 SEA calculates 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:

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

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):

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$$U_6 = 2 * 10^6 / (929)\,(176R + 0.13R^2) = 16{,}560 / (R^2 + 1{,}354R)\ mW/cm^2$$

U_6 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 Combined Result and RF Exposure Levels near KMBX WSR-88D

Table A-2 shows the time-averaged RFR power densities that would result at locations directly illuminated by the main beam of the KGSP or KRAX WSR-88Ds 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-2, use of modified scan pattern 31 would lower the elevation at which the lower half-power point (i.e. bottom edge) of 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 Time-Average RFR Power Densities at Various Distances within the KMBX WSR-88D Main Beam

Distance (ft)	Distance (mi)	Change in Elevation of Lower Half-Power Point (ft)	Original VCP 31 Time-Avg Power Density (mW/cm2)	Modified VCP 31 Time-Avg Power Density (mW/cm^2)
20*	0.004	No change	0.598	0.603
900	0.17	-3	0.0072	0.0100
5,280	1	-18	0.00021	0.00029
25,400	5	-89	0.000009	0.000013

*surface if WSR-88D radome

NWS may infrequently operate the KMBX 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

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

When operating in stationary antenna mode, the KMBX WSR-88D would exceed the ANSI/IEEE safety levels within the following distances:

ANSI/IEEE and FCC General Public Safety Level (1.0 mW/cm^2): 1,740 ft
FCC Occupational Safety Level (5.0 mW/cm^2): 780 ft
ANSI/IEEE Occupational Safety Level (9.65 mW/cm^2): 560 ft

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5. REFERENCES

American National Standards Institute / Institute of Electrical and Electronic Engineers (ANSI/IEEE). *IEEE Standard for Safety Levels with respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz*. IEEE Std C95.1-2005 (April 19, 2006).

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).

Edward Ciardi, Program Manager, EVP weather Systems, Centuria Corporation. email to James Manitakos, Sensor Environmental LLC, (September 13, 2018).

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APPENDIX B

TECHNICAL MEMORANDUM / TRIP REPORT

SENSOR ENVIRONMENTAL LLC
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TECHNICAL MEMORANDUM

TO: Edward Ciardi, Program Manager, EVP Weather Systems, Centuria Corporation	**FROM:** James Manitakos, CEO, Sensor Environmental LLC
CC: Jessica Schultz, Radar Focal Point, National Weather Service Andre Tarpinian, Senior RF Engineer, Alion Science and Technology Corp.	**SUBJECT:** Analysis of Lower Scan Angles For Weather Surveillance Radar, Model 1988 Doppler (WSR-88D) Serving the Minot, ND, Area
DATE: November 18, 2018	

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 the Minot, ND area (KMBX). Information on this radar is shown in Table 1.

TABLE 1: INFORMATION ON WSR-88D SERVING THE MINOT, SD, AREA	
Location	9 miles north of Granville, McHenry County, ND
International Civil Aviation Organization designator	KMBX
Elevation, ground surface at tower base (mean sea level, MSL)	1,492 ft
Elevation, center of antenna (MSL)	1,589 ft
Tower Height (m)	25 m (82 ft)
Latitude (WGS84)	48° 23’ 35” N
Longitude (WGS84)	100° 51’ 52” W
Weather Forecast Office (WFO)	2301 University Drive, Building 27 Bismarck, ND 58504
Meteorologist-in-Charge (MIC)	Jeffrey Savadel Email: jeffrey.savadel@noaa.gov Tel: (710)250-4224
Operating Frequency	2,895 megaHertz (MHz)
Spot Blanking or Sector Blanking used	No

NWS currently operates the KMBX 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 KMBX WSR-88D, NWS proposes to operate the radar with an center-of-beam scan angle as low -0.2 deg, which would result in the lower half power point of the main beam at -0.7 deg.

2. INVESTIGATIONS PERFORMED

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

1. We visited the KMBX WSR-88D with NWS staff from the Bismarck, ND, Weather Forecast Office (WFO) to ascertain site conditions and activities in the vicinity (see Attachment A, Trip Report).
2. We obtained 360-degree calibrated panoramic photograph taken at 20-m level of the WSR-88D tower, which is about 31 ft lower than the center of antenna height.
3. We 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 -0.2 degree.
4. We identified areas of terrain and potentially sensitive activities in proximity to the KMBX WSR-88D that would be directly illuminated by the main beam at each lower scan angle under consideration by NWS.

3. WSR-88D COVERAGE

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 KMBX and KMBX 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 of WSR-88D coverage. Table 2 shows coverage areas for KMBX WSR-88D for the range of minimum scan angles under consideration by NWS.

KMBX is located in a rural agricultural area. As shown in Attachment B, when operating at the current minimum center of beam minimum scan angle of +0.5 deg, the KMBX WSR-88D is subject to minimal terrain blockage to the southwest. At a minimum scan angle of +0.4 deg, coverage would increase in most directions, although terrain blockage to the southwest and northeast would reduce the amount of coverage improvement in those directions. Further lowering the minimum scan angle to +0.3 deg would achieve additional coverage improvements to the northwest, north, east, and southeast. Lowering the minimum scan angle below +0.3 deg would not further increase coverage area (see Table 2).

TABLE 2: KMBX WSR-88D Radar Coverage Areas For Minimum Scan Angles Between +0.5 deg And -0.2 deg				
Coverage Altitude Above Site Level (ft)	**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	0.0	10,712	n/a
2,000	+0.4	-0.1	13,334	+24.5%
2,000	+0.3, 0.2, +0.1, 0.0, -0.1, -0.2	-0.2 to -0.7	14,281	+33.3%

Watford City, ND is located at elevation 2,120 ft MSL about 119 miles west-southwest of the KMBX WSR-88D. The azimuth from the WSR-88D is 254 (0 = north, 90 = east, 180 = south, 270 = west). Table 3 shows the existing height of the center of the WSR-88D beam and the radar coverage floor over Watford City at the current minimum scan angle of +0.5 deg and at a lower scan angle of +0.4 deg. Lowering the minimum scan angle of the KMBX WSR-88D would reduce the altitude of the radar coverage floor over Watford City from the current 6,600 ft to an estimated 5,500 ft. Terrain blockage between the KMBX WSR-88D and Watford City would prevent any reduction in beam height or coverage floor altitude for minimum scan angles lower than +0.4 deg.

TABLE 3: Altitude over Watford City, ND, of KMBX WSR-88D Radar Coverage			
WSR-88D	**Minimum Scan Angle (deg)**	**Center of Beam Altitude over Watford City, ND (ft AGL)***	**Radar Coverage Floor Altitude over Watford City, ND (ft AGL)***
KMBX	+0.5	12,000	6,600
	+0.4	10,900	5,500

* rounded to nearest 100 ft

4. HUMAN EXPOSURE AND POTENTIALLY RF-SENSITIVE ACTIVITIES

Exposure to the WSR-88D main beam could represent a hazard to persons and certain sensitive activities. Table 4 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 operation are considered.

TABLE 4: Safe Setback Distances For Human Exposure And Potentially 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) and International Council for Non-Ionizing Radiation Protection (ICNIRP)
	Stationary Antenna	1,740	
Implantable Medical devices	2,060		ANSI/Association for the Advancement of Medical Instrumentation (AAMI)
EEDs	6,030		U.S. Air Force
Fuel Handling	537		Naval Sea Systems Command

5. DIRECTLY ILLUMINATED TERRAIN

Exposure to radiofrequency (RF) radiation can potentially be harmful to humans and RF-sensitive activities. 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 is 6,030 ft for exposure of EEDs, which include blasting caps, some types of ordnance, and equipment used in and aviation systems (e.g. ejection seats and separation systems for air-launched missiles).

Attachment C shows terrain within 3 miles of the KMBX WSR-88D that would be directly illuminated by the WSR-88D main beam. There would be no directly illuminated terrain within 3 miles at scan angles of +0.5 deg, 0+0.4 deg, +0.3, or +0.2 deg. For a minimum scan angle of +0.1 deg, the nearest directly illuminated terrain is about 12,400 ft (2.4 miles) southwest of the WSR-88D, which is farther from the WSR-88D than the applicable setback distances. Additionally, as show in Photographs 2A through 2D in Attachment A, no structures rise above the horizon in proximity to the WSR-88D. No hazards to persons or potentially RF-sensitive activities would result from lowering the minimum scan.

6. ASTRONOMICAL OBSERVATORIES

The only astronomical observatory within 150 miles of the KMBX WSR-88D is the Minot State University Observatory in Minot, ND, about 22.4 miles at azimuth 245 from the KMBX WSR-88D. The observatory telescopes are at an elevation about 1,730 ft MSL, which is about 140 ft higher in elevation than the center of the WSR-88D antenna. No higher terrain is located between the observatory and WSR-88D. At the current WSR-88D minimum scan angle of +0.5 deg, the observatory is 110 feet below the lower half-power point of the main beam. At scan angles of +0.4 deg or lower, the main beam would directly illuminate the observatory if no structural blockage were present. However, the terminal building at Minot International Airport and multi-story commercial buildings are located directly between the WSR-88D and the observatory and provides substantial structural blockage. Given this structural blockage, it

is unlikely that the lowered WSR-88D main beam would cause electromagnetic interference with the observatory.

7. WIND FARMS

Wind turbines are tall structures that have rotating sails to capture wind and generate electricity. The rotating sails produce Doppler radar returns that can mask meteorological returns. Basin Electric Cooperative operates Prairie Winds and Minot Winds wind farms which contain a total of 80 wind turbines, each of which is about 300 ft in height (Basic Electric Cooperative, 2018). These two wind farms are located along both sides of U.S. Highway 83 north of Max, ND, about 31 to 42 miles south-southwest of the KMBX WSR-88D at azimuths 203 to 218. Ground elevations at the wind farms range from 2,030 to 2,250 ft MSL (U.S. Geological Survey, 1954 and 1958). The wind turbines reach a maximum elevation of about 2,550 ft MSL with the highest turbines occur near the center of the wind farm. At the current minimum scan angle of +0.5 deg, the center of the WSR-88D main beam is at elevation 3,900 ft MSL and the lower half-power point is at 2,200 ft MSL at the center of the wind farms. Thus the wind turbines are currently directly illuminated by the main beam. If minimum scan angle of the KMBX WSR-88D is lowered to +0.3 deg, the center of the WSR-88D main beam would be at elevation 3,200 ft MSL and the lower half-power point at ground level at the center of the wind farms. More of the main beam would impinge on the wind turbines and the intensity of the Doppler returns from the wind turbines would be expected to increase. Scans above +0.3 deg would be unaffected.

8. RECOMMENDATION

Lowering the minimum scan angle of KMBX WSR-88D to +0.3 deg would increase the area of radar coverage at 2,000 ft ASL by 33.3% compared to the current minimum scan angle of +0.5 deg. The height of the radar coverage floor over Watford City, ND would decrease from the current 6,600 ft to 5,500 ft. No hazards to persons or potentially RF-sensitive activities would result from lowering the minimum scan. Although the intensity of the Doppler returns from the wind farms north of Max, ND, would increase during the +0.3 deg scan, this would affect only 15 deg of azimuth. Therefore, a minimum scan angle of +0.3 deg is recommended for the KMBX 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. 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 Alion's Project Manager.

10. REFERENCES

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ATTACHMENT A

TRIP REPORT, KMBX WSR-88D

SENSOR ENVIRONMENTAL LLC
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TRIP REPORT

Traveler: James Manitakos, Sensor Environmental LLC

Destination: Minot, ND Weather Forecast Offices (WFO) and Weather Surveillance Radar, Model 1988 Doppler (WSR-88D)

Dates: November 12-13,, 2018

Purpose: Field Inspection of KMBX and KMBX WSR-88D serving Minot, ND area

Summary: November 12, 2018: Mr. Manitakos flew from San Jose, CA to Bismarck, ND and drove to Minot, ND.

November 13, 2018: In the morning, Mr. Manitakos met at the WSR-88D with U.S. Air Force staff. Mr. Manitakos then proceeded to take a photograph of the KMBX WSR-88D (Photograph 1) and panoramic photographs (Photograph 2) from the 20-m level of the KMBX WSR-88D, which is 31 ft below the center of the WSR-88D antenna. In the afternoon, he drove to Bismarck, ND, and met with KMBX WFO with Meteorologist-in-Charge Jeffrey Savadel, Electronics Supervisor Eric Hayner, and other WFO staff. The group reviewed preliminary KMBX WSR-88D coverage charts for existing radar coverage and coverage at lower scan angles ranging from +0.4 to -0.2 deg. WFO staff expressed concern about radar coverage over Watford City, ND, which had a deadly tornado in the recent past.

In the evening, Mr. Manitakos flew back to San Jose, CA.

Weather: Partly cloudy, 15°F.

Photograph 1: KMBX WSR-88D serving Minot, ND, area viewed from the south.

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

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

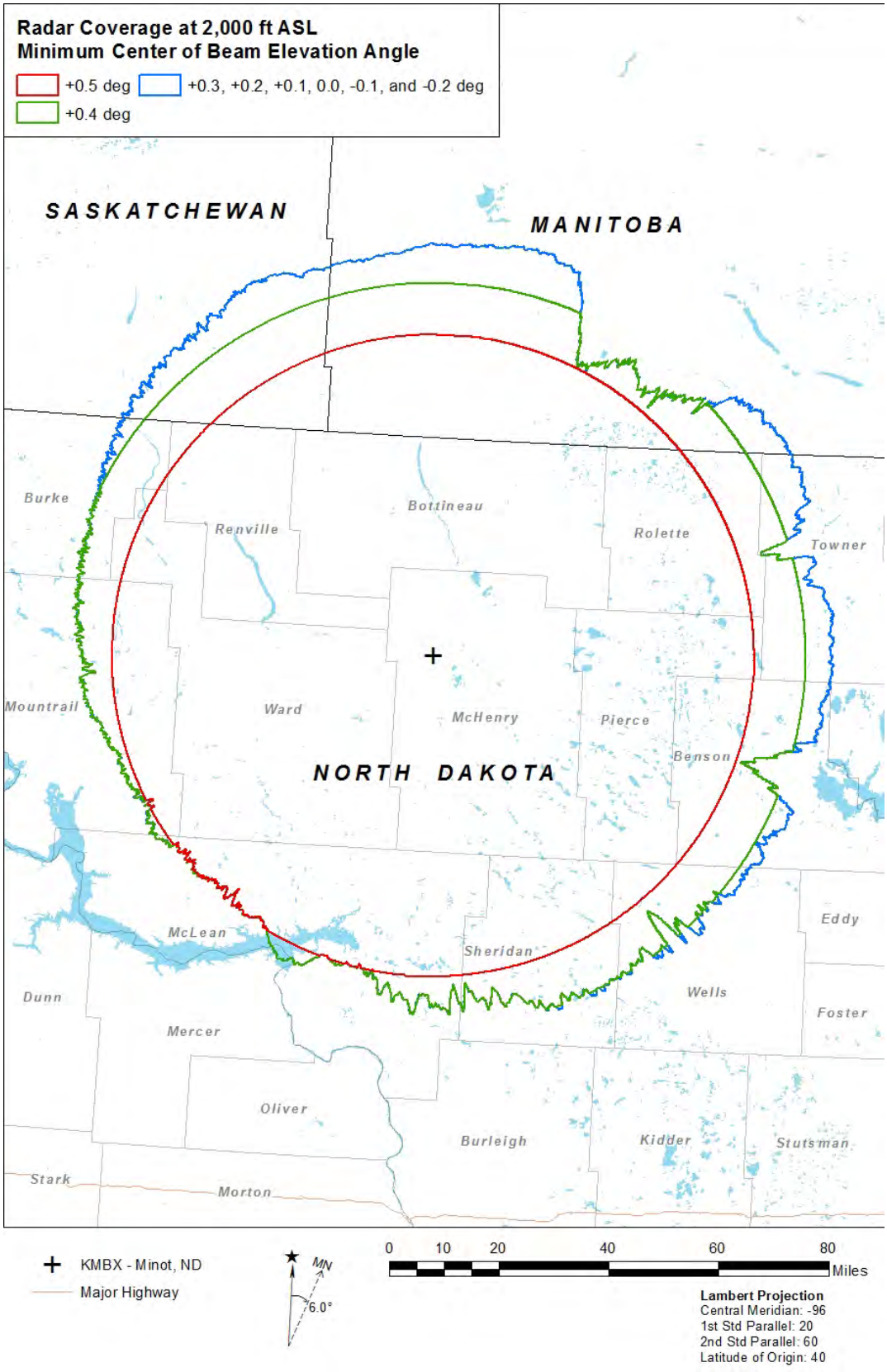
Photograph 2C: Panoramic photograph from KMBX WSR-88D tower [— 0 deg]

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

ATTACHMENT B

KMBX WSR-88D COVERAGE MAP

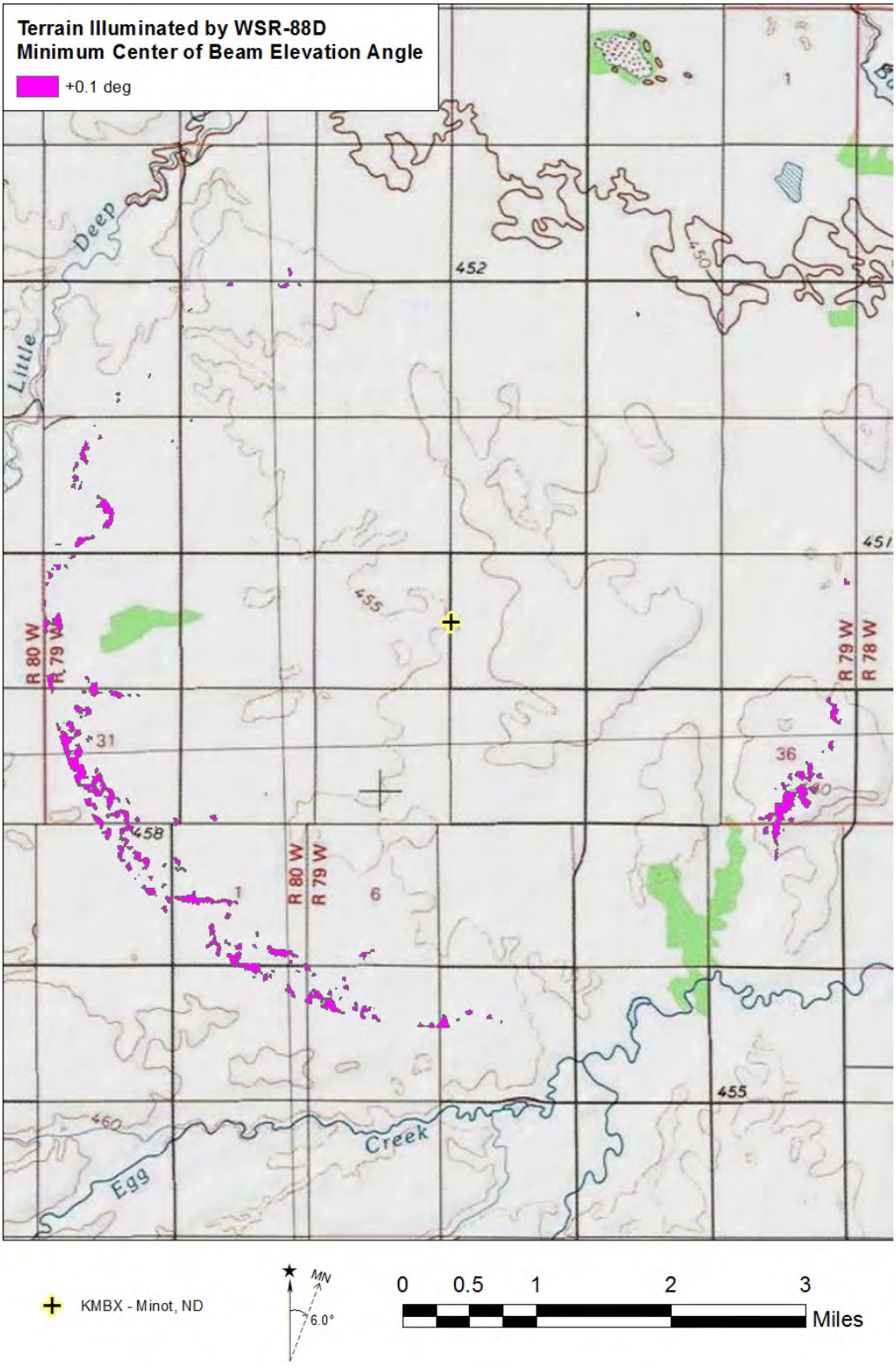
MINIMUM SCAN ANGLES +0.5 deg to -0.2 deg


Radar Coverage at 2,000 ft ASL
Minimum Center of Beam Elevation Angle
+0.5 deg
+0.3, +0.2, +0.1, 0.0, -0.1, and -0.2 deg
+0.4 deg
SASKATCHEWAN
MANITOBA
Burke
Renville
Bottineau
Rolette
Towner
Mountrail
Ward
McHenry
Pierce
Benson
NORTH DAKOTA
McLean
Sheridan
Eddy
Dunn
Wells
Foster
Mercer
Oliver
Burleigh
Kidder
Stutsman
Stark
Morton
KMBX - Minot, ND
Major Highway
MN
6.0°
0 10 20 40 60 80
Miles
Lambert Projection
Central Meridian: -96
1st Std Parallel: 20
2nd Std Parallel: 60
Latitude of Origin: 40

ATTACHMENT C

KMBX WSR-88D NEARBY DIRECTLY ILLUMINATED TERRAIN

AT SCAN ANGLE OF +0.1 deg


Terrain Illuminated by WSR-88D
Minimum Center of Beam Elevation Angle
+0.1 deg
Deep
Little
Egg
Creek
452
455
458
460
R 80 W
R 79 W
R 78 W
31
36
1
6
KMBX - Minot, ND
MN
6.0°
0 0.5 1 2 3
Miles