TO:	All Interested Parties
FROM:	Jessica Schultz, Radar Focal Point, National Weather Service (NWS) JS
SUBJECT:	Lowering the Minimum Scan Angle of the KBUF Weather Service Radar - Model 1988 Doppler (WSR-88D) serving Buffalo, NY, area
DATE:	May 22, 2018

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 KBUF WSR-88D serving the Buffalo, NY, 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 KBUF WSR-88D is an existing radar facility located at Buffalo Niagara International Airport in Cheektowaga, NY, about 9 miles northeast of Buffalo, NY. The KBUF WSR-88D was commissioned in April 1996 and is one of 159 WSR-88Ds in the nationwide network. The KBUF 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. Currently, the KBUF 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 KBUF WSR-88D from the current minimum of +0.5 deg to +0.3 deg to provide enhanced coverage of the lower portions of the atmosphere. No construction activities or physical modification of the KBUF 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 June 29, 2018. Please submit comments via either email or regular mail to:

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

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Comments sent by regular mail must be postmarked by June 29, 2018. 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 • May 2018

ENVIRONMENTAL ASSESSMENT (EA)

LOWERING THE MINIMUM SCAN ANGLE OF THE WEATHER SERVICE RADAR - MODEL 1988, DOPPLER (WSR-88D) SERVING THE BUFFALO, NY, AREA

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EXECUTIVE SUMMARY

The National Weather Service (NWS) owns and operates the existing Weather Service Radar, Model 1988 Doppler (WSR-88D) serving the Buffalo, NY, area. The radio call letters of the radar are KBUF and the radar is located at Buffalo Niagara International Airport, 9 miles northeast of downtown Buffalo, NY. The KBUF WSR-88D was commissioned in 1996 and is one of 159 WSR-88Ds in the nationwide network.

The KBUF 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 western New York and Northwestern Pennsylvania. The KBUF 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 KBUF 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 KBUF 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 KBUF 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 KBUF 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 49.7%. The minimum altitude of radar coverage over downtown Erie, PA would be reduced from 4,100 ft to 2,460 ft. These radar coverage improvements would be very beneficial to NWS forecasters and others parties (e.g. public safety agencies and emergency response workers) using the radar information.

The lower minimum scan angle would not result in the KBUF WSR-88D main beam impinging on the ground in the vicinity of the WSR-88D site. The proposed action would slightly increase RF exposure levels in the vicinity of the KBUF WSR-88D. As shown in Table S-1, during normal operation of the radar with rotating antenna, RF exposure would comply with the national safety standards developed by the Institute of Electrical and Electronic Engineers (IEEE) and the adopted by the American National Standards Institute (ANSI). RF emissions during normal operation would also comply with Federal Communications Commission and

Occupational Safety and Health Administration safety standards for RF exposure of the general public and workers.

Table S-1. RF Emissions of KBUF WSR-88D Operating at Minimum Scan Angle of +0.3 deg Compared to ANSI/IEEE Safety Standards

Location and Distance from Radar	Within WSR-88D Main Beam?	Time-Averaged Power Density (mW/cm²)	ANSI/IEEE General Public RF Safety Standard		ANSI/IEEE Occupational RF Safety Standard	
			Safety Std (mW/cm²)	Factor Below Std	Safety Standard (mW/cm²)	Factor Below Std
Surface of Radome	Yes	0.601	1.00	1.66	9.98	16.6
Base of WSR-88D Tower*	No	0.005	1.00	200	9.98	1,996
Airport Traffic Control Tower, 5,600 ft ESE	Yes	0.00027	1.00	3,700	9.98	36,900

Because the KBUF 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 have low potential to cause radio interference with television, radio, cellular telephone, personal communications devices (PCDs), electro-explosive devices, fuel handling, active implantable medical devices, or astronomical observatories.

Lowering the minimum scan angle of the KBUF 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

The no action alternative would result in continued operation of the KBUF 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 a 30-day comment period running from May 29, 2018 through June 29, 2018. 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 KBUF WSR-88D minimum scan angle after the Final EA report is completed.

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FIGURES

TABLES

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
ESA	Endangered Species Act
FAA	Federal Aviation Administration
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
KBUF	WSR-88D serving Buffalo, NY, 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
mya	million years ago
NAO	NOAA Administrative Order
NEPA	National Environmental Policy Act

NEXRAD	Next Generation Weather Radar (also known as WSR-88D)
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NWS	National Weather Service
PEIS	Programmatic Environmental Impact Statement
RF	radiofrequency
SHPO	State Historic Preservation Officer
sq mi	square mile(s)
U.S.	United States
USAF	U.S. Air Force
USFWS	U.S. Fish and Wildlife Service
WSR-88D	Weather Service Radar – 1988, Doppler

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 Service Radar-Model 1988 Doppler (WSR-88D) after the year they were first put into service and their capabilities to use Doppler shift measurements to determine wind velocities. They are also known as Next Generation Weather Radars (NEXRADs). Like all active radars, the WSR-88D transmits a radio signal, which reflects off targets and returns to the radar. The radar measures the strength of the return signal, its direction of return, and the time between transmission and return, which allows determination of the 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 Buffalo, NY, area. The radar identifier is KBUF and the radar is located at Buffalo Niagara International Airport in Buffalo, NY. The KBUF WSR-88D is part of the nationwide WSR-88D network. The NWS proposes operate the KBUF 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 KBUF 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, requires 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 KBUF WSR-88D at a minimum scan angle below +0.2 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 KBUF WSR-88D minimum scan angle to +0.3 deg). Potential environmental effects of alternative minimum scan angles down to -0.2 deg and the no-action alternative (i.e. continued operation of the KBUF 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 KBUF WSR-88D site and vicinity. The scope of this EA is limited to analyzing potential effects from lowering the minimum scan angle of the KBUF 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 KBUF WSR-88D, and are not applicable to other WSR-88Ds or the WSR-88D network as a whole.

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 KBUF WSR-88D serving the Buffalo, NY, 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)]; the Companion Manual for NOAA Administrative Order 216-6A; and 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

NEXAD 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 KBUF minimum scan angle to +0.3 deg; this EA report satisfies that requirement.

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 a 30-day comment period running from May 29, 2018 through June 29, 2018. 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 KBUF WSR-88D minimum scan angle after the Final EA report is completed.

3 DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

3.1 PROPOSED ACTION

3.1.1 Description of KBUF 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 KBUF WSR-88D, which serves the Buffalo, NY, area. Figure 2 shows the location of the KBUF WSR-88D. The KBUF WSR-88D is located at Buffalo Niagara International Airport. The radar antenna, radome, and steel-lattice tower are standard. Table 1 provides information on the KBUF WSR-88D.

Table 1: Information on the KBUF WSR-88D Serving the Buffalo, NY, Area	
Elevation, ground surface at tower base (mean sea level, MSL)	694 ft
Elevation, center of antenna (MSL)	791 ft
Tower Height (m)	25 m (82 ft)
Latitude (WGS84)	42°56’55” N
Longitude (WGS84)	78°44’13” W
Operating Frequency	2,993 megaHertz (MHz)
Spot Blanking or Sector Blanking used	No

Figure 1: Photograph of KBUF WSR-88D serving Buffalo, NY, Area

Figure 2: Location of KBUF WSR-88D serving the Buffalo, NY, area

Scale: 0 20 40 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 to +0.3 deg, which is 0.2 deg lower than the current minimum scan angle.

Figure 4 is a schematic drawing showing the change in coverage that would result from lowering the KBUF WSR-88D minimum scan angle. The floor of coverage would decrease slightly, but at the WSR-88D main beam would not impinge on the ground surface within 4 miles of the radar. Because the lowered radar main beam would not be 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 49.7% increase in coverage area at 2,000 ft above site level (ASL) to 18.4% 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 KBUF WSR-88D with Minimum Scan Angle of +0.3 deg

Center of Beam Scan Angle (deg)	Operational Status	Angle of Coverage Floor (deg)	Total Area Covered at 2,000 feet (ft) ASL in square miles (change from +0.5 deg scan)	Total Area Covered at 5,000 ft ASL in square miles (change from +0.5 deg scan)	Total Area Covered at 10,000 ft ASL in square miles (change from +0.5 deg scan)
+0.5	existing	0.0	9,042	24,464	50,900
+0.3	proposed	-0.2	13,533 (+49.7%)	31,203 (+27.6%)	60,275 (+18.4%)

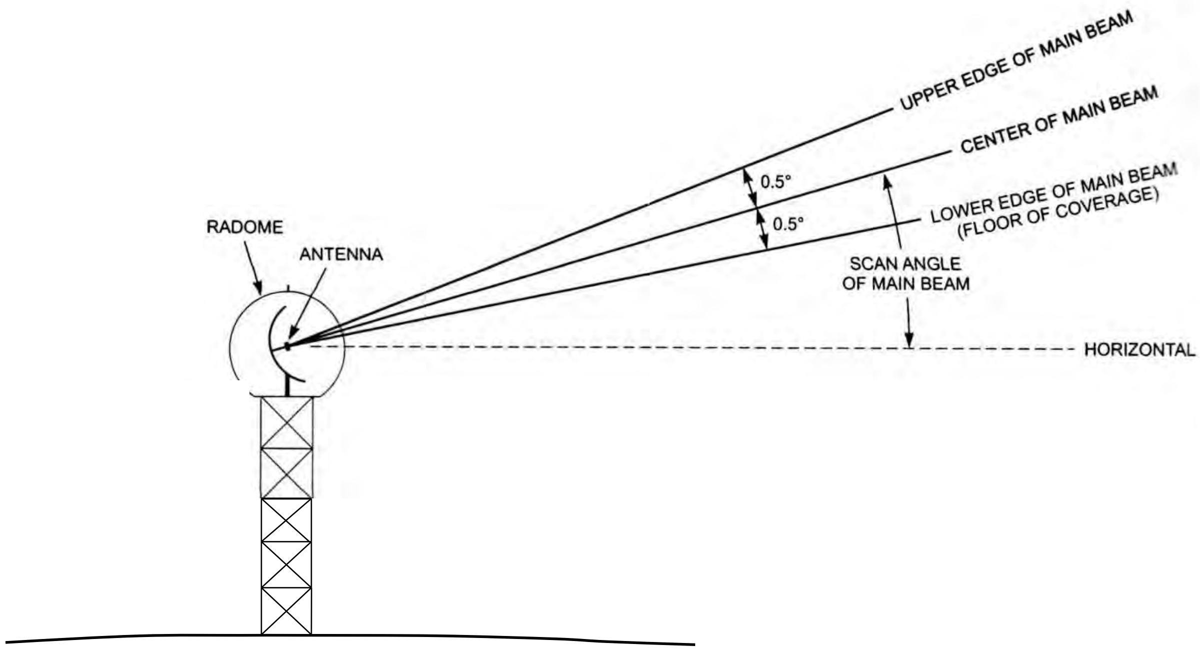

Figure 3: Schematic of WSR-88D Main Beam

(Not to scale, width of main beam exaggerated)

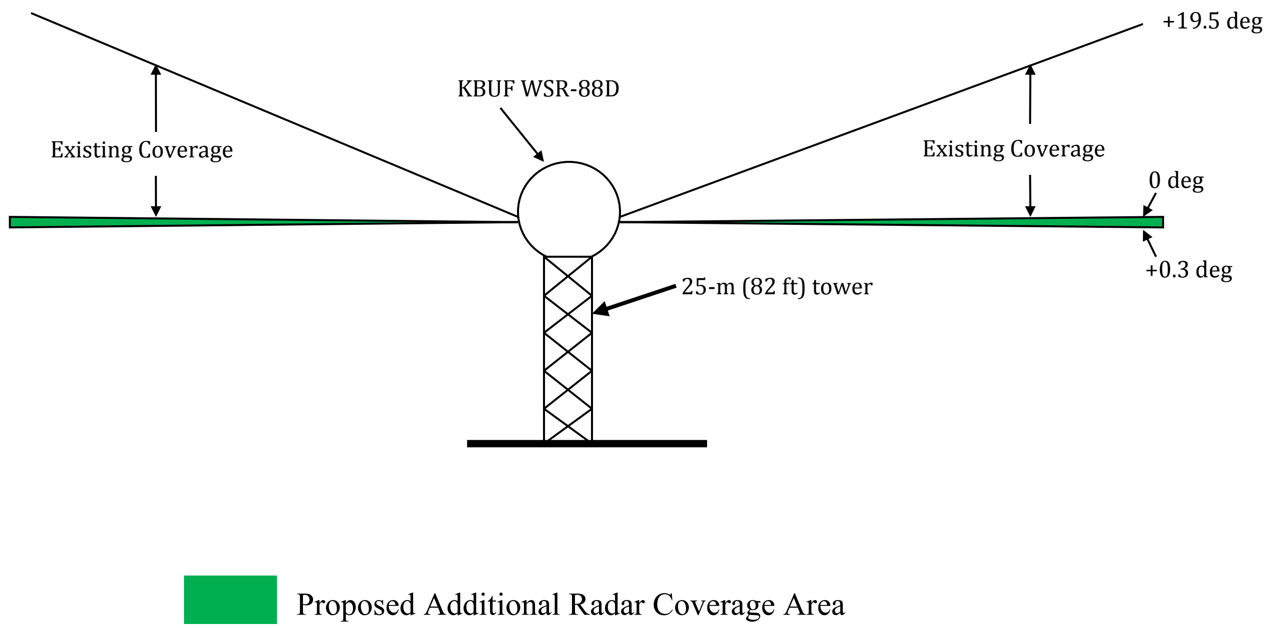

Figure 4: Drawing Showing Proposed Additional Radar Coverage

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

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

Figure 7: Existing and Proposed KBUF 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 KBUF WSR-88D 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.

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 KBUF WSR-88D transmits a radio signal with an operating frequency of 2,993MHz, 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 EM radiation. In this section only standards for non-ionizing radiation are addressed because the KBUF 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, pregnant women, and so forth) from adverse health effects from exposure to radiofrequency (RF), even if exposure should last over an entire lifetime. These guidelines set safety levels for maximum permissible exposure (MPE) to RF signals, which include a 10- to 50-fold safety margin and are intended to protect all members of the population.

MPEs are specified in power density of the radio signal in milliwatts per square centimeter (mW/cm^2) and vary with operating frequency. Separate MPEs have been established for exposure of the general public and workers and for time-averaged exposure and peak exposure. Occupational safety standards are higher than those for the general public because workers are trained in RF safety practices and have greater ability to use that knowledge to protect themselves from potentially harmful RF exposure. The KBUF WSR-88D operating frequency is 2,993 MHz. The IEEE/ANSI safety standards for that frequency are 1.0 mW/cm^2 for the general public, based on an averaging time of 30 minutes, and 9.98 mW/cm^2 for workers, based on an averaging time of 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 (averaging time of 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 KBUF WSR-88D is mounted on a 25 m tall steel-lattice tower. Ground elevation is ft 695 MSL. The center of the antenna is 791 ft MSL and the lower edge of the antenna is at 777 ft MSL, which is 82 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 in the vicinity of the WSR-88D.

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 in the vicinity of the radar. Appendix A includes calculations of the existing time-averaged RF exposure levels in the vicinity of the KBUF 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 and shows the RF exposure levels that would result at various locations near the radar during normal operations with a minimum scan angle of +0.3 deg.

Airport Traffic Control Tower (ATCT)

The Buffalo Niagara International Airport ATCT is located 5,600 ft east-southeast of the KBUF WSR-88D (see attachment A, Trip Report). The upper portion of the ATCT tower and the tower cab are directly illuminated by the main beam of the WSR-88D under current operations. Lowering the minimum scan angle would increase the portion of the tower directly illuminated, but would not result in direct illumination of the ground surface at the base of the tower. During normal operation of the WSR-88D with a rotating antenna, RF exposure levels at the ATCT comply with ANSI/IEEE safety standards for exposure of both workers (i.e. occupational exposure) and the general public. RF exposure levels at the ATCT would also comply with OSHA and FCC safety standards.

Table 3. RF Emissions of KBUF WSR-88D Operating at Minimum Scan Angle of +0.3 deg Compared to ANSI/IEEE Safety Standards						
Location and Distance from Radar	**Within WSR-88D Main Beam?**	**Time-Averaged Power Density (mW/cm^2)**	**ANSI/IEEE General Public RF Safety Standard**		**ANSI/IEEE Occupational RF Safety Standard**	
			Safety Std (mW/cm^2)	**Factor Below Std**	**Safety Standard (mW/cm^2)**	**Factor Below Std**
Surface of Radome	Yes	0.601	1.0	1.66	9.98	16.6
Base of WSR-88D Tower*	No	0.005	1.0	200	9.98	1,996
ATCT 5,600 ft ESE	Yes	0.00027	1.0	3,700	9.98	36,900

NWS may infrequently operate the WSR-88D with a stationary antenna for calibration purposes. Operation with a stationary antenna would result in RF exposure of 1.0 mW/cm^2 (i.e. ANSI/IEEE and FCC general public safety level) at a distance of 1,740 ft and 9.98 mW/cm^2 (i.e. ANSI/IEEE occupational safety level) at 550 ft (see Appendix A). The power density of the WSR-88D main beam would decrease with increasing distance and RF exposure at all distances beyond 1,740 ft would comply with all safety standards. No other structures or elevated terrain that could be directly illuminated by the WSR-88D main beam are located within 1,740 ft, and no RF safety hazards would result. The BUF ATCT is 5,600 ft from the WSR-88D and no safety hazards would result to persons at the ATCT.

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 KBUF WSR-88D would continue to operate at 2,993 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 of interest in the vicinity, RFR emitted by the WSR-88D would be at substantially below the safety standard for RF exposure of the general public. During normal operation of the WSR-88D, RF exposure levels at the ATCT would be 3,700 times below the general public safety level. 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 KBUF 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 several 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:

$$D = (781)(f)^{-1}(\text{average power x antenna gain})^{1/2}$$

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

$$D = (781)(2{,}848)^{-1}\ (475{,}000\ W \times 0.0021 \times 35{,}500)^{½}\ ft$$

$$D = 1{,}631\ ft$$

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

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

$$D = (2{,}873)(2{,}848)^{-1}\ (475{,}000\ W \times 0.0021 \times 35{,}500)^{½}\ ft$$

$$D = 6{,}003\ ft$$

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 KBUF WSR-88D main beam would not illuminate the ground within either 1,631 or 6,003 ft of the radar. The WSR-88D would not be a hazard to EEDs use in the vicinity. No mitigation is necessary.

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 illuminated by the WSR-88D main beam and hazards to fuel handling activities would not result. No mitigation is required.

4.2.5 Active Implantable Medical Devices

ANSI and the Association for Advancement of Medical Instrumentation (AAMI) developed the PC69:2007 standard to prevent external electromagnetic sources from causing electromagnetic interference with active implantable medical devices, including cardiac pacemakers and implantable cardiac defibrillators [ANSI/AAMI, 2007]. This standard specifies that cardiac pacemakers and ICDs must be tested by exposing them to a specified magnetic field and that the device must operate without malfunction or harm to the device. The specified field strength varies with frequency. For the WSR-88D operating frequency of 2,993 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 attenuation 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 is equal to the threshold in the 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 KBUF WSR-88D would not illuminate the ground within 2,060 ft of the radar and no hazards would results to persons on the ground with implanted devices.

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 KBUF WSR-88D would comply with the FCC safety standards. Exposure of persons wearing implantable medical devices to the KBUF 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 astronomical observatories located within 150 miles of the KBUF WSR-88D. The elevation of the KBUF WSR-88D main beam at each observatory is 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 and beam spreading. As can be seen from Table 4, elevated terrain between the observatories and the KBUF WSR-88D would shield 12 of the 14 observatories and prevent the WSR-88D main beam from impinging on the observatories. The two observatories not shielded by terrain are David Dunlap and the Mahalso Observatories.

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

Observatory	Location	Distance (mi) and Direction from WSR-88D	Observatory Elevation (ft MSL)	Terrain Blockage at +0.3 deg*?
Beaver Meadow Observatory	Java, NY	26 SE	1,530	Yes
C. Kenneth Mees Observatory	Naples, NY	70 SSE	2,270	Yes
Darling Hill Observatory	Tully, NY	127 E	1,550	Yes
David Dunlap Observatory	Richmond Hill, Ontario	70 N	830	No
Eileen Collins Observatory	Corning, NY	104 SE	1,740	Yes
Fuertes Observatory	Ithaca, NY	120 ESE	950	Yes
Ford Observatory	Ithaca, NY	120 ESE	1,180	Yes
Hartung Boothroyd Observatory	Ithaca, NY	125 ESE	1,780	Yes
Mahalso Observatory	Erie, PA	88 WSW	1,060	No
Martz Observatory	Frewsburg, NY	68 SSW	2,100	Yes
Oil Region Astronomical Observatory	Venango, PA	115 SW	1,410	Yes
RIT Observatory	Henrietta, NY	55 E	570	Yes
Smith Observatory	Geneva, NY	88 E	600	Yes
Stull Observatory	Alfred, NY	67 SE	1,950	Yes

*lower half-power point at -0.2 deg

The David Dunlap Observatory in Richmond Hill, Ontario is at elevation 830 ft MSL about 70 miles north northwest of the WSR-88D. Factoring in earth curvature, the WSR-88D main beam operating at +0.3 deg would have a radar coverage floor of 1,930 ft MSL, about 1,100 ft above observatory level. The observatory would not be directly illuminated by the KBUF WSR-88D operating at a minimum scan angle of +0.3 deg.

The Mahalso Observatory in Erie, PA is at elevation 1,060 ft MSL about 88 miles west-southwest from the KBUF WSR-88D. The path from the KBUF WSR-88D to the observatory is across Lake Erie and does not include elevated terrain. However, due to earth curvature, the WSR-88D main beam at +0.3 would have a radar coverage floor at elevation 3,110 MSL or 2,050 ft above the observatory. The Mahalso Observatory would not be directly illuminated by the KBUF WSR-88D operating at a minimum scan angle of +0.3 deg.

Lowering the minimum scan angle of the WSR-88D to +0.3 deg would not directly illuminate astronomical observatories and would not adversely affect operation of observatories.

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: Effects of KBUF WSR-88D RF Emissions on Equipment and Activities

Equipment / Activity	Applicable Standard	Setback Distance	Would Main Beam Impinge on Ground Within Setback Distance?	Potential for Significant Effects (Mitigation, if Applicable)
Television, Radio, and Cellular Telephone, and Personal Communications Devices (PCDs)	NTIA Frequency Allocations	n/a	n/a	Very Low
EEDs	U.S Navy HERO	6,003 ft	No	Very Low
Fuel Handling	U.S. Navy Hazards to Personnel, Fuel, and Other Flammable Material	537	No	Very Low

Table 5: Effects of KBUF WSR-88D RF Emissions on Equipment and Activities				
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	Very Low

4.3 Land Use and Coastal Zone Management

The State of New York administers a Coastal zone Management program approved by NOAA Office of Coastal Zone Management. In the Great Lakes region, the landward boundary of the coastal management zone extends from 500 to 1,000 feet from the shoreline (New York Department of State, 1982 to 2017). KBUF WSR-88D is about 9 miles inland from the shoreline of the Lake Erie/Niagara River and is not within the designated coastal management zone.

Land uses in the vicinity are aviation-related commercial and industrial uses. The proposed action would not change land uses at the KBUF WSR-88D site or vicinity and would not adversely affect nearby land uses.

4.4 Geology, Soils, and Seismic Hazards

The KBUF WSR-88D is located in the Allegheny Plateau region of western New York. Bedrock consists of flat-lying chert and limestone layers of the Onandaga formation of Devonian age (345 to 405 million years old) (American Association of Petroleum Geologists, undated). Soil is udorthents, smoothed, on 0 to 15% slope. Soil is moderately well drained with a depth to the water table of 36 to 72 inches. The WSR-88D site does not contain hydric soils or prime farmland (Natural Resources Conservation Service, 2018).

The risk of damaging earthquakes is relatively low in the Buffalo, NY area. U.S. Geological Survey (USGS) estimates the risk of an earthquake strong enough to could cause minor damage or greater at less than 1% per year (USGS, 2018).

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

4.5 Drainage and Water Quality

The KBUF WSR-88D is located about 0.25 miles southeast of Ellicott Creek, which flows northeast into the Erie Canal and the Niagara River. Storm runoff and snowmelt from the site flow to a small basin located 50 ft east of the site. Lowering the minimum scan angle of the KBUF WSR-88D would not result in ground disturbance. The proposed action would not affect the amount of impervious surface area at the radar site or the rate of storm runoff flowing from the site during or after precipitation events. The proposed action would have no effect on drainage or water quality. No mitigation measures are required.

4.6 Transportation

The KBUF WSR-88D is accessed via North Airport Drive, a two-lane paved public road. The WSR-88D is about 1.4 miles by road from the NWS WFO serving the Buffalo area.

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 technicians and engineers would travel to the KBUF 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 KBUF 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 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 KBUF WSR-88D site is mapped by the Federal Emergency Management Agency in Zone C, areas of minimal flooding, and is not within the base floodplain (FEMA, 2017). The proposed action of lowering KBUF WSR-88D minimum scan angle to +0.3 deg would not affect floodplains or flood hazards. No mitigation measures are required.

4.9 Wetlands

E.O. 11990, *Protection of Wetlands*, requires the Federal Government avoid funding or implementing projects which would adversely impact wetlands unless there is no practicable alternative [President, 1977b]. Based on National Wetland Inventory maps prepared by the U.S. Fish and Wildlife Service (USFWS), the WSR-88D site does not contain federal jurisdictional wetlands. The nearest federal-jurisdictional wetlands are palustrine emergent wetlands (PEM1B) located on the airport about 0.23 miles to the west and palustrine forested and scrub-shrub wetlands (PF01/SS1E) located along Ellicott Creek about 0.29 miles to the east (USFWS, 2018). 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 and Migratory Bird Treat Acts. The KBUF WSR-88D is located within the area served by the USFWS New York Ecological Services Field Office. Protected species lists were obtained from that office (see Appendix C). The only species listed under the Endangered Species Act that could potential occur in the general area is the Northern long-eared bat (*Myotis septentrionalis*). The Northern long-eared bat is found in 37 states in the Northeast, Midwest, and Upper South. This species is in decline primarily due to white-nosed syndrome, a widespread disease affecting several species of bats. The project site and vicinity does not contain critical habitat for any protected species or wildlife refuges.

The proposed action does not include construction activities and would not result in ground disturbance or vegetation removal. 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 3.5 ft thick at a distance of 1,000 ft from the WSR-88D and 18 ft thick at a distance of 1 mile.

Bats and migratory birds flying within the newly covered sliver of the atmosphere would be exposed to RF emissions from the WSR-88D. However, the RF levels in the newly covered 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. During normal operations, RF exposure levels would comply with human exposure safety standards at all locations in the vicinity and those safety standards include a 10 to 50 fold factor of safety. RF exposure of protected or migratory birds flying within the newly covered airspace would not be harmful.

Elevated RF exposure could result if birds or bats 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 6,000 ft of the WSR-88D where RF hazards to potentially RF-sensitive activities could result (see Table 5). The APE includes portions of the Towns of Amherst and Cheektowaga. A search of the New York State Cultural Resources Information System (CRIS) identified 12 places on the National Register of Historic Places (NRHP) in the Town of Amherst and 3 places in the Town of Cheektowaga (New Yok State CRIS, 2018).

All of the NRHP-listed places in the Towns of Amherst and Cheektowaga are over 6,000 ft from the WSR-88D and outside the APE except for the War of 1812 Cemetery in Cheektowaga (95NR00891), located about 1,800 ft east-southeast of the WSR-88D. The cemetery is at elevation 685 ft MSL, which is 106 ft lower than the center of the WSR-88D antenna. When operating at the proposed minimum scan angle of +0.3 deg, the bottom of the WSR-88D main beam would have at an elevation of 771 ft or 86 ft above ground level at the cemetery of 1812. No adverse effects on activities or structures at the cemetery would result and the proposed action would not have the potential to affect any properties listed on the NRHP.

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 New York SHPO regarding possible impacts on historic properties is not required [Advisory Council on Historic Preservation, 2010]. No mitigation measure is necessary.

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 KBUF WSR-88D is located at Buffalo Niagara International Airport. The proposed action would not generate air or water pollutants or hazards 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 within 4 miles of the radar and would comply with safety standards for human exposure to RF energy and setbacks for activities, such as fuel handling and EES 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 [NRCS, 2010]. The KBUF WSR-88D site and vicinity are developed for urban airport-related uses which precludes agriculture. The site is not classified as prime farmland (NRCS, 2018). The proposed action would affect prime farmland or convert farmland to non-agricultural 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.

4.16 Solid and Hazardous Waste

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

4.17 Wild and Scenic Rivers

The Wild and Scenic Rivers Act of 1968 protects free-flowing rivers of the U.S. These rivers are protected under the Act by prohibiting water resource projects from adversely impacting values of the river: protecting outstanding scenic, geologic, fish and wildlife, historic, cultural, or recreational values; maintaining water quality; and implementing river management plans for these specific rivers.

The KBUF WSR-88D site is within the watershed of Ellicott Creek, which drains northeastward to the Erie Canal and the Niagara River. Ellicott Creek is not a wild and scenic river. The closest wild and scenic river is the Genesee River, about 45 miles southeast of the KBUF WSR-88D (National Park Service, 2018). The proposed action would not affect the Genesee River or any other wild and scenic rivers. No mitigation is necessary.

5 ALTERNATIVES TO THE PROPOSED ACTION

5.1 Minimum Scan Angles Lower than +0.3 deg

NWS evaluated the benefits and potential impacts of lowering the minimum center of beam scan angle of the KBUF WSR-88D to each angle between +0.4 and -0.2 deg in 0.1 degree increments (see Appendix C). That analysis found that a minimum scan angle of +0.3 deg would improve radar coverage while avoiding direct illumination of the ground surface in the vicinity of the radar. A minimum scan angle of +0.3 deg would also comply with RF safety setback distances for all potentially RF-sensitive uses and activities in the vicinity of the radar.

Operating the KBUF WSR-88D at center of beam minimum scan angles at or below +0.2 deg (i.e. between +0.2 and -0.2 deg) would result in minimal improvement in radar coverage compared to the +0.3 minimum scan angle, and would have the drawback of increasing ground clutter returns. Therefore, NWS rejected the alternative of operating the KBUF WSR-88D at scan angles below +0.3 deg.

5.2 No Action

The no action alternative consists of continued operation of the KBUF WSR-88D at the existing minimum scan angle of +0.5 dg. 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 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
- Environmental Justice and Socioeconomic Impacts
- Farmlands
- Energy Consumption

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

6 FINDING

The proposed action of lowering the scan angle of the KBUF 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. This finding applies to operation of the radar at any minimum center of beam scan angle between +0.5 deg and +0.3 deg.

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 of the Buffalo, NY, area by improving the accuracy of forecast and severe weather alerts, which could result in environmental benefits if weather dependent economic activities (e.g., agriculture, timber production, 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 environment.

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. Ms. Judith Levan, Meteorologist-in-Charge, and staff from the Buffalo, NY, WFO, also assisted in preparation of this EA.

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ENVIRONMENTAL ASSESSMENT (EA)

LOWERING THE MINIMUM SCAN ANGLE OF THE WEATHER SERVICE RADAR - MODEL 1988, DOPPLER (WSR-88D) SERVING THE BUFFALO, NY, AREA

APPENDICES

APPENDIX A

RADIOFREQUENCY RADIATION POWER DENSITY CALCULATIONS

1. OBJECTIVE

To quantify the power densities of the radiofrequency radiation (RFR) emitted by the Weather Service 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-8D 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: WSR-88D Operating Characteristics

Parameter	Value
Operating Frequency	2,700 to 3,000 megahertz (MHz)
Wavelength at center frequency (2,850 MHz)	0.345 ft, 10.5 cm
Maximum radiated 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 KBUF 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 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 +0.2 deg (i.e. lower half power point of -0.3 deg), the lowest scan angles under consideration by NWS. Adding two -0.2 degree scans would result in the greatest possible increase in ground level RFR exposure. The modified VCP 31 would be as follows:

- Two complete rotations at +0.3 deg
- Two complete rotations at +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 RFR 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:

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

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 0.0 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

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

$$U_4 = (0.627)U_3$$

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

$$U_4 = 8.46 \times 10^3/R^2 \quad \text{mW/cm}^2$$

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:

$$U_5 = 8.46 \times 10^3/R^2 + 4/R^2 = 8.464 \times 10^3/R^2 \quad \text{mW/cm}^2$$

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 $Y = 28 \div R \text{ Tan } 2 \text{ deg} + 0.035R$. Since the modified scan pattern of interest includes scans of +0.3. +0.5, and +1.5 degs, the angular range is 1.2 deg, and we recalculate Y as follows:

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

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):

$$U_6 = 2 * 10^6 / (929)(176R + 0.13R^2) = 14{,}338 / (R^2 + 1{,}354\ R)\ \text{mW/cm}^2$$

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

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

Table A-2: Comparison of Time-Average RFR Power Densities Within the Illuminated Area Using VCP 31 and Modified VCP 31

Distance (ft)	Distance (mi)	Original VCP 31 Lowest Elev (ft MSL)	Original VCP 31 Time-Avg Power Density (mW/cm2)	Modified VCP 31 Lowest Elev (ft MSL)	Modified VCP 31 Time-Avg Power Density (mW/cm^2)
20	0.004	777*	0.598	777*	0.601
5,600	1	777	0.00027	757	0.00027
25,400	5	777	0.0000014	685	0.000014

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

The time averaged power density within the main beam at the Airport Traffic Control Tower (ATCT) can be calculated inserting the distance R = 5,600 ft into the equation U_5:

$$U_5 = 8.464 \times 10^3/(5{,}600)^2 = 0.00027\ \text{mW/cm}^2$$

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

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

When operating in stationary antenna mode, the 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 (9.98 mW/cm^2): 550 ft

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. emails to James Manitakos, Sensor Environmental LLC, (February 14, 2018).

APPENDIX B

PROTECTED SPECIES LIST

United States Department of the Interior

FISH AND WILDLIFE SERVICE
New York Ecological Services Field Office
3817 Luker Road
Cortland, NY 13045-9385
Phone: (607) 753-9334 Fax: (607) 753-9699
http://www.fws.gov/northeast/nyfo/es/section7.htm

In Reply Refer To: April 20, 2018
Consultation Code: 05E1NY00-2018-SLI-1864
Event Code: 05E1NY00-2018-E-05625
Project Name: Lowering the minimum scan angle of the KBUF WSR-88D

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

To Whom It May Concern:

The enclosed species list identifies threatened, endangered, proposed and candidate species, as well as proposed and final designated critical habitat, that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the U.S. Fish and Wildlife Service (Service) under section 7(c) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq*.). This list can also be used to determine whether listed species may be present for projects without federal agency involvement. New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list.

Please feel free to contact us if you need more current information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the ESA, the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally as desired. The Service recommends that verification be completed by visiting the ECOS-IPaC site at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the ECOS-IPaC system by completing the same process used to receive the enclosed list. If listed, proposed, or candidate species were identified as potentially occurring in the project area, coordination with our office is encouraged. Information on the steps involved with assessing potential impacts from projects can be found at: http://www.fws.gov/northeast/nyfo/es/section7.htm

Please be aware that bald and golden eagles are protected under the Bald and Golden Eagle Protection Act (16 U.S.C. 668 *et seq*.), and projects affecting these species may require development of an eagle conservation plan (http://www.fws.gov/windenergy/

eagle_guidance.html). Additionally, wind energy projects should follow the Services wind energy guidelines (http://www.fws.gov/windenergy/) for minimizing impacts to migratory birds and bats.

Guidance for minimizing impacts to migratory birds for projects including communications towers (e.g., cellular, digital television, radio, and emergency broadcast) can be found at: http://www.fws.gov/migratorybirds/CurrentBirdIssues/Hazards/towers/towers.htm; http://www.towerkill.com; and http://www.fws.gov/migratorybirds/CurrentBirdIssues/Hazards/towers/comtow.html.

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

Attachment(s):

- Official Species List

Official Species List

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

This species list is provided by:

New York Ecological Services Field Office
3817 Luker Road
Cortland, NY 13045-9385
(607) 753-9334

Project Summary

Consultation Code: 05E1NY00-2018-SLI-1864

Event Code: 05E1NY00-2018-E-05625

Project Name: Lowering the minimum scan angle of the KBUF WSR-88D

Project Type: COMMUNICATIONS TOWER

Project Description: The existing National Weather Service WSR-88D weather radar facility will be unchanged and no ground disturbance of construction will occur. The minimum scan angle of the radar will be reduced from +0.5 degree above the horizon to +0.3 deg.

Project Location:

Approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/place/42.94876816273417N78.73624835645731W

Counties: Erie, NY

Endangered Species Act Species

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

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

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

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

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

Mammals

NAME	STATUS
Northern Long-eared Bat *Myotis septentrionalis* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/9045	Threatened

Critical habitats

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

APPENDIX C

TECHNICAL MEMORANDUM / TRIP REPORT

SENSOR ENVIRONMENTAL LLC
296 West Arbor Ave, Sunnyvale CA 94085-3602, jmanitakos@sensorenvirollc.com

TECHNICAL MEMORANDUM

TO: Edward Ciardi, Program Manager, EVP Weather Systems, Centuria Corporation	**FROM:** James Manitakos, CEO, Sensor Environmental LLC
CC: Jessica Schultz, Director, Radar Focal Point, NWS Radar Operations Center Andre Tarpinian, Senior RF Engineer, Alion Science and Technology Corp.	**SUBJECT:** Analysis of Lower Scan Angles For Weather Service Radar, Model 1988 Doppler (WSR-88D), Serving the Buffalo, NY, Area
DATE: April 15, 2018	**Version:** Rev 1

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 Buffalo, New York, area. The radar identifier is KBUF and the radar is located at Buffalo Niagara International Airport (BUF) in Erie County, NY. The WSR-88D is about 9 miles northeast of downtown Buffalo. Table 1 presents information about KBUF WSR-88D.

TABLE 1: INFORMATION ON WSR-88D SERVING THE BUFFALO, NEW YORK, AREA	
Elevation, ground surface at tower base (mean sea level, MSL)	694 ft
Elevation, center of antenna (MSL)	791 ft
Tower Height (m)	25 m (82 ft)
Latitude (WGS84)	42°56’55” N
Longitude (WGS84)	78°44’13” W
Weather Forecast Office (WFO)	587 Aero Drive Cheektowaga, NY 14225
Meteorologist-in-Charge (MIC)	Judy Levan Email: judith.levan@noaa.gov Tel: (716)565-0204 x222
Operating Frequency	2,993 megaHertz (MHz)
Spot Blanking or Sector Blanking used	No

NWS currently operates the WSR-88D serving Buffalo, NY, area 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 KBUF WSR-88D, NWS proposes to operate the radar with a 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 KBUF WSR-88D, Sensor Environmental LLC and our subcontractor Alion Science and Technology Corporation performed the following tasks:

1. Sensor staff visited the KBUF WSR-88D with NWS staff from the Buffalo, NY, 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 from the 20 meter level of the WSR-88D tower, about 27 ft lower than the KBUF 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 KBUF WSR-88D that would be directly illuminated by the main beam at each 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 KBUF WSR-88D at 2,000 ft above site level (ASL). The radar coverage shown in Attachment B is 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 WSR-88D coverage for the range of minimum scan angles under consideration by NWS.

The center of KBUFWSR-88D antenna is at elevation 791 ft MSL. Attachment B contains a map showing the limits of radar coverage at 2,000 ft above site level (ASL) in all directions. When operating at the current minimum center of beam angle of +0.5 deg, coverage is obstructed by higher terrain to the east-northeast through south-southwest: azimuths 62 through 210 (0 = north, 90 = east, 180 = south, and 270 = west). The higher terrain at these azimuths would also obstruct the WSR-88D if operating at minimum scan angles below +0.5 deg. Lowering the minimum scan angle would provide negligible increase in radar coverage in those azimuths. To the southwest through northeast (azimuths 210 through 62, lowering the minimum scan angle would improve coverage. However, at a distance of about 21 miles, the WSR-88D main beam operating at +0.3 deg would intersect the ground surface. Lowering the minimum scan angle below +0.3 deg would produce little additional improvement in radar coverage.

Lowering the minimum center of beam scan angle to +0.3 deg would increase 2,000 ft ASL coverage area by 49.7% (see Table 2). Further lowering the minimum scan angle to +0.2 deg would only slightly increase coverage by an additional 1.3%. No increase in coverage area would result from lowering the minimum scan angle below +0.2 deg.

TABLE 2: KBUF WSR-88D RADAR COVERAGE AREAS FOR MINIMUM SCAN ANGLES BETWEN +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 in Compared to Existing
2,000	+0.5	0.0	9,042	0
2,000	+0.4	-0.1	11,189	+23.7%
2,000	+0.3	-0.2	13,533	+49.7%
2,000	+0.2	-0.3	13,653	+51.0%
2,000	+0.1	-0.4	13,653	+51.0%
2,000	0.0	-0.5	13,653	+51.0%
2,000	-0.1	-0.6	13,653	+51.0%
2,000	-0.2	-0.7	13,653	+51.0%

Lowering the minimum scan angle from +0.3 to +0.2 deg would increase coverage over a small area to the southwest over Lake Erie (azimuths 222 to 242), in the direction of Erie, PA. However, at a scan angle of +0.2 deg (lower half-power point = -0.3 deg), the WSR-88D beam would intersect the surface of Lake Erie at about 21 miles (33 km) from the radar and this would block the bottom 0.08 deg of the beam. This results in a coverage floor at -0.22 deg for areas more than 21 miles from the radar within azimuths 222 to 242. Table 3 shows the minimum height of KBUF WSR-88D coverage over the City of Erie, PA (elevation = 650 ft MSL) at each lower scan angle. The +0.2 deg scan angle would result in minimal lowering of the radar coverage floor by about 160 ft over Erie, PA as compared to the +0.3 minimum scan angle. In other directions the +0.2 deg scan would provide the same coverage area as the 0.3 deg scan. The 0.2 deg lower scan angle would result in greater ground clutter returns, which would offset the minor reduction in coverage floor height over Erie, PA.

TABLE 3: Minimum Height of KBUF WSR-88D Radar Coverage over Erie, PA (elevation 650 MSL)		
Minimum Center of Beam Scan Angle	**Coverage height (ft MSL)**	**Coverage Height (ft AGL)**
+0.5 deg (current minimum)	4,750	4,100
+0.4 deg	3,930	3,280
+0.3 deg	3,110	2,460
+0.2, +0.1, 0.0, -0.1, -0.2 deg	2,950	2,300

Photographs 2 through 5 in Attachment A, Trip Report, are panoramic photographs taken from about 27 ft below the center of the KBUF WSR-88D antenna. They show that the only structures at or near the airport or vicinity that would be directly illuminated by the WSR-88D main beam operating at the existing minimum of +0.5 deg or a lower minimum scan angle down to -0.2 deg are the Airport Traffic Control tower (ATCT) about 5,600 ft to the east of the WSR-88D, and the Airport Surveillance Radar, Model 9 (ASR-9), about 3,000 to the south. These structures are within the WSR-88D main beam at the current minimum scan angle of +0.5 deg, but a larger proportion of their towers would be illuminated at a lower minimum scan angle. The ATCT cab and the ASR-9 antennas are exposed to the full power of the WSR-88D main beam under current operations and lowering the minimum scan angle would not increase the RF exposure level at either location.

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.

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	1,700	
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

Safety Standards for human exposure are based on time-averaged exposure; therefore exposure during both rotating antenna and stationary-antenna operation are considered. The ATCT and ASR-9 are sufficiently distant from the WSR-88D to meet all setback distances, except for exposed (i.e. not in safe storage condition) EEDs. It is improbable that exposed EEDs would be in use at the ATCT cab or ASR-9 antenna deck level and no hazard would result.

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 4 miles (i.e. 21,120 ft) of the WSR-88D that would be directly illuminated by the WSR-88D main beam at each lower scan angle under consideration. Lowering the WSR-88D minimum scan angle to +0.4 or +0.3deg would not result in direct illumination of any terrain within 4 miles.

At +0.2 deg, the WSR-88D main beam would impinge on the ground surface at two small locations about 3.8 mi northeast and southeast of the radar. Lowering the scan angle to +0.1 deg would cause the main beam to impinge on the ground surface at about 3 mi to the east through southeast and about 4 mi to the west. The amount of ground impingement would increase at -0.1 or -0.2 deg to include broad swaths of terrain located 2 to 4 mi to the west, south, and east of the radar.

The KBUF WSR-88D operating frequency is 2,993 MHz, which is within the 2.7 to 2.9 MHz band allocated for federal aeronautical radionavigation and radiolocation use by the National Telecommunications and Information Agency of the Department of Commerce. Federal ground-based radars are allowed to use this band for meteorological purposes on the basis of equality with aeronautical radionavigation use. Non-federal radiolocation use is allowed if the FCC authorizes the use, arrangements are made with the federal agencies using the band, and a practicable argument is made of the need for the service. There have been no reports of the KBUF WSR-88D causing electromagnetic interference (EMI) with nearby radio communication systems in the last 10+ years (Schultz, 2018).

6. ASTRONOMICAL OBSERVATORIES

The WSR-88D can potentially cause harmful electromagnetic interference (EMI) with charge-couple devices (CCDs) which electronically record data collected by astronomical telescopes (NEXRAD JSPO), 1993). Due to the sensitivity of astronomical equipment which is designed to detect very faint signals from space, this equipment is vulnerable to EMI. The potential for harmful EMI would arise if the WSR-88D main beam would directly illuminate an astronomical observatory during low angle scanning. Table 5 lists astronomical observatories located within 150 miles of the WSR-88D serving Buffalo, NY, area. The 150-mile radius includes portions of New York, Ohio, Ontario, and Pennsylvania. Table 5 shows whether or not the WSR-88D beam at +0.3 deg would be blocked by terrain in the direction of each observatory, shielding the observatory from direct illumination. The analysis is based on observatory elevation, defined as ground elevation at the observatory plus the estimated height of the telescope above the ground, and factors in earth curvature. Observatories with terrain shielding would not be directly illuminated by the WSR-88D main beam; precluding adverse electromagnetic effects on the observatories.

TABLE 5: Astronomical Observatories within 150 miles of KBUF WSR-88D and Terrain Blockage

Observatory	Location	Distance (mi) and Direction from WSR-88D	Observatory Elevation (ft MSL)	Terrain Blockage at +0.3 deg?
Beaver Meadow Observatory	Java, NY	26 SE	1,530	Yes
C. Kenneth Mees Observatory	Naples, NY	70 SSE	2,270	Yes
Darling Hill Observatory	Tully, NY	127 E	1,550	Yes
David Dunlap Observatory	Richmond Hill, Ontario	70 N	830	No
Eileen Collins Observatory	Corning, NY	104 SE	1,740	Yes
Fuertes Observatory	Ithaca, NY	120 ESE	950	Yes
Ford Observatory	Ithaca, NY	120 ESE	1,180	Yes
Hartung Boothroyd Observatory	Ithaca, NY	125 ESE	1,780	Yes
Mahalso Observatory	Erie, PA	88 WSW	1,060	No
Martz Observatory	Frewsburg, NY	68 SSW	2,100	Yes
Oil Region Astronomical Observatory	Venango, PA	115 SW	1,410	Yes
RIT Observatory	Henrietta, NY	55 E	570	Yes
Smith Observatory	Geneva, NY	88 E	600	Yes
Stull Observatory	Alfred, NY	67 SE	1,950	Yes

Two observatories do not have terrain shielding: David Dunlap, and Mahalso Observatories. The potential for lowering the KBUF WSR-88D minimum scan angle to affect each of those observatories is analyzed below. The analysis below uses observatory elevation defined as ground elevation at the observatory plus the height of the telescope above the ground, and factors in earth curvature.

The David Dunlap Observatory in Richmond Hill, Ontario is at elevation 830 ft MSL about 70 miles north northwest (azimuth 333) from the WSR-88D. Factoring in earth curvature, the vertical angle from the KBUF WSR-88D to the observatory is -0.37 deg. The WSR-88D main beam operating at +0.3 deg would have a radar coverage floor at -0.2 deg., or about 1,100 ft above observatory level. As shown in Attachment A, lowering the minimum scan angle below 0.3 deg would not lower the floor of coverage in this direction. The observatory would not be directly illuminated by the KBUF WSR-88D operating at a minimum scan angle of +0.3 deg or any lower scan angle.

The Mahalso Observatory in Erie, PA is at elevation 1,060 ft MSL about 88 miles west-southwest (azimuth) from the KBUF WSR-88D. The path from the KBUF WSR-88D to the observatory is across Lake Erie and does not include elevated terrain. As shown in Table 3 above, the WSR-88D main beam at +0.3 or lower would intersect the surface of Lake Erie, resulting in radar coverage floor at elevation 3,110 MSL and 2,950 ft MSL for +0.3 deg and +0.2.deg scans, respectively. The floor of radar coverage would be 2,050 ft above the observatory for the +0.3 deg scan angle and 1,890 ft for the +0.2 deg scan angle. The Mahalso Observatory would not be directly illuminated by the KBUF WSR-88D at either +0.3 deg or +0.2 deg lower scan angle.

In conclusion, lowering the KBUF WSR-88D minimum scan angle to +0.3 deg would not result in direct illumination by the WSR-88D main beam of any astronomical observatories.

7. RECOMMENDATION

Operating the KBUF WSR-88D at a center of beam angle of +0.3 deg would improve low altitude radar coverage of the Buffalo, NY, and Erie, PA areas and would not result in potentially harmful exposure of persons, RF-Sensitive activities, or astronomical observatories. Lowering the minimum scan angle below +0.3 deg would provide negligible improvement in radar coverage and would increase ground clutter returns. Therefore, a center of beam minimum scan angle of +0.3 deg is recommended for the KBUF WSR-88D.

8. MEMORANDUM AUTHORS

This memorandum was prepared by Sensor Environmental LLC under contract to Centuria Corporation, which is a support contractor to the National Weather Service Radar Operations center 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 Environmental LLC. Mr. Andre Tarpinian, Radio Frequency Engineer, served as Alion's Project Manager.

9. REFRENCES

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ATTACHMENT A

TRIP REPORT, KBUF WSR-88D JANUARY 25, 2017

SENSOR ENVIRONMENTAL LLC
296 West Arbor Ave, Sunnyvale CA 94085-3602, jmanitakos@sensorenvirollc.com

TRIP REPORT

Traveler: James Manitakos, Sensor Environmental LLC

Destination: KBUF WSR-88D, Cheektowaga, NY

Dates: March 19-20, 2016

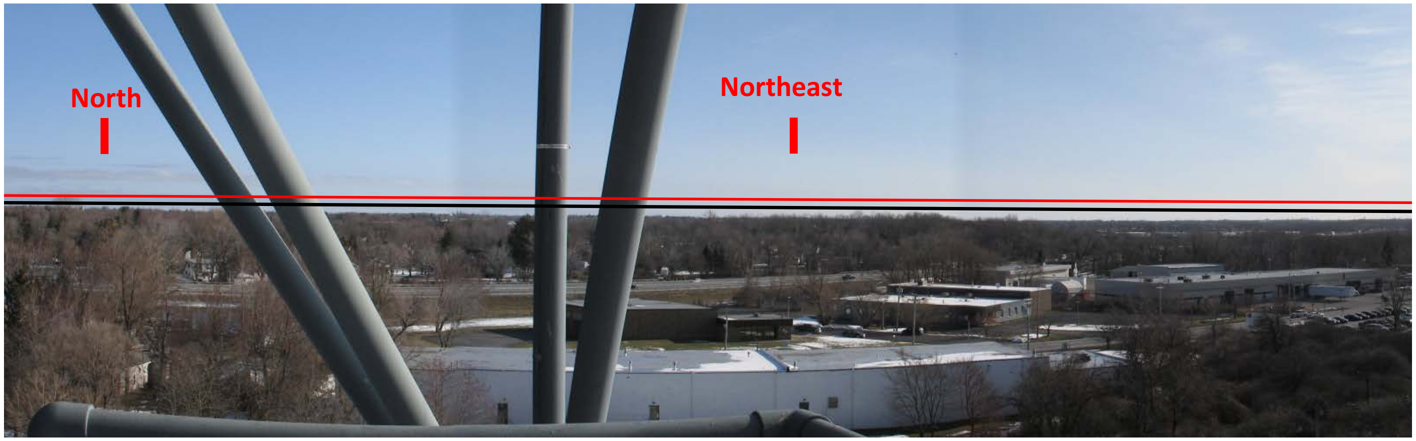
Purpose: Field Inspection of KBUF site, Meeting with Judith Levan, Meteorologist –in-Charge (MIC) and Staff

Summary: March 19, 2018: Mr. Manitakos traveled by car from Cleveland, OH to Cheektowaga, NY.

March 20, 2018: Weather was fair and breezy, with a temperature of 27° F. Mr. Manitakos met with Meteorologist-in-Charge Judith Levan and David Zaff of the WFO staff. We discussed the coverage plots and how lowering the minimum scan angle would lower the floor of radar coverage to the west, north and northeast. However, rising terrain would preclude improvements in radar coverage to the east, southeast, and south. Lowering the minimum scan angle would improve coverage over the Erie, PA area. The WFO has not received reports of electromagnetic interference attributed to the WSR-88D.

David Zaff escorted Mr. Manitakos to the WSR-88D, where he obtained photographs of the WSR-88D and surroundings, including a 360-degree panoramic photograph taken from 20-m level of the WSR-88D tower (See Photographs 1 through 5). The panoramic photographs were taken from an elevation of 764 ft MSL, which is about 27 ft below the WSR-88D center of antenna elevation of 791 ft MSL. The red line on the photographs show the lower half-power point of the WSR-88D main beam, which is at 0.0 deg when the WSR-88D is operating at the current minimum center of beam scan angle of +0.5 deg. The black line on the photographs shows the lower half-power point of the WSR-88D main beam at -0.7 deg, which would result if the center of beam minimum scan angle is lowered to -0.2 deg

Photograph 1: KBUF WSR-88D viewed from south (across N. Airport Drive)



Photograph 2: Panoramic Photograph from KBUF WSR-88D [—— 0 deg, —— - 0.7 deg]

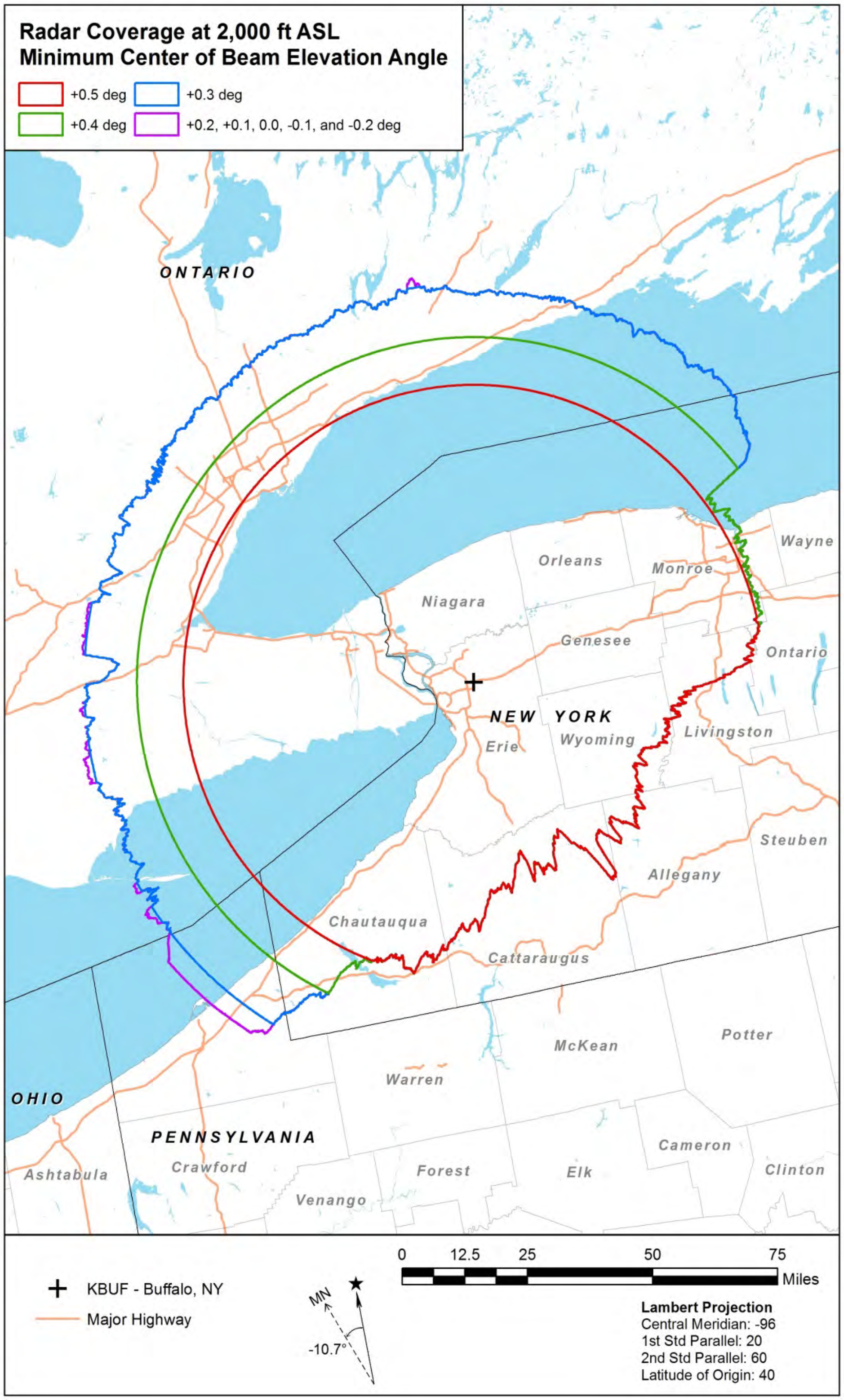
Photograph 3: Panoramic Photograph from KBUF WSR-88D [—— 0 deg, —— - 0.7 deg]

Photograph 4: Panoramic Photograph from KBUF WSR-88D [—— 0 deg, —— - 0.7 deg]

Photograph 5: Panoramic Photograph from KBUF WSR-88D [—— 0 deg, —— - 0.7 deg]

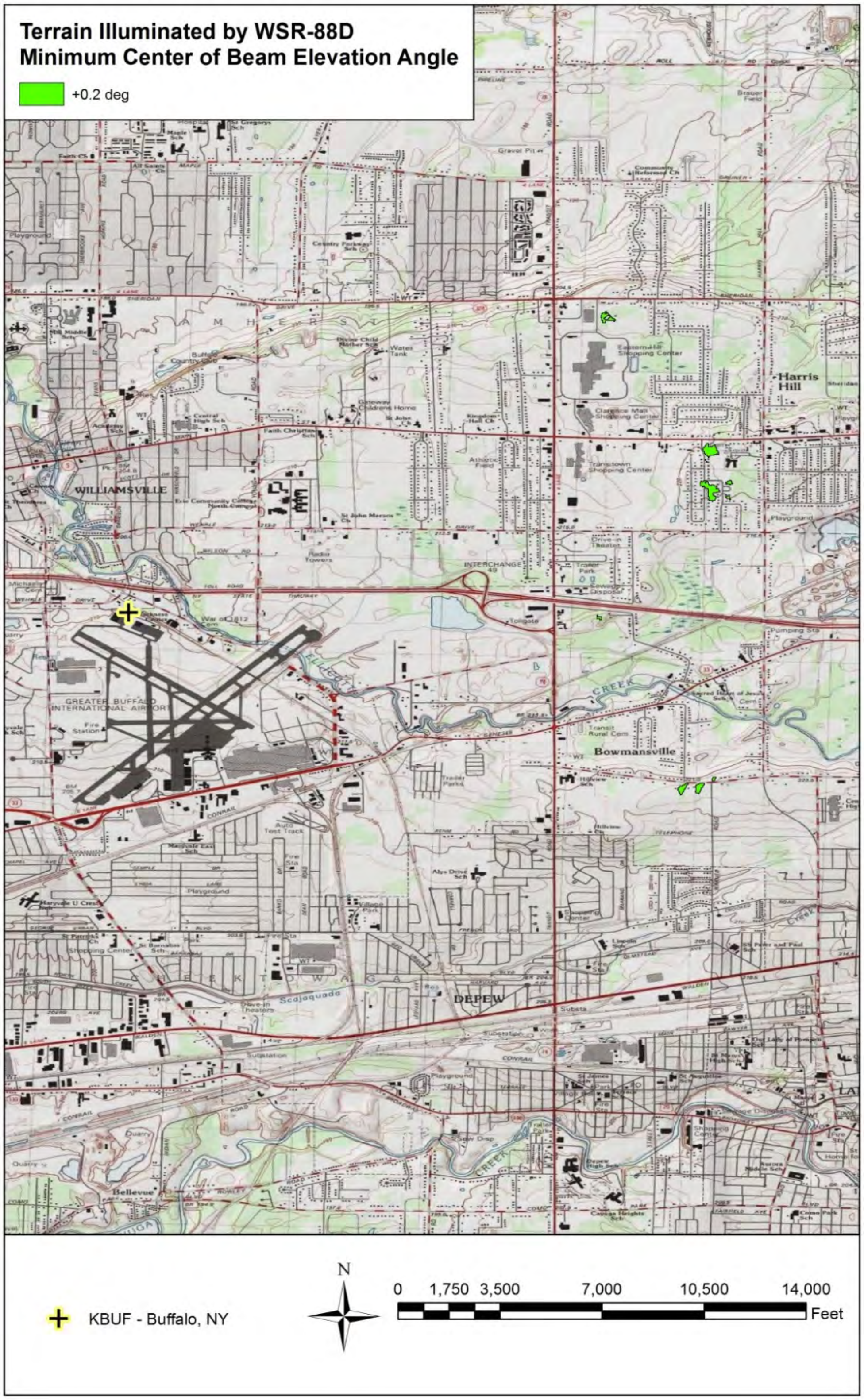
ATTACHMENT B

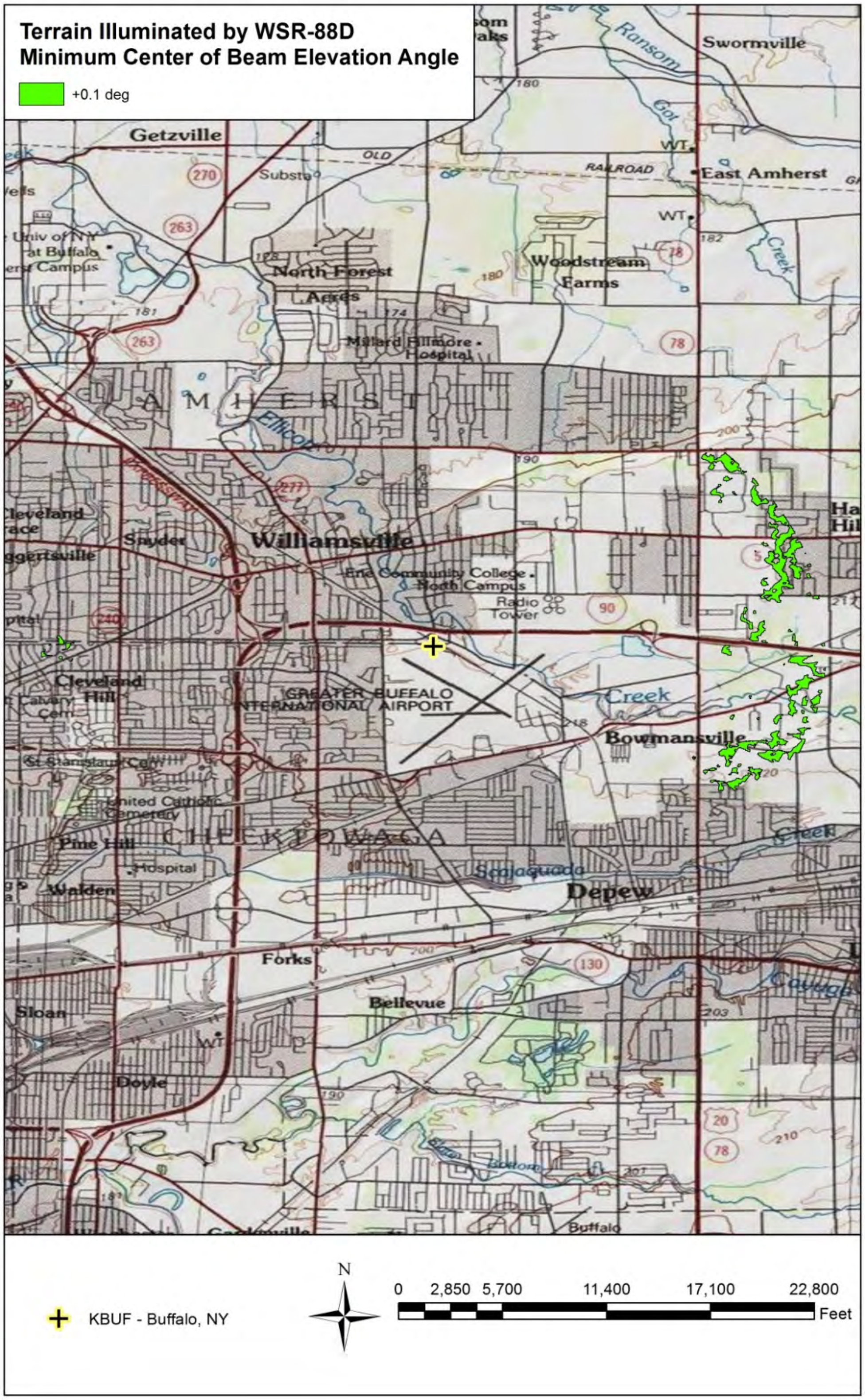
KBUF WSR-88D COVERAGE MAP, MINIMUM SCAN ANGLES +0.5 deg to -0.2 deg

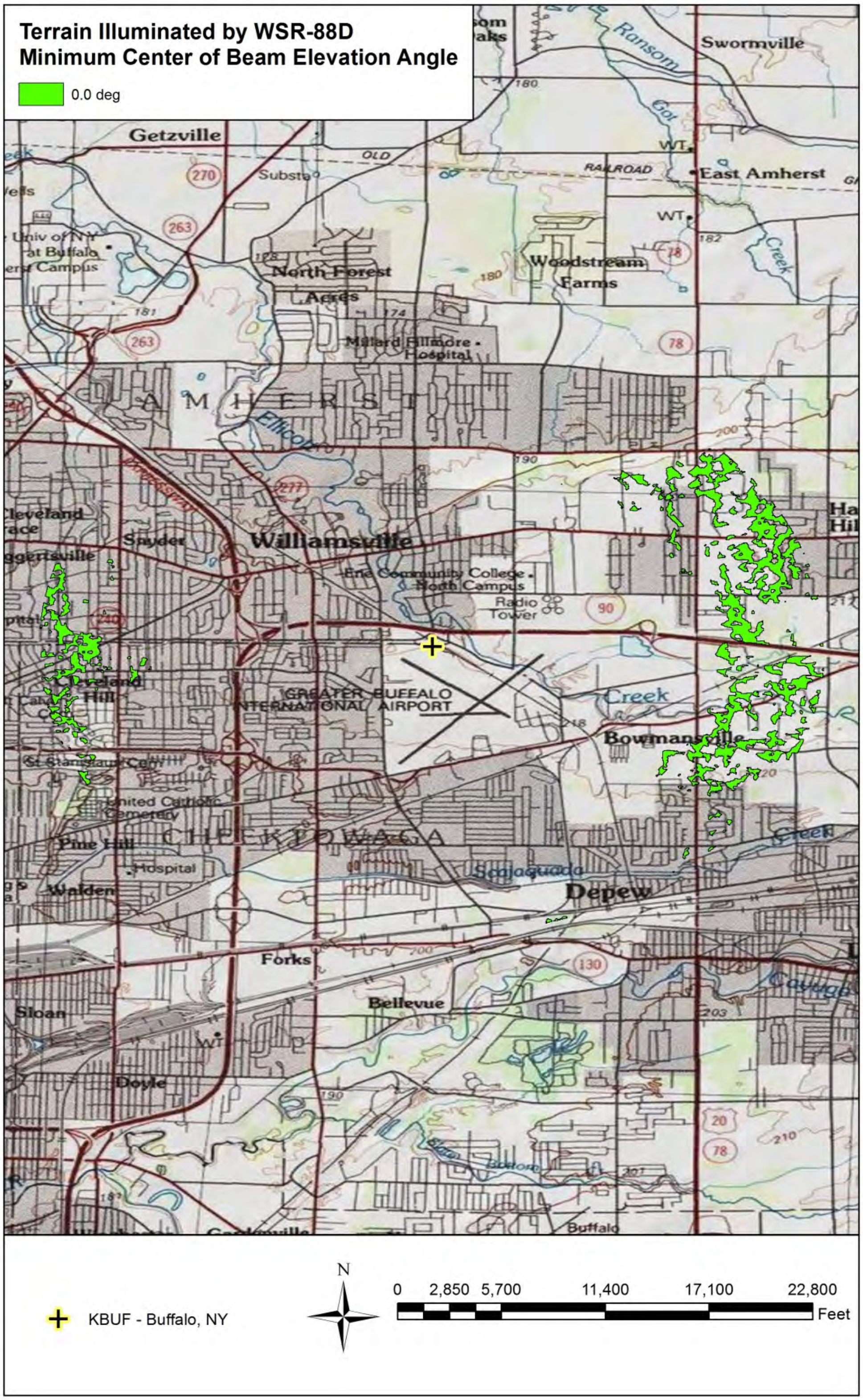

Radar Coverage at 2,000 ft ASL
Minimum Center of Beam Elevation Angle
+0.5 deg
+0.3 deg
+0.4 deg
+0.2, +0.1, 0.0, -0.1, and -0.2 deg
ONTARIO
NEW YORK
Orleans
Monroe
Wayne
Niagara
Genesee
Ontario
Erie
Wyoming
Livingston
Steuben
Allegany
Chautauqua
Cattaraugus
McKean
Potter
Warren
OHIO
PENNSYLVANIA
Crawford
Ashtabula
Forest
Elk
Cameron
Clinton
Venango
KBUF - Buffalo, NY
Major Highway
MN
-10.7°
0 12.5 25 50 75
Miles
Lambert Projection
Central Meridian: -96
1st Std Parallel: 20
2nd Std Parallel: 60
Latitude of Origin: 40

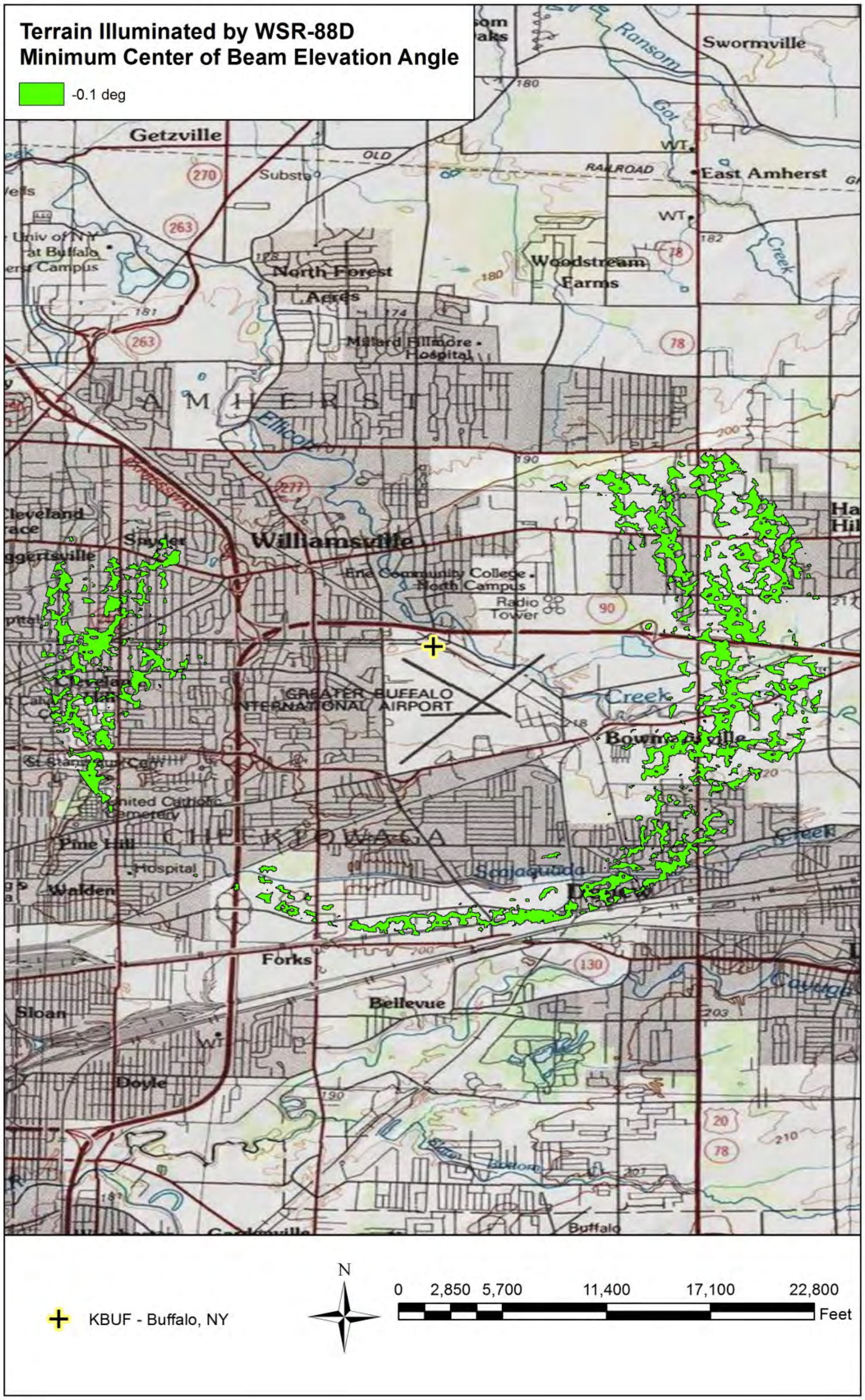
ATTACHMENT C

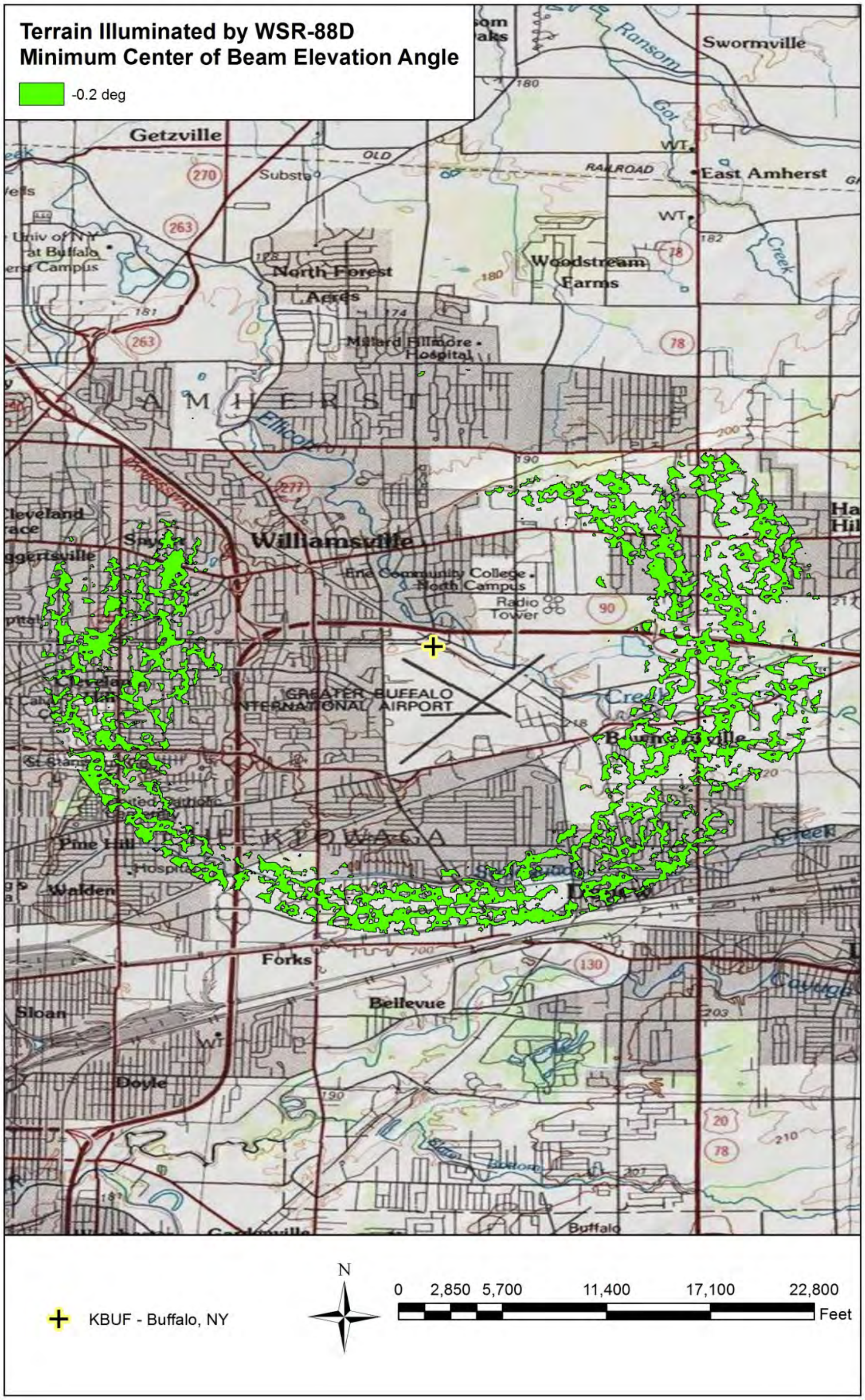
KBUF WSR-88D COVERAGE MAPS, NEARBY DIRECTLY ILLUMINATED TERRAIN AT MINIMUM CENTER OF BEAM SCAN ANGLES OF +0.2 THROUGH -0.2 deg


Terrain Illuminated by WSR-88D
Minimum Center of Beam Elevation Angle
+0.2 deg
KBUF - Buffalo, NY
N
0 1,750 3,500 7,000 10,500 14,000
Feet


Terrain Illuminated by WSR-88D
Minimum Center of Beam Elevation Angle
+0.1 deg
KBUF - Buffalo, NY
N
0
2,850
5,700
11,400
17,100
22,800
Feet
Getzville
Swormville
East Amherst
North Forest Acres
Woodstream Farms
Millard Fillmore Hospital
AMHERST
Williamsville
Snyder
Erie Community College North Campus
Cleveland Hill
GREATER BUFFALO INTERNATIONAL AIRPORT
Bowmansville
CHEEKTOWAGA
Depew
Pine Hill
Walden
Forks
Bellevue
Sloan
Doyle


Terrain Illuminated by WSR-88D
Minimum Center of Beam Elevation Angle
0.0 deg
Getzville
East Amherst
Swormville
North Forest Acres
Woodstream Farms
Millard Fillmore Hospital
AMHERST
Williamsville
Snyder
Erie Community College North Campus
Radio Tower
GREATER BUFFALO INTERNATIONAL AIRPORT
Bowmansville
CHEEKTOWAGA
Pine Hill
Walden
Depew
Forks
Bellevue
Sloan
Doyle
KBUF - Buffalo, NY
N
0
2,850
5,700
11,400
17,100
22,800
Feet


Terrain Illuminated by WSR-88D
Minimum Center of Beam Elevation Angle
-0.1 deg
Getzville
Swormville
East Amherst
Woodstream Farms
North Forest Acres
Millard Fillmore Hospital
Williamsville
Erie Community College North Campus
Radio Tower
GREATER BUFFALO INTERNATIONAL AIRPORT
Snyder
Forks
Bellevue
Sloan
Doyle
Pine Hill
Walden
N
0 2,850 5,700 11,400 17,100 22,800
Feet
KBUF - Buffalo, NY


Terrain Illuminated by WSR-88D
Minimum Center of Beam Elevation Angle
-0.2 deg
Getzville
Swormville
East Amherst
North Forest Acres
Woodstream Farms
Millard Fillmore Hospital
AMHERST
Williamsville
Erie Community College North Campus
Radio Tower
GREATER BUFFALO INTERNATIONAL AIRPORT
Forks
Bellevue
Sloan
Doyle
Pine Hill
Walden
KBUF - Buffalo, NY
N
0
2,850
5,700
11,400
17,100
22,800
Feet