Nationwide Public Safety Broadband Network
Final Programmatic Environmental Impact Statement for the Non-Contiguous United States

FirstNet®

First Responder Network Authority

Volume 1 - Chapters 1, 2, & 3

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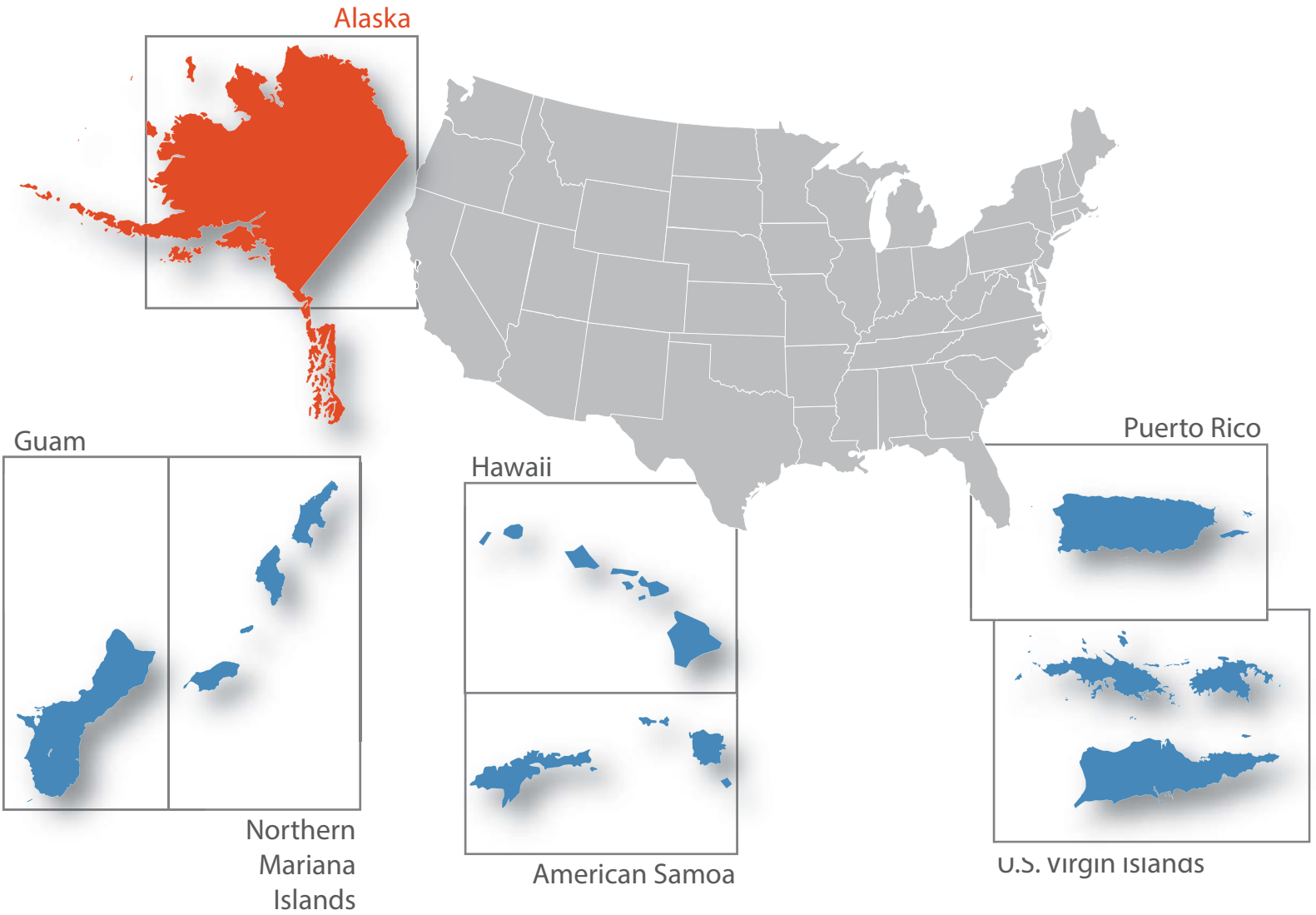

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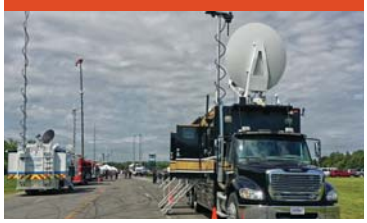

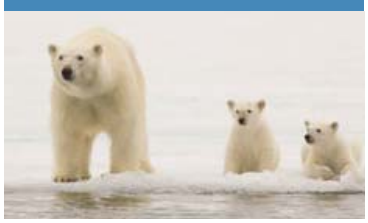

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First Responder Network Authority

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Volume 1

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Cooperating Agencies
Federal Communications Commission
General Services Administration
U.S. Department of Agriculture—Natural Resource Conservation Service
U.S. Department of Agriculture—Rural Utilities Service
U.S. Department of Agriculture—U.S. Forest Service
U.S. Department of Commerce—National Telecommunications and Information Administration
U.S. Department of Defense—Department of the Air Force
U.S. Department of Energy
U.S. Department of Homeland Security

May 2017

Cover Art Sources:

DVM (Digital Vector Maps). 2007. Blank Puerto Rico Outline. Digital Map. Accessed: April 2017. Retrieved from: http://digital-vector-maps.com/state-maps-detail/2194/Blank-Puerto-Rico-Outline-Adobe-Illustrator.htm

Environmental Resources Management, Inc. 2017. Map artwork: contiguous United States and states of Alaska and Hawaii.

Getty Images. Undated. Maps of Guam, U.S. Virgin Islands, and American Samoa. Accessed: April 2017. Retrieved from: http://www.gettyimages.com/

Marine Mammal Commission. Undated. *Polar bear (Ursus maritimus)*. Uncredited Marine Mammal Commission Photograph. Accessed: February 2017. Retrieved from: https://www.mmc.gov/priority-topics/species-of-concern/polar-bear/

Nakano, Hajime. 2006. *Latte Stones in Latte Stone Park, Hagnata, Guam*. Photograph. Wikimedia Commons. Accessed: March 2017. Retrieved from: https://upload.wikimedia.org/wikipedia/commons/a/ad/Latte_stones_in_Hagatna.jpg <https://upload.wikimedia.org/wikipedia/commons/a/ad/Latte_stones_in_Hagatna.jpg>

NPS (National Park Service). 2016. *Fruit Bat [White-necked Flying Fox (Pteropus tonganus)]*. Uncredited NPS Photograph. Accessed: January 2016. Retrieved from: http://www.nps.gov/npsa/learn/education/fruit-bats-are-our-friends.htm

Tapilatu, R. 2016. *Leatherback Turtle*. Photograph. National Marine Fisheries Service. Accessed: March 2017. Retrieved from: http://www.nmfs.noaa.gov/pr/species/turtles/images/leatherback_r.tapilatu.jpg

U.S. Census Bureau, Department of Commerce. 2012. TIGER/Line Shapefile, Commonwealth of the Northern Mariana Islands. Metadata updated May 17, 2013. Accessed: April 2017. Retrieved from: https://catalog.data.gov/dataset/tiger-line-shapefile-2012-state-commonwealth-of-the-northern-mariana-islands-current-census-tra

USFWS (U.S. Fish and Wildlife Service). 2013a. *Mariana Fruit Bat Pteropus mariannus / Fanihi*. Uncredited USFWS Photograph. Accessed: January 2016. Retrieved from: http://www.fws.gov/refuge/guam/wildlife_and_habitat/mariana_fruit_bat.html

_____. 2013b. *Nēnē Branta sandvicensis / Hawaiian Goose*. Photograph by Laura Beauregard, USFWS. Accessed: January 2016. Retrieved from: http://www.fws.gov/refuge/Hakalau_Forest/wildlife_and_habitat/nene.html

_____. 2015. *Rota blue damselfly (Ischura luta)*. Photograph by A. Asquith, USFWS. Accessed: January 2016. Retrieved from: https://www.fws.gov/news/ShowNews.cfm?ID=4DA36523-E516-A820-414BB2B0165E7461

_____. 2016. *West Indian Manatee.* Photograph by Keith Ramos, USFWS. Accessed: January 2016. Retrieved from: http://www.fws.gov/southeast/wildlife/mammal/manatee/

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ACRONYMS AND ABBREVIATIONS

°F	degree Fahrenheit
°N	degrees north
µg/m^3	microgram(s) per cubic meter
µPa	micro Pascal
%	percent
A	attained
AAC	Alaska Administrative Code
AAFIS	Alaska Public Safety Identification System
AAQS	Ambient Air Quality Standards
ACHP	Advisory Council on Historic Preservation
ACS	American Community Survey (U.S. Census Bureau)
ADEC	Alaska Department of Environmental Conservation
ADFG	Alaska Department of Fish and Game
AGL	above ground level
AIRFA	American Indian Religious Freedom Act
AJRCCM	American Journal of Respiratory and Critical Care Medicine
AKNHP	Alaska National Heritage Program
AKOSH	Alaska Occupational Safety and Health
AKWAS	Alaska Warning System
ALMR	Alaska Land Mobile Radio
ANCSA	Alaska Native Claims Settlement Act
ANFIRS	Alaska Fire Incident Reporting System
ANSI	American National Standards Institute
APE	Area of Potential Effect
APLIC	Avian Power Line Interaction Committee
APSIN	Alaska Public Safety Information Network
AQCR	air quality control region
ARFF	Aircraft Rescue and Firefighting
ARMS	Alaska Records Management System
ARPA	Archaeological Resources Protection Act of 1979
AS	Alaska Statute
ASAC	American Samoa Administrative Code
ASCA	American Samoa Code Annotated
ASCMP	American Samoa Coastal Management Program
ASDHS	American Samoa Department of Homeland Security
ASDMWR	American Samoa Department of Marine and Wildlife Resources
ASEPA	American Samoa Environmental Protection Agency
ASHPO	American Samoa Historic Preservation Office
ASPA	American Samoa Power Authority
ATO	Air Traffic Organization
ATWC	Alaska Tsunami Warning Center
AURORA	Alaska Uniform Response Online Reporting Access
BACT	best available control technology
BCE	before Common Era
BCR	Bird Conservation Regions
BGEPA	Bald and Golden Eagle Protection Act
BLM	Bureau of Land Management
BLS	U.S. Bureau of Labor Statistics
BMP	best management practice
BRFSS	Behavioral Risk Factor Surveillance System
BSAI	Bering Sea/Aleutian Island
BWG	BioInitiative Working Group
CAA	Clean Air Act
CAB	Clean Air Branch
CARB	California Air Resources Board
CBIA	Coastal Barrier Improvement Act of 1990
CBRA	Coastal Barrier Resources Act of 1982
CCP	Comprehensive Conservation Plan
CDC	Center for Disease Control
CDLNR	Commonwealth Department of Lands and Natural Resources
CE	Common Era
CELCP	Coastal and Estuarine Land Conservation Program
CEPD	Caribbean Environmental Protection Division
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFMC	Caribbean Fisheries Management Council
CFR	Code of Federal Regulations
cfs	cubic feet per second
CH_4	methane
CHC	Commonwealth Health Center
CIA	Central Intelligence Agency
CMIP3	Coupled Model Intercomparison Project phase 3
CNMI	Commonwealth of Northern Mariana Islands
CNMIAC	Commonwealth of Northern Mariana Islands Administrative Code
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalents
COMAR	Committee on Man and Radiation

CPA	Commonwealth Ports Authority
CRMP	Coastal Resources Management Program
CSP	Central South Pacific
CUC	Commonwealth Utilities Corporation
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
CZMP	Coastal Zone Management Program
DACA	Deployable Airborne Communications Architecture
DAR	Division of Aquatic Resources (Hawaii)
DAWR	Division of Aquatic and Wildlife Resources (Guam)
dB	decibel(s)
dBA	A-weighted decibel(s)
DBCP	1,2-dibromo-3-chloropropane
dBZ	Z-weighted decibel(s)
DCP	1,2-dichloropropane
DEC	Department of Environmental Conservation
DHHL	Department of Hawaiian Homelands
DLNR	Department of Land and Natural Resources (Hawaii)
DMA	Disaster Mitigation Act of 2000
DNER	Department of Natural and Environmental Resources of Puerto Rico
DOA	Department of Agriculture
DOD	Department of Defense
DOE	U.S. Department of Energy
DOH	Department of Health
DOH-CAB	Hawaii Department of Health, Clean Air Branch
DOT	U.S. Department of Transportation
DPNR	Department of Planning and Natural Resources (U.S. Virgin Islands)
DPS	Department of Public Safety
EA	Environmental Assessment
EAS	Emergency Alert System
EBS	Emergency Broadcast System
EDB	ethylene dibromide
EFH	essential fish habitat
EMS	emergency medical services
ENSO	El Niño/Southern Oscillation
EO	Executive Order
EPCRA	Emergency Planning and Community Right-to-Know Act
ERP	effective radiated power
ESA	Endangered Species Act
ESI	Environmental Sensitivity Index
FAA	Federal Aviation Administration
FAD	Fish Aggregating Device
FCC	Federal Communications Commission
FEMA	Federal Emergency Management Agency
FirstNet	First Responder Network Authority
FMP	Fishery Management Plan
FPPA	Farmland Protection Policy Act of 1981
FR	Federal Register
ft	feet
g/hp-hr	grams per horsepower-hour
g/mi	grams per mile
GAP	Gap Analysis Program
GCA	Guam Code Annotated
GDA	Guam Department of Agriculture
GEPA	Guam Environmental Protection Agency
GHG	greenhouse gas
GIS	geographic information system
GMP	General Management Plan
GOA	Gulf of Alaska
GRHP	Guam Register of Historic Places
GWP	global warming potential
H_2S	hydrogen sulfide
HDOH	Hawaii Department of Health
HEI	Health Effects Institute
HHCA	Hawaiian Homes Commission Act of 1920
HI-EMA	Hawaii Emergency Management Agency
HIANG	Hawaii Air National Guard
HIARNG	Hawaii Army National Guard
HIHWNMS	Hawaiian Islands Humpback Whale National Marine Sanctuary
HIOSH	Hawaii Occupational Safety and Health Division
hp	horsepower
HRD	(Guam) Historic Resources Division
HRHP	Hawaii Register of Historic Places
HRS	Hawaii Administrative Rules, Revised Statute
HTA	Hawai'i Tourism Authority
HUC	hydrologic unit code
I/M	Inspection/Maintenance
IARC	International Agency for Research on Cancer
IBA	Important Bird Area
IEEE	Institute of Electrical and Electronics Engineers
IFC	International Finance Corporation
in	inches
IPCC	Intergovernmental Panel on Climate Change
IR	ionizing radiation
ITCZ	Intertropical Convergence Zone
IUCN	International Union for Conservation of Nature
kg/gal	kilograms per gallon
KIRC	Kaho'olawe Island Reserve Commission

LAER	lowest achievable emission rate
lb/day	pounds per day
lb/hp-hr	pounds per horsepower-hour
LBJ	Lyndon B. Johnson
Ldn	day-night average sound level
Leq	equivalent noise levels
LNG	liquefied natural gas
LTE	Long Term Evolution
$\mu g/m^3$	microgram(s) per cubic meter
µPa	micro Pascal
m/s	meter per second
MBTA	Migratory Bird Treaty Act
mg/m^3	Milligram(s) per cubic meter
mgd	million gallons per day
MHz	megahertz
MLRA	Major Land Resource Area
mm/s	millimeters per second
MMPA	Marine Mammal Protection Act
MOA	Memorandum of Agreement
MPA	Marine Protected Area
mph	miles per hour
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MTR	Military Training Route
MUID	Map Unit Identification Data
MW	megawatt
mW/cm^2	milliwatts per centimeter squared
N	north; not attained
N_2O	nitrous oxide
NA	not applicable; not assessed
NAAQS	National Ambient Air Quality Standards
NAGPRA	Native American Graves Protection and Repatriation Act
NANSR	Nonattainment New Source Review
NAWAS	National Warning System
NCA	National Climate Assessment
NCD	non-communicable disease
NCDC	National Climatic Data Center
NCN	no common name
NCRP	National Council on Radiation Protection and Measurements
ND	no data
NE	northeast
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NFIP	National Flood Insurance Program
NFIRS	National Fire Incident Reporting System
NHPA	National Historic Preservation Act
NIR	non-ionizing radiation
NMFS	National Marine Fisheries Service
NMHC	non-methane hydrocarbon compounds
NMOG	non-methane organic compounds
NNE	north-northeast
NOAA	National Oceanic and Atmospheric Administration
NOx	nitrogen oxides
NP	National Park
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NPS	National Park Service
NPSBN	nationwide public safety broadband network
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NSPS	New Source Performance Standards
NTIA	National Telecommunications and Information Administration
NVSR	National Vital Statistics Report
NWI	National Wetland Inventory
NWR	National Wildlife Refuge
NWWS	National Weather Wire Satellite System
OHA	Office of History and Archaeology
OIA	Office of Insular Affairs (USDI)
OSHA	Occupational Safety and Health Administration
PA	Programmatic Agreement
PAG	Port Authority of Guam
PAHO	Pan American Health Organization
PCB	polychlorinated biphenyl
PCP	pentachlorophenol
PCS	Personal Communications Service
PDO	Pacific Decadal Oscillation
PEIS	Programmatic Environmental Impact Statement
PL	Public Law
PM	particulate matter
PM_{10}	particulate matter up to 10 micrometers in diameter
$PM_{2.5}$	particulate matter up to 2.5 micrometers in diameter
POPs	points of presence
ppm	parts per million
PRDNER	Puerto Rico Department of Natural and Environmental Resources
PREQB	Puerto Rico Environmental Quality Board
PR OSHA	The Puerto Rico Occupational Safety and Health Administration
PRASA	Puerto Rico Aqueduct and Sew Authority
PREPA	Puerto Rico Electric Power Authority
PRSHPO	Puerto Rico State Historic Preservation Office
PSD	Prevention of Significant Deterioration
PUAG	Public Utility Agency of Guam
Pub. L.	Public Law

PV	photovoltaic
RAN	radio access network
RCP	Representative Concentration Pathway
RCRA	Resource Conservation and Recovery Act
RF	radio frequency
RIN	Regulation Identification Number
rms	root mean square
ROW	right-of-way
SAAQS	State Air Quality Standards
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act:A Legacy for Users
SARA	Superfund Amendments and Reauthorization Act of 1986
SE	Standard of Error
SHPO	State Historic Preservation Office
SIP	State Implementation Plan
SLR	sea level rise
SMA	Special Management Area
SMS	Scenery Management System
SO_2	sulfur dioxide
SOx	sulfur oxides
SPCC	Spill Prevention, Control, and Countermeasure
SPCZ	South Pacific Convergence Zone
SPOC	State Single Point of Contact
SRES	Special Report on Emission Scenarios
SSA	sole source aquifer
STATSGO2	State Soil Geographic [Database]
SW	southwest
TAAQS	Territory Ambient Air Quality Standards
TCP	traditional cultural property
TEMCO	Territorial Emergency Management Coordinating Office
TMDL	Total Maximum Daily Load
TOC	total organic compound
tpy	tons per year
TRI	Toxic Release Inventory
TSCA	Toxic Substances Control Act
U.S.	United States
UAMES	University of Alaska Museum Earth Sciences
USACE	U.S. Army Corps of Engineers
USC	United States Code
USDA	U.S. Department of Agriculture
USDI	U.S. Department of the Interior
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGCRP	U.S. Global Climate Change Research Program
USGS	U.S. Geological Survey
USVIDOH	U.S. Virgin Islands Department of Health
USVIPD	U.S. Virgin Islands Police Department
UVA	University of Virginia
VdB	vibration decibel(s)
VIC	Virgin Islands Code
VIPA	Virgin Islands Port Authority
VISHPO	Virgin Islands State Historic Preservation Office
VOC	volatile organic compound
vog	volcanic smog
VRM	Visual Resource Management
W	watt(s)
W/m^2	watts per meters squared
WAPA	Water and Power Authority
WHO	World Health Organization
WIMARCS	West Indies Marine Animal Research and Conservation Science
WNP	Western North Pacific
WNW	west-northwest
WPC	watts per channel
WPRFMC	Western Pacific Regional Fishery Management Council

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2. DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES

In accordance with the National Environmental Policy Act (NEPA), FirstNet must examine a range of reasonable alternatives to design, construct, and operate the Nationwide Public Safety Broadband Network (NPSBN). These alternatives must be reasonable ways in which FirstNet could meet the purpose and need for the Proposed Action. In addition to the range of reasonable alternatives, this document also describes those alternatives considered but not carried forward for analysis. Alternatives not carried forward were initially considered but found to not reasonably meet the purpose and need. FirstNet is also required to include the alternative of no action as part of the alternatives analysis in the Programmatic Environmental Impact Statement. The "No Action Alternative" describes what would happen if FirstNet did not construct the NPSBN, and is used as a baseline against which the potential impacts of the action alternatives can be compared.

2.1. PROPOSED ACTION

The Proposed Action would encompass the design, deployment/construction, and operation of the NPSBN by FirstNet or a partner organization(s)[1] through a comprehensive network procurement process, currently underway. FirstNet anticipates a competitive process to procure a comprehensive technical and business solution to meet its stated mission and objectives. By statute, the network must have several characteristics, including security, resiliency, backwards compatibility with existing commercial networks, integration with public safety answering points[2] or their equivalents, substantial rural coverage; it must be built to open, non-proprietary, commercially available standards; and it must use existing infrastructure to the maximum extent economically desirable. The FirstNet network would have two components, the core network, and the radio access network (RAN). The core network is a key component for ensuring that users have a single interoperable platform nationwide, and would consist of a wide range of telecommunications infrastructure including fiber optic cable, towers, data centers, microwave technology, and others. The core is envisioned to have six primary functions: it switches data, processes and reformats information, stores and maintains data, and keeps it secure. The core network would interface with local, tribal, state, and federal networks, including 911 and the internet, thereby serving as the backbone connecting the 50 states, 5 territories, and the District of Columbia. The core network would be constructed and maintained to the most up-to-date technological standards, comprised of all standard Evolved Packet Core (EPC) elements under the 3rd Generation Partnership Project (3GPP). The EPC is the collection of systems that manages the connection of all voice calls, data sessions, messaging, and video services in a wireless network. Since the EPC is responsible for the management of all services, it is the central "brain" of the network. The RAN would consist of all radio base station infrastructure that would connect user devices. This infrastructure would include communication towers, cell site equipment, antennas, deployable mobile hotspots, and backhaul equipment required to

[1] FirstNet's partner organization(s) would assist in providing resources as necessary to deploy and operate the NPSBN.

[2] Public safety answering points are call centers responsible for answering calls to an emergency telephone number for police, fire, and emergency medical services.

enable wireless communications with devices using the public safety broadband spectrum. Finally, the Act states that FirstNet must continue to maintain and improve the NPSBN to account for new and evolving technologies.

FirstNet may enter into Spectrum Manager Lease Agreements (SMLAs) with states that opt-out of the FirstNet network. However, as NEPA applies equally to opt-in and opt-out states, the range of methods that would be employed by states to connect their RAN to the FirstNet core network are expected to include methods described and analyzed in the various alternatives listed below.

2.1.1. Characteristics of the NPSBN

The Act specifies that the FirstNet network would be based on the minimum technical requirements on the commercial standards for Long Term Evolution (LTE) service. LTE is a proven upgradeable technology, now in its fourth generation (4G). Improvements in speed and function are achieved with each subsequent generation, and 4G LTE standards are continuing to evolve. FirstNet is involved in the research and development of new standards and is working closely with the public safety community as part of this process, with the goal of ensuring that the unique needs of public safety can be met.

As stated above, the core network is envisioned to have six primary functions: it would switch data, process and reformat information, store and maintain data, and keep that data secure. Other functions, such as applications, services, and operational and business support systems would also be part of the core network. The backhaul, or intermediate links that carry user traffic, including voice, data, and video, and signaling from radio base stations to the core network, would likely be accomplished through fiber optic and microwave technology, with an emphasis on redundancy to allow the network to continue to function in events of extreme demand.

The RAN would place an emphasis on reliability, prioritizing physical hardening and security. Redundant power backup, redundant backhaul capabilities, structural hardening, and security measures would be implemented as appropriate to provide a resilient and reliable radio base station infrastructure.

2.1.2. Proposed Action Infrastructure

There is currently a wide range of technologies that FirstNet may use to implement and deploy the NPSBN, ranging from fixed assets to mobile, deployable infrastructure. The following are general descriptions of the types of wired, wireless, and deployable projects that FirstNet may consider.

2.1.2.1. Wired Projects

New Build – Buried Fiber Optic Plant

The installation of fiber optic cable would generally consist of plowing or trenching cable alongside the road usually within a utility corridor or within public road right-of-way (ROW), where possible. Utility ROWs could also include other easements and may be public or private.

This could involve either burying both conduit and cable inside the conduit or only direct buried cable. Installation may involve plowing, trenching (including vibratory plowing), or directional boring, and may involve the construction of points of presence (POPs),[3] huts, or other facilities to house outside plant equipment or hand-holes to access the fiber.

Use of Existing Conduit – New Buried Fiber Optic Plant

The installation of new fiber optic cable in existing conduit typically requires blowing or pulling new fiber optic cable into existing, buried conduit. In this project scenario, any ground disturbance would usually be limited to the entry and exit points of the existing conduit.

New Build – Aerial Fiber Optic Plant

Construction of new aerial fiber optic cable would generally consist of installing new poles and hanging cables in previously disturbed or new (undisturbed) ROWs or easements, or installing replacement poles in previously disturbed ROWs or easements. Installation of new poles and fiber may involve construction of access roads, depending on the availability of ROWs. This type of activity may also involve the constructions of POPs, huts, or other facilities to house outside plant equipment.

Collocation on Existing Aerial Fiber Optic Plant

Installation of new fiber on existing poles may require structural hardening or reinforcement to improve disaster resistance and resiliency. It may also require pole replacement to accommodate an increased load from new users. All replacement poles must be placed in the exact same hole in order for the action to qualify as "collocation".

Use of Existing Buried or Aerial Fiber Optic Plant or Existing Submarine Cable

This project type would involve lighting up dark fiber owned by and leased from various providers. Dark fiber is fiber that has been installed without a transmitter and receiver, typically to provide capacity for future growth.

New Build – Submarine Fiber Optic Plant

Deployment of new submarine cable, if implemented, would involve the installation of specially sealed cables in limited near-shore or inland bodies of water, and construction of landings/ facilities on the shore to accept a cable, which is typically buried close to shore. Transoceanic submarine cables are not anticipated to be used as part of the Proposed Action; therefore, submarine repeaters and large marine vessels for installation or repairs would not be used. However, small marine vessels could be required for installation and repairs of smaller, non-transoceanic cables in limited near-shore or inland bodies of water.

[3] POPs are connections or access points between two different networks, or different components of one network.

Installation of Optical Transmission or Centralized Transmission Equipment

All fiber installation activities may require additional installation of equipment to enhance the digital signals travelling through the fiber, depending on the network configuration. FirstNet may also install transmission equipment as part of the core network construction.

This equipment is usually installed in small boxes or huts in the ROW of the utility corridor, and may involve construction of access road, depending on the availability of public ROW.

2.1.2.2. Wireless Projects

New Wireless Communication Towers

FirstNet may undertake the construction of new towers of various heights and configurations (e.g., monopoles, lattice, and guy-wired) to support wireless infrastructure, such as antennas and microwave dishes. Tower construction may also include associated structures including generators, equipment sheds, fencing, security lighting, aviation lighting, electrical feeds, and concrete foundations and pads. This type of project may require the construction of access road, depending on the availability of public ROW.

Collocation on Existing Wireless Tower, Structure, or Building

Collocation projects would involve mounting or installation of equipment such as antennas or microwave dishes on an existing tower to transmit and/or receive signals, or provide backhaul. Installation of power units, such as an uninterruptible power supply could be added. Existing towers, structures, or buildings may require structural hardening or increased physical security measures.

2.1.2.3. Deployable Technologies

As part of the Proposed Action, there may be areas where permanent, fixed infrastructure cannot be erected due to a variety of factors. Deployable technologies may provide an option to either provide coverage in such areas, or they may be used to supplement existing coverage during a large-scale planned or emergency event. In addition, deployable technologies could also be used in areas where potential permanent impacts to significant sensitive resources/receptors cannot be avoided or mitigated. In general, some limited construction could be associated with the implementation of deployable technologies such as land clearing or paving for parking or staging areas.

Cell on Wheels

The Cell on Wheels deployable technology consists of a cellular base station on a trailer with an expandable antenna mast, typically between 15 feet and 40 feet, and usually a microwave or satellite link back to the main controller. Cell on Wheels typically contain a small generator and may also connect to utility power cables. This type of technology is designed to be part of a cellular network and augment existing capacity.

Cell on Light Truck

The Cell on Light Truck deployable technology consists of a cellular base station on a light truck platform with an expandable antenna mast, typically between 15 feet and 40 feet, and usually a microwave or satellite link back to the main controller. Cell on Light Truck typically contains a small generator and may also connect to utility power cables. This type of technology is designed to be part of a cellular network and augment existing capacity.

System on Wheels

The System on Wheels deployable technology consists of a full base station and controller on a large towable trailer or truck. A System on Wheels is a fully self-contained cellular system that can provide an island system with no need for satellite/microwave link back. System on Wheels typically contains a power generator and a larger antenna mast (ranging from approximately 50 feet to 120 feet), suitable to address larger localized coverage or capacity shortages in the event of planned or unplanned incidents.

Deployable Aerial Communications Architecture

Deployable Aerial Communications Architecture consists of aerial vehicles, including, but not limited to, drones, piloted aircraft, balloons, and blimps, which would be deployed at a variety of altitudes and are capable of providing wide-area coverage, although with relatively low capacity/throughput. Deployable Aerial Communications Architectures would be used for addressing wide scale loss of coverage after a major catastrophic event, which would have the network down for a significant period.

2.1.2.4. Satellites and Other Technologies

Satellite-Enabled Devices and Equipment

FirstNet may install permanent equipment on existing structures or support the use of portable devices that use satellite technology, such as satellite phones or video cameras.

Deployment of Satellites

FirstNet does not anticipate launching satellites as part of the deployment of the NPSBN; however, it could include equipment on satellites that are already being launched for other purposes and may work with other federal agencies or commercial entities that engage in satellite launches to use Global Positioning System satellites to support devices requiring location information.

2.2. DESCRIPTION OF ALTERNATIVES

In accordance with NEPA, FirstNet has considered a variety of alternatives to ensure the building, deployment, and operation of the NPSBN. The Council on Environmental Quality has defined reasonable alternatives as those that are economically and technically feasible ways to meet the purpose and need. NEPA also requires the analysis of the No Action Alternative, which provides a baseline against which the potential impacts of the Action Alternatives may be

compared. FirstNet is carrying two alternatives plus the No Action Alternative forward for analysis. Furthermore, FirstNet has considered three additional alternatives and dismissed them from further consideration (see Section 2.3., Alternatives Considered but not Carried Forward, below).

2.2.1. Preferred Alternative

Under the Preferred Alternative, FirstNet and/or its partners would construct a nationwide broadband LTE network using a combination of the wired, wireless, deployable, and satellite technologies. This may include, but is not limited to, the following methods: collocation of the network equipment on existing towers, poles and structures; construction of new communication towers, poles and associated structures to include generators, equipment sheds, fencing, and concrete pads; use of existing fiber facilities, including lighting up dark fiber and installation of new fiber on existing poles and in existing conduit; installation of new conduit and fiber using trenching (including vibratory plowing) or directional boring (including horizontal directional drilling); deployment of satellite phones and other portable satellite technology; launching of satellites; installation of microwave facilities for cell-site backhaul communication; and the utilization of deployable technologies.

2.2.2. Deployable Technologies Alternative

Under the Deployable Technologies Alternative, FirstNet would procure, deploy, and maintain a nationwide fleet of mobile communications systems, including ground-based and aerial deployable technologies, to provide temporary coverage in areas not covered by existing, usable infrastructure, as there would be no collocation of equipment or new construction associated with wired or wireless projects discussed above under the Preferred Alternative. Generally, these units would be deployed at times of an incident to the affected area for either planned or unplanned incidents or events. Equipment would be stationed in every state and territory, often at multiple locations in each state or territory, to facilitate suitable response. These mobile communication units would be temporarily installed and may use existing satellite, microwave, or radio systems for backhaul. In general, some limited construction could be associated with the implementation of deployable technologies such as land clearing or paving for parking or staging areas. However, these construction activities would be minimal in comparison to the combination of project types associated with the Preferred Alternative as described above.

2.2.3. No Action Alternative

Under the No Action Alternative, the NPSBN would not be constructed; there would be no nationwide, coordinated system dedicated to public safety interoperable communications. The existing multiplicity of communications networks would remain in place, as would the current, known limitations and problems of existing communication networks during times of emergency or disaster. This alternative would require an act of Congress to revise the Act, which currently requires the NPSBN.

2.3. ALTERNATIVES CONSIDERED BUT NOT CARRIED FORWARD

During the course of the development of the Proposed Action, several additional alternatives to implement the Proposed Action were considered. Each of these alternatives was found deficient in some way, and did not meet the purpose and need for the Proposed Action as discussed below.

2.3.1. New Construction Only Alternative

Under the New Construction Only Alternative, FirstNet would construct a nationwide network using all new construction and installation of fiber optic cable, conduit, utility poles, communication towers, and installed equipment. This alternative has been dismissed from further consideration because it is counter to FirstNet's legislative mandate to leverage existing infrastructure. Furthermore, new construction of the entire network would be cost-prohibitive and the construction timeline would cause unnecessary delays in network implementation as a result of the need for building an entirely new NPSBN from the ground up, which would not meet the agency's legislative purpose and the needs of the Proposed Action.

2.3.2. New Satellite Alternative

Under the New Satellite Alternative, FirstNet would construct a nationwide network using new and existing satellite technology only. Generally, satellite technology is not cost effective due to limited spectrum, and technical issues such as limited in-building coverage and performance. This alternative has been dismissed from further consideration because it is counter to FirstNet's mandate to use standards-based LTE technology to provide coverage, and its performance capabilities would not meet the purpose and need of the Proposed Action.

2.3.3. Collocation-Only Alternative

Under the Collocation-Only Alternative, FirstNet would construct the NPSBN using existing infrastructure only, by collocating equipment exclusively on existing towers, buildings, or other structures. This alternative has been dismissed from further consideration because suitable infrastructure does not exist to provide nationwide broadband coverage using only existing infrastructure. Many areas of the country, particularly rural areas, would have little to no service options from FirstNet if existing infrastructure alone were required to build the network. Therefore, this alternative would not meet the purpose and need of the Proposed Action.

2.4. RADIO FREQUENCY EMISSIONS

2.4.1. Introduction

General interest in the topic of the safety of radio frequency (RF) electromagnetic field emissions (RF emissions),[4] a form of radiation, from communication towers and their relationship to human health and the environment has increased with the number of devices being used and the

[4] RF emissions refer to RF radiation emitted by devices. OSHA defines RF radiation as "electromagnetic radiation in the frequency ranges 3 kilohertz (kHz) - 300 Megahertz (MHz), and 300 MHz - 300 gigahertz (GHz), respectively" (*OSHA Undated*).

degree of connectivity needed for people to go about their daily lives. This interest has been demonstrated in the comments received during the scoping and public comment periods by FirstNet for its Programmatic Environmental Impact Statement (PEIS) for the nationwide public safety broadband network (NPSBN), other telecommunications projects, as well as active discussions within the human health and environmental science communities and among the general public. Accordingly, FirstNet has determined it is important to analyze the potential human and environmental effects in the PEISs.

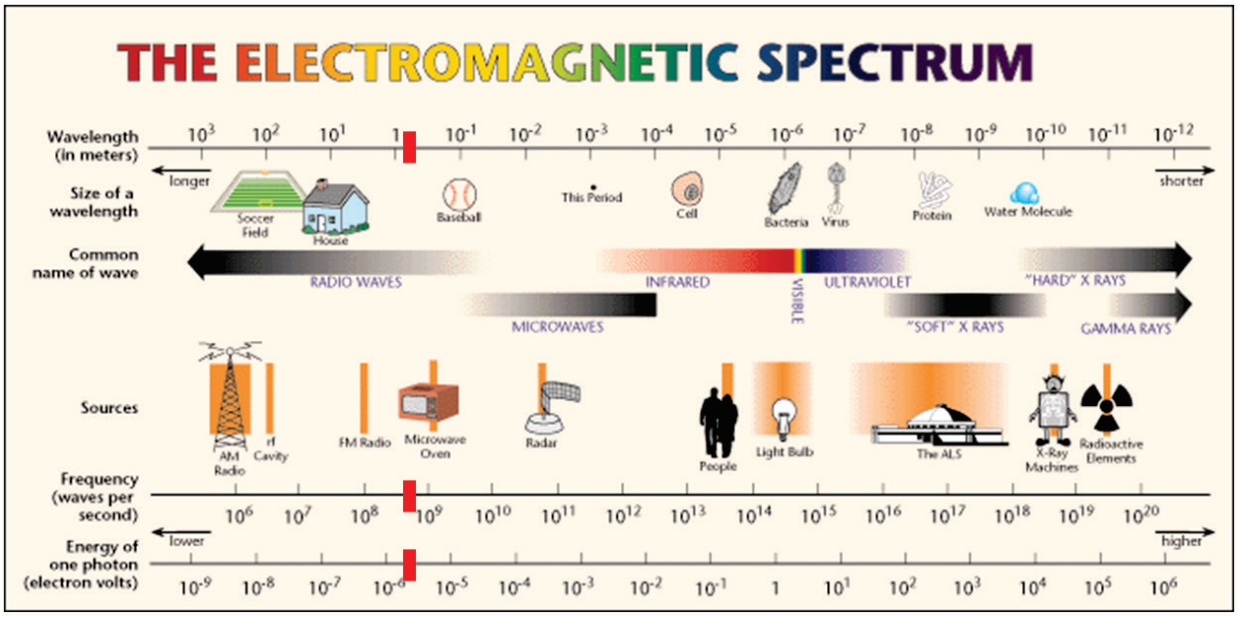
This document provides a general overview regarding RF emissions, the existing regulatory framework for limiting RF exposures, the general discussions on the current state of research for potential effects on humans, as well as information on animal and plant species, and some of the general conclusions on data gaps and the paths forward. While this document is not intended to be a complete analysis of all aspects of RF emissions and their potential effects, it does provide a general discussion of some of the credible scientific literature and information that relates to RF emissions and potential effects to human health and other species.

In general, radiation is the product of a wide range of energies that form the electromagnetic spectrum. A number of radiation sources exist in nature—such as the radon emitted from the breakdown of certain minerals in the ground or the radiation from energy in space—and others are artificial (such as RF emissions created by broadcasting, radio, and cellular equipment).

The electromagnetic spectrum is divided into two main classes:

- **Non-ionizing radiation (NIR)**. NIR is as the low end of the electromagnetic spectrum. Visible Light, AM/FM radio, cellular, and microwaves are all classified as NIR. The FirstNet system would operate in the 700 megahertz (MHz) frequency band, which means that it would emit NIR in the microwave spectrum (*Zamanian and Hardiman 2005*).
- **Ionizing radiation (IR)**. IR can produce charged particles (ions) in matter and is produced by unstable atoms that have an excess of energy or mass or both. Gamma radiation and x-rays are examples of IR. FirstNet equipment would not produce any IR (*Zamanian and Hardiman 2005*).

This review focuses on NIR related to cellular systems (e.g., tower and building-mounted equipment) and, specifically, the 700 MHz Long Term Evolution spectrum band licensed for use by FirstNet. Figure 2.4.1-1 details the full electromagnetic spectrum (*U.S. Department of Energy 2009*). The red band on each line of Figure 2.4.1-1 indicates the 700 MHz frequency band, portions of which are already being used for both commercial wireless and public safety communications.



Source: U.S. Department of Energy 2009

Note: The red band on each line indicates the 700 MHz frequency band licensed for use by FirstNet.

Figure 2.4.1-1: The Electromagnetic Spectrum

Radiation is frequently presented in the terms of *power intensity* or *irradiance*. The power intensity is the radiant flux[5] received by a specific surface area. The units for irradiance are watts (W) per meters squared (W/m^2). Frequently, RF emissions and exposure standards are defined in terms of power density. Some standards are explicitly defined while others are a function of the frequency of the radiation. Table 2.4.1-1 below summarizes the current Federal Communications Commission (FCC) standards for RF emissions for occupational/controlled exposure, as well as uncontrolled exposure.

Since FirstNet is licensed to operate in the 700 MHz range,[6] the FCC regulations establishing exposure limits would govern FirstNet operations and (power density) would be between 2.33 milliwatts per centimeter squared (mW/cm^2) and 2.66 mW/cm^2 for occupational or controlled exposure for frequencies of 700 and 799 MHz, respectively.[7] For these same frequencies and general population/uncontrolled exposure, the FCC standard exposure limits are 0.47 mW/cm^2 to 0.53 mW/cm^2. This analysis is intended to outline some preliminary information on the topic to describe the state of current research, science, and the unsettled issues surrounding RF emissions.

[5] The radiant flux is the amount of energy per unit time radiated from a source.
[6] FirstNet holds a single 700 MHz Public Safety Broadband Nationwide License, under Call Sign WQQE234.
[7] See *47 USC § 1421(a)*.

Table 2.4.1-1: FCC Regulatory Levels

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm^2)	Averaging Time $(E)^2$, $(H)^2$, or S (minutes)
Limits for Occupational/Controlled Exposure				
0.3-3.0	614	1.63	(100)[a]	6
3.0-30	1842/f	4.89/f	$(900/f^2)$[a]	6
30-300	61.4	0.163	1.0	6
300-1500[b]	--	--	f/300	6
1500-100,000	--	--	5	6
Limits for Uncontrolled Exposure				
0.3-1.34	614	1.63	(100) [a]	30
1.34-30	842/f	2.19/f	$(180/f^2)$ [a]	30
30-300	27.5	0.073	0.2	30
300-1500	--	--	f/1500	30
1500-100,000	--	--	1.0	30

Source: FCC 1997

A/m = amperes per meter; f = frequency in MHz; MHz = megahertz; mW/cm^2 = milliwatts per centimeter squared; V/m = volts per meter
[a] Plane-wave equivalent power density
[b] Frequency range within which FirstNet would operate

2.4.2. RF Emissions and Humans

For 20 years, the regulatory levels for human exposure to RF emissions have been established by the FCC as a means of protecting both workers and the general public from any potential effects.[8] Concerns about RF emissions have been raised for a number of years by various nongovernmental stakeholder groups about whether the FCC's exposure levels—and similar standards established by other developed nations—are protective enough based upon the current science on the potential health effects.

The FCC's standards were first established in 1996 based upon the guidelines formulated by the National Council on Radiation Protection and Measurements (NCRP), a Congressionally chartered nonprofit corporation that prepares recommendations on matters of radiation protection, as well as those promoted by two independent nonprofit organizations, the Institute of Electrical and Electronics Engineers (IEEE) and the American National Standards Institute (ANSI), both of whom have helped set industry standards for decades (*FCC 2013, 2014*).

These standards set effective radiated power (ERP) of no more than 500 watts per channel (WPC), depending on tower height and the total number of radio channels (transmitters) authorized at a specific site, so that the RF power transmitting at any particular location will vary, with most urban and suburban sites operating at an ERP of less than 100 WPC. According to the FCC and depending upon the type of antenna being used, the typical cell site emits an ERP of 100 WPC, which corresponds to an actual radiated power of 5 to 10 watts (*FCC 2014*).

[8] See *47 CFR §§ 1.1307(b), 1.1310, 2.1091, 2.1093.*

The power of RF emissions rapidly decreases as the distance from the transmitter increases. As a result, measurements taken of typical ground-level exposures are usually well below the FCC exposure standards. Those standards recommend a maximum permissible exposure level to the general public of approximately 580 microwatts per square centimeter for cellular and Personal Communications Service (PCS) cell site transmitters. The RF levels typically found near the bases of cellular or PCS cell site towers or in the vicinity of other, lower-powered cell site transmitters are many times less than this limit (*FCC 2014*).

Demonstrating cause and effect in humans from low-level[9] environmental exposures is considered to generally require multiple studies over many years before consensus is reached and a clear cause and effect can be established (*Webb and Bain 2011*). In order to respond to a request by Congress to study the potential health effects of electric and magnetic fields on humans and other living organisms, the Department of Energy entered into an agreement with the National Research Council for the National Academy of Science to prepare a study.

That report, in looking at routine exposures to electric and magnetic fields found in homes and communities as the cause of disease and abnormalities, stated the following:

> "There is no widely accepted understanding of how extremely low-frequency electric and magnetic fields, such as those associated with the distribution and use of electric power, could cause a disease or whether it causes a disease. Considerable research has been conducted in this area, and numerous research data can be found on the subject, but given the lack of a specific disease end point to track or a well-accepted theory of how the fields might affect biologic systems, the data are discordant; they have been gathered using different exposure conditions and have resulted in conflicting observations of different effects or no effects." (*National Research Council 1997*)

Hence, the investigations into RF have not yet achieved scientific consensus on cause and effect. Some of the major problems with demonstrating cause and effect for RF are listed below:

- No consistent measures of exposure. Exposure is changing with the proliferation of cell phone use, and there is no real unexposed or "control" population (*Ahlbom et al. 2004; Khurana et al. 2010*).
- No scientifically agreed upon biological mechanism for harm. The lack of a clear biological mechanism increases uncertainty into whether the health end point that the study examined is the correct endpoint to try and measure (*Hauri et al. 2014; Ahlbom et al. 2004*).
- Some potential effects of major concern are rare, such as brain cancer and acoustic neuroma, both of which have been potentially linked to RF exposure. If the health outcome is rare, it is even harder to demonstrate cause and effect (*Ahlbom et al. 2004*).

[9] For the purposes of this review, "low-level" is a qualitative description of the small amount of energy contained in these emissions.

However, there is an active scientific research effort worldwide concerning the potential health effects of RF emissions, with new studies being published frequently. This research environment reflects the public interest in the topic, the increased level of interest within the scientific community, and the desire by governments and health organizations to determine conclusively whether there are any potential effects from RF emissions to either people or the environment.

2.4.2.1. Regulatory Framework for RF Emissions

As indicated above, RF emissions have been identified by the FCC as a potential environmental factor to be weighed in evaluating a transmitter's effect on the human environment. Currently, the FCC implements and enforces both occupational and public exposure limits to RF electromagnetic fields through its authorization and licensing process. In order for a facility operation or transmitter to be authorized or licensed, FCC requires licensees to be in compliance with its regulations relating to RF emissions.

In 1996, as a consequence of the authority granted by Congress to the FCC in the Telecommunications Act of 1996 to "prescribe and make effective rules regarding the environmental effects of radio frequency emissions" (Telecommunications Act of 1996, 104 P.L. 104), the agency adopted new guidelines and procedures reflected in its revised Office of Engineering and Technology Bulletin 65, *Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields,* originally issued in 1985 (*FCC 1997*). The revised guidelines include limits for Maximum Permissible Exposure for transmitters operating between 300,000 hertz and 100 GHz which are averaged over a specified time-interval. The limits are different based on whether an occupational setting or a general population exposure setting is being evaluated. These standards have been challenged in federal courts and have been upheld (See, for example, *Cellular Phone Taskforce v. FCC,* 205 F.3d 82 [2d Cir. 2000]).

The FCC has updated its standards for evaluating mobile or personal communication devices "localized absorption" as well. The FCC's Maximum Permissible Exposure "localized absorption" limits are based on recommendations from the NCRP and the IEEE [10] and were adopted by the ANSI to replace the earlier ANSI guidelines of 1982. These limits are based on thermal effects (i.e., the amount of RF energy required to heat tissue). According to the FCC, the established limits are well below levels that are considered to have adverse health effects. These levels are shown in Table 2.4.1-1. Additionally, the IEEE's Committee on Man and Radiation (COMAR) states that the amount of RF emissions in buildings "will be lower than outside, since a substantial fraction of the signal is absorbed when it passes through most building materials" (*IEEE COMAR 2000*).

[10] Outside of the United States, many countries (including most of Europe) use exposure guidelines developed by the International Commission on Non-Ionizing Radiation Protection). The International Commission on Non-Ionizing Radiation Protection safety limits are similar to those of the NCRP and IEEE (*Classic 2015*).

COMAR cites a study (*Health Physics Society 1997*) that measured the power density of radiation on the top floors of buildings with roof-mounted antennas (*IEEE COMAR 2000*). The study found that radiation emissions on these floors "were less than 0.0004 mW/cm^2 per 100 W Effective Radiated Power (ERP) per channel." For purposes of reference, this indicates that it is 1,000 times less than the FCC standard for general population exposure and 5,000 times less than the FCC standard for occupational workers.

COMAR also found that "roof-mounted base station antennas are normally designed to radiate energy in the horizontal direction away from the building, and they radiate very little energy into the building itself. Therefore, exposure to residents inside a building with roof-mounted base station antennas is invariably very low" (*IEEE COMAR 2000*).

In March 2013, the FCC voted to review current RF rules and regulations and put forth a *Notice of Inquiry*. The *Inquiry* was intended to open discussion around whether the existing RF exposure limits and policies need to be reassessed. Through this process, the FCC has gathered input from industry, scientific experts, and members of the public to help the agency to determine whether current policies and rules need to be changed (*FCC 2013*).

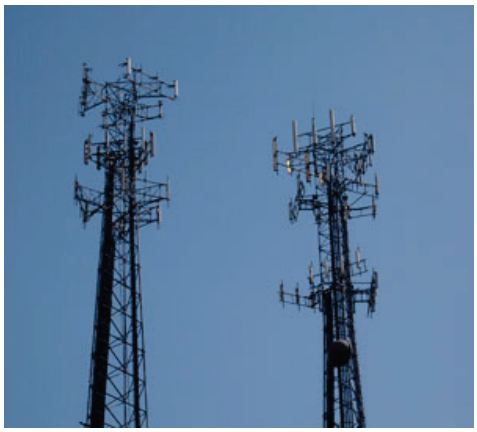
2.4.2.2. Overview of Research for Potential Non-Thermal Effects to Humans

A few organizations have provided research that is useful as a framework for the state of the research on RF and the basis of some of the concerns. For example, several studies of the potential non-thermal health effects cited below have focused on cancer outcomes (primarily childhood leukemia and brain cancers); however, reproductive/neonatal problems, neurological and neurobehavioral issues, and genotoxicity have also been studied. In addition to these studies, one group has raised concerns about potential non-thermal effects resulting from RF emissions coming from telecommunications equipment: the International Association of Fire Fighters (*IAFF 2015*).

As with any source, RF emissions from the FirstNet system would be dependent on the location, type, and power of antennas used. There are three basic forms of antennas: omnidirectional, narrow horizontal gain (focused beam), and panel.

The most common type of antenna is a panel antenna, as these are easily mounted on towers or rooftops and provide approximately 60 degrees of horizontal and vertical coverage. Omnidirectional antennas are frequently used for things such as Wi-Fi where a widespread area needs to be covered by a signal. Directional beam antennas are used to propagate a strong, focused beam to a specific location which is ideal for sending a stronger signal for greater distances without affecting areas outside the target. Thus, the omnidirectional and beam antennas are generally not suitable for deploying a cellular network.

Panel antennas do not produce a significant amount of radiation outside of the primary lobe, making them an ideal candidate for providing widespread coverage while maintaining control of the radiation beam. Figure 2.4.2-1 shows a typical lattice cell tower with multiple panel antennas arranged radially.



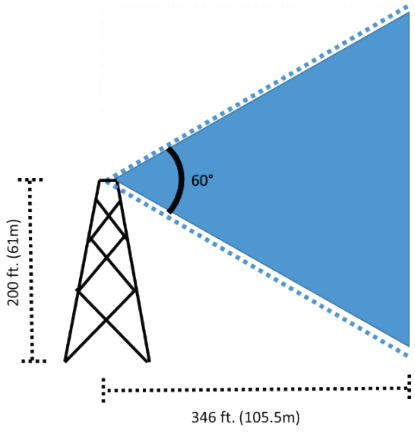
Source: The Fiber Optic Association, Inc. 2014

Figure 2.4.2-1: Lattice Cell Tower with Multiple Panel Antennas

Using the power intensity formula described above and assuming an antenna fixed to a base station transmits 60 W of power:

- The power density 0.30 meters (1 foot) from the base station would be 4.77 W/m^2;
- The power density 0.61 meters (2 feet) from the base station drops to 1.2 W/m^2; and
- At 100 meters (328 feet), the power intensity drops to 0.000477 W/m^2, a 99.99 percent reduction.

Figure 2.4.2-2 below depicts the radiation beam from a panel antenna on a 200-foot (61-meter) tower. Assuming a 60-degree vertical spread and no vertical tilt, the primary lobe of the radiation beam (shaded blue) would not reach the ground until 346 feet (approximately 106 meters) from the tower. At the point where the beam reaches the ground (approximately 346 feet [106 meters] from the base), there is a 99.99 percent reduction in power density compared to the power intensity 0.30 foot (1 meter) from the panel.

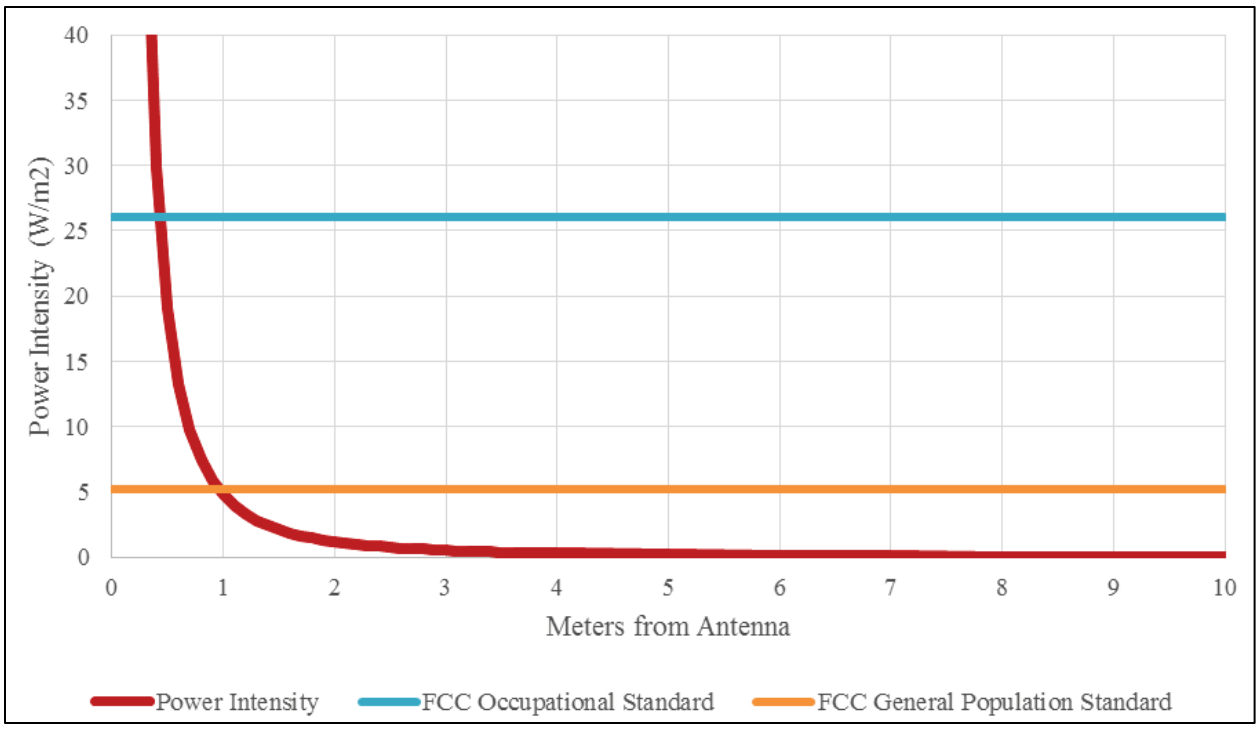


Source: FCC 1997

Figure 2.4.2-2: Depiction of Primary Radiation Lobe of a Panel Antenna Attached to a 200-foot (61-meter) Cell Tower

Correspondingly in Figure 2.4.2-2, the zone outside of the blue-shaded area is not within the primary radiation lobe of the antenna, and thus, would receive very little radiation (less than 0.01 percent of the density 0.30 meter [1 foot] in front of the antenna). This means that buildings and people under the tower would receive little RF emissions from those antennas, assuming none of the antennas are tilted downward.

Figure 2.4.2-3 depicts the decrease of power intensity from a 60 W antenna as a function of distance from the antenna and displays the FCC standards for 780 MHz frequency. The 780 MHz frequency is used for these calculations since it splits the two operating frequency bands at which the FirstNet system would operate (i.e., 758 to 769 MHz and 788 to 799 MHz). While the FirstNet system would not operate specifically at 780 MHz, this frequency best represents all of the possible frequencies at which the system would operate.



Source: FCC 1997

Note: This figure is a simple representation of the power intensity versus distance from a 60 W antenna. There are many other factors that may affect the power intensity at a specific location, which are not accounted for in this graph. Some factors include positive or negative interference with other electromagnetic waves, absorption by building materials or other items, and varying power outputs dependent on signal demand.

Figure 2.4.2-3: 60-W Antenna (780 MHz) - Power Intensity vs Distance with Respect to FCC Guidelines for Limiting Thermal Radiation

Figure 2.4.2-3 further demonstrates that the FCC occupational standard is met at 0.42 meters (1.4 feet) while the standard for the general public is met at 0.96 meters (3.1 feet). While these distances may seem small and insignificant, this chart only represents one 60 W antenna. Generally speaking, there may be three or more antennas serving one area (one transmitter, two receivers). Assuming there are three antennas operating at a power of 60 W at 780 MHz each, the standards are then met at 0.72 meters (2.4 feet) and 1.66 meters (5.5 feet), respectively using the formulas in Table 2.4.1-1.

As previously described, radiation can elicit both thermal and non-thermal effects in humans and other biological organisms. Given that thermal effects are only elicited when exposed to intense amounts of radiation, this section summaries the available credible scientific information about potential non-thermal effects of RF emissions, particularly at low power intensities.

Among the research organizations studying RF emissions, the World Health Organization (WHO)—as an agency of the United Nations—is the most prominent. According to the WHO, there have been tens of thousands of papers published on RF, extremely low frequency and potentially related health effects over the last 30 years. A recent (May 2015) statement on the WHO website states:

> "The heating effect of radio waves forms the underlying basis for current guidelines. Scientists are also investigating the possibility that effects below the threshold level for body heating occur as a result of long-term exposure. To date, no adverse health effects from low level, long-term exposure to radiofrequency or power frequency fields have been confirmed, but scientists are actively continuing to research this area." (*WHO 2015*)

In 2011, based upon the inconclusive data and in an abundance of caution, WHO classified RF exposures due to cell phone use as a 2B carcinogen—indicating that it was possibly carcinogenic to humans—based upon some studies that found a potential increased risk of glioma (a type of brain cancer) associated with cell phone use (*IARC 2011*). However, WHO's International Agency for Research on Cancer (IARC) noted that the evidence for carcinogenicity for occupational and environmental exposures (exposures to emissions from cell towers would fall into the "environmental" category) was inadequate to draw conclusions regarding carcinogenic potential.

The conclusions made by the IARC specifically identify RF emissions from wireless phones as the source for positive associations with negative health effects. Many of the studies examined by the IARC for fixed transmitter emissions suggested that living close to fixed transmitters increased the risk of developing brain cancer, leukemia, or lymphoma; nonetheless, the IARC identified several shortcomings of these studies, including (*IARC 2013*):

- Not accounting for mobile phone use or exposure to RF emissions from other sources (ambient RF emissions levels or confounding factors);
- Not accounting for buildings or other geographic features which impact the strength of the radiation;
- Small population size;
- Lack of controls;
- Poor exposure assessment (no individual data);
- Non-differential disease misclassification; and
- Lack of cumulative measure of exposure to RF emissions (take into account individual's place of residence between birth and diagnosis of cancer/disease).

While some of the studies indicated a negative (inverse) correlation between distance from transmitters and risk of cancer, the caveats identified by the IARC indicate general lack of scientific rigor of previous research projects. Furthermore, most of the studies reviewed by the IARC focus on cellular telephone use rather than low-level, background radiation emitted from fixed transmitter sites. Overall, these studies do not indicate a clear trend, reproducible with regard to the effects of fixed transmitter radiation.

WHO is currently undertaking a health risk assessment of radiofrequency electromagnetic fields, to be published as a monograph in the Environmental Health Criteria Series. WHO scientists themselves began conducting research on RF emissions, and electromagnetic fields more broadly, when it established the International EMF Project in 1996 (*Repacholi 2001*). However, recent studies on behalf of WHO have concluded that "there is insufficient data to draw firm conclusions about health effects from long-term low-level exposure [to RF electromagnetic fields] typically occurring in the everyday environment" (*Röösli et al. 2010*).

In contrast to the WHO's statement on health effects, a public advocacy group of scientists, known as the BioInitiative Working Group (BWG), published the BioInitiative Report, first in 2007 and followed by a revised version in 2012 (*Carpenter and Sage 2012*), that found substantial evidence of adverse health effects associated with RF and extremely low frequency exposures. However, the BWG itself has been criticized by other scientific, professional, and governmental bodies for ignoring conflicting, inconsistent, or other credible evidence that clashed with its report (e.g., *Dolan and Rowley 2009*).

The BWG report concluded that there was evidence to support adverse health effects resulting from sustained low-intensity electromagnetic radiation on decreased male fertility, fetal and neonatal effects, brain tumors, childhood leukemia, genotoxicity, in addition to several other effects. The BioInitiative Report noted further that health effects due to emissions from cell towers were cited in a number of studies that possibly linked headaches/sleep disturbance/ concentration issues in children, adolescents, and adults at levels in the range of 0.003 to 0.05 $\mu gW/cm^2$, much lower than current regulatory standards shown in Table 2.4.1-1. BWG recommends lower standards be established and that cell phone towers not be built within certain

distances of sensitive receptors, such as schools, daycare centers, and hospitals (*Carpenter and Sage 2012*).

These two positions illustrate the scientific and philosophical divide. First, there is some evidence of adverse health effects at levels below the current standards in a number of studies, but as is the case with other epidemiological studies attempting to prove causality, these studies are subject to a variety of uncertainties inherent in the epidemiological process.[11] Consequently, it appears that the preponderance of the evidence to date does not definitively demonstrate that there are adverse health effects caused by RF emissions and there is still no single, plausible biological mechanism to indicate adverse effects. Second, although there is some scientific data in certain studies to warrant further investigation, some researchers urge that precautions should apply to reduce exposures as much as possible (*Carpenter and Sage 2012*).

2.4.2.3. Conclusions on RF Emissions and Humans

Based on the analysis above, there is insufficient and inconclusive data to make a definitive determination of effect of RF emissions on humans. Although there is some evidence of adverse health effects at levels below the current standards in a number of studies, these studies are subject to a variety of uncertainties inherent in the epidemiological process. The preponderance of the evidence to date does not definitively demonstrate that there are adverse health effects caused by RF emissions and there is still no single, plausible biological mechanism to indicate adverse effects.

2.4.3. RF Emissions and Non-Human Species

Unlike those established for human exposure, no federal regulatory levels have been set for non-human species exposure to RF emissions. Regardless, under NEPA an environmental analysis is required to be conducted by the lead federal agency prior to undertaking any major federal action. This analysis requires the federal agency to consider any and all types of environmental impacts associated with the project, make qualitative decisions concerning the likelihood and severity of the potential effects, and give potential environmental effects due consideration in making engineering and economic decisions.

As is the case with considering the potential effects of RF emissions on humans, demonstrating cause and effect in animal and plant species from low-level environmental exposures is challenging and it too requires multiple studies over many years and across many species. Although there is some research that shows that there could be potential effects on some animal and plant species associated with RF emissions, here too there is no clear or definitive scientific research and literature, especially for animals or plants in North America, to achieve scientific consensus on whether there exists demonstrable cause and effect.

[11] It is difficult to attribute causation when other effects cannot be ruled out. The complexity of health conditions also makes it difficult to imply causation. Epidemiological studies can never provide proof or 100 percent certainty of an effect (*Webb and Bain 2011*).

Undoubtedly, there is considerable public interest into the potential effects of RF emissions on both humans and other species. Research is continuing with a number of scientific and academic centers, although there is still no consensus within the larger scientific community. Consequently, there is still the need for more targeted information, research, and studies on RF emissions and human, plant, and animal life. This means that we should expect that additional research will likely both continue and increase over the coming years.

2.4.3.1. Research on the Potential Effects to Animal and Plant Species

Since the 1980s, numerous studies have been conducted that focus on the potential effects of RF emissions on animal and plant species. Mirroring the findings indicated by the growing body of scientific research, the United States (U.S.) Fish and Wildlife Service (USFWS) has indicated in reports and agency memoranda that RF emissions could be potentially harmful to migratory birds, even at levels too low to cause thermal effects (*Manville 2007, 2009, 2014*).[12] Further, a comment letter on the Draft PEIS for the Western U.S. presented by Dr. Albert Manville, former USFWS agency lead on avian-structural impacts, summarizes the state of scientific knowledge of the potential effects of RF on wildlife, particularly migratory birds; the comment letter is presented in its entirety in Appendix H, *Radio Frequency Emissions Comments Received–All Regions*. Such studies and scientific knowledge generally agree that exposure to RF may result in adverse impacts on wildlife, although a distinct causal relationship between RF exposure and responses in wild animal populations has not been established. Further, important questions regarding the mechanisms of impact, the exposure levels that trigger adverse effects, and the importance of confounding factors in the manifestation of effects, among other questions, remain unanswered (*Manville 2016*) (see Appendix H, *Radio Frequency Emissions Comments Received–All Regions*).

Research conducted to date under controlled laboratory conditions has identified a wide range of physiological and behavioral changes in avian and mammalian subjects, including embryonic mortality in bird eggs, genetic abnormalities, cellular defects, tumor growth, and reproductive and other behavioral changes in adult birds and rodents (*Wyde 2016; Levitt and Lai 2010; Di Carlo et al. 2002; Grigor'ev 2003; Panagopoulos and Margaritas 2008*).

Laboratory studies conducted with domestic chicken embryos have shown that emissions at the same frequency and intensity as that used in cellular telephones have appeared to result in embryonic mortality (*Di Carlo et al. 2002; Manville 2007*). These studies suggest that RF emissions at low levels (far below the existing exposure guidelines for humans) (see Section 2.4.2, RF Emissions and Humans) may be harmful to wild birds; however, given the controlled nature of the studies and potential exposure differences in the wild, it is unclear how this exposure would affect organisms in the wild. A number of other studies link RF exposure and the disruption of biological processes that are fundamental to plant and animal growth and health, including but not limited to behavior, deoxyribonucleic acid damage, immune

[12] Although discussions of RF emissions generally involve "biological effects," meaning terrestrial and avian species, the research and environmental community have focused largely on bird species, especially migratory. Some studies have also indicated the potential for adverse effects to vegetation from RF emissions.

deficiencies, reproductive system effects, hormone dysregulation, degraded cognition and sleep, and desynchronization of neural activity (*Carpenter and Sage 2007 and 2012; Balmori 2015*).

Few studies of the effects of RF exposure on wild animal populations have been conducted due to the difficulty of performing controlled studies on wild subjects. Those that have been conducted are observational in nature (i.e., documenting reproductive success and behavior in birds near RF-emitting facilities). These studies lack controls on exposure levels or other potentially confounding factors. Nevertheless, findings from these studies indicate reduced survivorship at all life stages; physiological problems related to locomotion and foraging success; and behavioral changes that resulted in delayed or unsuccessful mating in several species of nesting birds (*Balmori 2005 and 2009; Balmori and Hallberg 2007; Manville 2016)* (see Appendix H, *Radio Frequency Emissions Comments Received–All Regions*).

For example, research conducted by Balmori (*2005, 2009*), Balmori and Hallberg (*2007*), and Di Carlo *et al.* (*2002*) suggests that the presence of electromagnetic fields in the microwave range may be a consideration in the decline of some urban bird populations. Research in Balmori (*2005*) focused on several species of wild birds in relation to cellular tower sites in Spain and indicated negative correlations between levels of RF emissions and bird breeding, nesting, and roosting. Also, nest and site abandonment, plumage deterioration, locomotion issues, and even death were noted for some house sparrows, white storks, rock doves, magpies, collared doves, and other species where roosting and nesting in close proximity to cellular antennas. The research suggested that these symptoms were not observed prior to construction of the cellular towers, although studies were not conducted prior to the cellular tower installation. Balmori (*2005*) documented these effects as far as 1,000 feet from the RF source.

Balmori and Hallberg (*2007*) reported that declines of urban house sparrows in Spain increased as electromagnetic field strength increased. Everaert and Bauwens (*2007*) also found negative correlations between the amount of RF emissions present and the presence of male house sparrows and concluded that long-term exposure to higher emission levels may be affecting bird abundance or bird behavior in this species.

Similarly, Bhattacharya and Roy (*2014*) looked at bird and nest occurrence in relation to tower proximity and electromagnetic fields in India. The study examined bird species within proximity to towers and used the point count method to identify the presence of birds and nests at various distances in all four cardinal directions from towers. This study found that bird occurrence was lowest within 20 meters of towers, which is the zone where power density was at peak values. Also, it was found that within this zone food sources were readily available and avoided. Additionally, no nests were identified within this zone and the closest nest was well outside this zone (approximately 80 meters or 263 feet).

It has also been suggested that RF emissions may act as an attractant to certain species of birds. Magnetite is a mineral found in high concentrations in bird eye, beak, and brain tissues and is used by birds for navigation. Since magnetite is highly sensitive to the electromagnetic frequencies, it has been suggested that RF emissions could lead to increased bird strikes and/or direct exposure to high levels of RF emissions due to the attractant quality of materials used in some equipment (*Ritz et al. 2004; Balmori 2015*).

Along these same lines, Balmori (*2015*) has noted that other flying species that use magnetic fields for navigation purposes have been found to be affected by RF emissions, primarily honeybees and butterflies. After several studies were published regarding the effects of cell phones on bees, the author of one of the studies, Stefan Kimmel, "emailed *The Associated Press* to say that there is 'no link between our tiny little study and the Colony Collapse Disorder (CCD)-phenomenon…anything else said or written is a lie" (*U.S. Department of Agriculture 2015*). Other, less defensible studies have purported to find that RF emissions from cell towers affect bees' behavior and could be responsible for colony collapse disorder. In general, these studies are not published in peer-reviewed and in credible journals, such as some well-known honeybee studies either published in predatory open access journals[13] or that are informal in nature.

2.4.3.2. Conclusions on RF Emissions and Species

The amount of research related to determining whether there are identifiable effects from RF emissions to animal species and, to a lesser degree, plant species is fairly extensive and growing. Experts in this field generally agree that exposure to RF might adversely affect wildlife species, particularly birds and bats, although a clear case of cause and effect between RF exposure and impacts to wild animal populations has not been established and many questions remain unanswered, including but not limited to the thresholds at which impacts may occur and the implications of impacts at the population level. The widespread conclusion of nearly every study or expert/agency assessment of the issue is that more research is essential to better understand the patterns of cause and effect, variations among species, and the potential sensitivities and severity of impacts to such species.

The common practice for NEPA documents related to cellular towers is to cite FCC standards and point to the fact that they would be built and operated according to allowable FCC RF emission limits. Some NEPA documents that have more directly addressed the RF emissions potential largely point to the existing literature and suggest that although there is evidence that RF emissions could potentially affect some species, the evidence is insufficient to support a finding of adverse impacts on these species due to RF emissions (*BMDO 2000; FCC 2012*).

2.4.4. Summary

FirstNet is a licensee of the FCC and FirstNet's operations in the 700 MHz range are governed by FCC regulations establishing exposure limits for RF emissions. Federal law authorizes the FCC to establish regulatory levels for human exposure to RF emissions. Over the years, the FCC has revised its standards and guidelines for protecting both workers and the general public—including limits for Maximum Permissible Exposure for transmitters covering the 700 MHz range and localized absorption limits for mobile devices—and these have been upheld by the federal courts.

[13] Predatory journals are issued by publishers that "are characterized by various levels of deception and lack of transparency in their operations…they may claim a stringent peer-review where none really exists" (*Elliott 2012*). Open access journals are available online and require no fee or membership; they are accessible to anyone who has access to the internet.

The studies cited in this PEIS do not indicate any clearly reproducible trend and, consequently, there is insufficient and inconclusive data to make a definitive determination of effect of RF emissions on humans. As explained above, scientific investigations into RF emissions and the possible effects of exposure on wildlife and plants are inconclusive. However, as there is a body of evidence that suggests potential impacts to wildlife, FirstNet concurs with recommendations from Dr. Manville and the U.S. Department of Interior that further studies should be performed that are designed to determine thermal and non-thermal impacts from RF emission on birds and other wildlife.

2.5. REFERENCES

Ahlbom, A., A. Green, L. Kheifets, D. Savitz, and A. Swerdlow. 2004. *Epidemiology of Health Effects of Radiofrequency Exposure*. Environmental Health Perspectives, 112(17). Accessed: December 2016. Retrieved from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1253668/

Balmori, A. 2005. *Possible Effects of Electromagnetic Fields from Phone Masts on a Population of White Stork (Ciconia ciconia)*. Electromagnetic Biology and Medicine, 24:109-119. Accessed: December 2016. Retrieved from: http://www.livingplanet.be/Balmori_EBM_2005.pdf

_____. 2009. *Electromagnetic Pollution from Phone Masts*. Pathophysiology, 16:191-199. Accessed: December 2016. Retrieved from: http://www.wifiinschools.org.uk/resources/Balmori+2009.pdf

_____. 2015. *Anthropogenic Radiofrequency Electromagnetic Fields as an Emerging Threat to Wildlife Orientation*. Science of the Total Environment, 518-519:58-60. Accessed: December 2016. Retrieved from: https://www.researchgate.net/profile/Alfonso_Balmori/publication/273121908_Anthropogenic_Radiofrequency_Electromagnetic_Fields_as_an_Emerging_Threat_to_Wildlife_Orientation/links/54fb6f000cf2c3f524204910.pdf

Balmori, A. and O. Hallberg. 2007. *The Urban Decline of the House Sparrow (Passer domesticus): A Possible Link with Electromagnetic Radiation*. Electromagnetic Biology and Medicine, 26:141-151. Accessed: December 2016. Retrieved from: http://www.livingplanet.be/Balmori_and_Hallberg_EBM_2007.pdf

Balmori, A., O. Hallberg, R. Bhattacharya, and R. Roy. 2014. *Impact of Electromagnetic Pollution from Mobile Phone Towers on Local Birds*. International Journal of Innovative Research in Science, Engineering and Technology, 3(2): 32-36. Accessed December 2016. Retrieved from: https://www.researchgate.net/publication/272172047_Impact_of_electromagnetic_pollution_from_mobile_phone_towers_on_local_birds

BMDO (Ballistic Missile Defense Organization). 2000. *Environmental Assessment of the Ballistic Missile Defense Organization Cooperative-Engagement-Capability/PATRIOT (CEC/PATRIOT) Interoperability Test*. July 2000. McLean, VA: The Mangi Environmental Group, Inc. Accessed: December 2016. Retrieved from: http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA515936

Carpenter, D. and C. Sage (eds.). 2007. *BioInitiative Report: A Rationale for a Biologically-based Public Exposure Standard for Electromagnetic Fields (ELF and RF)*. BioInitiative Working Group. August 2007. Accessed: December 2016. Retrieved from: http://www.spini.ch/upload/BioInitiative_Report_2007__englische_Originalfassung_.pdf

_____. 2012. *BioInitiative Report: A Rationale for a Biologically-Based Public Exposure Standard for Electromagnetic Radiation*. BioInitiative Working Group. December 2012. Accessed: December 2016. Retrieved from: http://www.bioinitiative.org/table-of-contents/

Classic, K. 2015. *Radiofrequency (RF) Radiation.* Health Physics Society. Accessed: July 8, 2016. Retrieved from: http://hps.org/hpspublications/articles/rfradiation.html

Di Carlo, A., N. White, F. Guo, P. Garrett, and T. Litovitz. 2002. *Chronic Electromagnetic Field Exposure Decreases HSP70 Levels and Lowers Cytoprotection*. Journal of Cellular Biochemistry, 84:447-454. Accessed: December 2016. Retrieved from: http://onlinelibrary.wiley.com/doi/10.1002/jcb.10036/abstract

Dolan, Mike and Jack Rowley. 2009. *The Precautionary Principle in the Context of Mobile Phone and base Station Radiofrequency Exposures*. Environmental Health Perspectives 117 (9): 1329-1332. Accessed: December 2016. Retrieved from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2737005/pdf/ehp-117-1329.pdf

Elliott, Carl. 2012. *On Predatory Publishers: a Q&A with Jeffrey Beall*. Brainstorm Blog--The Chronicle of Higher Education. June 5, 2012. Accessed: June 2016. Retrieved from: http://www.chronicle.com/blogs/brainstorm/on-predatory-publishers-a-qa-with-jeffrey-beall/47667

Everaert, J. and D. Bauwens. 2007. *A Possible Effect of Electromagnetic Radiation from Mobile Phone Base Stations on the Number of Breeding House Sparrows (Passer domesticus)*. Electromagnetic Biology and Medicine, 26:63-72. Accessed: December 2016. Retrieved from: http://www.livingplanet.be/Everaert_and_Bauwens_EBM_2007.pdf

FCC (Federal Communications Commission). 1997. *Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields: Additional Information for Amateur Radio Stations*. OET Bulletin 65: Supplement B, Edition 97-01. Prepared by Jerry L. Ulcek and Robert F. Cleveland, Jr. Accessed: January 2016. Retrieved from: https://transition.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet65/oet65.pdf

_____. 2012. *Final Programmatic Environmental Assessment for the Antenna Structure Registration Program*. March 13, 2012. Germantown, MD: URS Group, Inc. Accessed: December 2016. Retrieved from: https://apps.fcc.gov/edocs_public/attachmatch/DOC-312921A1.pdf

_____. 2013. *In the Matter of Reassessment of Federal Communications Commission Radiofrequency Exposure Limits and Policies. Proposed Changes in the Commission's Rules Regarding Human Exposure to radiofrequency Electromagnetic Fields.* First Report and Order, Further Notice of Proposed Rule Making and Notice of Inquiry. ET Docket No.13-39, ET Docket No. 03-137. Adopted March 27, 2013. Released March 29, 2013. Washington: Federal Communications Commission.

_____. 2014. *Human Exposure to Radio Frequency Fields: Guidelines for Cellular and PCS Sites.* FCC Consumer Guide. Last Reviewed: October 25, 2016. Washington: Federal Communications Commission, Consumer and Governmental Affairs Bureau. Accessed: December 2016. Retrieved from: https://www.fcc.gov/consumers/guides/human-exposure-radio-frequency-fields-guidelines-cellular-and-pcs-sites

Fiber Optic Association, Inc., The. 2014. *Guide to Fiber Optics & Premises Cabling*. Accessed: January 2016. Retrieved from: http://www.thefoa.org/tech/ref/appln/FTTA.html

Grigor'ev, I. 2003. *Biological effects of mobile phone electromagnetic field on chick embryo (risk assessment using the mortality rate)*. Radiats Biol Radioecol 43(5):541-3.

Hauri, D., B. Spycher, A. Huss, F. Zimmerman, N. Grotzer, N. von der Weid, A. Spoerri, C. Kuehni, and M. Röösli. 2014. *Exposure to Radio-Frequency Electromagnetic Fields from Broadcast Transmitters and Risk of Childhood Cancer: A Census-Based Cohort Study*. American Journal of Epidemiol, 179(7):843-851. Accessed: December 2016. Retrieved from: file://usholdc01/data/cpf/US%20Dept%20of%20Commerce%20FirstNet/Final%20PEIS/Chapter%201%20and%202/Reference%20PDFs/Hauri%20et%20al._2014_Exposure%20to%20Radio-Frequency%20Electromagnetic%20Fields.pdf

Health Physics Society. 1997. *Non-Ionizing Radiation: An Overview of the Physics and Biology*. Edited by K. Hardy, M. Meltz, and R. Glickman. Madison, WI: Medical Physics Publishing, pp. 197-226.

IAFF (International Association of Fire Fighters). 2015. *Position on the Health Effects from Radio Frequency/Microwave (RF/MW) Radiation in Fire Department Facilities from Base Stations for Antennas and Towers for the Conduction of Cell Phone Transmissions.* IAFF Division of Occupational Health, Safety and Medicine. Accessed: July 8, 2016. Retrieved from: http://www.iaff.org/hs/facts/CellTowerFinal.asp.

IARC (International Agency for Research on Cancer). 2011. *IARC Classifies Radiofrequency Electromagnetic Fields as Possibly Carcinogenic to Humans.* Accessed: July 2016. Retrieved from: http://www.iarc.fr/en/media-centre/pr/2011/pdfs/pr208_E.pdf

_____. 2013. *Non-Ionizing Radiation, Part 2. Radiofrequency Electromagnetic Fields.* Volume 102. Accessed August 2016. Retrieved from: http://monographs.iarc.fr/ENG/Monographs/vol102/mono102.pdf

IEEE COMAR (The Institute of Electrical and Electronics Engineers Committee on Man and Radiation). 2000. *Safety Issues Associated with Base Stations Used for Personal Wireless Communications*. September 2000. Accessed: August 2016. Retrieved from: http://ewh.ieee.org/soc/embs/comar/base.htm

Khurana, V., L. Hardell, J. Everaert, A. Bortkieicz, M. Carlberg and M. Ahoden. 2010. *Epidemiological Evidence for a Health Risk from Mobile Phone Base Stations.* International Journal of Occupational Health, 16: 263-267. Accessed: December 2016. Retrieved from: http://wifiinschools.org.uk/resources/Khurana+et+al+2010.pdf

Levitt, B.B., and H. Lai. 2010. *Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays*. Environ. Rev. 18 (2010): 369–395. doi:10.1139/A10-018. Accessed: December 2016. Retrieved from: http://www.nrcresearchpress.com/doi/pdf/10.1139/A10-018

Manville II, A. 2007. *U.S. Fish & Wildlife Service Concerns Over Potential Radiation Impacts of Cellular Communication Towers on Migratory Birds and Other Wildlife – Research Opportunities*. May 10, 2007. Congressional Staff Briefing on the Environmental and Human Health Effects of Radiofrequency (RF) Radiation, Washington D.C. Accessed: December 2016. Retrieved from: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0ahUKEwjCoq7mwYrRAhXCTCYKHVFqAhkQFgggMAE&url=http%3A%2F%2Fwww.emrpolicy.org%2Freview%2Fmanville_dc.ppt&usg=AFQjCNEqGd2rGYuWrMe4seS2pp0R5crUBg&sig2=MaQrmcjaU4314tawg8lcIw&bvm=bv.142059868,d.eWE&cad=rja

_____. 2009. *Towers, Turbines, Power Lines, and Buildings–Steps Being Taken By the U.S. Fish and Wildlife Service to Avoid or Minimize Take of Migratory Birds at These Structures*. Proceedings of the Fourth International Partners in Flight Conference: Tundra to Tropics, 262–272. Accessed: December 2016. Retrieved from: https://www.fws.gov/migratorybirds/pdf/management/manville2009.pdf

_____. 2014. *Talking Points and Literature Citations, Available to the Public*. Status of U.S. Fish and Wildlife Service Developments with Communication Towers with a Focus on Migratory Birds: Updates to Services Staff Involved with Tower Issues – A Webinar, Washington D.C. Released to the public: March 7, 2014. Accessed: December 2016. Retrieved from: https://www.fws.gov/midwest/es/planning/pdf/usfws2013revisedguidancecommtowerssupportinginfo27sept.pdf

_____. 2016. *Comment letter regarding National Telecommunications Information Administration's (NTIA) First Responder Network (FirstNet) Draft Programmatic Environmental Impact Statement (DPEIS) for the Western United States*. Letter dated September 29, 2016.

National Research Council. 1997. *Possible Health Effects of Exposure to Residential Electric and Magnetic Fields*. Committee of the Possible Effects of Electromagnetic Fields on Biologic Systems, Board of Radiation Effects Research, Commission on Life Sciences. Washington: National Academy Press.

OSHA (Occupational Health and Safety Administration). Undated. *Radiofrequency and Microwave Radiation*. Accessed: August 2016. Retrieved from: https://www.osha.gov/SLTC/radiofrequencyradiation/

Panagopoulos, D.J., and L.H. Margaritis. 2008. *Mobile telephony radiation effects on living organisms*. Chapter 3, pp. 107-149, *In* A.C. Harper and R.V. Buress (eds.), Mobile Telephones, Nova Science Publishers, Inc. ISBN: 978-1-60456-436-5. Accessed: December 2016. Retrieved from: http://kyttariki.biol.uoa.gr/THALHS-II-PUBLICATIONS/Panagopoulos-Margaritis-review-2008.pdf

Repacholi, Michael H. 2001. *Health risks from the use of mobile phones.* Toxicology Letters 120: 323-331. Accessed: December 2016. Retrieved from: http://www.wireless-health.org.br/downloads/RepacholiHealthrisk-mobile.pdf

Ritz, T., P. Thalau, J.B. Phillips, R. Wiltschko, and W. Wiltschko. 2004. *Resonance Effects Indicate a Radical-Pair Mechanism for Avian Magnetic Compass*. Nature Publishing Group, 429:177-180. Accessed: December 2016. Retrieved from: http://www.physics.uci.edu/~tritz/Publications/RITZ2004.pdf

Röösli, M., P. Frei, E. Mohler, and K. Hug. 2010. *Systematic review on the health effects of exposure to radiofrequency electromagnetic fields from mobile phone base stations*. Bulletin of the World Health Organization, 88:887-896G. Accessed: December 2016. Retrieved from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2995180/pdf/BLT.09.071852.pdf

U.S. Department of Agriculture. 2015. *ARS Honey Bee Health and Colony Collapse Disorder.* Accessed: August 18, 2016. Retrieved from: https://web.archive.org/web/20160806221115/http://www.ars.usda.gov/News/docs.htm?docid=15572 (Updated October 2016)

U.S. Department of Energy. 2009. *Electromagnetic Spectrum*. Accessed: August 18, 2016. Retrieved from: http://www2.lbl.gov/MicroWorlds/ALSTool/EMSpec/EMSpec2.html

Webb, P. and C. Bain. 2011. *Essential Epidemiology: An Introduction for Students and Health Professionals*. 2nd ed. New York: Cambridge University Press. Accessed: December 2016. Retrieved from: http://medfac.tbzmed.ac.ir/Uploads/3/cms/user/File/10/workshops/9/Penny%20Webb.pdf

WHO (World Health Organization. 2015. *Radio Frequency Fields: Environmental Health Criteria Monograph*. Accessed: July 8, 2016. Retrieved from: http://www.who.int/peh-emf/research/rf_ehc_page/en/

Wyde, M. 2016. *National Toxicology Program finds cell phone radiation causes cancer*. Summary Presentation at BioEM 2016 Meeting, Ghent, Belgium, by M. Wyde, Dir. NTP Studies of Cell Phone Radiation, NIEHS, June 8. Accessed: December 2016. Retrieved from: http://ntp.niehs.nih.gov/ntp/research/areas/cellphone/slides_bioem_wyde.pdf

Zamanian, A. and C. Hardiman. 2005. *Electromagnetic Radiation and Human Health: A Review of Sources and Effects*. High Frequency Electronics, July 2005. Accessed: August 2016. Retrieved from: http://www.highfrequencyelectronics.com/Jul05/HFE0705_Zamanian.pdf

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