



SIRN 20/20 VHF COVERAGE PLAN AND DESIGN

11.2 FINAL REPORT SUPPLEMENTAL DOCUMENT

Contract Deliverable # 3

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DELIVERABLE 3: SIRN VHF COVERAGE DESIGN AND PLAN

This document provides an overview of the Proposed North Dakota Statewide Interoperable Radio Network (SIRN) VHF Network Coverage Design and Plan.

SIRN COVERAGE OBJECTIVES AND BASELINE REQUIREMENTS

Coverage objectives were established through direct stakeholder engagement. Over the course of the SIRN 20/20 Feasibility Study and the preliminary study (2014 – 2015), online surveys, individual county meetings and regional conference working sessions were held with over 45 counties to outline coverage requirements and objectives. The following are key factors extracted from these sessions that drove the coverage plan development.

A widely adopted SIRN:

- Has to provide equal to or better overall coverage than current radio systems
- Has to aim to provide 95% mobile radio coverage in each county
- Has to address coverage gaps outlined by stakeholders
- Has to provide in-building coverage in densely populated areas of the State
- Has to provide on-street portable service along roadways and populated areas
- Has to support paging services or integration of current paging systems
- Has to support the addition of vehicular repeaters to supplement network service as necessary

COVERAGE PLAN DESIGN PRINCIPLES

To fulfill the objectives outlined above, various radio coverage design principles were followed, as discussed below.

- **Addressing Coverage Equivalence:** Public safety entities have deployed *several hundred transmitter* facilities across the state to fulfill their unique voice and paging needs. Therefore, careful analysis of the level of coverage delivered by the current constellation of sites was undertaken to ensure that SIRN maintains coverage equivalence in critical service areas. A comprehensive database of all current transmitter locations illustrates that State and County governments have deployed strategically located “booming” transmitters targeting maximal coverage across the jurisdictional area, while municipalities and independent agencies have deployed localized transmitters to ensure portable and paging service in their jurisdictions. In some cases, the “booming” State or County site provides sufficient coverage within the municipalities; however, several of the “local” transmitters have to be retained to maintain local community coverage equivalence. These legacy phenomena are depicted in

Figure 1. In general, where it is clear that a given entity has implemented localized service because the State or County tower does not fulfill their coverage needs, these local repeaters were retained. In particular, where existing assets are already well-equipped with the civil and other base network infrastructure and their elimination could have a limited but noticeable effect on the user base, such assets were included in the SIRN coverage plan due to the lower overall cost of incorporating a site with readily available civil and backup power infrastructure. While in some cases, the State and/or County sites provide the required coverage, removing the need for the local towers (typically located near or within a town/city); in other cases, these towers have to be retained to maintain “coverage equivalence.” In a few cases, a more centrally located private tower, or new leased tower, was selected in order to eliminate the use of multiple towers.

- Robust On-Street Coverage in Large Municipalities:** As an extension of the principle above, the SIRN coverage plan sought to ensure robust on-street portable service in medium and larger municipalities. These jurisdictions typically already have one or more centrally located repeater; in cases, where a larger and farther-away tower provided reasonable coverage, these “in-jurisdiction” repeaters were eliminated. However, in most cases they were retained to ensure coverage equivalence. These sites could later be implemented in a cost-effective configuration such as Receive Only¹ or Low-Power/In-Fill Station.

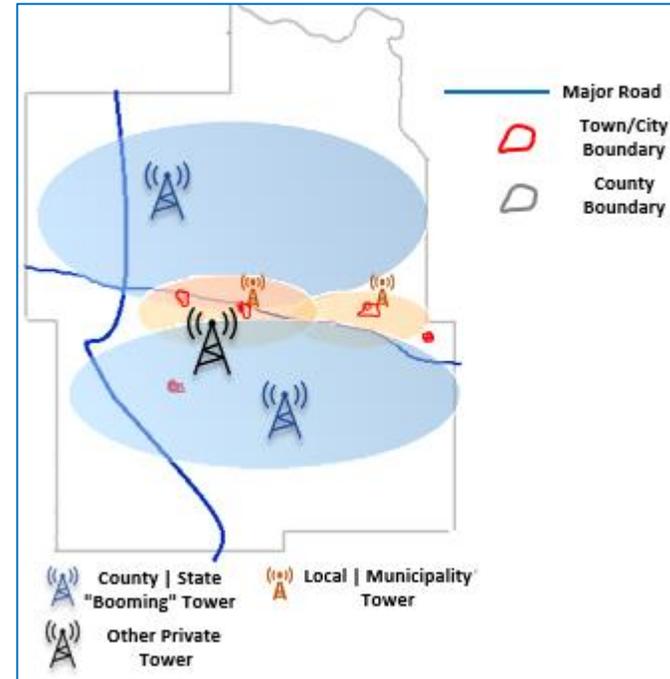


Figure 1: Sample Illustration of State, Local, and Municipal Towers and Coverage

- Addressing Coverage Gaps:** Coverage gaps exist throughout the State. However, in some cases, coverage is deficient due to the current architecture of disparate systems,² not due to an absolute lack of infrastructure. The SIRN coverage plan is designed to address gaps in key areas, roadways, and other locations where the current constellation of sites is not located to address the required coverage. Where an existing government-owned or government-used asset is not available, an existing *privately owned asset* was included into the coverage design.³ (See Figure 2)

¹ Receive Only facilities are a more cost-effective coverage implementation and are designed to provide direct coverage for portable and mobile radios that would experience difficulties “talking-back” to the base station tower.

² Because of the individually implemented and managed systems, users only have access to a subset of the sites within their jurisdiction. For instance, as illustrated in Figure 1, County users within the town may not have access to the Local | Municipality Tower and hence experience coverage gaps despite the presence of additional towers.

³ There are over 1,500 privately-owned vertical assets in the State, some of which are already leased by government entities. For various reasons, the SIRN design integrates a limited number of existing privately owned sites over new tower builds. Some of these sites were visited during the data collection effort to evaluate their usability.

- **Leverage Existing Assets:** For various reasons, SIRN is primarily anchored on assets that are currently owned or used by public safety. While this has benefits, it should be noted that a truly fresh design based on strategically situated conceptual sites could have resulted in fewer towers. However, this approach would require building new sites, significantly prolongs SIRN deployment, would increase the implementation budget, and disregards the available infrastructure and investments. The proposed approach does include up to five (5) new site builds, all of which are at locations that have already been surveyed by private entities and have had some level of approval by regulatory bodies, but have yet to be built. Therefore, there is an opportunity to collaborate with these entities; it is also possible that these entities will have already erected these towers prior to SIRN implementation.
- **Maximize Consolidating Transmitters:** An integrated solution enables the consolidation of duplicative transmitters. Several examples exist where the State, County, and a municipality (and agencies within a given municipality) have multiple proximate sites. SIRN aims to eliminate such duplication; typically, the assets with the most desirable attributes from a technical and financial implementation perspective is selected. However, as previously stated, in some cases, no single existing site fully addresses the overall coverage objectives. Therefore, an additional site may be required to ensure coverage equivalence. In some cases, a single new and strategically located site could better address the coverage objective; however, leverage two existing assets has been chosen as the desired approach rather than building a new tower.

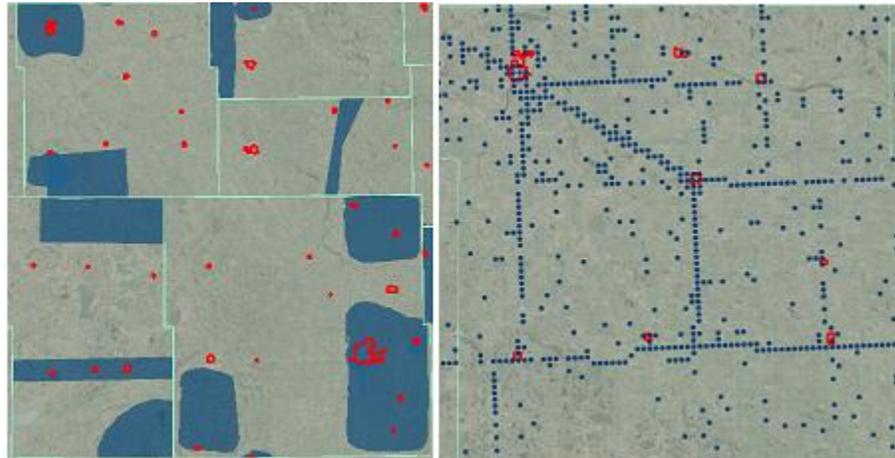


Figure 2: Coverage Gap Sessions Session (Left); CAD Data Analysis (Right)

- **Composite Radio Service:** SIRN is currently designed as a replacement for all land mobile radio (LMR) service within the state by public safety and public service entities. These systems include voice systems, paging systems, fire station alerting solutions, hospital transmitters, and other related systems. Providing composite service requires limited incremental increase over a voice only network and paves the way for a

truly integrated network that can cost effectively replace all LMR systems in the State. Therefore, the objective of the coverage design is to address these requirements.

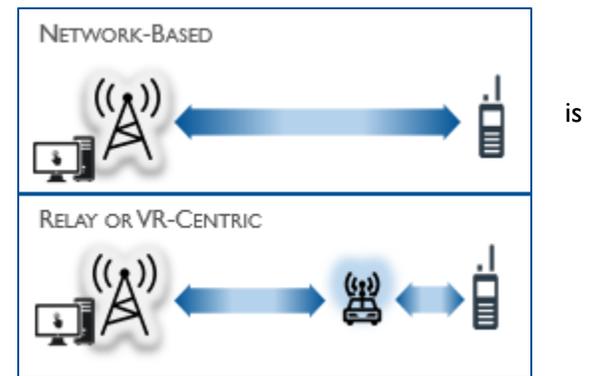
- Computer Aided Dispatch (CAD) Data Analysis:** CAD data, among other qualitative variables, were used to prioritize coverage expansion to areas with documented issues. On the other hand, a similar approach was used to eliminate an existing site that was determined to provide limited incremental value over those already in its vicinity. Figure 2 depicts CAD data over a three-year period; this data was leveraged to design SIRN coverage with the objective of ensuring service in areas with frequent incidents.

Overall, the coverage plan followed a conservative approach to ensure the SIRN 20/20 solution fulfills the various coverage requirements collected from the user community.

OTHER SERVICE DELIVERY OPTIONS

The Coverage Design presented in this document prioritizes delivery of *network* VHF service as per the Baseline Requirements. Other approaches were considered as discussed below, some of which have been incorporated into the proposed plan.

- Vehicular Repeater (VR) Centric Portable Service:** SIRN could be designed to primarily provide mobile radio service with portable radio service delivered mainly through vehicle-mounted repeaters⁴ (VR). This approach may be suitable for very rural counties, and in fact, is currently employed by various law enforcement agencies. However, even within those jurisdictions, additional network infrastructure has been implemented to support paging or other portable service. Since, SIRN is considered an “all-in” radio network that aims to provide all voice and paging services, it is designed to meet the baseline requirements through *network* service. Nonetheless, there are areas where VRs are required to ensure adequate and reliable portable service. Therefore, a portion of the statewide users are expected to be equipped with VR units.⁵



- Receive Only Sites:** 15% or more of the proposed sites may be configured for receive-only (Rx) operation. There are many instances where an Rx only configuration is a clearly suitable and cost-effective solution, and can essentially fulfill the baseline coverage objectives. There are

⁴ A vehicular repeater extends coverage to portable radios that affiliate with the mobile radio repeating the communicating signal over the vehicular repeater installed in the responding vehicle.

⁵ See Costs Estimates for assumptions on VR quantities.

additional technical factors that may compel the use of an Rx Only site such as availability of tower and shelter space, frequency limitations, capacity requirements and available vendor solutions.

- **Lower Power/Infill Sites:** Several smaller jurisdictions and existing coverage gaps may be adequately served by lower power sites that provide “in-fill” service. These sites could be cost-effective and have a form factor with a limited footprint, potentially obviating the need for traditional shelters. Currently, there are limited offerings for such base stations in the land mobile radio (LMR) vendor market space; however, progress is expected in the near future and could yield substantial savings. (It should be noted there may be other technical and regulatory constraints that may already require certain sites to transmit at lower than full power).
- **Statewide 800 MHz Service:** Rough Order of Magnitude cost for an alternative 800 MHz Mobile Only (with VR based Portable Service) has been provided for consideration. However, no network designs have been provided.

SITE SELECTION PROCESS

Data collection was an integral and extensive element of the feasibility plan with a multi-pronged purpose. While the initial purpose was to document and quantify existing assets, the efforts were later focused on gathering the required information to determine the suitability/usability of assets for the SIRN plan. From a coverage perspective, the baseline requirements and design principles drove site selection. However, multiple civil and network attributes (listed in Table 1) were used to classify and rank sites to drive site selection from a timely and cost-effective implementation standpoint. These attributes account for approximately 40% of the cost of bringing up a site for SIRN service and require attention. (A full list of site attributes and classification is detailed within Deliverable 8). Sixty sites were visited as part of the SIRN Feasibility Study; it is recommended that a similar concerted effort be applied to all candidate sites. Additional surveys may uncover that some preliminary SIRN sites are not suitable; the tower database document includes alternative sites for some portion of the SIRN sites for this purpose. These alternative sites may not be most optimal from a coverage delivery standpoint, but could provide sufficient service in a timely and cost-effective fashion over a new site. Finally, if a SIRN site is deemed to be completely unusable, a new tower could be constructed within a reasonable budget particularly at the proposed locations where other civil infrastructure is readily available.

Table 1: SIRN Radio Site Consideration

SITE ATTRIBUTE	CONSIDERATIONS
Generator Availability	Sites with access to existing generator prioritized
Shelter Space Availability	Sites with access to available shelter space prioritized

SITE ATTRIBUTE	CONSIDERATIONS
Tower Space Availability	Tower space availability is the most important attribute, as a site with no space precludes itself from usage. In some cases, sites that have limited space but are primarily occupied by public safety antennas are included in the SIRN plan. These sites have an opportunity for a transition plan that consolidates or converges service from existing antennas with that of SIRN.
Fiber Optic Cable Availability	Sites with Fiber Optic cable available are prioritized; however, only five of the proposed sites do not have the required Line of Sight (LOS) clearance to use microwave links if microwave is selected as the transport medium.
Proprietorship/Ownership	Sites owned by government entities have been prioritized; sites that are currently leased by government entities follow. The SIRN plan includes about 20 sites that are currently neither owned nor used by a government entity
Structural Integrity	No technical structural analysis was conducted, which remains a risk, and will need to eventually be performed. However, visual inspection of 60 visited sites, and anecdotal input from stakeholders, was used to prioritize or eliminate a site. Additionally, given sufficient space, certain structures such as Water Towers and Buildings are expected to easily withstand additional weight.

It should be noted that in developing the SIRN cost models, several assumptions on the usability of existing infrastructure such as generators and shelter space were made. In various cases, probability ratios were used to account for the availability of an asset; e.g., some sites were classified as 75% shelter availability, or 50% generator access, meaning that 1 in 4 of those sites are expected to require a new shelter, or 1 in 2 will require a new generator, respectively.

STATISTICS BY SITE TYPES

Detailed classification of all proposed SIRN sites are provided in the SIRN_D8_Tower_Database_June2016_FinalDeliverable1.xlsx (Deliverable 8). The following table provide a high level overview of some relevant site attributes.

Table 2: SIRN Radio Site Analysis

STRUCTURE TYPE	QUANTITY
Radio Towers ⁶	119
Water Towers ⁷	21
Others	6

OWNERSHIP/USE	QUANTITY
Government Owned	73
Government Used ⁸	121
New Lease	25

BACKHAUL TYPE	QUANTITY
DCN or other Fiber On-site	128
DCN or other Fiber Within < 0.1 Mile	2
DCN or other Fiber Within < 0.5 Mile	4
Rest on Microwave	9

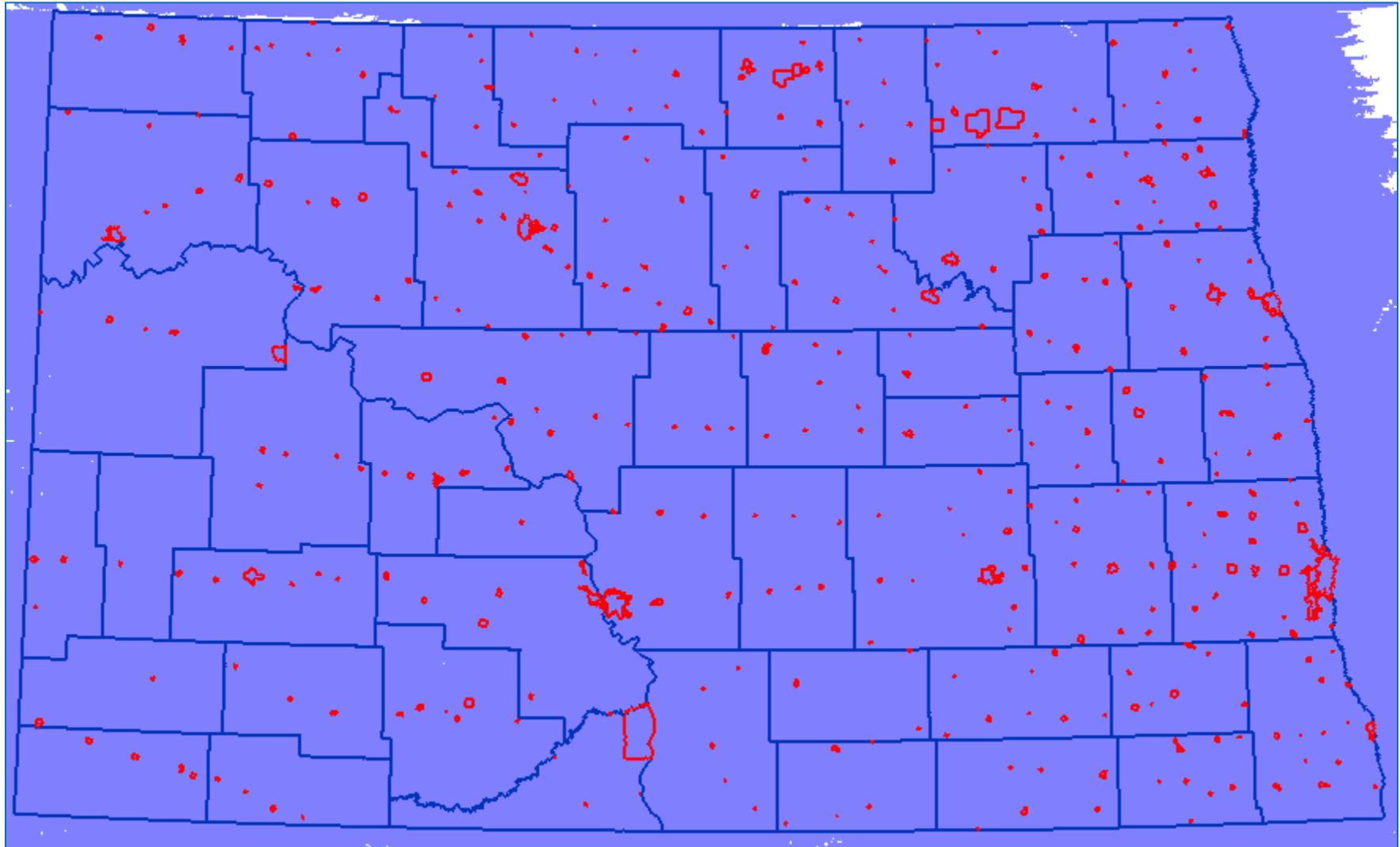
⁶ Comprises all structures including lattice, self-support, guyed towers, and Monopole towers

⁷ Building Structures and other unknown structures

⁸ Includes sites that are currently used by government entities (government-owned and used)

SIRN VHF COVERAGE MAPS

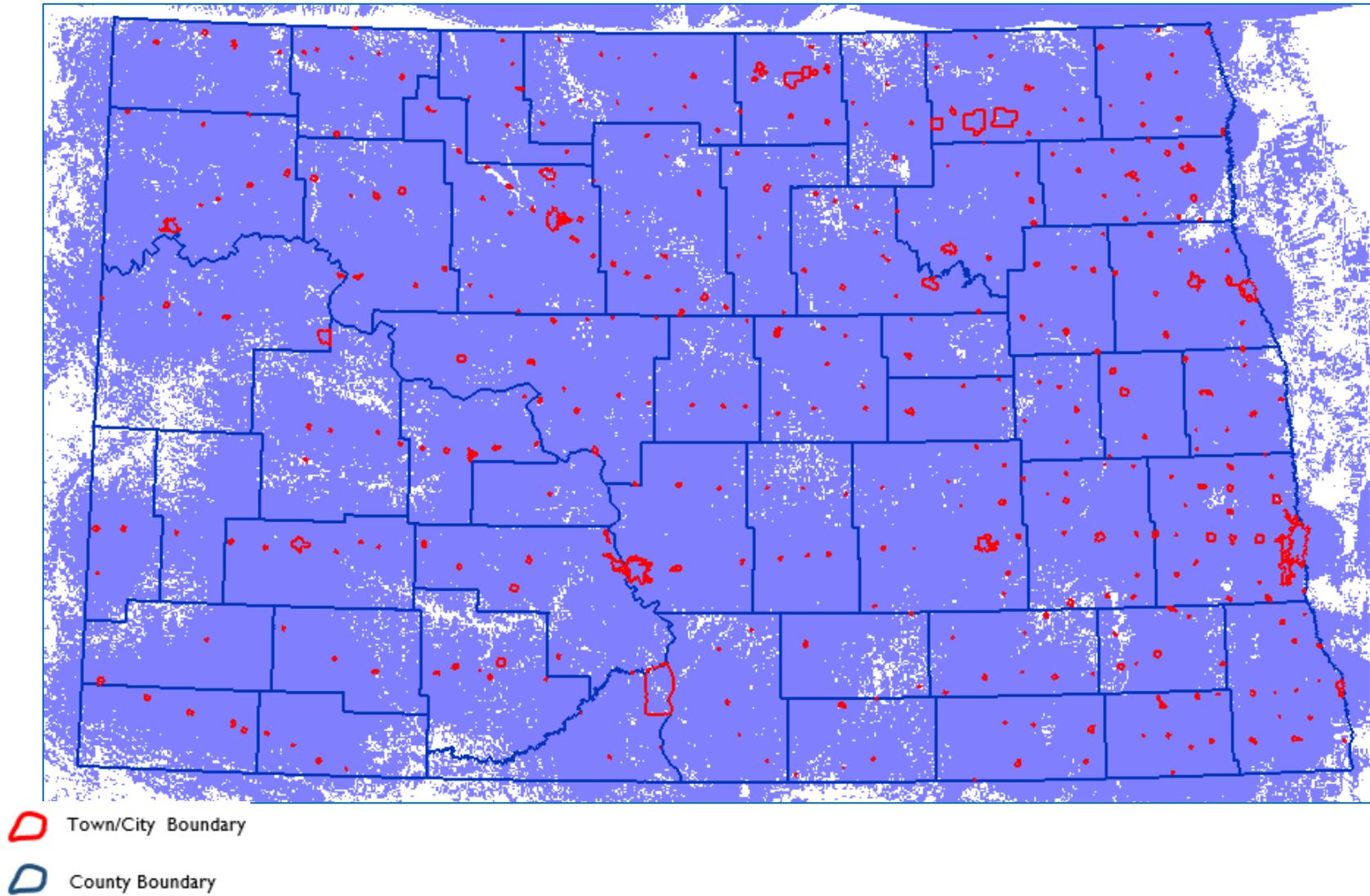
Mobile Talk-In



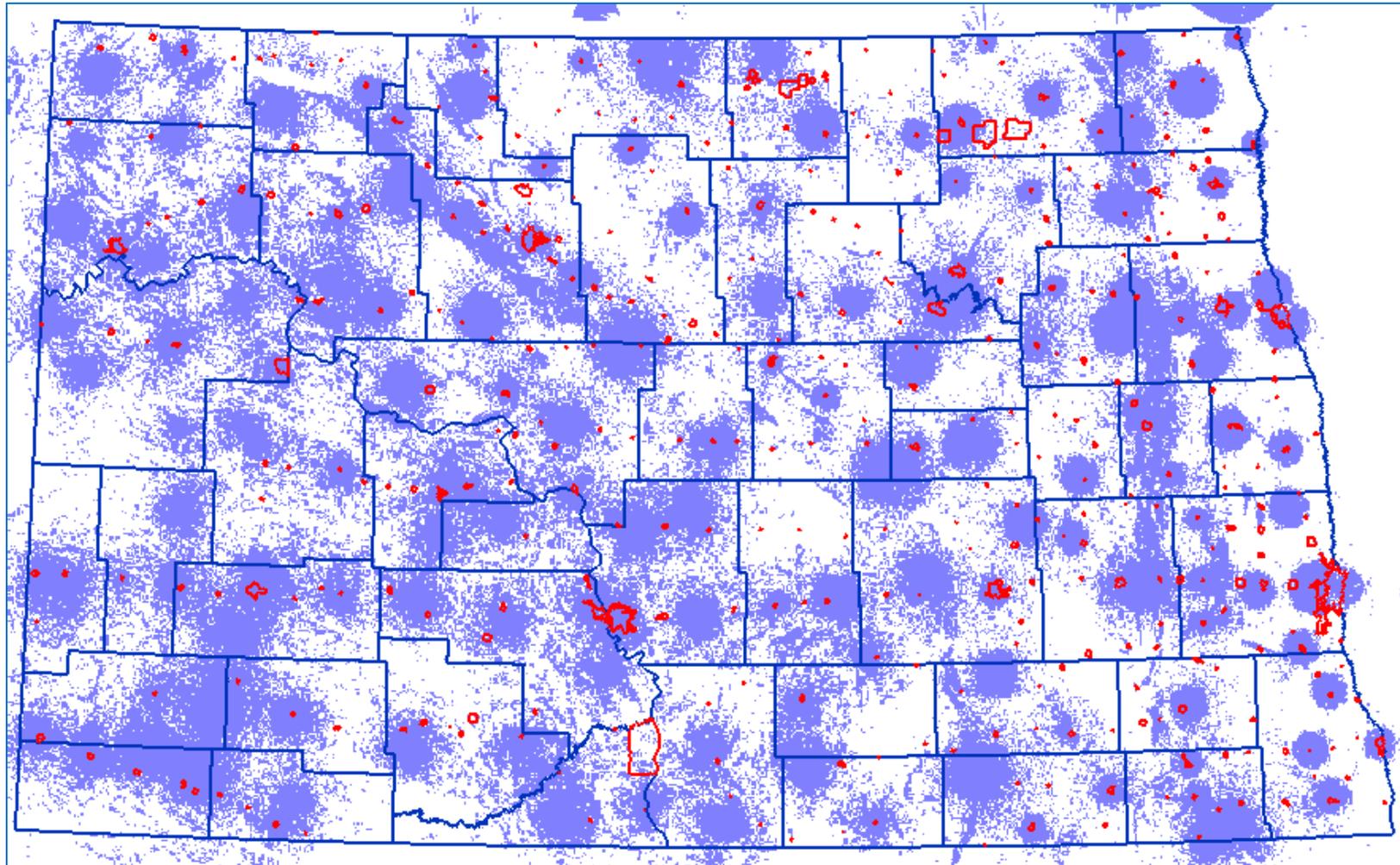
 Town/City Boundary

 County Boundary

Portable On-Street Talk-In



“Light⁹” Indoor Portable Talk-In

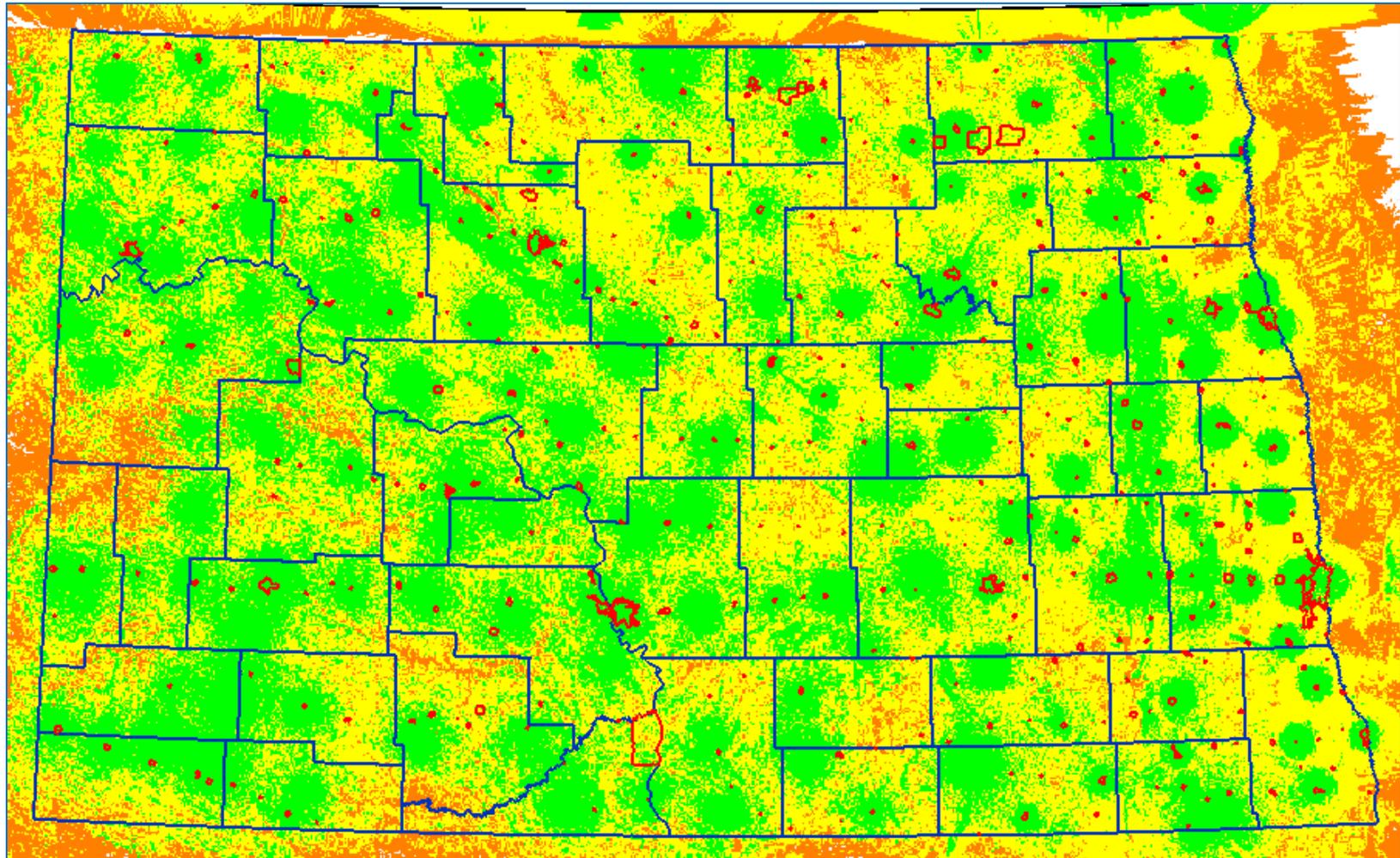


 Town/City Boundary

 County Boundary

⁹ Light Indoor refers to stronger signal and service that could support communications within a typical single-family residential structure. In general, the VHF spectrum is not well-suited for indoor or urban environments; however, VHF is well-suited to cover large rural geographies such as North Dakota more cost-efficiently.

Composite (Portable/Mobile) Talk-in



800 MHz URBAN AREAS COVERAGE

Six metropolitan areas¹⁰ within the State of North Dakota are currently recommended for 800 MHz service for the following reasons:

- Delivers critical in-building portable coverage to major urban areas
- Supports better interoperability with their counterparts for cities along the Minnesota border
- Vacates a portion of the VHF frequencies for incorporation into the VHF SIRN layer
- Releases upgradeable VHF radios to be provisioned for use by Rural/County users
- Supports a pilot phase as the legacy VHF networks and 800 MHz networks can co-exist to further validate SIRN

VHF service would also be available in these cities. Typically, in addition to the VHF site providing the VHF service, one or two additional 800 MHz sites would be required to provide the requisite level of indoor service.

COVERAGE STATISTICS BY JURISDICTION

Excel spreadsheets tabulating the predicted coverage percentages by County and Municipality have been provided separately. A brief sample of the spreadsheets is provided below:

Table 3: Coverage Statistics by County

County	Light Indoor Portable Service	On-Street Portable Service	Mobile Service
County A	43%	99.4%	99.9%
County B	50%	90.0%	99.9%
County C	22%	85.1%	99.9%
County D	47%	98.7%	99.9%

¹⁰ These include Fargo/West Fargo Metropolitan area, Bismarck/Mandan, Minot, Grand Forks, Dickinson, and Williston.

Table 4: Coverage Statistics by Municipality¹¹

Municipality ¹²	Light Indoor Portable Service	On-Street Portable Service	Mobile Service
Municipality 1	63%	>99%	>99%
Municipality 2	>99%	>99%	>99%
Municipality 3	0%	0%	>99%
Municipality 4	25%	>99%	>99%

Similar statistics for service along three layers of roads – Interstate, State and County – are included by County as follows:

SITES BY COUNTY

Table 7 summarizes the number of sites by County. It should be noted that certain sites located near a county border will provide service within multiple counties. The five largest and most populous counties account for 25 % of the sites; the remaining counties have on average 2.2 sites. This is a by-product of ensuring the coverage equivalence in counties that have invested on infrastructure to support their denser topologies. However, further effort, as discussed later in this document, could refine the overall site counts.

¹¹ Note these values include the service level of the SIRN VHF Network. Service levels over 800 MHz within these jurisdiction is designed for more robust service for indoor and on-street service.

¹² It should be noted, the final site constellation may change based on further investigation. Given the small size of most municipalities, coverage statistics for towns may change considerably with even a minor change in site location or parameters.

Table 5: Summary of SIRN Site per County

County	Quantity	County	Quantity	County	Quantity	County	Quantity
ADAMS	2	EMMONS	2	MERCER	2	SIOUX	2
BARNES	3	FOSTER	2	MORTON	4	SLOPE	3
BENSON	2	GOLDEN VALLEY	1	MOUNTRAIL	4	STARK	3
BILLINGS	3	GRAND FORKS	5	NELSON	4	STEELE	2
BOTTINEAU	2	GRANT	2	OLIVER	1	STUTSMAN	4
BOWMAN	3	GRIGGS	1	PEMBINA	4	TOWNER	1
BURKE	2	HETTINGER	1	PIERCE	2	TRAILL	2
BURLEIGH	4	KIDDER	2	RAMSEY	3	WALSH	2
CASS ¹³	8	LAMOURE	2	RANSOM	1	WARD	5
CAVALIER	4	LOGAN	1	RENVILLE	3	WELLS	3
DICKEY	3	MCHENRY	2	RICHLAND	4	WILLIAMS	6
DIVIDE	2	MCINTOSH	2	ROLETTE	2		
DUNN	2	MCKENZIE	6	SARGENT	3		
EDDY	1	MCLEAN	5	SHERIDAN	1		

¹³ Cass County is currently assessing a strategy to join the Minnesota ARMER 800 MHz statewide radio network and implement an 800 MHz network within the County. The Cass County plan includes the objective to integrate this network into SIRN when available. Therefore, only a portion of the noted Cass sites would be needed to provide a VHF layer for interoperability within the County.

OPPORTUNITIES FOR COST REDUCTION

As previously discussed, the SIRN coverage plan is based on a conservative design strategy; therefore, there may be opportunities to reduce the total site constellation. Further working sessions with county and municipality representatives may identify areas with more than the required level of service. However, it is possible that these sessions may also identify additional coverage gaps yielding a net-neutral effort. A similar process could be followed to better identify candidates for more cost-effective low power or Receive-Only sites.

VENDOR REQUIREMENTS DEVELOPMENT

Various approaches are available in developing objective and measurable coverage requirements during network procurement. Typically, a certain level of coverage over a geographic area with a given reliability is prescribed to facilitate the development and eventual validation of vendor designs. For instance, a vendor would provide 95% Mobile coverage (with 95% reliability) within a County or Municipality boundary. However, this approach needs to be weighed against the possibility of altering the “coverage equivalence” principle. In fulfilling such a statistical requirement, key areas may be overlooked. Development of the coverage requirements will require detailed discussion by the stakeholders.

FURTHER WORK

Various informed assumptions have been made about the usability of the sites in the coverage plan and the corresponding cost; comprehensive site surveys are required to validate those assumptions. Additionally, as previously detailed, no structural analysis has been performed to validate the ability of the SIRN candidate sites to support additional weight. These activities could be performed prior to a procurement/vendor selection or be conducted by the selected vendor.

RELATED DOCUMENTS

List of Supplementary Documents Submitted with Deliverable 3

- SIRN_D8_Tower_Database_June2016_FinalDeliverableI.xlsx (Deliverable 8)
- SIRN_Coverage_GIS_D3_20160602.xls