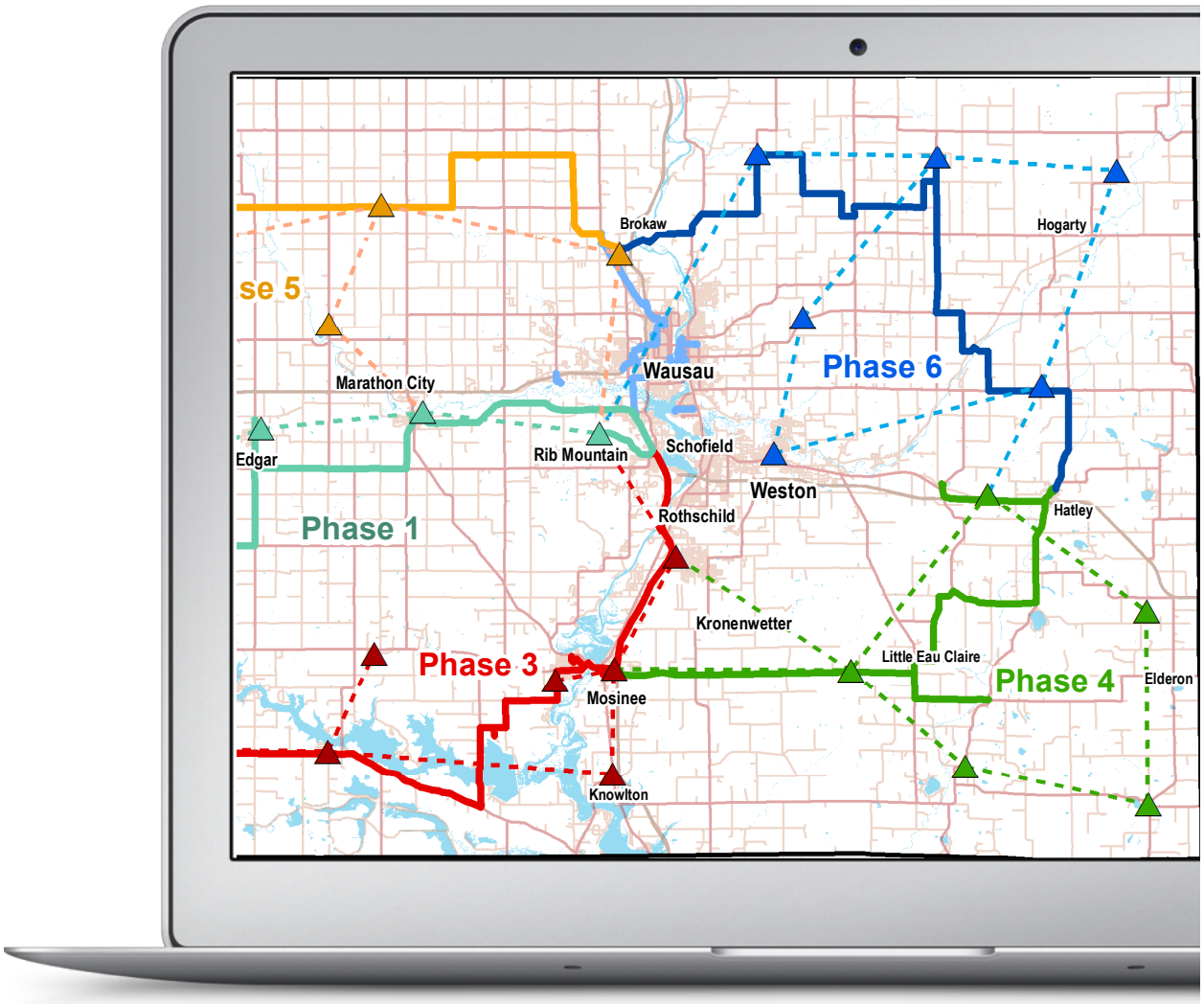
BROADBAND FOR MARATHON COUNTY

BROADBAND ASSESSMENT AND PLAN



DESIGN NINE
broadband planners

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1 EXECUTIVE SUMMARY

This report provides an analysis of the current state of broadband infrastructure and services in Marathon County. It also examines future broadband uses and needs, and proposes a series of improvements in broadband infrastructure, including a fixed point broadband wireless tower network and a county-wide fiber network.

Large portions of the county qualify as "unserved" or "underserved" by the FCC definitions of broadband service. Conversely, there are very few areas of the county that meet the FCC standard of 25/3 Megabits as "served."

Residential and business use of Internet bandwidth continues to increase by 30% per year. Marathon County will fall farther and farther behind other areas of Wisconsin and the Midwest without a strategic plan to develop modern broadband infrastructure.

In Wisconsin, local governments are constrained by law from offering retail Internet services. Instead, the County should develop public/private partnerships with Internet providers, who would offer all retail services to residents and businesses. The goal should be for the County and the localities to make investments in basic broadband infrastructure—digital road systems. Local governments build and maintain roads, but they do not own the businesses that use those roads to deliver goods and services.

Section Nine of this study provides network designs for a countywide fixed point wireless network and a Gigabit fiber network. The development of the two networks has been divided into six phases. While the two proposed networks have been designed to complement each other to provide a highly redundant design, portions of each network could be built without any particular regard to the sequence of the phases in this document.

The fixed point wireless design recommends improvements to existing towers in the county and several new towers. Space on the new and existing towers would be leased to Wireless Internet Service Providers (WISPs). Propagation studies of the proposed tower sites indicate nearly 90% of address points in the county could receive service if clear line of sight is available, and about twenty new towers could provide service to nearly all homes and businesses (close to 90%) in the county.

With the towers recommended in the report, WISPs would be able to deliver the state's speed goal of 25 Megabits per second download and 3 Megabits per second upload to virtually anywhere in the county—meeting the Governor's goal of this speed to all Wisconsin homes by 2025.

The proposed fiber network is a highly redundant and resilient design with multiple fiber rings that would deliver a full Gigabit fiber connection to residents and businesses. The network will also support large institutional and enterprise customers with 10Gig, 100Gig, and wavelength services.

The fiber network as proposed has been designed to support expansion over time to take fiber to the home (FTTH) services throughout the county, including the smaller communities outside the Wausau area.

Table 5.1 in Section Five shows that residents, businesses and institutions in Marathon County are spending huge sums for broadband and telecom services in Marathon County. Using today's average costs for common Internet, TV, and voice services, over the next twenty years, an estimated $3 billion in telecom fees will be paid out by the residents, businesses and institutions in the county. If as little as 4% of those funds were re-directed to local and community ownership of broadband infrastructure,

every home and business in the county could have Gigabit fiber connections—as little as $16/month/household could finance fiber to the home and business throughout the county. The ability of the County to bond for no more than twenty years is not an obstacle to a countywide fiber to the home effort.

As part of this study, a ten year financial analysis was developed that indicates a robust fiber to the home effort to develop an open access fiber network (with ISPs offering all retail services) could be in the black in as little as three years and could easily provide services to thousands of Marathon County households and businesses.

Given the steady growth of Internet services for both business and residential use, current usage patterns in the county are not a good predictor of future broadband needs. Network investments in the county must be designed to scale gracefully to support future uses over the next thirty years. Those uses include K12 education, work from home opportunities, tele-medicine and tele-health services, home security, energy management, and many other emerging services and uses. A strategic broadband initiative should invest in infrastructure that will meet future needs, not current demand. A future-proof community has the following characteristics:

- Abundant, inexpensive local bandwidth to homes, businesses and institutions.
- Massive connections to the worldwide Internet.
- Network redundancy available in many locations throughout county.
- Rich local, regional, national, and international content and services from a multitude of sources.

Marathon County can be attractive to an emerging new group of business people and entrepreneurs that typically are well-educated, own their own businesses or work for large global corporations, and are making choices about where they lived based on family needs and interests rather than business interests.

This new breed of entrepreneurs and workers places a high value on the kinds of amenities that contribute to a good quality of life, such as traditional neighborhoods, vibrant downtown areas, a wide range of cultural and recreation opportunities, good schools, and a sense of place.

These businesspeople and their families make relocation decisions based on quality of life only where there is abundant and affordable broadband, because broadband enables this new approach to personal and work life.

1.1 RECOMMENDATIONS

OBTAIN SUPPORT FOR REPORT RECOMMENDATIONS

Formal letters of support for the recommendations contained in this report should be obtained from major businesses, County Board of Supervisors, and towns in the county.

SET PROJECT AND FUNDING GOALS

The broadband project team should review the recommendations in this report and set one-, two-, and three-year project and funding goals. These goals should be used to provide guidance on which grants to apply for and which projects and areas should be be included in each grant application. The project and funding goals document should be reviewed and updated twice yearly.

INVEST ONLY IN BASIC TELECOM INFRASTRUCTURE – LEAVE INTERNET TO THE PRIVATE SECTOR

The towns, cities, villages, and the county government should not engage in retail Internet service delivery. Government investments should be focused on basic infrastructure like wireless towers, conduit, and fiber that can be leased out to the private sector for their use.

DEVELOP A LONG TERM FUNDING STRATEGY

The State of Wisconsin is providing grant funds to support fiber and wireless infrastructure, and some other Wisconsin counties have successfully partnered with Internet providers to win substantial funding. Federal grant programs from USDA and HUD can also be important sources of funding. It is important to recognize that grants may not provide sufficient funds to reach the county's long-term goals and some local funding sources may be needed to achieve the County's long term broadband goals. Section Twelve provides more information of a variety of funding approaches.

IMPROVED AND AFFORDABLE FIBER AND WIRELESS IS NEEDED

Residents and businesses outside of communities with cable Internet service rely on poor DSL internet access and need an alternative. Making county-owned towers available to Wireless Internet Service Providers (WISPs) and provisioning new towers in some underserved areas will support improved Internet service. Business parks, industrial parks, and the downtown areas of smaller communities in the county will all benefit from a strategic broadband initiative with appropriate funding. Affordable and available fiber in economic growth target areas can increase property values, make commercial and industrial building spaces more attractive, and help attract and retain jobs and businesses. This report contains a fixed point wireless broadband strategy that would provide improved wireless Internet service to as much as 90% of addresses in the county (see Section Nine).

SUPPORT MIDDLE-MILE FIBER EFFORTS

While improved broadband wireless service is going to be a critical part of any plan, the county needs some middle-mile fiber. Bandwidth needs for residents and businesses are increasing 30% each year, so fiber will be needed to ensure that wireless broadband is able to provide the needed performance. Some fiber is also critical to any economic development efforts to attract jobs and businesses to the county. In Chapter Nine, a comprehensive middle mile fiber network is described. This network would immediately connect hundreds of public and private facilities with Gigabit Internet, but would also have the capacity to support expansion over time to take Gigabit Internet services to most homes and businesses in the county.

FUND FOR SUCCESS

Successful expansion of broadband in the county will be most successful by recognizing that funding will come from a range of funding sources rather than a single source. Grants, public/private partnerships, some local funds, and other sources may all be needed to achieve success.

Grants can be extremely important in the early stages of an effort to support planning activities and/or to fund a first-phase build-out initiative. However, grants rarely allow spending on operational expenses. Grants should be used carefully as one-time cash injections to support very specific goals. Communities that have relied too heavily on "the next grant" as a key source of expansion or operational funding usually experience severe financial problems.

ATTRACT SERVICE PROVIDERS

Once an initial plan is in place to make broadband infrastructure improvements (conduit, handholes, fiber cable, wireless towers), Internet Service Providers (ISPs) should be invited to meet to discuss making use of the planned infrastructure.

PUBLIC SAFETY PARTNERSHIPS

The availability of public-safety towers and/or new towers can enable new services and applications for police, fire, and rescue in the county. Secure WiFi hotspots can be set up around and near the towers, so that reports can be filed from the field using the WiFi Internet connection. Other communities that have done this have found that it saves time and keeps patrol cars out in the field longer.

There are often grants available for public-safety voice and data communications improvements, like new towers and upgrades to existing tower facilities, that could also support the broadband initiative. Any public-safety tower or communications expenditure should be analyzed to determine if the expenditure can also support expanded broadband access in the region.

2 BROADBAND IS A NECESSITY

Affordable high speed Internet is essential to the future growth and prosperity of Marathon County. Over the past 20 years, Internet access has evolved from a luxury to a necessity. School students need Internet access to complete homework and to study. Online shopping can save energy and make it easier for the elderly and homebound to obtain daily necessities. Telemedicine and telehealth services and applications are revolutionizing health care, reducing costs, and allowing older citizens to live independently longer. More and more workers and business people are working from home, either on a part-time or a full-time basis. New work-from-home job opportunities are growing rapidly, but most of those jobs require reliable, symmetric Internet service to qualify.

Many business employees are already trying to work from home more often (e.g. one or two days per week) to reduce travel costs. Some major businesses in other parts of the U.S. are actively planning to have 20% of their workforce work full time from home to reduce employee travel costs and office energy costs. Corporate employees working from home require high bandwidth services to be connected to the office network and to use corporate videoconferencing systems. These corporate network services often require 10-50 Megabit-per-second (Mbps) symmetric connections (symmetric Internet service is not widely available in the county).

The ability to obtain full-time employment work from home with good pay can be a game changer for the communities in the county – but only if residents and businesses have access to affordable broadband services that support work from home.

The county has many lifestyle amenities that are highly desirable in today's economy: small towns with excellent quality of life, a tremendous variety of recreational opportunities, and a low cost of living. However, the most important data point from the broadband survey is that 68% of respondents indicated that the availability of good broadband was affecting where they choose to live. For remote employees to leverage those the area's amenities, and for the county to reap the community and economic benefits of better employment opportunities, the county must have good broadband.

Broadband has become essential community infrastructure.

Just as communities had to take on the task of building and maintaining roads in the early twentieth century, communities must now provide basic broadband infrastructure as a matter of community and business survival.

Governments build and manage roads, but don't own or manage the businesses that use those roads to deliver goods and services.

The tremendous versatility of the Internet and the underlying technology bases now allows services that used to require their own, separate (analog) road system (voice telephony and TV services) to be delivered alongside other services like Internet access on a single, integrated digital road system.

If we managed overnight package delivery the way we manage telecom, UPS and Fedex would only deliver packages to residences and businesses where each delivery firm had built a private road for their exclusive use. We recognize immediately the limitations of such a business model--few of us would have overnight package delivery to our homes

because the small number of packages delivered would not justify the expense of building a private paved road.

Before the rise of the automobile, most roads were built largely by the private sector. After cars became important to commerce and economic development, communities began building and maintaining roads because it became an economic development imperative to have a modern transportation system in communities.

Before the rise of the Internet, digital networks were built largely by the private sector. As broadband has become critical to commerce and economic development, communities with digital roads are more competitive globally.

The time has come to recognize that it is inefficient and wasteful to build full duplicated digital road systems, which only raise the cost of telecom services to all public and private users. Networks that share capacity among a wide variety of public and private users have a lower cost of construction and a lower cost of operation—benefiting all users.

Table 2.1: Utility Comparison

SHARED ROADS	SHARED AIRPORTS	SHARED TELECOM
Historically, roads have been built and maintained by the community for the use of all, especially private firms that want to use them to deliver goods and services.	Airports are built and maintained by a community or region as an economic and community development asset. Both public and private users benefit from the shared use of a single, well-designed airport	Towers, conduit and fiber may be installed and maintained by the community and/or a neutral owner/ operator for the use of all, including private firms that want to use them to deliver goods and services.
Access to the community road system is provided by parking lots and driveways, built by property owners, developers and builders.	Airport assets like departure gates, ticket areas, and runways provide access to the airline services.	In the digital road system, access across private property to the community–wide network in the public right of way is provided by towers, conduit and fiber built by property owners and/or developers and builders.
The local government uses roads only to deliver government services. Local government does not offer services like overnight package delivery.	While the local government or a consortium of local governments typically own the airport facility, the local governments do not offer flight services.	Local government uses the digital transport system only to deliver government services. Government does not offer services like Internet access or Voice over IP.
Private sector businesses use roads so that their own cars and trucks can deliver goods and services to customers. Because businesses do not have to build and maintain roads, all businesses benefit directly by being able to reach more customers at less expense.	Private sector airlines are able to offer competitively priced airfares because of the shared cost of the airport terminal facilities. Each airline does not build its own airport (which would sharply increase the cost of airfare).	Private sector businesses use the digital transport system to deliver goods and services to customers. Because businesses do not have to build and maintain a digital road system, all service providers benefit directly by being able to reach more customers at less expense.
There are no road connection fees, and anyone may connect to the road system for free. Governments pay for the cost of maintaining roads largely from those that use the roads . Fees are proportional to use, from taxes on tires and gasoline.	Businesses and citizens do not pay a fee to access the airport facility. The cost of maintaining the airport facility is paid by the airlines, which bundle that cost into the price of airfare. Fees are proportional to actual use by flying customers. Airlines benefit because they do not have to build, own, and operate the airport directly. Those costs are shared across all users.	Any qualified service provider may connect to the digital road system for a nominal fee and begin to offer services, without any significant capital expense. Network capital and operating costs are recovered by charging service providers a small fee that is based on a percentage of their income from services offered over the system.

2.1 THE SHARED INFRASTRUCTURE BUSINESS MODEL

Traditionally, the telecom services market has been vertically integrated, with telephone and cable companies owning the cable infrastructure (i.e. twisted pair copper cable for telephone, and coaxial copper cable for TV). These companies bundled analog services with their own infrastructure, which made sense when only one service could be delivered over the cable.

American residents and businesses needed two networks: one for voice telephone service, and one for television. The rise of the Internet and associated changes in technology led to digital services (voice, video, Internet) that could be delivered simultaneously over a single cable or wireless connection.

By the early 2000s, it was becoming apparent that it was inefficient and costly to have two competing "retail" cable systems (e.g. telephone, cable) delivering the same content and services—it was only creating higher costs for residents and businesses.

A new business model became possible: wholesale leasing of the cable/wireless infrastructure to private sector service providers, which unbundles the infrastructure from the services. A side effect of this unbundling is that it becomes much easier to determine what a customer is actually paying for a given service: in the vertically integrated 20th century model, with the cost of infrastructure maintenance bundled together with the services, it is much more difficult to determine what a service actually costs.

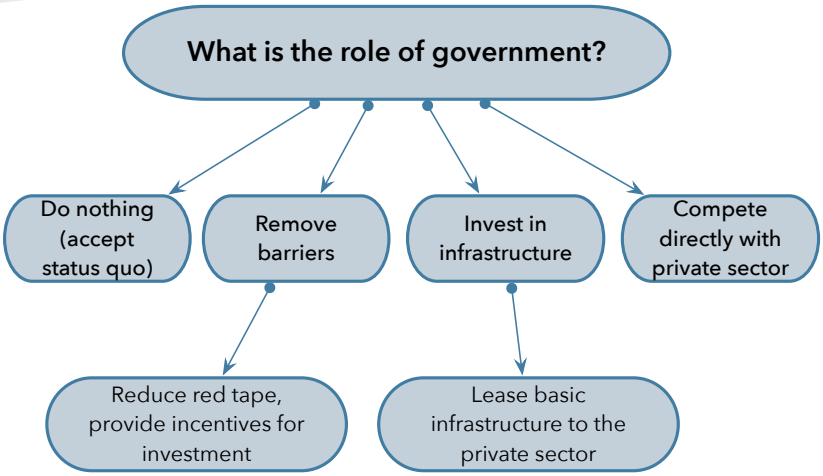
In the wholesale infrastructure business model, local government investments are limited to passive infrastructure like conduit, dark fiber, and wireless tower space. Services for businesses and residents are offered by private sector providers offering Internet, TV, telephone and other data services. The components of the transport network include conduit, handholes, cabinets and shelters, splice closures, and network equipment.

In Marathon County, improved wireless broadband is going to be an important part of improving broadband service availability and affordability, and WISP access to existing and/or new towers should continue. Fiber to the business in key areas and fiber to the home in key areas is also critical to support long term community and economic development goals.

For both fiber and wireless infrastructure, Marathon County should pursue the wholesale broadband infrastructure business model. WISPs and ISPs using the broadband infrastructure should provide the retail services to businesses and residents.

2.2 WHAT IS GOVERNMENT'S ROLE?

Successful improvements in broadband access, affordability, and reliability for Marathon County involves several decision points, as outlined in the illustration to the right. Government has several "first choice" options.



Do nothing is to accept that businesses and residents in the county will have to continue to use whatever is available, despite the cost and bandwidth limitations that limit what many are able to do online.

Government can ***remove barriers*** to private sector investment. This can be an effective and low cost strategy. Possibilities include reducing permit fees for fiber construction and tower installation, incentives to developers to install conduit and meet-me boxes in new residential and commercial construction, simplified permit requirements for rural utility pole installation on private property, and identifying areas of residential and business demand and sharing that information with providers.

The County could choose to make ***investments in basic infrastructure*** and make that infrastructure available to the private sector via revenue-generating lease agreements.

When communities have chosen the option to ***compete directly with the private sector*** by offering retail Internet, phone, and TV services lawsuits from incumbents often create difficulty moving forward as well as expensive legal fees.

RECOMMENDATION

Marathon County and the cities, towns, and villages within the county can both **remove barriers** and **make targeted investments** in infrastructure. These two activities can be executed in parallel, with investments taking place as funding sources are identified. There are a variety of low cost and no cost efforts, mostly at the policy level, that the county can do to encourage more private investment—with a primary focus on keeping the cost of permitting and constructing new wireless towers as low as possible.

As one example, investments in improvements to existing county-owned towers and/or adding new county-owned towers could help existing wireless providers bring more services to underserved areas and/or attract much competitive broadband wireless providers into the county.

3 HISTORY OF PAST BROADBAND EFFORTS

The 2009 Broadband Gap Analysis study team data *"indicated that broadband offerings in Marathon County are diverse in capacity and cost."* The same can be said of broadband offerings in 2019, only more so. Judged by the definition of minimum broadband speed in 2009 it would appear that the nation and Marathon County have made great strides forward in the provision of broadband services. As the Gap Analysis authors stated in their rationale for the study: "*For the purposes of this Report, we have used the definition of 'broadband' set forth recently by the National Telecommunications and Information Administration (NTIA), that is, at least 768 Kbps [768 thousand bits per second] downstream and 200 Kbps upstream.*" Practically every county resident can acquire this 2009 defined minimum broadband speed even if it means a nighttime drive to the local library parking lot or paying expensive cell phone data fees.

The Gap definition of minimally acceptable broadband is a quaint vestige of the "early days" of the digital transformation in 2009 but which is totally inadequate for life in 2019. The "Strategic Plan" described in the Gap Analysis called for bold steps in the context of 2009: *"In order to use the Internet to its greatest potential (such as operating online businesses, telecommuting, and participating in video-based education) Marathon County should plan for a long term future that provides reliable Internet speeds in excess of 1 Megabits/second – perhaps 5-20 Megabits/second – in all homes and businesses."*

The strategic goal of 5-20 Megabits/second proposed in the Gap Analysis seemed bold in 2009. However, the current FCC minimum recommended speeds of 10 Megabits/second download and 1 Megabits/second upload and Wisconsin's adoption of the more common definition of minimum broadband speeds of 25 Megabits/second download and 3 Megabits/second upload by 2025 can barely accommodate 2019 broadband applications. Nevertheless, these broadband speeds would be welcomed improvement to the low speed and inconsistent quality of digital communications available now to many Marathon County rural homes and businesses.

Ten years of technological advancement since the release of the 2009 Gap Analysis has allowed certain broadband improvements to seep into Marathon County. Broadband speeds of 100 Mb/s and faster that are now commonly available in large metropolitan areas, even in Wausau, were unimagined a decade ago.

But many of the factors that caused poor communications in the 2009 Gap Analysis remain readily observable today and are endured by many Marathon County residents. *"A map developed during this process [2009 analysis] show several "dead zones" (Appendix I). In addition to these areas that lack coverage it is important to understand that a number of homes and businesses within the shown wireless coverage areas cannot obtain wireless service. They are blocked by trees or located in a low-lying area which wireless signals cannot reach. We have anecdotal evidence to suggest that as many as 50% of the homes within the indicated coverage areas cannot receive an adequate wireless connection. And in some areas where DSL is generally available, the quality of the copper cabling to some homes is too poor for DSL to work."*

Rolling countryside with hills and dales, dense foliage and sparse tower locations hinder wireless signal propagation in 2019 much as they did in 2009. And DSL is still based largely on services developed

decades ago despite technological advancements in wireline services that are available in many urban areas.

The 2009 Broadband Gap Analysis Executive Summary implies that poor digital connectivity may only be an inconvenience for a small portion of the rural population:

> *"While there does not seem to be an overwhelming groundswell of demand in Marathon County for broadband services, there are instances in which the lack of broadband capacity leaves rural small businesses and residents at a distinct disadvantage when compared to their counterparts in more densely populated areas."*

Recent meetings with stakeholders indicate that there is indeed an overwhelming groundswell for more broadband capacity.

In 2019 poor broadband has become a hurdle to effective economic development in rural areas of the county. Rural residents know this. Most have investigated all broadband options available for their businesses, farms and homes. In 2009 Gap Analysis survey 64% of residences and 26% of businesses were unsatisfied with their broadband speed.

In 2019, with vital applications typically available only online, dissatisfaction with broadband speed appears to be much higher now than it was in 2009, primarily because Internet-enabled services have multiplied. Many kinds of services and opportunities require not just Internet access but robust bandwidth. Telemedicine and telehealth services increasingly use two way HD video. For rural residents who may have longer drives to reach medical clinics and offices, telemedicine services can save travel time and travel costs. But the FCC standard of 25/3 Megabit is barely adequate to support two way HD video.

The potential of new broadband technologies was discussed in the Gap Analysis. 4th Generation cellular (4G), Broadband over Power Line (BPL) and Fiber to the Premise promised relief from the broadband drought in 2009. 4G cellular has become the standard for mobile communications and its technology has become widely and successfully integrated into fixed-wireless point-to-point solutions offered by many wireless Internet service providers (WISPs).

The country is now beginning the transition to 5G using many of these same standards. The high hope for BPL expressed in the 2009 Gap Analysis has not been realized. The high level of interference inherent in BPL has rendered this technology unworkable for typical broadband applications.

Even "white space" technology which propagates wireless broadband on spectrum previously owned by TV broadcasters for their analog systems has been shown to be very slow. While it allows for minimal connectivity in rural areas, it has not been widely deployed, and is available in only a few areas of the country. A Microsoft-funded white space project in rural Virginia, after several years, has only a few hundred users. Microsoft recently announced a program to expand the availability of white space Internet systems, but the cost of the equipment remains higher than current broadband wireless systems.

Satellite broadband services have become more prevalent in rural areas as a last resort for broadband and TV. This service is expensive and displays the high latency and reception delay that would be expected from a radio signal being transmitted from geosynchronous orbit 22,000 miles in the sky.

Of all the new technologies reference in the Gap Analysis, fiber to the premises (FTTP) showed the greatest promise to relieve the broadband gap. The use of fiber in the core network and in the direct connections to residences and business still offers the most potential to "future proof" broadband

interconnectivity in 2019 and for many years in the future. This 2019 Broadband Study provides a plans for the implementation of a 21st century broadband network, its technology, funding and management.

BGA 2015 RECOMMENDATIONS

The Broadband Connectivity Task Force made several important recommendations in 2015 that are aligned with the recommendations in this report:

- The County government has an important role to play as "visionary" and "educator" for the citizens and businesses of Marathon County. Recognizing that much of the broadband improvements will be made by private sector providers, the County should define and promote a vision and goal of a "connected" county and support that with a regular awareness campaign with public and private stakeholders as well as citizens at large.
- The County should promote and encourage a county-wide dig once policy for both public and private users of right of way. The County should, at a minimum, make investments in shared telecom conduit wherever private firms want to place fiber/conduit in public right of way. This can be negotiated in a variety of ways, including sharing costs (e.g. County shares construction costs with a private provider and installs County-owned conduit that can then be leased out to other providers).
- The County should plan to maximize use of County-owned public safety towers for fixed point broadband use. All public safety towers should be analyzed for available WISP space and should have a current structural analysis to determine if each tower can accommodate additional WISP equipment. Tower space lease fees should be modest.

WISCONSIN BROADBAND PLAN

The Wisconsin Broadband Plan has several important features that could support Marathon County's effort to improve broadband affordability and access:

- A target of 25/3 Megabits/second is set for the entire state by 2025. This could be achieved in Marathon County by expanding tower space availability to support local and regional WISPs. It is important to note that the 25/3 target should be regarded as one step towards much higher speeds, and that over the longer term, much wider fiber Internet availability should be part of the County's strategy.
- The Broadband Plan allocates $78.6 million over the next two years for broadband improvements, and specifically indicates that those funds are available to municipalities. Marathon County should work with ISPs to apply for these funds as soon as possible to support a phase one (first year) broadband expansion plan (only ISPs can apply for these funds).
- There is a commitment from state agencies, including the state Broadband Office, to assist with USDA ReConnect grants. Marathon County should plan to submit a ReConnect grant, and should begin working with county and state agencies as soon as possible—a minimum of six months is recommended for preparation of a ReConnect application. The deadline for the next grant cycle will be mid-spring 2020.

4 BROADBAND GAP ANALYSIS

4.1 LOCAL USES AND NEEDS

BUSINESS COMMUNITY BROADBAND MEETING

Nine (9) members of the business community met in July to discuss their interest in the Broadband Feasibility Study and high speed Internet needs. Meeting participants were asked to discuss their interest and background in high speed Internet:

Eric Budleski, stated that his business obtains Internet service through a satellite provider, which is costly. Budleski relayed that a new network should be forward thinking and plan for future expansion. Budleski also mentioned that without high speed Internet service, he would have to relocate.

Will Hsu, stated that his business relies on e-commerce and precision agriculture. Hsu's Ginseng is located in the Town of Texas and was able to connect to a junction site in Brokaw. Hsu's Ginseng worked with area property owners and Charter to extend services. Without extension of broadband the company would have been forced to look at relocating to Wausau or another national location. The company has difficulty with employees accessing Internet from remote locations in the field or from their home. For example, customer service staff working remotely is limited because employees can't support VOIP at their personal residence.

Jacee Feit of Lemke Industrial Machine relayed that the company's service is provided by satellite, which experiences frequent interruptions in service (up to several days at a time) and has experienced up to two and a half weeks without phone service. The Company manufactures infrastructure for multiple state and Federal infrastructure projects. There has been difficulty uploading large files, causing the company to lose the opportunity to bid jobs, due to slow upload speeds.

Joe Thompson, IT Manager Aspirus, relayed that Aspirus has centralized data centers in Marathon County and is looking at expanding telehealth options. Thompson also lives in Town of Wausau and does not have access to landline phone or broadband. Aspirus has lost candidates who were drawn to the rural environment but frustrated with the lack of opportunity to live in a rural area with high speed Internet infrastructure.

Meeting participants communicated that the lack of broadband infrastructure makes it difficult to complete in a global or even national economy and that there is opportunity for additional business if Marathon County had the infrastructure to accommodate it.

INCORPORATED COMMUNITY BROADBAND MEETING

Nine (9) individuals attended Marathon County's incorporated communities in July to discuss the current broadband environment and need for infrastructure in their communities.

Meeting participants were asked to discuss the high speed Internet environment in their community:

Randy Fifrick, Village of Kronenwetter Community Development Director, communicated that the more rural areas of the Village need reliable high speed Internet access. The Village is not currently partnered with TDS because their proposal would not provide access to the entirety of the Village.

Richard Downey, Village of Kronenwetter Administrator, relayed that the Village is served by a mix of wireless technologies including satellite, cellular carrier, DSL, and dial up. There are areas of spots without coverage and the Village is working with TDS to expand service to limited areas.

Gaylene Rhoden, Town of Rib Mountain, stated that TDS is building a hub on public property but that the Town chose to not partner with TDS because they did not want to serve the entirety of the Town and they are looking to provide service to the 20% of the Town currently without broadband service. There are geographical constraints to expansion of high speed Internet in the Town.

Nate Crowe, Village of Weston, communicated that the Village Board paid TDS $175,000 to expand service within the Village, with an extra $50K for additional services. After construction 80% of the Village will be served by TDS. Crowe relayed that TDS has been good to work with and has shared the location of their fiber with the Village.

TOWN BROADBAND MEETING

Three (3) representatives of Marathon County's Towns met in July to discuss the current broadband environment and need for infrastructure in their communities. Meeting participants were asked to discuss the high speed Internet environment in their community:

Marilyn Bhend, Town of Johnson, indicated that satellite service was the only option in her area and costs $103.33 a month.

Sharon Hunter, Town of Weston, communicated that areas of the Town do not have access to broadband which is surprising given the proximity of the Town to the City of Wausau.

Al Christiansen, Town of Ringle, indicates that his current wireless Internet service doesn't meet modern needs and that small businesses are interested in obtaining broadband service.

INTERNET SERVICE PROVIDER MEETING

Jack Maytum with Design Nine met with ISPs that offered services in Marathon County in July. Maytum provided an overview of the Broadband Feasibility Study and reiterated that the County wants to determine the best way to assist the private sector in expanding broadband service.

Scott Nyman, Cirrinity a subsidiary of Wittenberg Telephone Company, communicated that Cirrinity has installed fiber in Town of Bevent and has other planned projects in the Hatley and Pike Lake areas. Cirrinity has received four State of Wisconsin grants and some Federal funding. Cirrinity has recently acquired Electronic Innovations, a wireless provider with towers on Rib Mountain and Mosinee Hill. Community letters of support assist the grant process. There is potential for expansion along Highway 153 to connect the eastern edge of the County with the City of Mosinee. Nyman relayed that Cirrinity would be open to leasing conduit or fiber depending on the quality of construction. Cirrinity budgets $40,000 per mile for fiber installation and installs a 576 strand fiber.

Mike Schaefer, President and CEO of Taylor Electric, relayed that the Cooperative funded a study in Taylor County to connect substations with fiber with a total cost of approximately $20 million. Taylor County is working with Vantage Point Solutions on a feasibility study; the County would like to have the study completed to appropriately allocate funds in the 2020 budget. TDS, Charter, CenturyLink and Frontier are Internet providers in Taylor County. At this time, the Cooperative is not looking at functioning as an ISP.

Jeremy Carlofi, Country Wireless, commented that most of their coverage is on a legacy 7 Megabit system providing and the company is actively upgrading their towers to 50/6 Megabits. Country Wireless also serves areas that also have DSL, and that many of their their customers come to them because of the slow DLS speeds. Expansion is limited by labor shortage. Country Wireless focuses on the western portion of the County to make the most efficient use of their resources. Country Wireless is

currently constructing 190-foot towers to replace infrastructure that was previously on farm silos. Installation of community towers would assist in the provision of wireless Internet service. Pole costs range from $1,000 on a used utility pole to tens of thousands for monopoles. Country Wireless leases fiber from Marshfield Utilities.

Nick Kumm, Marshfield Utilities, stated that the Utility connected substations with fiber and leases strands to other organizations. The Marshfield Utilities service areas is 120 square miles and includes the Town of Spencer and the Stratford area.

Damien Sweeny, Network Professionals, communicated that Network Professionals provides service in portions of eastern Marathon County. Network Professionals provides 25/3 Megabit service for residential services and 100 Megabit to companies in industrials parks, which is competitive with Charter. This also provides redundancy in case of fiber issues. Network Professionals would like to backhaul with fiber, but there isn't fiber available.

There was a general consensus among service providers that 25/3 Megabit would serve most single family residences and small businesses well. The providers also agreed that they would be interested in leasing fiber, as long as the playing field was fair, with standard contacts.

EDUCATIONAL COMMUNITY MEETING

Jack Maytum met with school officials in July and provided an overview of the project, which includes developing an understanding of the current broadband environment and facilitating the design and installation of a 21st Century broadband network.

Mike Endreas, Spencer School District Administrator, communicated that portions of district are unserved due to the district being in two separate counties. Marshfield Utilities and Solarus provide service in portions of the District.

Brady Mesenberg, Mosinee School District Director of Technology, stated that eRate has enabled good quality broadband service within school facilities. The District provides wireless hotspots for students to take home, but they don't always function. There is a significant cost for high speed Internet in the rural areas of the District. The State has promoted digital learning days, but that can be difficult without access to high speed Internet.

School officials agreed that they informally provide WI FI hotspots after school hours in school facilities, at youth sporting events and in school parking lots.

Emmett McBride, D.C. Everest Director of Technology, communicated that it isn't very far from the incorporated areas that high speed Internet is unavailable or extremely costly. The D.C. Everest School District is part of the Wausau CAN, where the CAN is not available the District relies on Charter to provide Internet service, which is costly. A lot of parents anticipated living in the County's rural communities, but end up living in the Wausau or Weston area due to limited Internet options. Technology staff cannot work remotely and lack of high speed Internet negatively impacts the attraction and retention of staff. Lack of high speed Internet coverage also limits the amount of available appealing housing and increases the cost of housing with Internet service.

Chris Trawicki, Edgar School District Technology Coordinator, relayed that the majority of the Village of Edgar is served by Charter and the outskirts of the Village are served by Frontier DSL.

Dee Brewster, Athens School District Information and Technology Coordinator, relayed that the District is examining installing hot spots in community facilities.

Map 4.1 depicts how severe the broadband problem is in Marathon County. This state-supplied data illustrates that well over half the county does not meet the FCC minimum "underserved" speed of 10/1 Megabits.

4.2 CURRENT AND FUTURE DEMAND

In the previous section, it is worth noting that many of the service providers interviewed felt that asymmetric (different upload and download speeds) service of 25 Megabits download, 3 Megabit upload was adequate for residential customers. In our work in other rural counties, the difficulty of working from home is frequently cited as a major issue. The ability to work from home, part or full time, usually needs symmetric bandwidth (equal upload and download speeds). Home-based businesses and home-based workers need VoIP telephone service, HD videoconferencing services, and the ability to move large files back and forth between the home and the corporate office and/or client sites. All of those applications perform substantially better with symmetric service, and may not perform at all with highly asymmetric service.

Asymmetric bandwidth: Download speeds much faster than upload speeds; typically adequate for home use.

Symmetric bandwidth: Download and upload speeds are equal; typically required for work-from-home. Many businesses also want and need symmetric bandwidth service options.

In many areas of the county, many residents and businesses are limited to the FCC "underserved" bandwidth definition of 10 Megabits/second down/1 Megabits/second up. This slow-speed service is impacting economic and community development:

- It limits residents' ability to work from home.
- It limits the ability of the county to retain existing businesses and to attract new businesses and jobs.
- It limits school children's ability to access the K12 and higher education resources needed to complete homework assignments.
- It limits residents' ability to access cost-saving tele-medicine and tele-health services from home.
- It limits residents' ability shop from home to save money on gas and travel expenses.

In Marathon County, the real issue as it relates to broadband speeds is the future of work. In eastern Kentucky's rural Jackson and Owsley counties, the People's Rural Telephone Co-op deployed high speed fiber service, and the improved infrastructure brought more than 800 new work-from-home jobs to the two counties. Residents in Marathon will not have the opportunity to pursue the kinds of jobs that are now available without better and more affordable access to broadband.

The FCC has defined the next broadband tier (fully served) to be 25 Megabits/second down and 3 Megabits/second up. The problem with the 25/3 definition is that the upload speed (3 Megabits/second) is not always going to be adequate to support work from home, especially where home-based workers need to connect to a corporate Virtual Private Network (VPN). Work-from-home and business-from-home activities should have at a minimum 10 Megabits/second down and 10 Megabits/second up speeds. Higher speed service could include service levels like 25 Megabits/second down and 10 Megabits/second up. The critical requirement is an upload speed that supports work from home.

If the goal is to enhance residential and business access to broadband, there can be no upper limit on the definition of broadband. Defining "broadband" as 5 Megabits/second or 10 Megabits/second of bandwidth is telling residents and businesses in the county that there will be limits on their work and job opportunities.

Broadband is a community and economic development issue, not a technology issue. The essential question is not, "What system should we buy?" or "Is wireless better or cheaper than fiber?" Instead, the question is:

"What do businesses and residents of Marathon County need to be able to compete globally over the next thirty years?"

In short, in Marathon County today there are many areas hampered by low-end broadband in the form of DSL, very limited wireless, expensive satellite Internet, and and very limited cable modem service. They also have a very limited high-end broadband in the form of fiber to a few businesses and institutions.

If the County is to make investments in broadband and telecommunications infrastructure, it is absolutely critical that those investments are able to scale gracefully to meet business and economic development needs for decades.

To close that gap between the FCC definitions and what the county needs to support future work opportunities and to support K12 and higher education school work, the county needs the following:

Table 4.1: Broadband Services, Technologies, and Needs

BROADBAND SERVICE	TARGET DATE	WHERE NEEDED	PHASE RECOMMENDATIONS
25 Megabits/ second upload 3 Megabits/ second download	2021	As much of Marathon County as possible, given funding constraints.	Implementation of wireless phases 1-6 will fulfill this goal.
25 Megabits/ second upload 10 Megabits/ second download	2022	In some locations throughout the county.	Improvements in wireless access equipment and fiber to some wireless towers will fulfill this goal.
1 Gbps upload 1 Gbps download	2021	In some key business and commercial areas.	Fiber service in at least some of the fiber phases 1-6 will fulfill this goal.
50 Megabits/ second upload 10 Megabits/ second download	2023	In many locations in in Marathon County.	Fiber to most broadband towers in the county will meet this goal. Fiber phases 1-6 will need to be largely complete.
100 Megabits/ second upload 100 Megabits/ second download	2023	Available to a minimum of 50% of residents and businesses in the county.	All fiber phases 1-6 will have to be completed, plus additional expansion of fiber in some towns (i.e. FTTH-Fiber To The Home).

Two key concepts that should drive community investments in telecom are:

"Broadband" is not the Internet

Bandwidth is not a fixed number

Broadband and "the Internet" are often used interchangeably, but this has led to much confusion. Broadband refers to a delivery system, while "the Internet" is just one of many services that can be carried on a broadband network. The challenge for the county is to ensure that businesses and homes have a broadband network with sufficient bandwidth to deliver all the services that will be needed and expected within the next three to four years, including but not limited to "the Internet."

The economic impact on Marathon County can include the following effects:

- Difficulty retaining some existing businesses. As business bandwidth needs continue to increase over the next several years, some businesses may need to move out of the county to ensure that they have the right bandwidth to support their business operations.
- Difficulty attracting new businesses. New businesses interested in some of the advantages of the county, like low cost of living, good recreational opportunities, and good workforce ethic, may be deterred by the cost and limited bandwidth available, and therefore choose other areas to locate.
- Difficulty keeping younger workers and families in the county. Younger workers and families tend to be heavy users of Internet services, and real-estate agents are reporting that younger house buyers are reluctant to live in areas with poor Internet service.
- Reductions in real estate value. Homes with poor Internet service are more difficult to sell, leading to lower prices, negatively impacting county income from property taxes.

4.3 LIMITING FACTORS

The factors limiting broadband availability and affordability in Marathon County include:

- Low population density. The generally low density of homes and businesses in many areas of the county make it more difficult for competitive service providers, like WISPs, to justify the expense of building towers and offering Internet service.
- Poor service from telephone providers. Like many other areas of Wisconsin, Frontier has not upgraded infrastructure and Frontier DSL service is slow and unreliable.
- Limited cable Internet service. Related to the low density, cable Internet service is very limited in many areas.
- Additional towers are needed to assist WISPs with expansion of their services. The high cost of towers deters many WISPs from expanding service. While there are many silos in the county where fixed point wireless equipment is currently mounted, the low height of silos limits how many households can access service from a give silo location.

4.4 HOW MUCH BANDWIDTH IS ENOUGH?

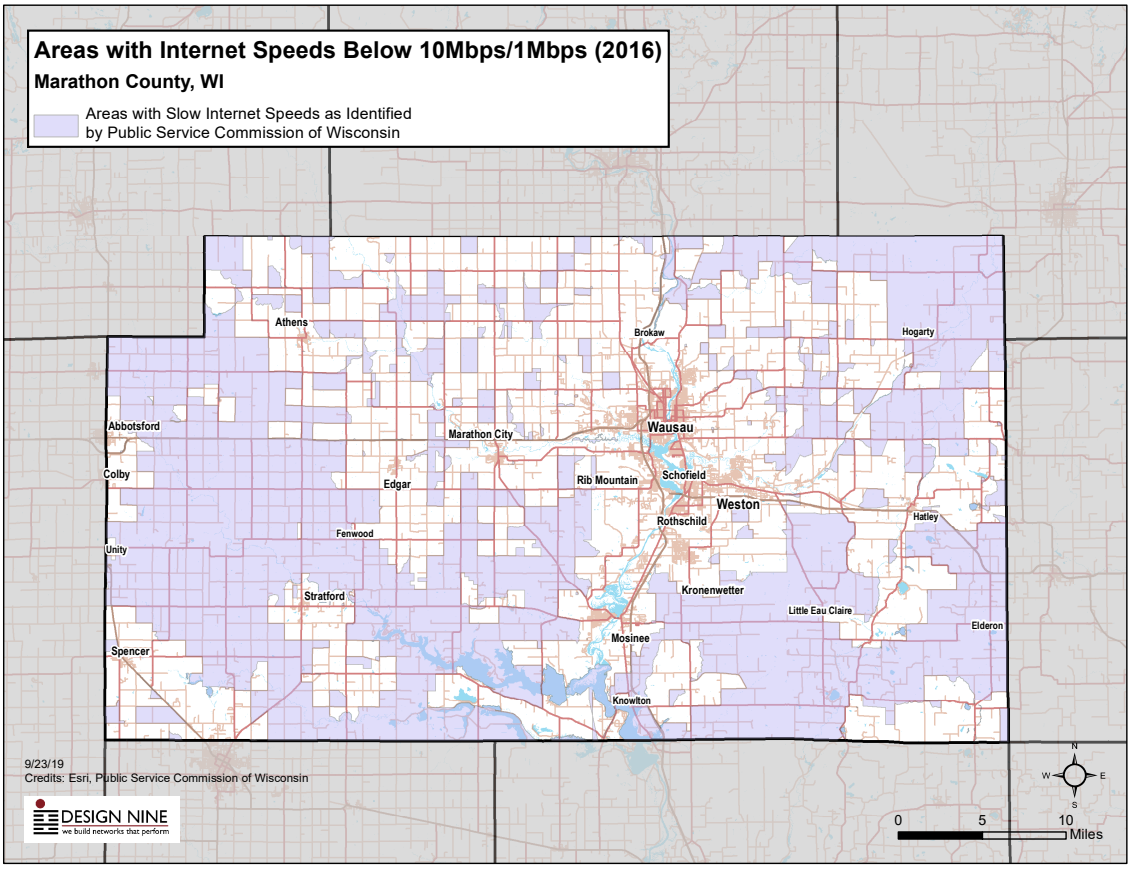
Bandwidth needs for the past several years have been growing by an estimated 30% per year and show no sign of slowing.

This means residential and business bandwidth needs are doubling every three years.

As computers and associated hardware (e.g. video cameras, audio equipment, and VoIP phones) become more powerful and less expensive, new applications and services are continually emerging that drive demand for more bandwidth.

"Next generation" is the term used to describe future planning for network connectivity and infrastructure. Next-generation broadband reaps substantial benefits. There are several key benefits of Next-generation broadband:

- Dramatically faster file transfer speeds for both uploads and downloads.
- The ability to transmit streaming video, transforming the Internet into a far more visual medium.
- Means to engage in true-real time collaboration.
- The ability to use many applications simultaneously.



Map 4.1: Areas with Internet speeds below 10 Megabits/second/1 Megabits/second (2016) in Marathon County (Provided from Public Service Commission of Wisconsin)

- Ability to maintain more flexible work schedules by being able to work from home on a part-time or full-time basis.
- The ability to obtain health-related services for an occasional illness and/or long term medical services for chronic illnesses.

Clearly, consumers have a strong interest in a visual medium from when and wherever they are. YouTube is the second most popular search engine after Google, which demonstrates the need to support the infrastructure to transmit streaming video. In addition to video streaming, true real-time collaboration also provides an effective way for people to interact from wherever they are. People can engage in a two-way real-time collaboration so that fruitful, visual conversations can be held between friends, family, business associates from the state, country, or internationally.

Because of fiber networks, employees have the capability of working from home. Findings suggest that if all Americans had fiber to the home, this would lead to a 5 % reduction in gasoline use, a 4% reduction in carbon dioxide emissions, $5 billion in lower road expenditures, and 1.5 billion commute hours recaptured.

In Marathon County, many residents and businesses are still relying on copper-based services or expensive and slow satellite Internet service. The bandwidth tables below show what is likely to be needed over the the next several years in terms of bandwidth. Within the next five years, existing copper infrastructure is going to become an even more limiting factor in economic development.

4.5 BUSINESS BANDWIDTH NEEDS

The table below shows bandwidth consumption for several types of businesses and a projection of the bandwidth needed 5 and 10 years out. The cost of fuel is already affecting business travel decisions, and more and more businesses will invest in high definition (HD) quality business videoconference systems to reduce the need for travel. These HD systems require substantial bandwidth; a two-way HD video conference requires 20-25 Megabits/second during the conference, and a three-way conference requires 30-35 Megabits/second during the conference. As more workers try to reduce the cost of driving to and from work by working from home, the business location must provide network access (Virtual Private Network (VPN)) to employees working from home. These home-based workers will make extensive use of videoconferencing to attend routine office meetings remotely and to enhance communications with co-workers, including videoconferences with other home-based workers in the company. A VPN network providing remote access to just two or three home-based employees could require 50 Megabits/second of bandwidth during normal work hours.

Table 4.2: Business Bandwidth Needs

	LARGE BUSINESS		SMALL BUSINESS		HOME BASED WORKER		BUSINESS FROM HOME	
Description:	A larger business with about 50 workstations.		A small business with 10 to 15 employees, and 7-10 workstations.		A single employee working at home for his/her company.		A home business with one or two employees working at home.	
Usage:	Concurrent Use	Megabits /second	Concurrent Use	Megabits /second	Concurrent Use	Megabits /second	Concurrent Use	Megabits /second
Telephone	20	1.28	5	0.32	1	0.064	1	0.064

	LARGE BUSINESS		SMALL BUSINESS		HOME BASED WORKER		BUSINESS FROM HOME	
TV		0		0		0		0
HDTV		0		0		0		0
Credit Card Validation	4	4	1	1		0		0
Security System	1	0.25	1	0.25	1	0.25	1	0.25
Internet	20	30	7	10.5	1	1.5	1	1.5
VPN Connection	5	25		0	1	5		0
Data Backup	5	7.5	1	1.5	1	1.5	1	1.5
Web Hosting	1	2		0		0		0
Workforce Training (online classes)	2	20	1	10	0	0	1	10
HD Video-conferencing	10	100	2	20	1	10	1	10
Telecommuting workers	5	15	2	6	0	0	0	0
Totals		205.0		49.6		18.3		23.3
5 YEARS FROM NOW (MBPS)	615		149		55		70	
10 YEARS FROM NOW (MBPS)	1845		446		165		210	

4.6 RESIDENTIAL BANDWIDTH NEEDS

The table below depicts the bandwidth needed for typical residential services which are available now or will be available in the near future. In a next-generation network all services will be delivered over a single network infrastructure which will require a network that can support providing most services to most consumers simultaneously. Today's shared networks (cable and wireless in particular) rely on the "bursty" nature of traffic to provide services to end users. If all end users were consuming their advertised maximum bandwidth, today's cable and DSL networks would grind to a halt. Existing cable modem network users are overwhelming the digital cable networks that were upgraded as little as three or four years ago, and the firms have had to artificially reduce the bandwidth available for certain kinds of high bandwidth services (e.g. peer to peer file sharing). Some cable providers have even run into capacity issues with the TV portion of their networks, and some consumers have observed that some HD TV channels have been so highly compressed that picture quality has been noticeably degraded.

Table 4.3: Residential bandwidth needs

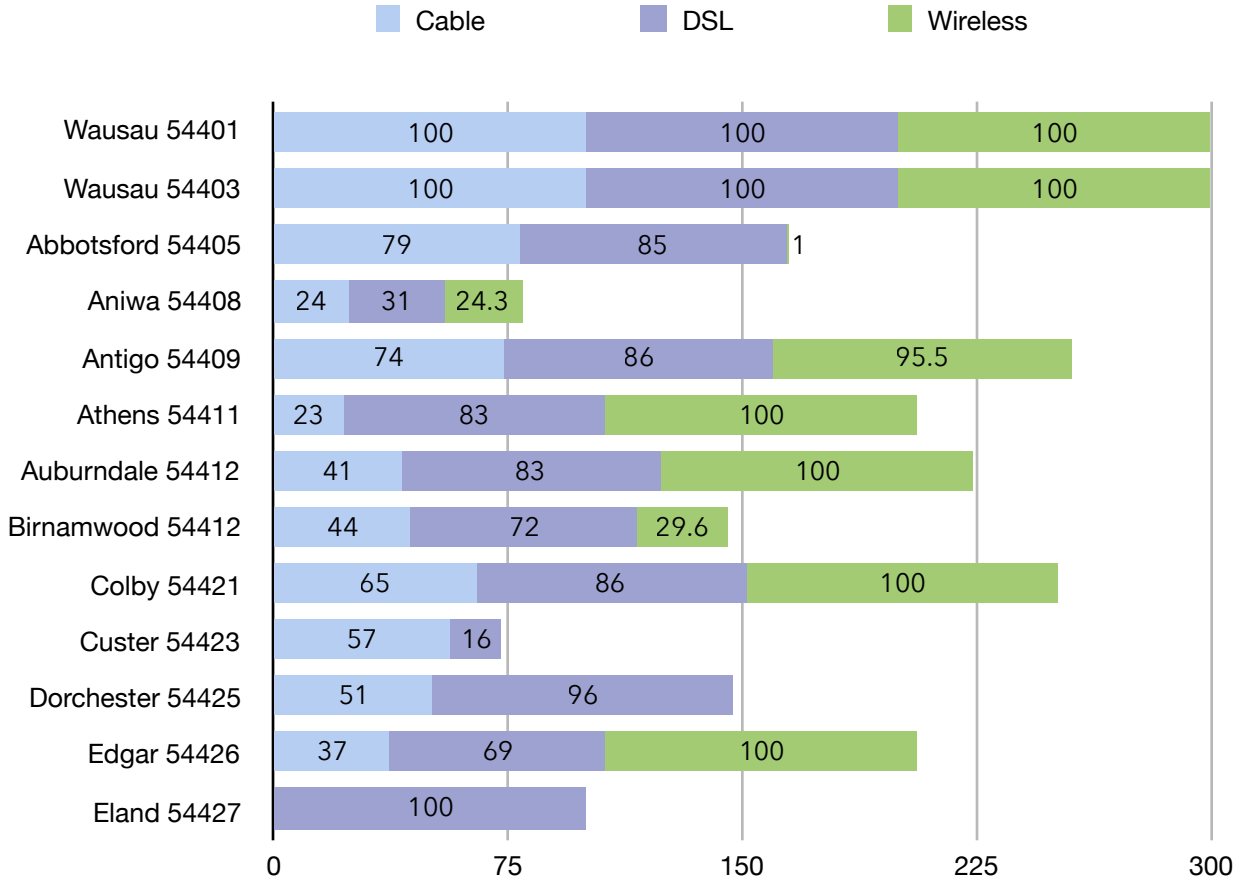
	RESIDENTIAL DAYTIME		EARLY EVENING		EVENING & LATE NIGHT		SNOW DAY	
Description:	Intermittent Television and Internet use across a small percentage of households.		Increased Internet use as children arrive home from school and employees from work.		Peak television/Internet use. Multiple TV's are on, phone and computer being used.		On top of typical daytime traffic children are home from school, and many employees are home working.	
Usage:	Concurrent Use	Megabits /second	Concurrent Use	Megabits/ second	Concurrent Use	Megabits/ second	Concurrent Use	Megabits/ second
Telephone	1	0.064	1	0.064	1	0.064	1	0.064
Standard Definition TV	1	2.5	1	2.5	1	2.5	1	2.5
HD TV	1	4	2	8	2	8	3	12
Security System	1	0.25	1	0.25	1	0.25	1	0.25
Internet	1	1.5	1	1.5	2	3	3	4.5
Online Gaming		0.25		0.5		1		1
VPN Connection	0	0	1	2	1	2	2	4
Data Backup		0	1	5	1	5	1	0
Telehealth (subscriber)	1	4	1	4	1	4	0	0
Distance Learning / Workforce Training		0	1	10	1	10	2	20
HD Video-conferencing		0		0		0	1	14
Totals		12.6		33.8		35.8		58.3
5 YEARS FROM NOW (MBPS)	**38**		**101**		**107**		**175**	
10 YEARS FROM NOW (MBPS)	**113**		**304**		**322**		**525**	

5 SERVICE PROVIDER AND SERVICES ANALYSIS

5.1 OVERVIEW OF SERVICES

Our service provider report provides key insights into the services currently available in Marathon County. It also provides data that show which zip code areas are most impacted by poor Internet service and/or the lack of Internet Service provider options.

Six of the thirteen zip code areas have less than 51% coverage of services that provide 25 Megabits/ second download speeds. Four of the zip codes have no or minimal fixed wireless Internet Service Providers. Seven of the zip code areas have 51% or less residents with access to cable services. Ten of the zip codes have more DSL coverage than cable. Very few residents have real choice in broadband. The chart below shows estimates of available broadband technology type in many areas of the county. This data is assembled from public sources and data is not available for all zip codes. Also note that zip code boundaries are not aligned with local government jurisdictions, and some zip code data may include some areas outside the county.

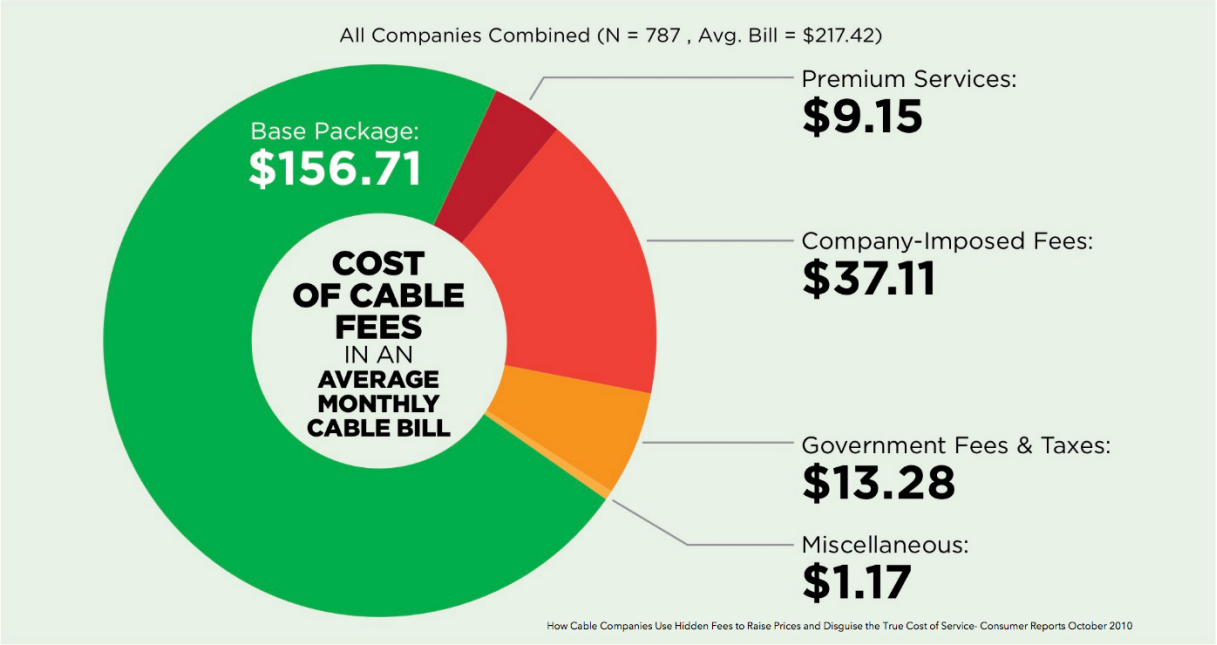


According to a recent Consumer Reports study the average advertised price for standard triple play services of Internet, television, and telephone across the country is $156.17. Because of hidden fees and taxes, the actual average bill is $217.42. Consumers get an average of 24% added to their bill

mostly in fees created by the cable industry. Again according to Consumer Reports, the industry imposted fees average "$37.11 per month which adds up to an estimated $28 billion in revenue each year in fees created by the cable industry."

Because of these high prices according to another Consumer Reports report, one in five households with traditional triple play bundles will abandon them in the next year- with sixty-two percent saying they are cutting the cable TV cord because of rising prices.

Figure A: Cost of Cable Fees in an Average Monthly Cable Bill (2018)



Another significant trend besides cutting the cable TV cord is using a smartphone as your sole Internet connection. Smartphones have become a substitute for wireline Internet services. According to Wireline, the average home used 271 GB of data in the second quarter of 2019. That was an increase of 25% over the previous year. A single smartphone with an unlimited data plan can be found for $70 plus fees and taxes per month. According to a June 2019 Pew Research Center Report, "37% of Americans now go online mostly using a smartphone." Cost of regular broadband services is also one of the reasons people use their smartphones. However, few people want to watch a football game, a movie, or do their class work on their smartphone. When considering using a cell phone as an Internet only solution, the cost of the cell phone also has to be factored in since they rarely last over two or three years.

Using the best available data, the table below shows communication costs for Marathon County families receiving the Internet, telephone, and TV in different ways. ***The average monthly cost of the services presented on the graph in Marathon County is from $155 a month to $188 per month***. To make comparisons accurate we have included sample cell phone costs in the total. All samples include television costs.

Table 5.1 below shows that the residents and businesses in Marathon County will spend an estimated $3 billion on telecom costs over the next thirty years. Most of these funds are being shipped out of the county and out of the state. The real explanation for poor broadband service in many areas of the county is not lack of money—it is that too much money is being taken out of the county. If as little as 5% of total telecom expenditures were re-allocated to broadband infrastructure improvements, most homes and businesses could have Gigabit fiber installed in the next three or four years.

Table 5.1: Telecom Expenditures - Marathon County, WI

Marathon County 20 Year Estimated Telecom Expenditures				
Total Households	54,820		Businesses	3,353
Estimated Internet Access Type	Households using Cell Phone for Internet	Households with "little" broadband DSL	Households with Cable Modems	Households with no Internet
Household Percentage	16%	42%	32%	10%
Number of households	8,771	23,024	17,542	5,482
Average monthly telecom expenditures	Cell Phone for Voice/Internet $90 Cable/satellite TV: $66 bundle	Cell Phone $70 Phone: $13 Satellite TV: $66 Broadband Internet: $45	Cell Phone $70 Phone $15 TV $43 Broadband Internet $45	Cell Phone, no Internet, $70 Cable/satellite TV: $66
Monthly Cost of Services	$156	$194	$173	$136
Annual household cost	$1,872	$2,328	$2,076	$1,632
Annual cost all households	$16,419,686	$53,600,803	$36,418,022	$8,946,624
20 year expenditure	$328,393,728	$1,072,016,064	$728,360,448	$178,932,480
Total residential expenditures	$2,307,702,720			
Total Estimated Cost of Hidden Fees	$498,144,077			
Total Business Costs	$208,221,300			
Total expenditures	**$3,014,068,097**			

5.2 LOCAL PRICING DATA

This information provides pricing data and services available from providers in Marathon County. Prices, availability and promotional offers change frequently and sometimes vary depending on street address. Information was compiled using Broadband Now (.com), High Speed Internet (.com), InMyArea (.com), and Internet Service Provider (ISP) websites. Exact availability requires specific street addresses.

Table 5.2: Summary of Service Provider Data - Marathon County, WI

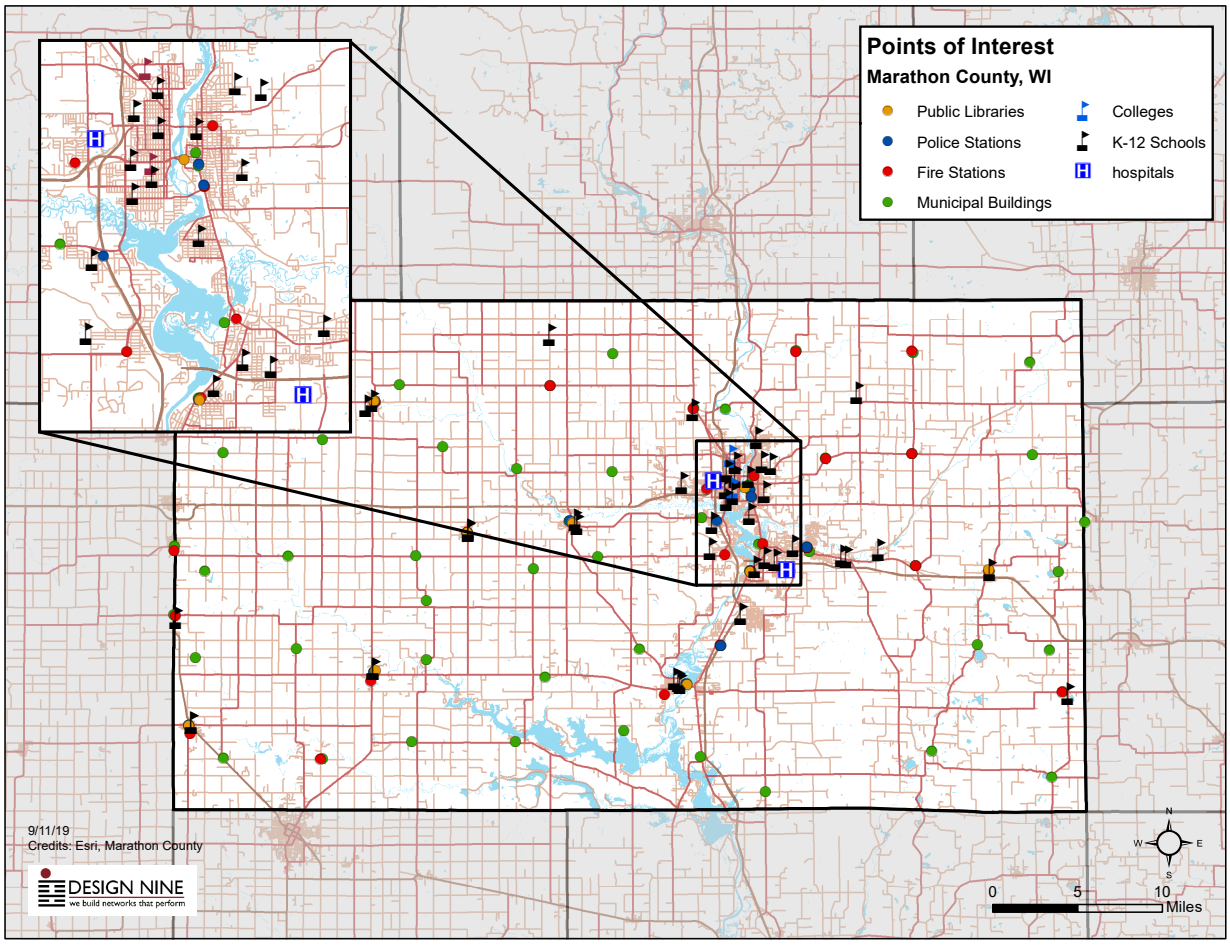
Prices include modem *Indicates promo rate Regular rate shown if possible	Least Expensive Internet Only Service	Least Expensive Internet Only Service Meeting 25/3	Least Expensive Triple Pay Package Meeting 25/3
Frontier DSL	$28 for 6 Mbps down- no upload speed provided	$44.99 for 25 Mbps down- no upload speed provided. 1-year promo- actual price unavailable	N/A
Amerherst Communications DSL	$74.95 for 10 Mbps down. Upload speed unavailable	N/A	N/A
TDS DSL	$68.95 for 6-15 Mbps down and 0.768 Mbps upload. 1-year promo pricing of $29.95	$73.95 for 75-100 Mbps download and 15 Mbps upload. 1-year promo price of $37.95	N/A
Wittenberg DSL	$91.50 for for 5 Mbps down. Upload speed unavailable	N/A	
Packerland Broadband Cable	$39 for 50 Mbps down. Upload speed unavailable 1-year promo- actual price unavailable	N/A	N/A
Spectrum Cable	$65.99 for 100 Mbps down- 10 Mbps up. 1-year promo pricing $44.99	$65.99 for 100 Mbps down- 10 Mbps up. 1-year promo pricing $44.99	$99.97 for 100 Mbps down- 10 Mbps up. TV Select- Home phone- 1-year promo pricing.
Amherst Fiber	N/A	$99.99 Includes Internet and phone. 120 Mbps down. Upload speed unavailable	N/A
Airrunner Wireless	$67.95 for 10 Mbps down- 2 Mbps upload	$125.93 for 25 Mbps down- 4 Mbps upload	N/A
Aris Wireless	$48.52 for 4 Mbps down- 1 Mbps up	N/A	N/A

Prices include modem *Indicates promo rate Regular rate shown if possible	Least Expensive Internet Only Service	Least Expensive Internet Only Service Meeting 25/3	Least Expensive Triple Pay Package Meeting 25/3
Bertram Wireless	$59.95 for 5 Mbps down- Upload speed unavailable	$149.95 for 25 Mbps down- Upload speed unavailable	N/A
Country Wireless	$32.00 for 1 Mbps down- 1 Mbps up	N/A	N/A
Network Professonals	$44.98 for 5 Mbps down- 1 Mbps upload	$134.98 for 25 Mbps down- 4 Mbps upload	N/A

6 ASSET ANALYSIS

6.1 POINTS OF INTEREST

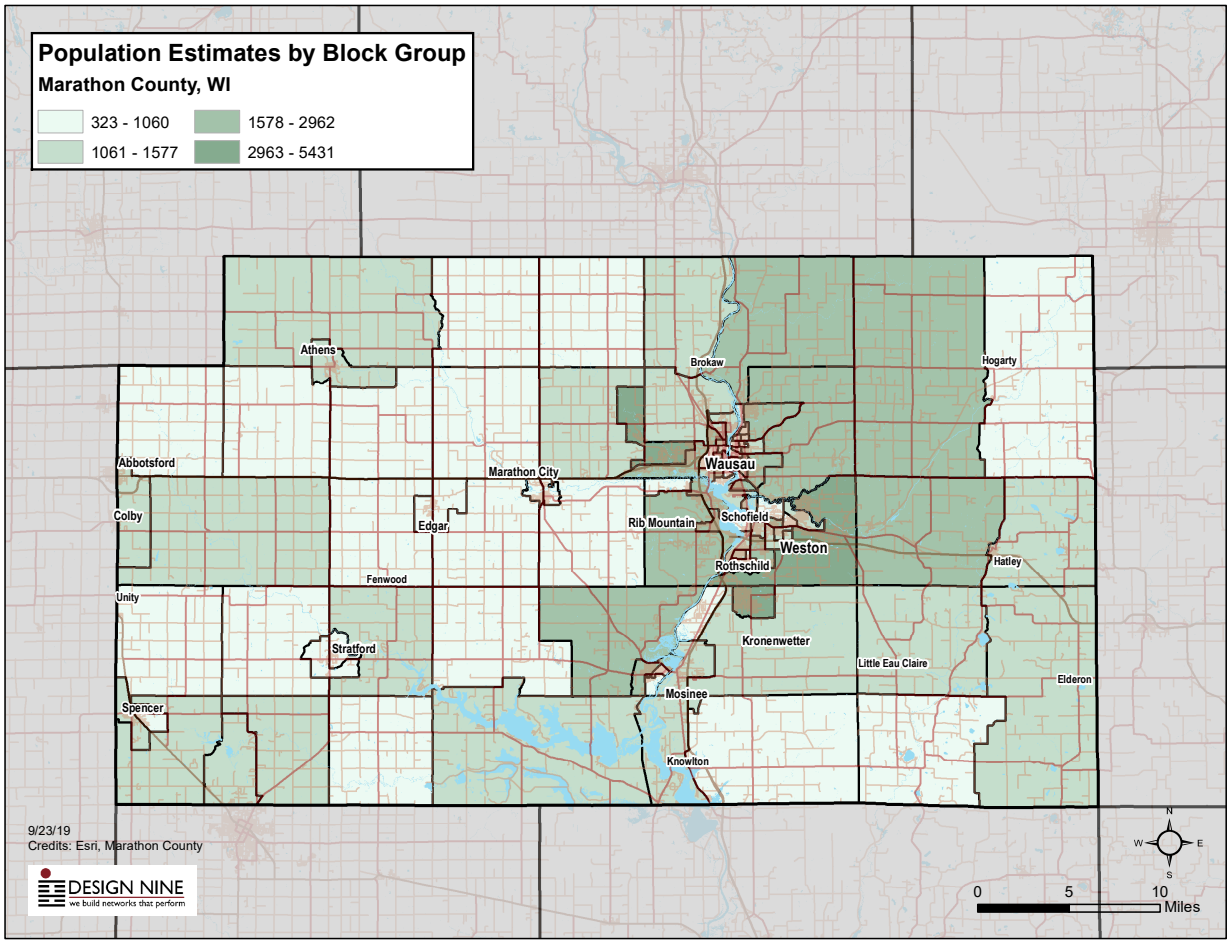
County facilities, municipal facilities, libraries, K12 and higher education facilities, fire and rescue stations, and public safety locations are all candidates to be anchor tenants for fixed point wireless and/or fiber services.



Map 6.1: Asset analysis points of interest for Marathon Country, WI

6.2 POPULATION DENSITY

The low population density in many parts of the county indicates that a fixed point wireless broadband solution is going to be an important part of a long term strategy until fiber becomes widely available in the county.

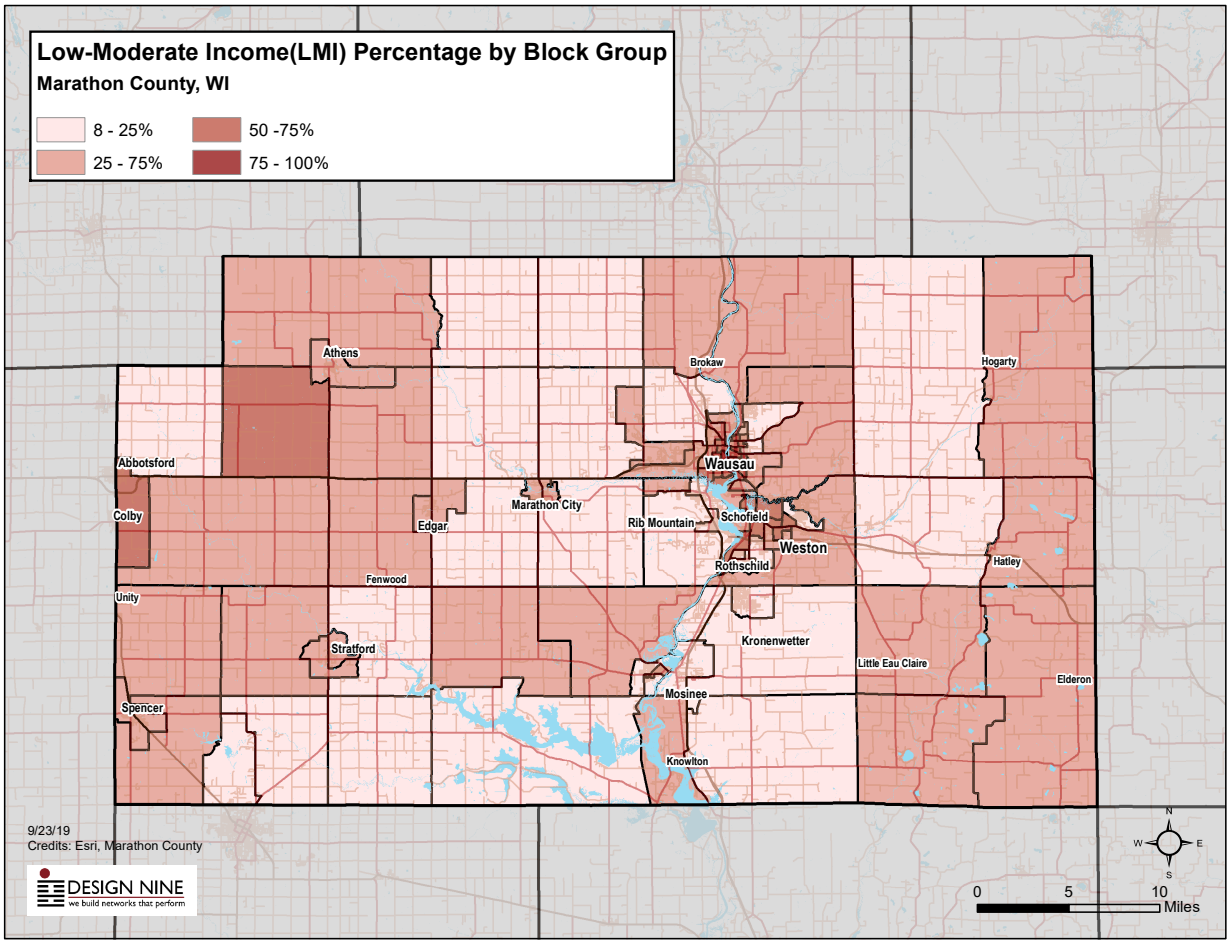


Map 6.2: Population estimated by block group for Marathon Country, WI

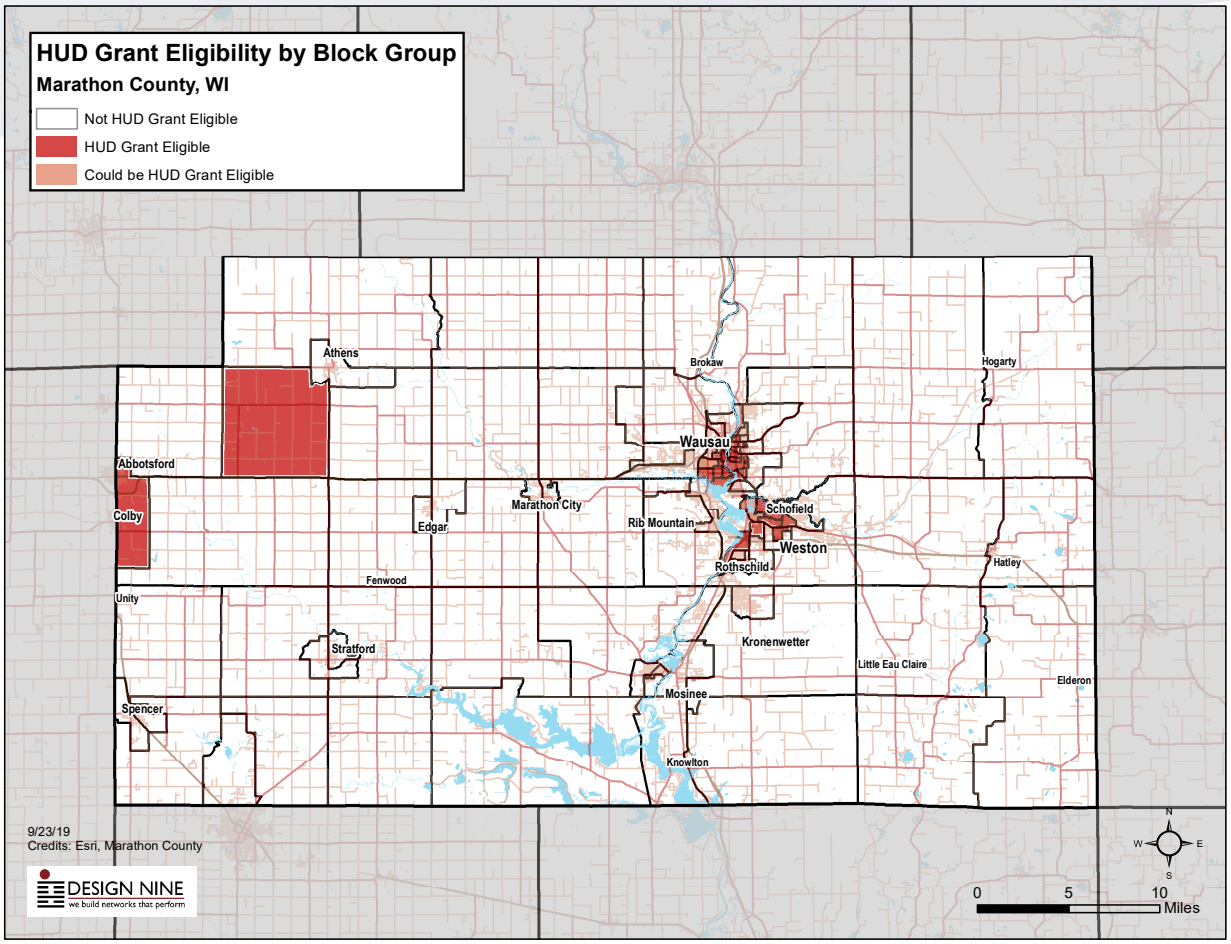
6.3 LMI AND HUD ELIGIBLE AREAS

HUD-eligible areas are determined by LMI (Low and Moderate Income) statistics—but can be different from census blocks in the county that meet LMI thresholds.

HUD-eligible census blocks can qualify for CDBG funding for telecom infrastructure projects.



Map 6.3: Low-moderate income (LMI) percentage by block group for Marathon County, WI



Map 6.4: HUD grant eligibility by block group for Marathon Country, WI

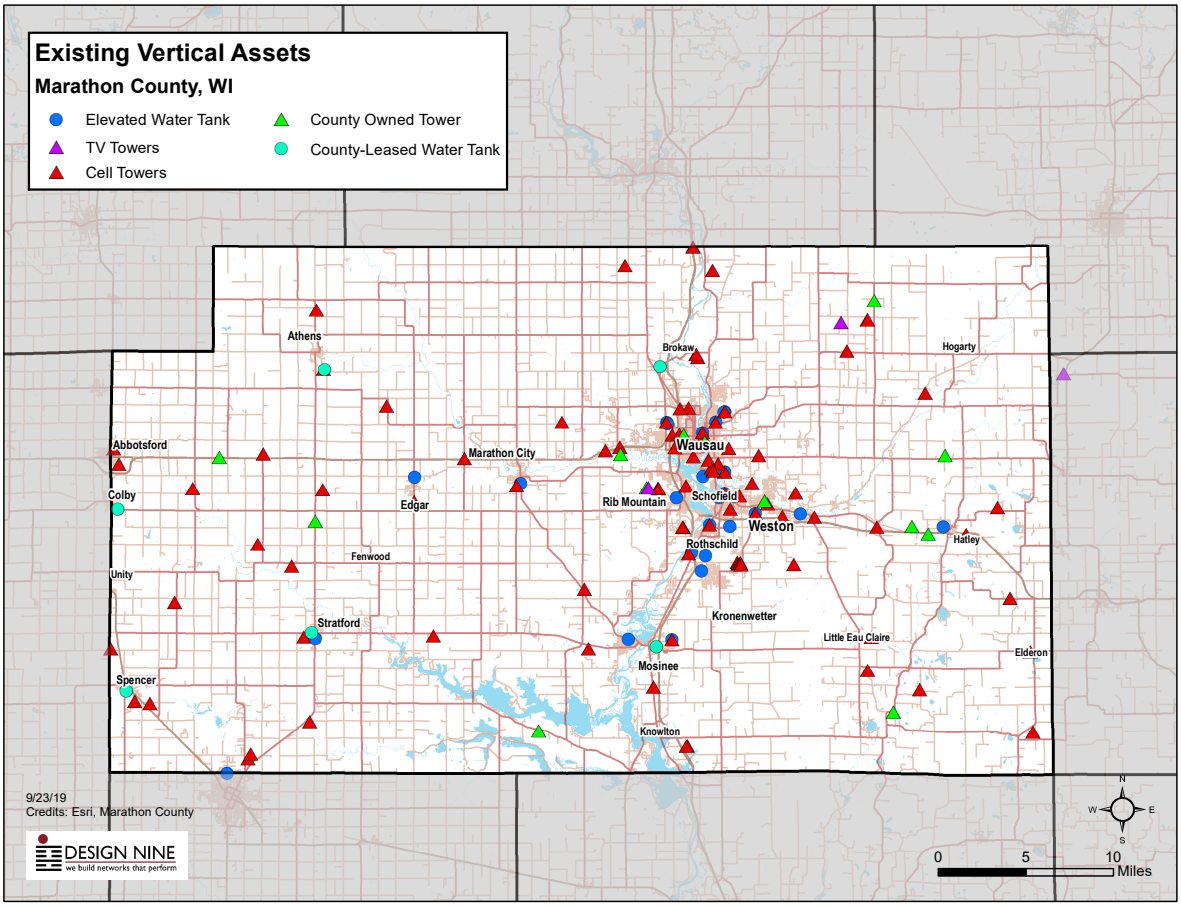
6.4 TOWERS IN THE COUNTY

A variety of publicly-owned and privately owned towers are shown here. Tower data is collected from an FCC database, County data, and other publicly available sources. The FCC database usually includes most towers that are in a locality, and generally includes all or nearly all cellular towers.

There are a large number of cell towers in the county, but a common complaint heard during the study was that there are many areas of the county with poor cellular service. Improved broadband access can address this issue by allowing the use of cellular nano-cells. Nano-cells are small devices placed in the home or business and connected to the customer's broadband Internet connection. The nano-cell provides cellular service within the home or business without being near a cell tower.

Note that lease fees for space on cellular towers are often too high for a WISP (Wireless Internet Service Provider) to make a business case to rent space on the tower. Additionally, the space that may be available on a cellular tower at a reasonable cost may be too low to cover enough area to capture sufficient customers (the higher the antennas on the tower, the larger the area covered by the service). In some cases, it may be necessary to place a new fixed point broadband tower near an existing cellular tower so that residents and businesses in the area have some options for competitive service.

The table on the following pages provides more information about the towers illustrated on the map.



Map 6.5: Existing vertical assets for Marathon Country, WI

Owner data for towers has been obtained from County, FCC (Federal Communications Commission) and other public sources. FCC data is not always updated in a timely fashion. Tower owner data does not always provide any information on the cellular providers and WISPs that may have equipment on a tower. Some registered towers have missing or incomplete owner and/or address data. Towers lower in height than two hundred feet are not required to register with the FCC (although many towers below that height are registered).

Table 6.1: Vertical asset details for Marathon County, WI

OWNER/LICENSEE	SOURCE/ TYPE	HEIGHT (FEET)	ADDRESS	LAT	LONG
Marathon County	County Owned/ Leased Tower	100	1209 UTILITY DR ATHENS	45.01910	-90.06790
Marathon County	County Owned/ Leased Tower	125	300 W FIR ST STRATFORD	44.80110	-90.08240
Marathon County	County Owned/ Leased Tower	126	514 S PARK ST SPENCER	44.75260	-90.29710
Marathon County	County Owned/ Leased Tower	180	1096 S COUNTY ROAD Y BEVENT	44.73410	-89.40850
Marathon County	County Owned/ Leased Tower	160	700 INDUSTRIAL DR COLBY	44.90290	-90.30790
Marathon County	County Owned/ Leased Tower	250	2315 W COUNTY ROAD C BERGEN	44.72000	-89.81950
Marathon County	County Owned/ Leased Tower	110	500 FOREST ST WAUSAU	44.95810	-89.62560
Marathon County	County Owned/ Leased Tower	110	5401 N 32ND AVE BROKAW	45.02100	-89.67700
Marathon County	County Owned/ Leased Tower	80	7025 PACKER DR WAUSAU	44.94820	-89.72320

Marathon County	County Owned/ Leased Tower	58	1125 MAPLE ST WAUSAU	44.96380	-89.64980
Marathon County	County Owned/ Leased Tower	160	4650 PARK RD RIB MOUNTAIN	44.92070	-89.69360
Marathon County	County Owned/ Leased Tower	105		44.88740	-89.38540
Marathon County	County Owned/ Leased Tower	130	12399 COUNTY ROAD Q HEWITT	45.07410	-89.42720
Marathon County	County Owned/ Leased Tower	70		44.89320	-90.07830
Marathon County	County Owned/ Leased Tower	76		44.88090	-89.36660
Marathon County	County Owned/ Leased Tower	110	590 FLORENCE ST MOSINEE	44.78930	-89.68280
Marathon County	County Owned/ Leased Tower	280	2392 STATE HIGHWAY 29 JOHNSON	44.94600	-90.19020
Marathon County	County Owned/ Leased Tower	110		44.90920	-89.55620
Marathon County	County Owned/ Leased Tower	60		44.90920	-89.55630
Marathon County	County Owned/ Leased Tower	180	1345 FIRE LANE RD PLOVER	44.94580	-89.34610
WRIG Inc.	Cell Tower	Not Provided	125200 JAKUBOWSKI RD EDGAR	44.98840	-89.99560
Roberts Broadcasting	Cell Tower	Not Provided	6333 RAINBOW DR MERRILL	45.10410	-89.71770
SpectraSite Communications	Cell Tower	Not Provided	246207 COUNTY ROAD W MERRILL	45.09990	-89.61550

Starboard Media	Cell Tower	Not Provided	234935 EAU CLAIRE RIVER RD ANIWA	44.99730	-89.36880
Charter Cable Partners	Cell Tower	Not Provided	S 3RD AV EDGAR	44.90950	-89.96340
Central Wisconsin Communications	Cell Tower	Not Provided	113462 BLACKBERRY RD STRATFORD	44.87390	-90.14520
Seehafer Broadcasting Corp.	Cell Tower	Not Provided	201309 COUNTY ROAD E MARSHFIELD	44.69680	-90.15590
SBA Towers II LLC	Cell Tower	Not Provided	201319 COUNTY ROAD E MARSHFIELD	44.70100	-90.15280
Verizon North	Cell Tower	Not Provided	521 N 4TH ST WAUSAU	44.96120	-89.62640
Sunrise Broadcasting	Cell Tower	Not Provided	1110 E WAUSAU AV WAUSAU	44.97450	-89.61310
Airadigm Communications	Cell Tower	Not Provided	4502 E EVEREST AV WESTON	44.89890	-89.56710
WRIG Inc.	Cell Tower	Not Provided	2879 COUNTY ROAD X MOSINEE	44.85840	-89.58820
WRIG Inc.	Cell Tower	Not Provided	2879 COUNTY ROAD X MOSINEE	44.85710	-89.58760
WRIG Inc.	Cell Tower	Not Provided	2879 COUNTY ROAD X MOSINEE	44.85730	-89.58570
WRIG Inc.	Cell Tower	Not Provided	2879 COUNTY ROAD X MOSINEE	44.85770	-89.58470
AT&T	Cell Tower	Not Provided	3510 PARK RD WAUSAU	44.92020	-89.68010
Christian Life	Cell Tower	Not Provided	3500 PARK RD WAUSAU	44.91980	-89.67930
	Cell Tower	Not Provided	3511 CAMP PHILLIPS RD WESTON	44.92390	-89.57080
	Cell Tower	Not Provided	3508 PARK RD WAUSAU	44.92000	-89.67950
	Cell Tower	Not Provided	229201 CORINTH RD ATHENS	44.94880	-90.13880
	Cell Tower	Not Provided	1211 UTILITY DR ATHENS	45.01900	-90.06900
SpectraSite Communications	Cell Tower	Not Provided	228911 COUNTY ROAD S RIB FALLS	44.94510	-89.90480
Global Tower LLC	Cell Tower	Not Provided	225934 PIONEER DR WIEN	44.91940	-90.06990
Communication Enhancement LLC	Cell Tower	Not Provided	242507 STATE HIGHWAY 97 ATHENS	45.06770	-90.07740
Wausau Cellular Telephone	Cell Tower	Not Provided	S 11TH ST ABBOTSFORD	44.94030	-90.30680
	Cell Tower	Not Provided	N 5TH ST ABBOTSFORD	44.95270	-90.31290
American Tower Corp.	Cell Tower	Not Provided	118257 KRAUS ST MARSHFIELD	44.72770	-90.08440
Wausau Cellular Telephone Co	Cell Tower	Not Provided	212655 HAMLET LN EDGAR	44.79860	-89.94140
Wausau Cellular Telephone Inc	Cell Tower	Not Provided	116693 COUNTY ROAD P STRATFORD	44.85620	-90.10590

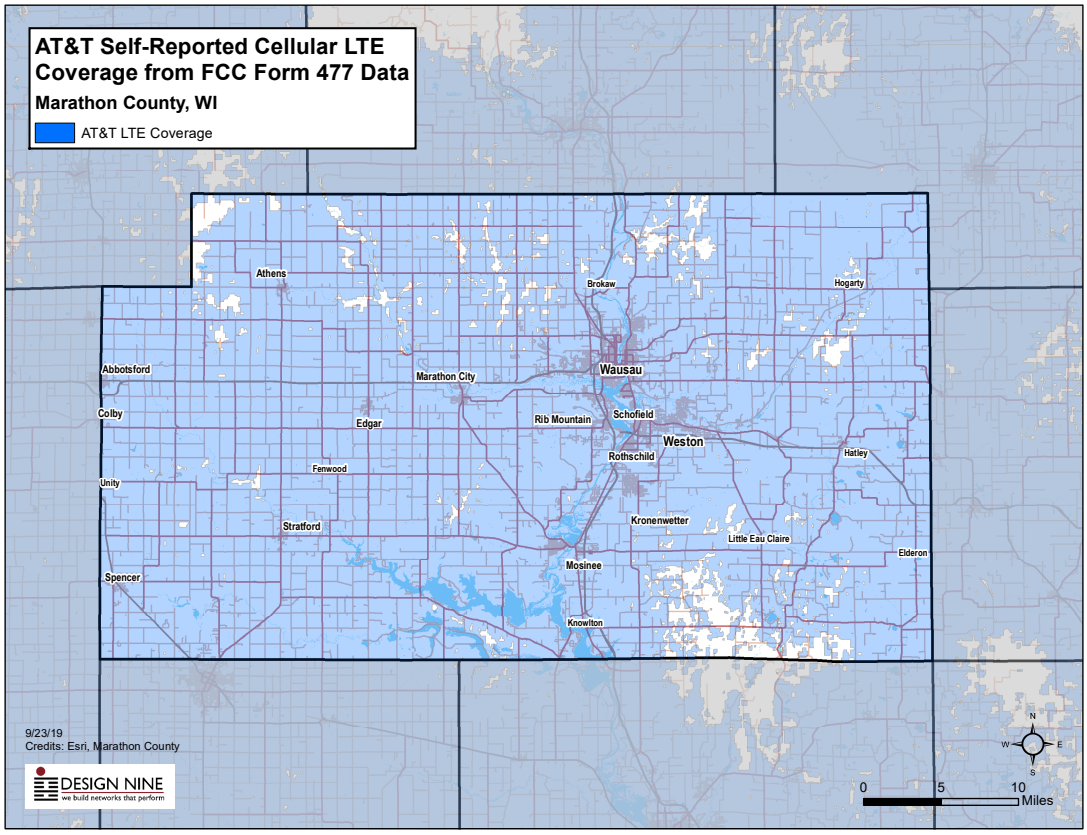
NSIGHTTELL WIRELESS	Cell Tower	Not Provided	207880 MORRAINE RD HATLEY	44.75240	-89.37790
RLM Communications Inc.	Cell Tower	Not Provided	143318 SUNNY LN MOSINEE	44.83690	-89.76610
	Cell Tower	Not Provided	143859 STATE HIGHWAY 153 MOSINEE	44.78770	-89.76130
Pinnacle Towers Acquisition LLC	Cell Tower	Not Provided	149659 RIDGE RD MOSINEE	44.75570	-89.68620
SpectraSite Communications	Cell Tower	Not Provided	202609 ROZAK RD MOSINEE	44.70720	-89.64730
Wausau Cellular Telephone Co Cellcom	Cell Tower	Not Provided	202587 ROZAK RD MOSINEE	44.70670	-89.64850
American Tower Corp.	Cell Tower	Not Provided	182122 COUNTY ROAD II ELAND	44.82770	-89.27180
SpectraSite Communications & American Towers Inc.	Cell Tower	Not Provided	178125 STATE HIGHWAY 29 HATLEY	44.88020	-89.32230
Central Wisconsin Communications	Cell Tower	Not Provided	238183 STEEL LN WAUSAU	45.02830	-89.63310
SpectraSite Communications	Cell Tower	Not Provided	8315 STEWART AVE WAUSAU	44.95120	-89.74100
Wausau Cellular Telephone Co Cellcom	Cell Tower	Not Provided	7019 STEWART AV WAUSAU	44.95390	-89.72420
WAOW-WYOW Television, Inc.	Cell Tower	Not Provided	605 E KENT ST WAUSAU	44.93340	-89.60240
Airadigm Communications	Cell Tower	Not Provided	221 SCOTT ST WAUSAU	44.96040	-89.62840
Davis Television	Cell Tower	Not Provided	1000 N 3RD ST WAUSAU	44.96580	-89.62780
Sprint Spectrum LP	Cell Tower	Not Provided	1233 JUNCTION ST WAUSAU	44.94040	-89.61010
WAOW - WYOW Television, Inc.	Cell Tower	Not Provided	1930 GRAND AV WAUSAU	44.93690	-89.61780
	Cell Tower	Not Provided	1200 GROSSMAN DR SCHOFIELD	44.91610	-89.60260
Airadigm Communications	Cell Tower	Not Provided	2000 WESTWOOD DR WAUSAU	44.96400	-89.66320
New Cingular Wireless PCS, LLC	Cell Tower	Not Provided	159002 TOWNLINE RD WAUSAU	44.94680	-89.56300
Wausau Cellular Telephone	Cell Tower	Not Provided	10005 SCHOFIELD AV RINGLE	44.89570	-89.49840
SBA Towers II LLC	Cell Tower	Not Provided	3861 E NICK AV WESTON	44.85640	-89.52280
AT&T	Cell Tower	Not Provided	680 PARKVIEW DR STRATFORD	44.79750	-90.09140
WRIG Inc.	Cell Tower	Not Provided	2879 COUNTY ROAD X MOSINEE	44.85640	-89.58420
American Tower Corp.	Cell Tower	Not Provided	103723 BACK COUNTRY RD SPENCER	44.74240	-90.26990
NSIGHTTEL WIRELESS LLC	Cell Tower	Not Provided	S MONROE ST SPENCER	44.74430	-90.28760

New Cingular Wireless PCS, LLC	Cell Tower	Not Provided	212612 PAGE RD Hatley	44.79590	-89.43330
New Cingular Wireless PCS, LLC	Cell Tower	Not Provided	169977 RINGLE AV Ringle	44.88720	-89.42610
New Cingular Wireless PCS, LLC	Cell Tower	Not Provided	169095 LANDING RD WAUSAU	45.05820	-89.43530
Wausau Cellular Telephone	Cell Tower	Not Provided	169095 LANDING RD HEWITT	45.05810	-89.43520
Wausau Cellular Telephone	Cell Tower	Not Provided	OFF INTERSTATE 39, SOUTH OF US HWY 51 INTERCHANGE JAEGLER	45.11950	-89.63830
New Cingular Wireless PCS, LLC	Cell Tower	Not Provided	16000 BRANDENBURG AVENUE Merrill	45.11940	-89.63830
Wausau Cellular Telephone	Cell Tower	Not Provided	153477 COUNTY ROAD WW BROKAW	45.03070	-89.63550
	Cell Tower	Not Provided	153477 COUNTY ROAD WW BROKAW	45.03080	-89.63500
Wausau Cellular Telephone	Cell Tower	Not Provided	CAMPUS DRIVE, WAUSAU TECHNICAL COLLEGE WAUSAU	44.98640	-89.64420
Wausau Cellular Telephone	Cell Tower	Not Provided	811 21ST STREET WAUSAU	44.95340	-89.66040
Wausau Cellular Telephone	Cell Tower	Not Provided	3801 Wood Duck Lane Rib Mountain	44.92220	-89.64740
Wausau Cellular Telephone	Cell Tower	Not Provided	7700 MOSINEE TOWER ROAD WAUSAU	44.88770	-89.65080
Wausau Cellular Telephone	Cell Tower	Not Provided	3107 CONCORD AVENUE WESTON	44.91360	-89.58550
Wausau Cellular Telephone	Cell Tower	Not Provided	1706 MORRISON AVE ROTHSCHILD	44.86570	-89.64480
Wausau Cellular Telephone	Cell Tower	Not Provided	1201 SOUTH HIGHWAY 107 MARATHON CITY	44.92280	-89.84430
New Cingular Wireless PCS, LLC	Cell Tower	Not Provided	181134 COUNTY ROAD DD BIRNAMWOOD	44.90240	-89.28560
	Cell Tower	Not Provided	162555 GUSMAN RD WESTON	44.91590	-89.52030
	Cell Tower	Not Provided	1735 MERRILL AV WAUSAU	44.98590	-89.65380
	Cell Tower	Not Provided	215682 COUNTY ROAD F UNITY	44.82620	-90.24160
	Cell Tower	Not Provided	7700 MOSINEE TOWER ROAD WAUSAU	44.88780	-89.65130
	Cell Tower	Not Provided	7700 MOSINEE TOWER ROAD WAUSAU	44.88780	-89.65150
Central States Tower	Cell Tower	Not Provided	5600 STERNBERG AVE WESTON	44.90690	-89.55280
American Tower Corp.	Cell Tower	Not Provided	6703 RYAN ST WESTON	44.89640	-89.53580

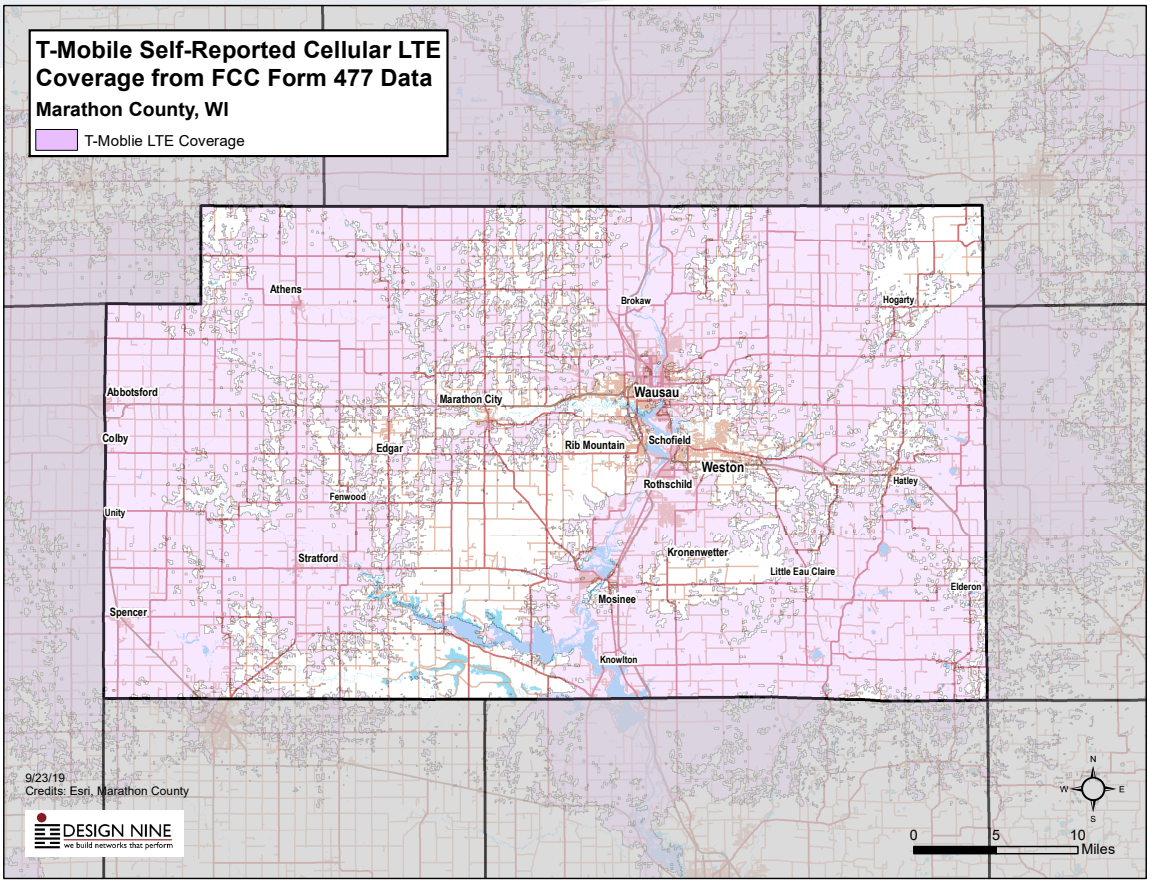
New Cingular Wireless PCS, LLC	Cell Tower	Not Provided	5815 ALTA VERDE ST WESTON	44.90280	-89.59640
Wisconsin Public Service Corp.	Cell Tower	Not Provided	156426 MCINTOSH ST WAUSAU	44.95280	-89.59770
AT&T	Cell Tower	Not Provided	1217 S 3RD AV WAUSAU	44.94620	-89.63880
City of Wasau	Cell Tower	Not Provided	2700 W WAUSAU AV WAUSAU	44.97450	-89.67000
WRIG Inc.	Cell Tower	Not Provided	3021 COATES LN WAUSAU	44.98310	-89.60220
	Cell Tower	Not Provided	201 N 17TH AVE WAUSAU	44.96450	-89.65480
	Cell Tower	Not Provided	1ST ST ROTHSCHILD	44.88960	-89.62040
	Cell Tower	Not Provided	1320 GRAND AVE WAUSAU	44.94330	-89.62130
New Cingular Wireless PCS, LLC	Cell Tower	Not Provided	200 E KENT ST WAUSAU	44.93470	-89.61550
	Cell Tower	Not Provided	200 E KENT ST WAUSAU	44.93450	-89.61560
	Cell Tower	Not Provided	141278 STETTIN DR WAUSAU	44.97480	-89.79180
	Cell Tower	Not Provided	226148 COUNTY ROAD F COLBY	44.92040	-90.22070
	Cell Tower	Not Provided	238800 SUNRISE RD HEWITT	45.03290	-89.45940
AT&T	Cell Tower	Not Provided	183973 CORNER RD FRANZEN	44.71670	-89.24700
	Cell Tower	Not Provided	211425 FAIRHAVEN AV SPENCER	44.78750	-90.31550
	Cell Tower	Not Provided	184125 STATE HIGHWAY 153 ELDERON	44.78280	-89.24880
New Cingular Wireless PCS, LLC	Cell Tower	Not Provided	1000 INDIANHEAD DR MOSINEE	44.79510	-89.66450
	Cell Tower	Not Provided	209262 PINERY RD HATLEY	44.76840	-89.43790
Seaway Comm	TV Tower	Not Provided	Rhinelander	45.01250	-89.20750
Davis Television Wau	TV Tower	Not Provided	Wittenberg	45.05600	-89.46590
Educ Comm Board-WI	TV Tower	Not Provided	Wausau	44.92060	-89.69130
Shockley Communicatiion	TV Tower	Not Provided	Wausau	44.92070	-89.69130
Benedek License Corp	TV Tower	Not Provided	Wausau	44.92080	-89.69130

6.5 CELLULAR COVERAGE IN MARATHON COUNTY

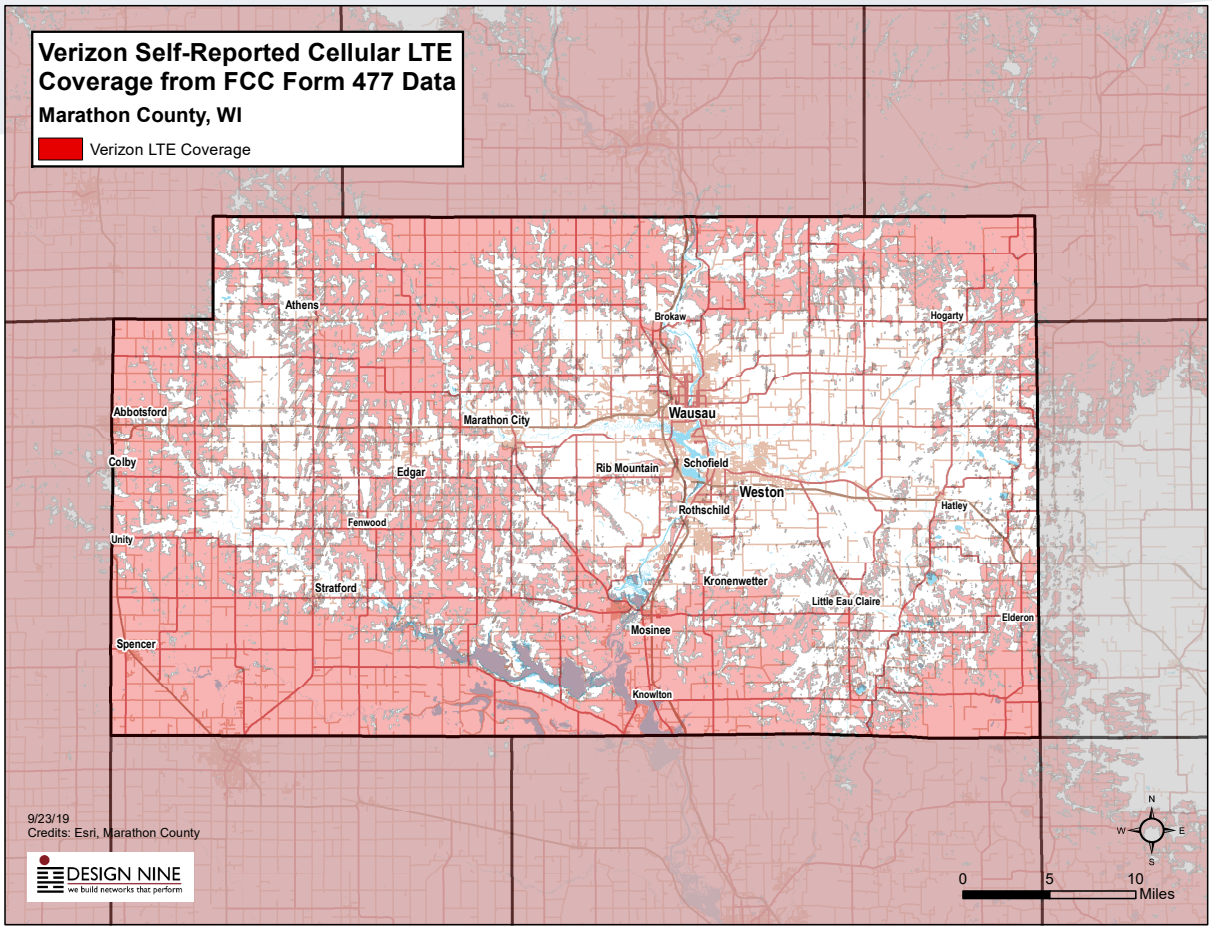
Cellular coverage data is compiled from an FCC database. Cellular providers submit their own data to FCC, and that coverage is not verified independently. Cellular coverage areas as reported by the cellular carriers is often optimistic.



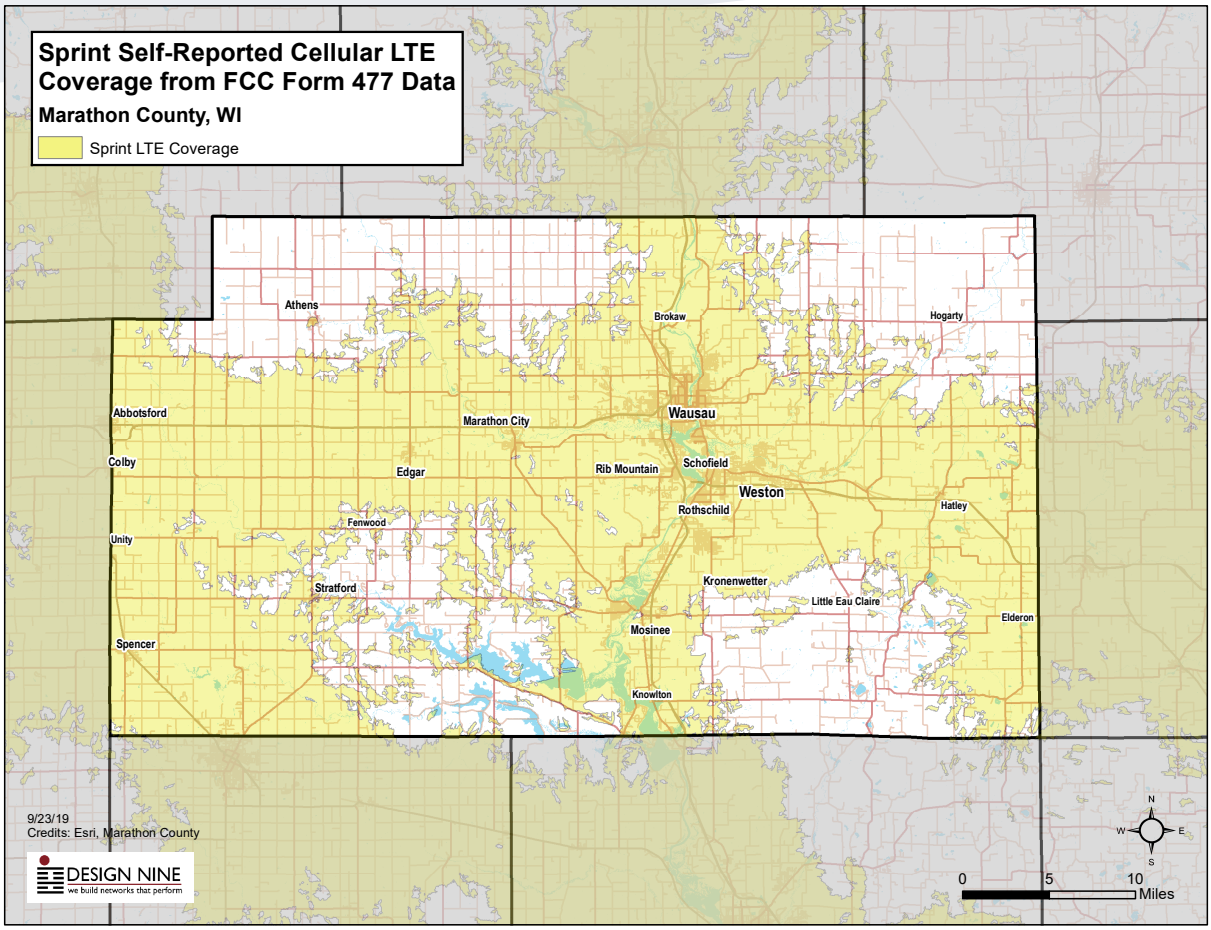
Map 6.6: AT&T self-reported cellular LTE coverage (FCC From 477)



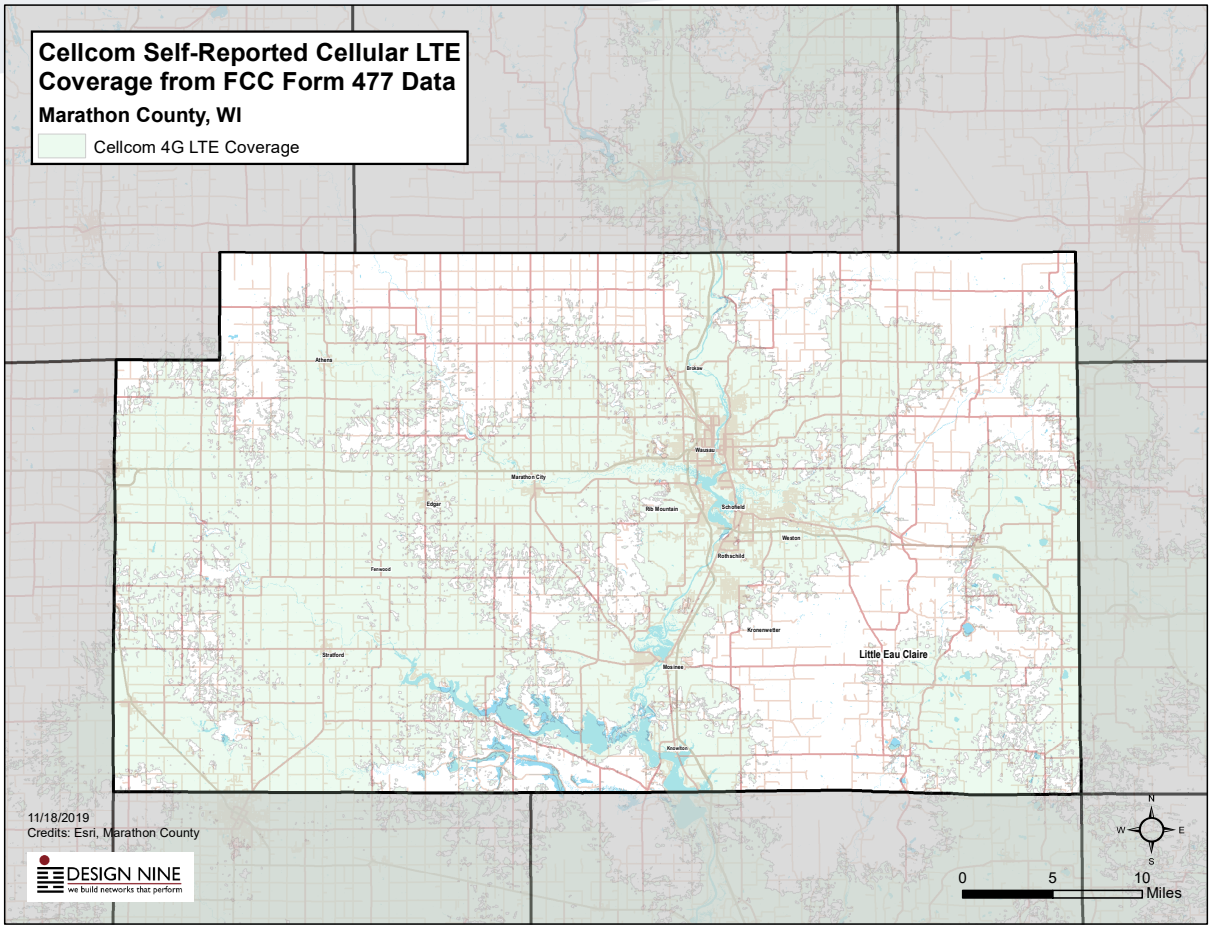
Map 6.7: T-Mobile self-reported cellular LTE coverage (FCC Form 477)



Map 6.8: Verizon self-reported cellular LTE coverage (FCC From 477)



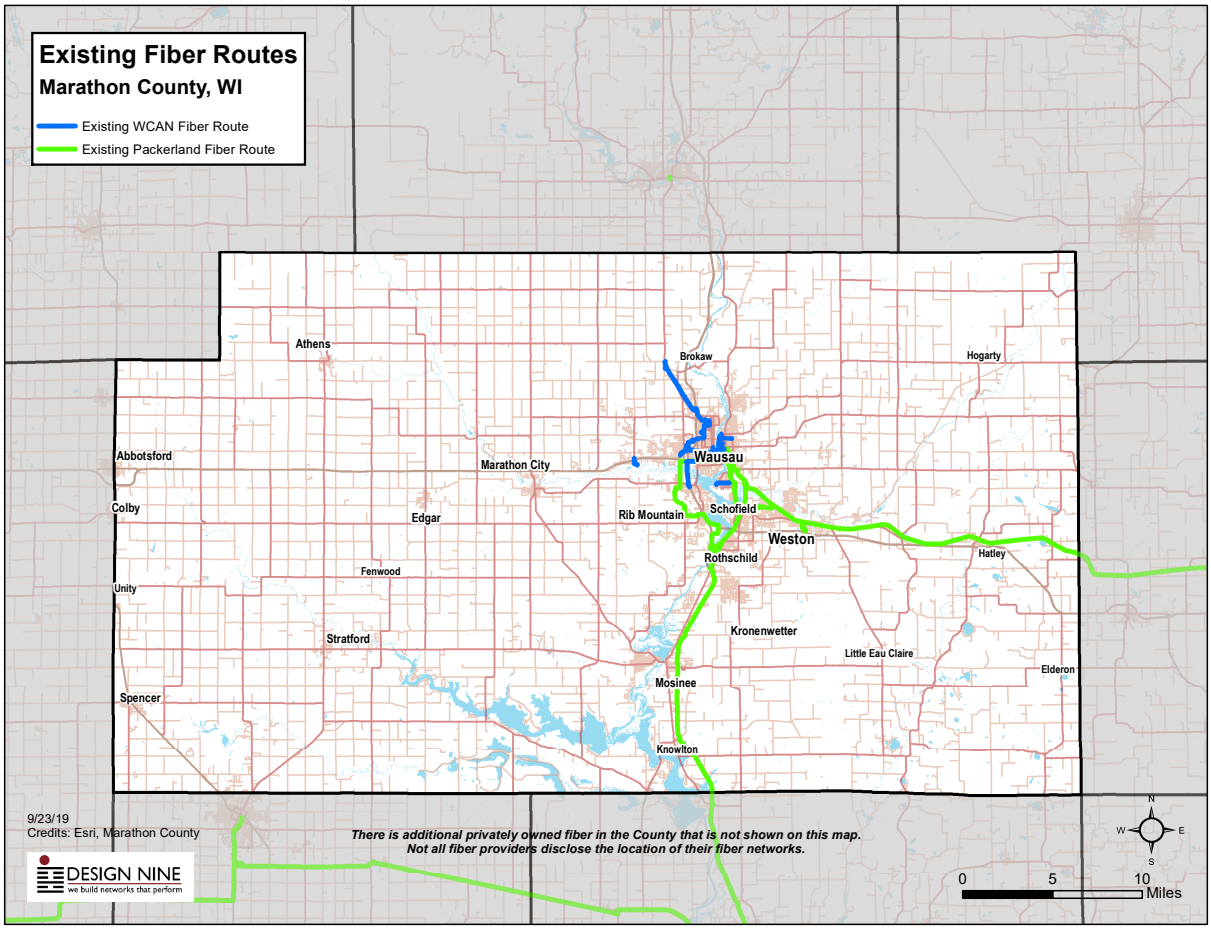
Map 6.9: Sprint self-reported cellular LTE coverage (FCC From 477)



Map 6.10: Cellcom self-reported cellular LTE coverage (FCC From 477)

6.6 FIBER ROUTES IN THE COUNTY

Fiber route data is compiled from publicly available sources. Some telecom providers do not share their route data. Both the telephone and cable companies have substantial amounts of fiber in Marathon County, but that fiber is generally not affordable or available for third party use. Packerland Broadband has some fiber in the county, but according to the Wisconsin Public Service Commission broadband service map, Packerland does not offer any service in Marathon County.



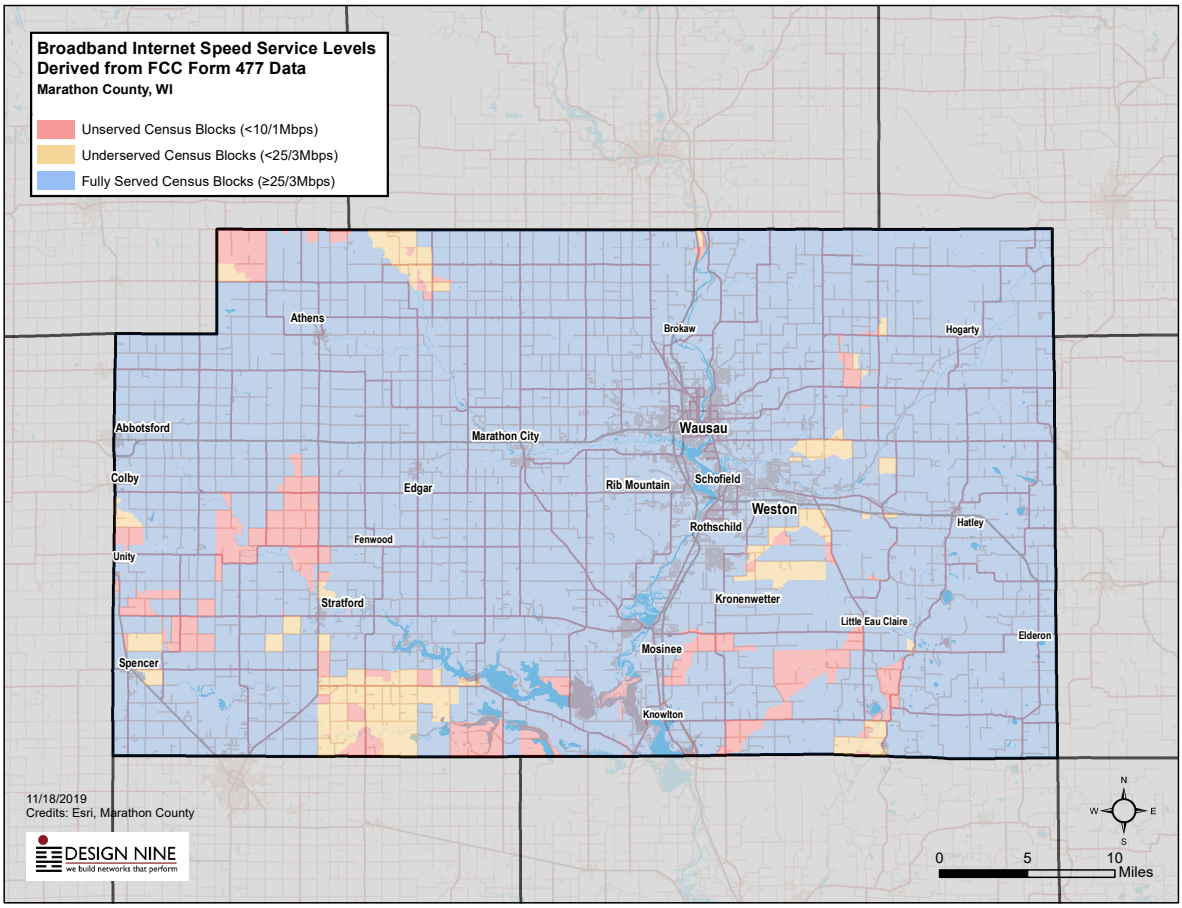
Map 6.11: Fiber routes for Marathon County, WI

6.7 FCC 477 BROADBAND SERVICE DATA

Map 6.12 shows served, underserved, and unserved areas of Marathon County. As defined by the FCC (Federal Communications Commission), the three categories are classified as follows:

- Fully served – The areas in blue depict census blocks with broadband speeds equal to or higher than 25 Megabits/second download, 3 Megabits/second upload.
- Underserved – The areas in yellow depict census blocks with broadband speeds equal to or greater than 10 Megabits/second download, 1 Megabit/second upload but less than 25 Megabits/second download, 3 Megabits/second upload.
- Unserved – The areas in pink depict census blocks with broadband speeds less than 10 Megabits/second download, 1 Megabit/second upload.

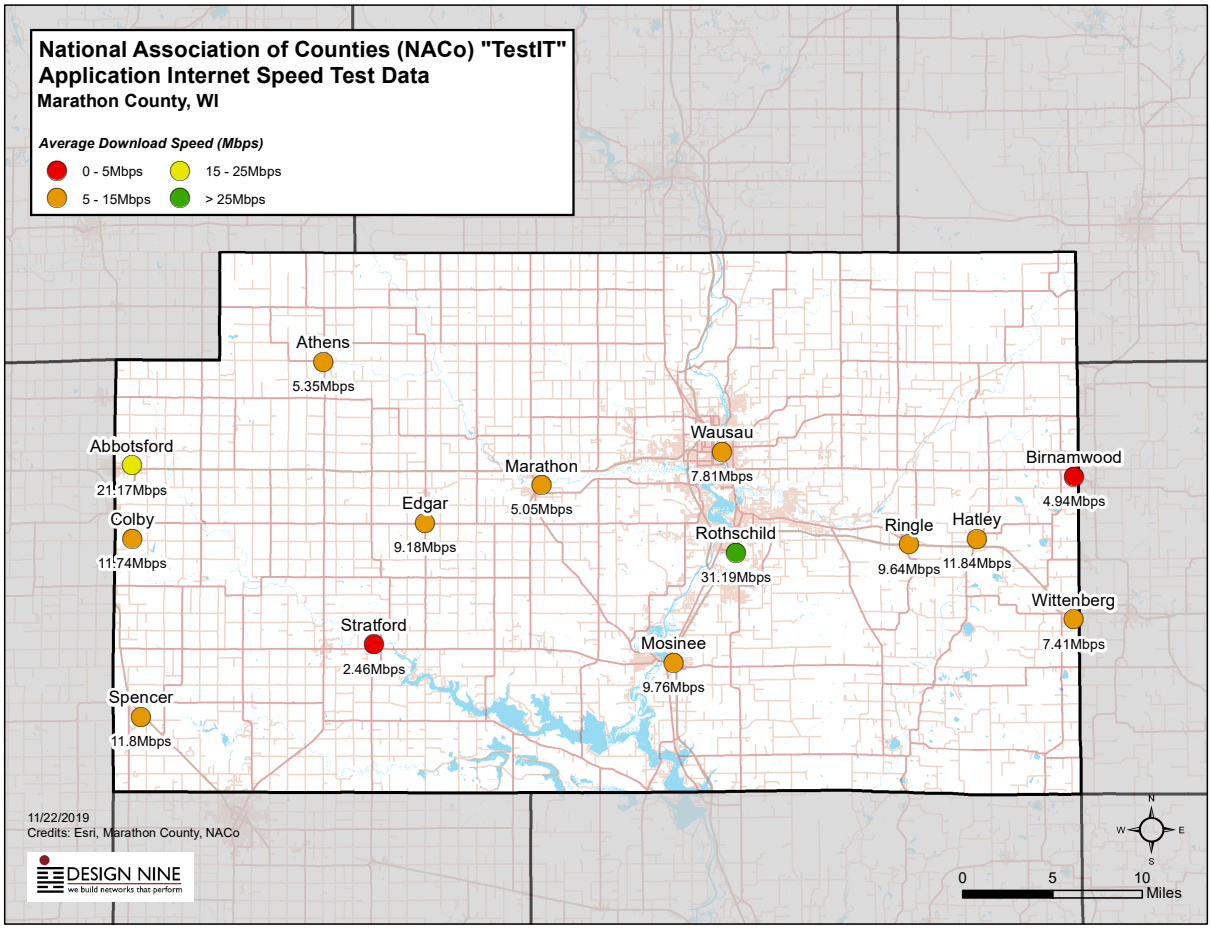
These speeds are self-reported by the Internet providers, and are generally optimistic. Providers supply data by census tract, and if a single customer in a census tract has a certain level of service (e.g. Fully Served), all of the households in that census tract are counted as served. This means that in many areas, particularly rural areas, the data may not accurately reflect what households and business actually are able to receive.



Map 6.12: FCC 477 Internet Speeds for Marathon County, WI

6.8 NACO TEST IT SPEED TEST DATA

This map provides results from the National Association of Counties (NACo) speed test (TestIT). The only area of Marathon County with the 25 Meg/second down, 3 Meg/second up "served" broadband speeds is in the Wausau area. The rest of the county is either "underserved" or "unserved." The NACo data only provided information on a few population centers in the county.



Map 6.13: NaCO Test IT Internet Speeds for Marathon County, WI

7 CASE STUDIES

7.1 DAKOTA COUNTY, MINNESOTA

Dakota County and eleven independent cities in the county developed a Joint Powers Agreement in 2018 in which the twelve municipalities agreed to collaborate on developing both a government network and a commercial network. The impetus for the work began several years earlier, when it was recognized that adjacent counties that had made investments in open fiber networks were attracting new businesses and jobs. The project leveraged existing fiber assets owned by the County and two of the cities. The County took the lead on the effort, committing most of the funds needed to fund construction of needed links to create a county-wide fiber loop that passed by many County facilities and also passed by at least one high priority location in each city (typically the administration building). The two networks share a single cable, but each network uses its own fiber strands for complete physical separation of government/public safety data and data generated by commercial customers. Network management has been outsourced to a local nonprofit firm that provides network management services to local governments in the Twin Cities area.

7.2 NOBLES COUNTY, MINNESOTA

Nobles County conducted a broadband feasibility study that led to successful grant awards of several million dollars for a fiber and wireless network. After the feasibility study was completed, the County met with several service providers and invited them to become partners in a broadband initiative. Lismore Telephone Coop agreed to partner, and provided a 50% match to the grant award, which provided a total project funding of nearly $6 million. The project paid for new wireless towers and eighty-two miles of fiber cable. The wireless broadband service is capable of delivering 25/3 Internet service, and the fiber network can deliver Gigabit Internet service. Nobles county staff and elected officials play the key role in bringing the project to completion.

7.3 VILAS COUNTY, WISCONSIN

In Vilas County, poor Internet service was affecting tourism. Many visitors coming to the county for the recreational opportunities in both summer and winter were not staying long because they had difficulty keeping up with work while on vacation. The Vilas County Economic Development Corporation took the lead to organize schools, businesses, state, and local governments to develop a plan to bring better broadband to the county. The coalition was able to convince Frontier Communications, the incumbent telephone and Internet provider, to apply for CAF II (Federal) funding to bring improved broadband to the area. ChoiceTel, another incumbent provider in the County, applied for and received state grant funds to construct fiber to the home service in the Town of Land O' Lakes in Vilas County in 2016, 2017, and 2018.

7.4 ONEIDA COUNTY, WISCONSIN

Oneida County's Economic Development Corporation has had an active Broadband Development Committee since 2015. The committee has been successful in applying for and receiving three state broadband grants over the past several years. The grant funds, combined with cash from County

government, have been used to build new fixed point wireless broadband towers and to assist making existing local government-owned towers available to Wireless Internet Service Providers (WISPs).

7.5 BOZEMAN, MONTANA

The City of Bozeman conducted a broadband feasibility study in 2014, and the following year made the decision to build a 23 mile Gigabit fiber network. The City chose to form a 501(c)4 non profit to own and manage the network. Initial construction was completed in the fall of 2016 and the first customers began receiving service in late fall of that year. The network passes through many of the commercial and business areas of the City, and the marketing and focus has been on providing improved services to local businesses. CenturyLink and Charter both made reductions in the service prices, which has been an economic benefit for businesses and residents that are not connected to the network.

The network is operated as a multi-provider, multi-service enterprise; businesses have a range of services and price points from four different private sector providers.

7.6 FAIRLAWN, OHIO

In 2015, the city of Fairlawn, Ohio built a municipal fiber network to ensure that businesses in the city had high speed, affordable business class Internet access. The network, now called FairlawnGig, has been a big success. The network provides 2.5Gbps service for small and medium sized business, and larger business enterprises can select 10Gbps and 100Gbps services to meet their needs. The network has also been extended to residential areas of the city, and the take rate for residential customers is over 50 percent. Revenues from the network are now adequate to pay operating expenses, and the city expects that revenues will continue to rise and will allow paying off the debt incurred by the city.

The network has spurred both business and residential growth in the community. Older rental properties and large parcels are being purchased by developers to add condos because of increased demand for homes in the city. The network is also attracting new jobs and businesses, with engineering and IT firms moving into the city to take advantage of affordable high speed broadband services.

7.7 ASHLAND, VIRGINIA

The Town of Ashland, Virginia recently completed construction of two miles of dark fiber that passes many of the businesses in that community. Town staff have been trained to manage 811 (Miss Utility) calls and to do locates on the conduit and fiber. The Town leaders initiated the project in response to local businesses asking for more choice of providers and more bandwidth at lower prices. A major regional telecom/Internet provider signed a service agreement and began offering services on the dark fiber as soon as the network was completed. The Town has allocated additional funds to expand the network to pass more businesses in the community. Some residential neighborhoods are also being evaluated for fiber infrastructure.

7.8 CHARLEMONT, MA

The town of Charlemont, Massachusetts has decided to combine a grant from the state with an $11/month/household assessment to build fiber throughout the entire town of 524 households. Comcast had offered to make modest upgrades to the existing copper-based cable network but was asking for nearly half a million dollars from the town. Instead, voters agreed with Town officials to build their own network. Once finished, Internet service will be provided by a private sector ISP. Gigabit fiber Internet service is expected to cost about $80/month with no data caps. Phone service is expected to cost $23 month, and Internet, phone, and several Over The Top (OTT) services like Netflix, Hulu, and YouTube TV is expected to cost around $140/month, or about 15% to 20% less than Comcast service.

7.9 CITY OF EAGAN, MN

The City of Eagan began planning for a city-owned fiber network in 2008 at the urging of key business leaders who represented both large and small businesses, including some Fortune 500 companies. One of the first efforts by the City included asking the private sector, including the incumbents, to help solve the bandwidth affordability problem. Both the primary cable and telephone company in Eagan declined to offer any substantive improvements. Several other private sector firms also submitted proposals, but none were deemed adequate to meet the needs of a diverse business community employing tens of thousands of employees.

During the planning process, the City also began to examine strategies to attract one or more commercial data centers to the community, and it was determined that the availability of City-owned competitive fiber would assist in that effort.

In 2011, the City allocated funds to construct 17 miles of high performance, business class Gigabit fiber that passed many business and commercial areas of the city. The network was constructed to meet the most demanding technical requirements of Eagan's larger businesses, with a Gigabit connection as standard for any connected business, and the active Ethernet network has ample capacity to provide 10Gig, 40Gig, 100Gig, and wavelengths as needed to meet business requirements.

Operating as an open access network, four private sector providers signed master agreements to sell services, and the City began taking orders from those providers for the first connected businesses in 2013. The municipal fiber did attract a major data center to the City, and the facility is connected to the AccessEagan network with two fully redundant connections.

7.10 AMERICAN FORK, UTAH

The City of American Fork, Utah is currently evaluating a 100% fiber to the home build out to all 8,600 homes and businesses in the City. Increasing demand for better broadband services from younger residents and work from home residents led the City to evaluate the feasibility of a rapid build out financed by bonding. The current strategy to minimize financial risk is to assess a very small monthly broadband utility fee (in the range of $10 to $12) on all households. Businesses would pay a slightly large fee of $18-$25 per month. Every home and business would receive a Gigabit fiber connection and a "minimal" package of Internet would be included in the monthly fee. The base Internet package would be something like 5 Meg down, 1 Meg upload. Most residents and businesses are expected to upgrade to 250/250 Meg or 1 Gig/1 Gig packages. All Internet services would be provided by private sector ISPs.

8 WIRELESS AND FIBER TECHNOLOGY ANALYSIS

8.1 OVERVIEW OF THE TECHNOLOGY

In large portions of the county, broadband wireless will be an important strategy for improved Internet access for businesses and residents. But both fiber and wireless technologies and systems are going to be important to meet the goal of improving access to broadband. The rest of this section provides more detail and some specific build out strategies.

Businesses and residents may obtain Internet service:

- With a small radio directly attached to their home or business that receives a signal directly from a towers owned by a private provider, from a County-owned tower (e.g. shared with public safety use), or from a community-owned tower (e.g. a coop).
- With a small radio attached to a utility pole (60 or 70') to improve line of sight to a tower.
- With a small radio directly attached to their home or business that receives a signal from a "community" utility pole. The "community" pole will receive a signal from a distant tower and redistribute it locally to a cluster of customers (typically within a half mile).
- With a fiber connection to the fiber installed in areas where economic development is important, and in other areas as additional fiber network segments are added.

The table below summarizes how fiber and wireless can work together in a variety of ways.

Table 8.1: Wireless and fiber distribution and access combinations

DISTRIBUTION TYPE	ACCESS TYPE	CAPACITY
WIRELESS	**WIRELESS**	Typical customer connection starting at 5 to 10 Megabits, can be higher, with 50 Meg connections common. More dependent on the capacity of the wireless Distribution link. In Marathon County, fixed point wireless will be an important bridge technology for many parts of the county until fiber service is more widely available. Providing additional space on existing county towers and adding new towers for WISP use is a relatively low cost strategy for quickly providing more rural residents and businesses with access to improved broadband (e.g. 25/3 service or better).

DISTRIBUTION TYPE	ACCESS TYPE	CAPACITY
WIRELESS	**FIBER**	Users can have fiber Gigabit connections locally, but total throughput dependent upon the capacity of the wireless link, which can be up to a Gigabit, depending on distance and budget. Smaller towns in the county could build some fiber to the home/business immediately and use high performance microwave backhaul to deliver Internet service until affordable middle mile fiber becomes available. This approach of building fiber to the premises locally also improves the business case needed for private capital to invest in middle mile fiber because a local market for Internet has been created.
FIBER	**FIBER**	Any amount of bandwidth needed, with standard connection typically a Gigabit (1,000 Megabits). Competitive, affordable fiber services can be important to help attract and retain businesses, especially in business parks, industrial parks, and downtown "Main Street" areas. Fiber to the home can also be an economic development strategy to help attract younger workers and families from metro areas where FTTH service is more common. There has also been a steady increase in work from home and business from home workers and entrepreneurs who need affordable fiber services.
FIBER	**WIRELESS**	Typical customer connection starting at 5 to 10 Megabits, can be higher, with 50 Meg connections common. In some rural areas of the county, as middle mile fiber becomes more widely deployed, clusters of homes can be served with broadband wireless where the pole or tower is connected to the middle mile fiber network. Wireless broadband towers and poles can provided faster and more reliable service if connected to a fiber middle mile network.

8.2 WIRELESS TECHNOLOGIES

WISPs (Wireless Internet Service Providers) use a wide variety of radio frequencies to deliver fixed point wireless broadband. By "fixed point," this means that these systems are not designed to support roaming in the way that cellular voice/data radios are (that is, mobile phone and data services).

Fixed point broadband is broadcast from a tower to individual homes and businesses (fixed points). Most of the frequencies used require clear line of sight between the tower and the location where service is desired. In some parts of the county, tree cover may be an obstacle to getting good service.

The topography of the area can work for or against good wireless broadband service. Towers located on the tops of hills can provide service over a larger area than a tower in relatively flat terrain, but hills also block the signal. A residence can be a short distance from a large tower, but heavy tree cover or an intervening hill will block service. The solution to this can be addressed in several ways:

MORE LARGER TOWERS OF 180' TO 300'

The taller the tower, the wider the coverage, but as tower height increases, the cost of the tower also increases. Towers taller than 190' require a light at the top to make them visible to low-flying aircraft, and lighted towers are more expensive to erect, and the bulbs have to be changed periodically at significant expense. Many broadband towers are 180' to avoid the additional cost of lighting.

SMALL CELL BROADBAND UTILITY POLES

Small cell broadband utility poles, often called community poles, are shorter towers or utility poles of typically 60' to 80', located in or very near a cluster of homes. The towers can be wooden utility poles or relatively low cost steel monopoles or steel lattice towers. These towers are located to get above local tree cover so that clear line of sight to a distant taller tower is available. Local access point radios provide service to homes and businesses with line of sight to the pole. In many parts of the county, these are going to be an important part of a strategy to get better broadband to rural residents and businesses.

VARIETY OF RADIO FREQUENCIES

WISPs are beginning to deploy a wider range of licensed and unlicensed radio frequencies to overcome distance, bandwidth, and line of sight issues. Traditional 2.4 Ghz and 5.7 Ghz WiFi and WiMax frequencies are being supplemented or replaced with LTE broadband radios that provide better bandwidth and will tolerate light tree cover better (2.5 Ghz, 3.5-3.7 Ghz). Some WISPs are also using lower frequencies (e.g. 900 Mhz) that will travel farther and will also provide better penetration in light tree cover.

8.3 EMERGING WIRELESS TECHNOLOGIES

MIMO WIRELESS

MIMO (Multiple Input, Multiple Output) describes a variety of technologies that can be summarized as using more than one receive and transmit antenna for wireless data applications. Wireless protocols that are using the MIMO concept include IEEE 802.11n (Wi-Fi), IEEE 802.11ac (Wi-Fi), 4G, LTE (Long Term Evolution), and WiMAX. Each of these protocols use the MIMO technology to increase the amount of available bandwidth in a given section of radio frequency spectrum.

New hardware is required to make effective use of MIMO. While the technology increases wireless bandwidth, the typical amount of bandwidth being used by wireless devices is also increasing rapidly. Some applications where MIMO is likely to provide noticeable improvements are in home wireless routers, where the effective throughput will be able to better handle the demanding bandwidth requirements of HD and 4K video streams. MIMO is slowly being developed for use with cellular smartphones, but both the phones and the cell tower radios have to be upgraded to support MIMO.

LTE/4G/5G

LTE (Long Term Evolution) is a set of protocols and technologies designed to improve the performance of voice/data smartphones. Like MIMO, both the user phone and the cell tower radios have to be upgraded to support LTE improvements. In 2013, only 19% of U.S. smartphone users were able to take advantage of LTE speeds, although that percentage has been increasing rapidly since then, and more than 85% of the U.S. cellular towers have been upgraded to LTE. As noted previously, the actual bandwidth available to a smartphone user is highly variable and depends on distance from the cell tower, the number of smartphones accessing the same tower simultaneously, and the kinds of services and content being accessed by those users.

The primary purpose of cellular bandwidth caps is to keep cellular users from using too much bandwidth and degrading the overall service. While LTE and MIMO improvements will improve overall cellular service, these technologies are not going to replace fiber to the home and business.

In 2017, new fixed broadband wireless systems entered the marketplace using LTE frequencies, and many WISPs have begun to replace existing wireless radio systems with LTE equipment. These LTE systems do not provide any cellular voice services; they are designed specifically to support only broadband/Internet service.

Reports of performance have been mixed. In our conversations with both vendors of these systems and WISPs that have begun testing them, we get two very different stories. The vendors have been conservative in discussing the improvements, while some WISPs have been taking single user test results and suggesting that they will be able to deliver higher speeds at greater distances to all users.

There is little debate that the LTE equipment offers higher bandwidth, at somewhat greater distances, and with somewhat better penetration of light foliage and tree cover. Over the next two to four years, most WISPs will change out most of their existing radio systems for the improved LTE radios.

The much touted 5G wireless technology, as of 2019, is still largely marketing hype. The official standard for 5G radio technologies is planned for release later in 2019, although some companies, like Verizon, have begun trials of the equipment with a few customers.

5G does bring much higher speeds to wireless broadband (e.g. it might be able to deliver 30 to 50 Meg of bandwidth consistently). But 5G has significant limitations that do not make it a good solution in rural areas.

The fact that 5G can deliver much higher bandwidth means that 5G cell sites will require fiber connections. This is going to effectively limit 5G deployments to denser urban environments where both customers and fiber are plentiful.

To achieve the full benefit of 5G technology, more fiber is needed

There is no free lunch in the physics of radio frequencies. The higher bandwidth of 5G means that cell sites need to be closer together because the 5G frequencies do not travel as far as existing 4G/LTE

frequencies currently being used by the cellular industry. Most users will have to be within 500 to 1,000 feet to receive 5G service. Some experts estimate that more than a million miles of new fiber will have to be deployed just to support the 25 largest metro areas in the U.S. 5G will not appear overnight.

As many as 60 cell sites per square mile may be needed to make 5G widely available in a given area. If, as an example, about 50%, or 772 square miles of Marathon County is underserved, four thousand or more cell sites would be needed to provide ubiquitous coverage.

For rural areas, the cost of 5G service may be one of the most significant obstacles. The cellular carriers see the increased customer bandwidth use possible on 5G networks as a major revenue opportunity. While they will increase the "standard" bandwidth package for monthly service, bandwidth caps and rate limiting is likely to keep 5G cellular customers bills high.

WHITE SPACE BROADBAND

White space broadband uses some of the frequencies that were formerly used by analog TV channels. These lower frequencies travel farther and provide better penetration of light foliage. Microsoft has been supporting a number of community white space experiments, and has promised much wider support for this technology, but there are few other users, equipment is still relatively expensive, and few WISPs have ventured into this still largely experimental technology. The Microsoft white space project in southern Virginia, although still underway, serves less than three hundred households and is still regarded as experimental.

In Wisconsin in early 2018, Packerland received a Wisconsin Public Service Commission grant to work with Microsoft on a white space deployment in Marinette County. Equipment problems delayed the effort and deployment was expected to complete in the spring of 2019. Results of the experiment don't seem to be publicly available.

8.4 DARK FIBER AND LIT FIBER

ABOUT DARK FIBER

Dark fiber is installed in conduit underground and/or hung on utility poles. It is called "dark" because no network electronics are installed to "light" the fiber (using small lasers in a fiber switch). For small municipal/local government fiber installations, dark fiber has a significant advantage in terms of management—very little ongoing operational responsibility is required.

Dark fiber is leased out to service providers, who install their own network electronics in cabinets or shelters attached to the fiber cables. The providers typically lease fiber pairs between the cabinet and their customers, and are responsible for all equipment-related management and maintenance.

Dark fiber networks do not generate large amounts of revenue, but this is offset by very low maintenance costs—primarily an emergency break-fix arrangement with a local or regional firm qualified to splice fiber. Emergency break-fix contracts are usually based on a time and materials basis, so there is little or no expense if there are no fiber breaks.

Other costs include "locates," which are called in to Wisconsin Call811 (Miss Utility) and are performed by either the local Public Works department or a private sector contractor. For small fiber networks, locate costs are generally modest.

ABOUT LIT FIBER

A "lit" fiber network includes the network electronics needed to transmit data over the fiber (using the small lasers in a fiber switch, hence there is light traveling over the fiber cable). In a lit network, "lit circuits" are leased out to service providers rather than fiber pairs. The muni/local government/community network provides the network electronics, which reduces costs for the service provider—meaning they are able to pay higher lease fees for the circuits they use to deliver services (like Internet) to their customers. Lit networks generate more revenue, but also have higher expenses because the network electronics have to be monitored and managed on a 24/7/365 basis (this task can usually be outsourced at reasonable cost). However, very small fiber deployments often do not pass enough homes or businesses to generate sufficient revenue to cover the higher costs.

Like dark fiber, a lit network incurs break-fix and locate costs as well.

8.5 THE MEET-ME BOX CONCEPT

In some of the larger towns, some smaller communities, rural neighborhoods, and subdivisions, "meet me" boxes could be installed. A meet me box is a telecom cabinet with fiber cables installed between the cabinet and nearby homes and/or buildings. Providers only have to reach the meet-me box, lowering their costs. Both wireline and wireless providers can use this infrastructure. This approach can also be used to provide fiber services in business and industrial parks. A small Virginia county installed five miles of fiber in their business park and was able to attract a Tier One provider to provide service to an existing business (a manufacturing plant that was going to leave if the county did not help them get better Internet service).

Figure 8.1: Meet-me box

The dark fiber approach minimizes operational costs. Service providers would install their own equipment in the cabinet and would pay a small monthly lease fee for the fiber strands they use to connect customers to their services.

For a meet-me box installed in a "main street" area (e.g in an alley behind commercial/retail buildings) with relatively inexpensive and short fiber drop cables into nearby buildings, the lower end of an installation might start at $35,000. For a box installed in a rural subdivision that requires distribution conduit/fiber and drop cables, the cost to connect 25 homes might start at $175,000 on the low end and increase as the number of homes connected increases. Larger numbers of homes or businesses will each add to the cost, but adding more connected premises also increases the value of the infrastructure and increases the revenue potential.

8.6 CONNECTIVITY SOLUTIONS

Both wireless and fiber networks, as well as legacy copper-based networks, all share three primary components. How these are designed and deployed can vary greatly, but all networks have these three parts in some form.

- The **Core Network** provides access to the Internet, a place for service providers (ISPs) to distribute their services locally on the network, and for larger institutional and business customers to meet service providers. The county has both landline and wireless service providers, but there are still areas that are underserved. Each of these providers has their own Core Network, but wireless broadband could be more widely available if additional county-owned towers were available to the private sector providers.
- The **Distribution** portion of the network connects the Core Network with collections of users. A Distribution network can include both fiber and wireless portions of a network.
- The **Access or Last Mile** portion of the network connects residential users and businesses to the network, and like the Distribution network, that connection will be by fiber or by a wireless link.

The illustration below shows the full range of technology options (fiber and wireless) and how they can be connected together in various ways to meet the diverse needs of the county. More detail is provided on the following pages.

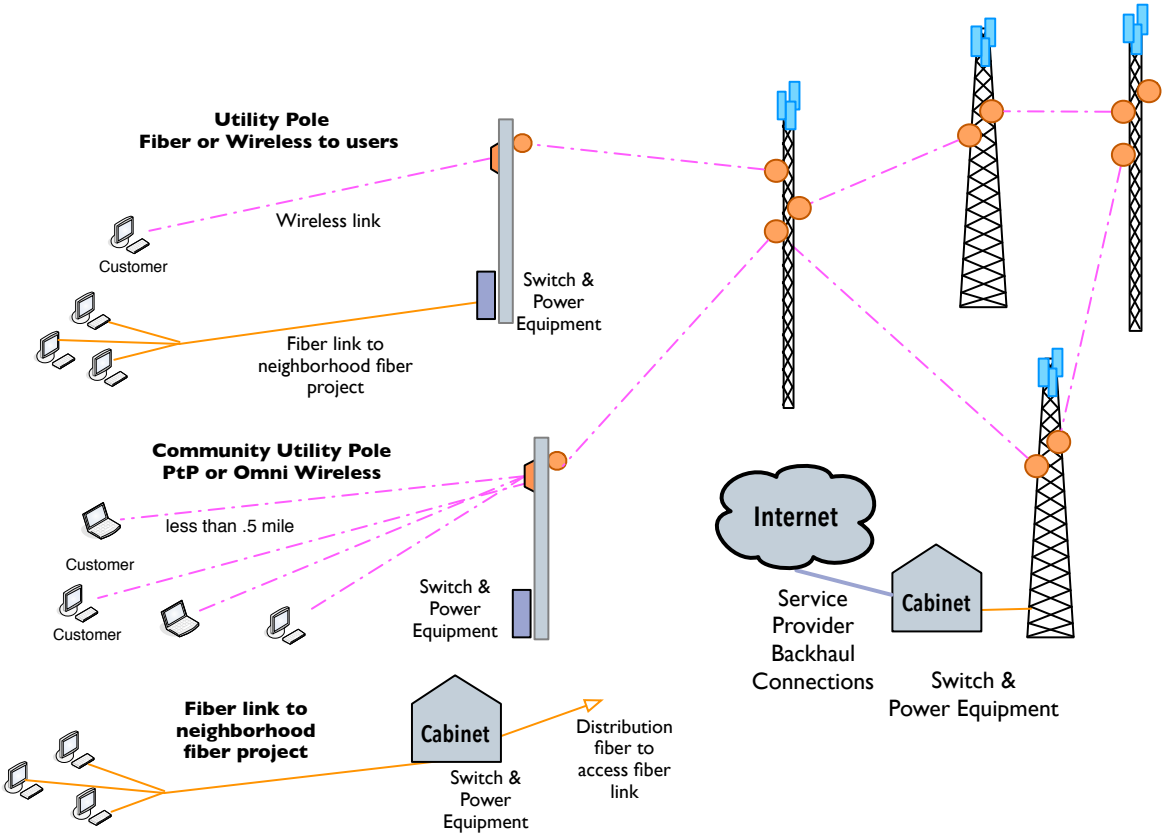
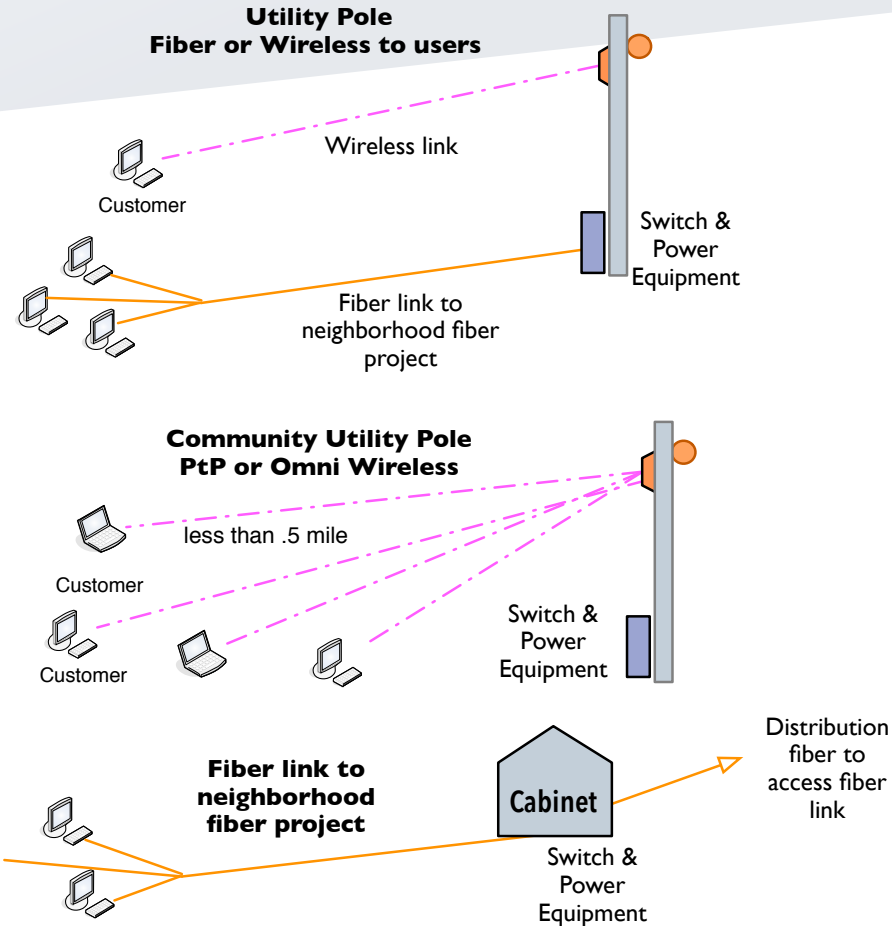


Diagram show core/middle mile network on right, and various middle mile/access network options on the left.

LAST MILE ACCESS

The Last Mile Access is the portion of the network that connects customers to their service provider and the Internet. Both broadband wireless and fiber links can be utilized to provide service. There are several ways that customers can receive service:



Last mile access options

- Service providers can install their own local access radios on the Distribution towers, using both point to multi-point and point-to-point radios to deliver service to their customers.
- A single user utility pole (or inexpensive steel lattice tower) can be installed on the property of a single resident or business. A radio at the top of the pole receives service from another tower site (typically one of the Distribution towers).
- A utility pole (or inexpensive steel lattice tower) can be installed near a cluster of homes (e.g. a rural residential sub-division, several homes in close proximity on a rural road). Service providers can install their point to multi-point radios on this pole and provide economical service to several customers from a single pole.
- A utility pole (or inexpensive steel lattice tower) can be installed in a rural subdivision. A service provider installs a point to point radio on the pole, and fiber cable can be run from the pole past several homes to offer fiber service with wireless backhaul.
- Customers near existing fiber can have a fiber drop installed directly to their home or business.

DISTRIBUTION NETWORK

Distribution is the portion of the network between the Distribution sites to the Last Mile Access portion of the network. It is desirable for each distribution site to have a connection back to more than one Distribution site (tower) on a redundant ring. This ring topology protects against hardware failure at

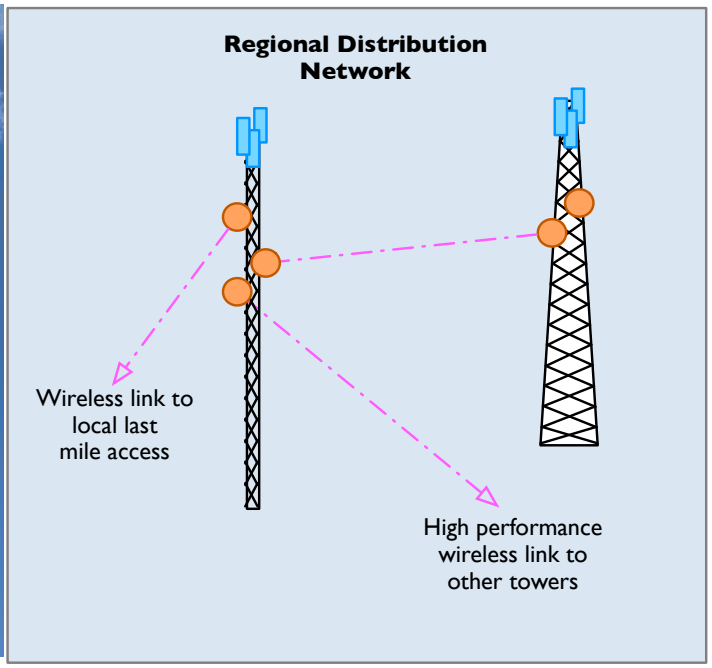
the port level and does provide some protection if one of the tower to tower wireless links is disabled by an equipment failure.

These tower sites are typically 120′ to 180′ tall to provide the height needed to enable Line Of Sight (LOS) between towers, and for local access, to enable service providers to mount point to multi-point radios on the towers.

Towers taller than 199′ become subject to FAA regulations because the height can be a potential hazard to airplanes. Towers that exceed 199′ usually have to be painted (alternating red/white) and have a blinking light at the top. These requirements increase the long term maintenance costs, but the taller towers can improve line of sight to other towers.

The towers can provide two functions:

- Space for backhaul connections to other towers in the county.
- Space for local access radios to provide Internet access within 2-3 miles of the tower (or farther with good Line Of Sight).



Regional distribution network

CORE NETWORK AND SERVICE PROVIDERS

In the past, the telephone company switch office (Central Office, or CO) has provided the location where local telecom cables were connected to the nationwide telephone network. Today, many communities have either a community-owned data center or a privately owned data center that provides a location for inter-connection of public and private networks and connections to the worldwide Internet.

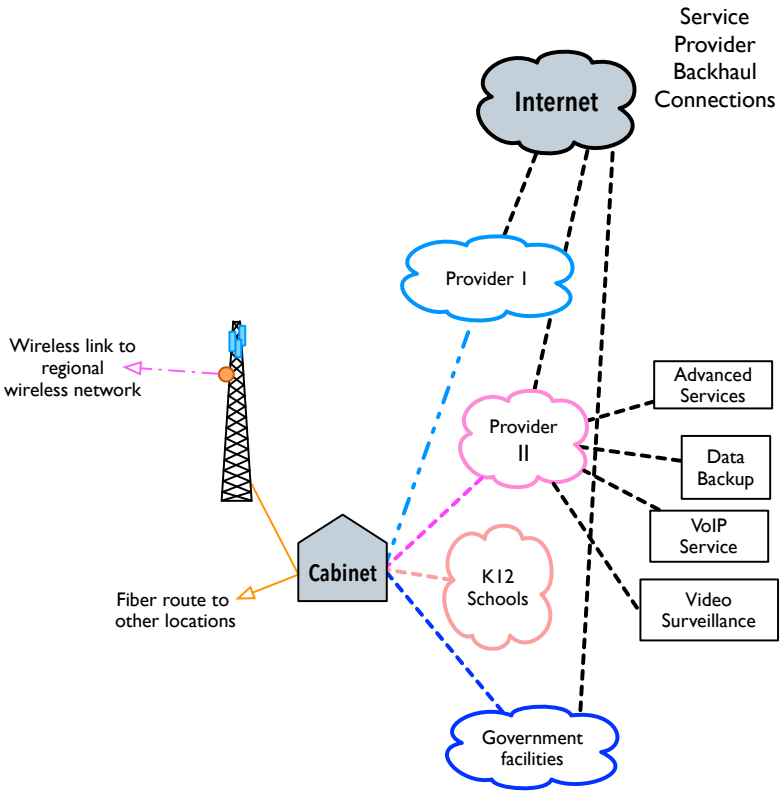
The Co-Location facility provides a meet point for various public and private fiber cables and networks to inter-connect. A local facility with space available for both public and private uses could help attract additional private sector investments (e.g. a long haul fiber provider wants connect to this facility because of increased access to customers).

A colocation facility is a controlled environment (i.e. secure, heated, and air-conditioned) room with Internet access through wired and/or wireless systems. The colocation facility is a place where fiber, wireless, and copper-based network facilities meet. It is equipped to house high-end network equipment, servers, and other electronic gear.

A variety of middle layer network components and services can be located within the co-lo including, for example, directory services, replicated content servers, routing services, and other elements needed to deliver new multimedia services to the home and small office from multiple, competing providers.

The rise of Software as a Service (SaaS) and cloud-based computing and data services has increased the need for affordable data centers. Many companies now backup company data in multiple, geographically diverse data centers to reduce the likelihood of any data loss. We know of one company that uses multiple data centers for storage of corporate data and enforces a rule that any two data centers must be a minimum of twenty miles apart to reduce the likelihood of a natural disaster (e.g. flood, wind storm, earthquake, etc.) would affect both data centers at the same time.

Marathon County will house its "meet-me" location and its initial distribution switches (and eventual core routes) in either an existing colocation facility or a new prefab shelter and Service Providers will connect to one or both of the core devices.



Co-location facility

Characteristics of the colocation facility are:

- A reliable source of AC electric power is required, with backup UPS (Uninterruptible Power Supply) service, and additional power backup available by an onsite generator is desirable.
- Controlled access to the facility (e.g. by electronic keycard) 24 hours/day, seven days a week. Service providers need to be able to gain access to the equipment room as needed, and work activities performed at night or on weekends is common.
- Racks for locating network equipment and servers, and optionally locked cages for equipment racks.
- Sufficient cooling capacity for the network's current and long-term needs. Equipment rooms require both a cool air input vent and an air return vent.

8.7 BROADBAND UTILITY POLES

Line of sight issues are a constant problem for rural residents and businesses, as clear line of sight (or near line of sight) is required for fixed wireless Internet services. Even newer technologies like white space and LTE systems work better with clear line of sight to distant towers.

The increased use of wooden utility poles is already common in some other areas of the country, and increased use of this technique to get the customer CPE radio/antenna above tree cover is a relatively simple solution.

The utility poles would normally be placed on private property, subject to existing or updated ordinances governing the placement of wooden utility poles. The local government would have no responsibility for maintenance and repairs.

Examples of broadband utility poles

The cost of placing an eighty foot pole can range from a low of about $2,000 to $7,000 or more, depending on permitting, engineering requirements, and the location of the pole. Some counties provide "by right" permitting of these poles if they are placed on private property, which can reduce the cost of installing them.

Because these are placed on private land, local government would not have to provide any direct funding. However, the localities could encourage wider use of this option with a public awareness campaign developed in partnership with wireless providers. Local banks could be encouraged to provide low cost financing of the poles so that property owners could make a small interest and principal payment monthly over several years to reduce the financial impact.

8.8 NANO-CELL AND WIFI CALLING SERVICE

A common complaint in the county is the poor cell service in many areas. In some parts of the area, there may be adequate broadband service via DSL or cable modem Internet, but poor cellular phone/ data service. There are now two solutions to improving rural cellular service that do not involve the expense or difficulty of attracting and/or building more cellular towers.

WIFI CALLING

This approach takes advantage of the WiFi Calling feature that is now common in many late model cellphones. Once the phone is connected to a WiFi network (e.g. in the home using the home's broadband Internet service), the phone will automatically route the call over the WiFi network– phone calls and text work normally, as if the phone is connected to a cellular tower.

Wifi router and phone

NANO-CELL CALLING

Poor or no cellular service in rural areas can be addressed by promoting the wider use of "nano-cell" devices. These small pieces of equipment are connected to the DSL or wireless broadband connection and provide improved cell service in the home or business. The working distance of these devices is limited, and service generally drops off once you leave the house itself (it may work for some short distance in the yard). These devices work very well and do not require an upgrade to a newer phone.

The cellular providers do not always promote the use of these devices, so many cellular users who would benefit from their use are not aware that this option is available. The device averages around $200 retail, but the cellular providers often provide substantial rebates (50% discount or more) and in some cases may provide them at no charge.

The improved wireless broadband service will also support use of WiFi calling and/or nano-cell devices.

This strategy is important because improved broadband service can also improve cellular service without the need for more cellular towers, especially in parts of the county where cellular providers have not been able to make the business case for more towers.

9 A NETWORK FOR MARATHON COUNTY

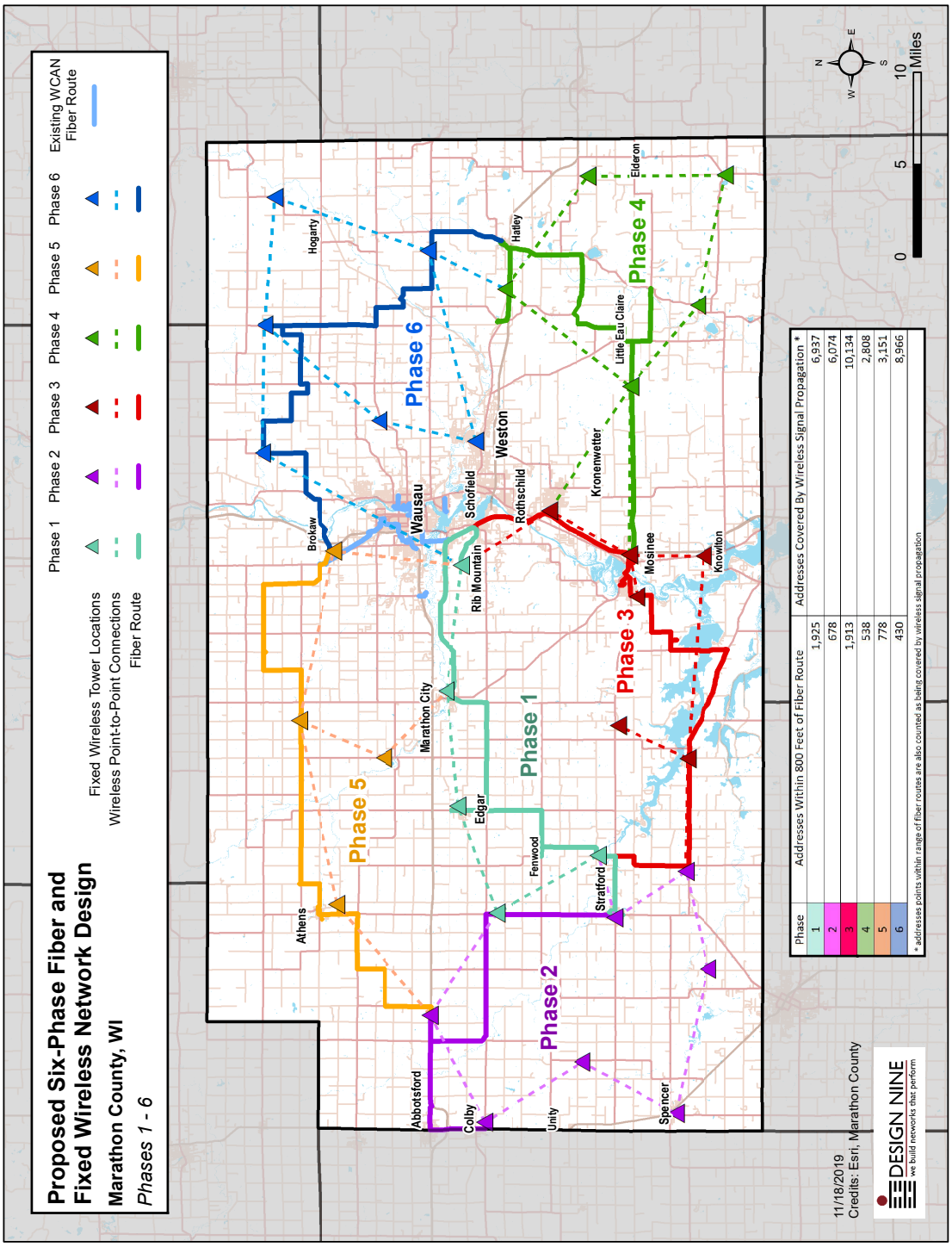
This section provides the detail for a fixed point wireless broadband network in the county and a Gigabit fiber network throughout the county. The county-wide fiber backbone could provide improved service at less cost to county facilities, wireless towers, including cellular towers, and could be expanded over time to provide Fiber To The Home (FTTH) services to many of the smaller towns in the county. Map 9.1 on the next page provides an overview of both proposed networks.

Both the wireless and fiber infrastructure has been separated into six phases.

- The fiber and wireless portions of the network do not have to be built out together. That is, Phase One wireless is not dependent upon the Phase One fiber.
- The phases (both fiber and wireless) do not have to be built out sequentially. This is especially true of the wireless phases. Depending on local demand and political considerations, the Phase Six wireless (or any other phase) could be constructed before the Phase One wireless.
- If network redundancy is considered a high priority in some areas of the county, some wireless and fiber portions of the network will have to be built out at the same time so that the wireless network can provide redundancy for the fiber network and vice versa.

This map provides an overview of all six proposed phases of both the fiber and wireless network. As noted previously, the wireless and fiber portions of the network do not have to be constructed at the same time.

Map 9.1: Countywide Fiber and Wireless Network Design



Phase	Addresses Within 800 Feet of Fiber Route	Addresses Covered By Wireless Signal Propagation *
1	1,925	6,937
2	678	6,074
3	1,913	10,134
4	538	2,808
5	778	3,151
6	430	8,966

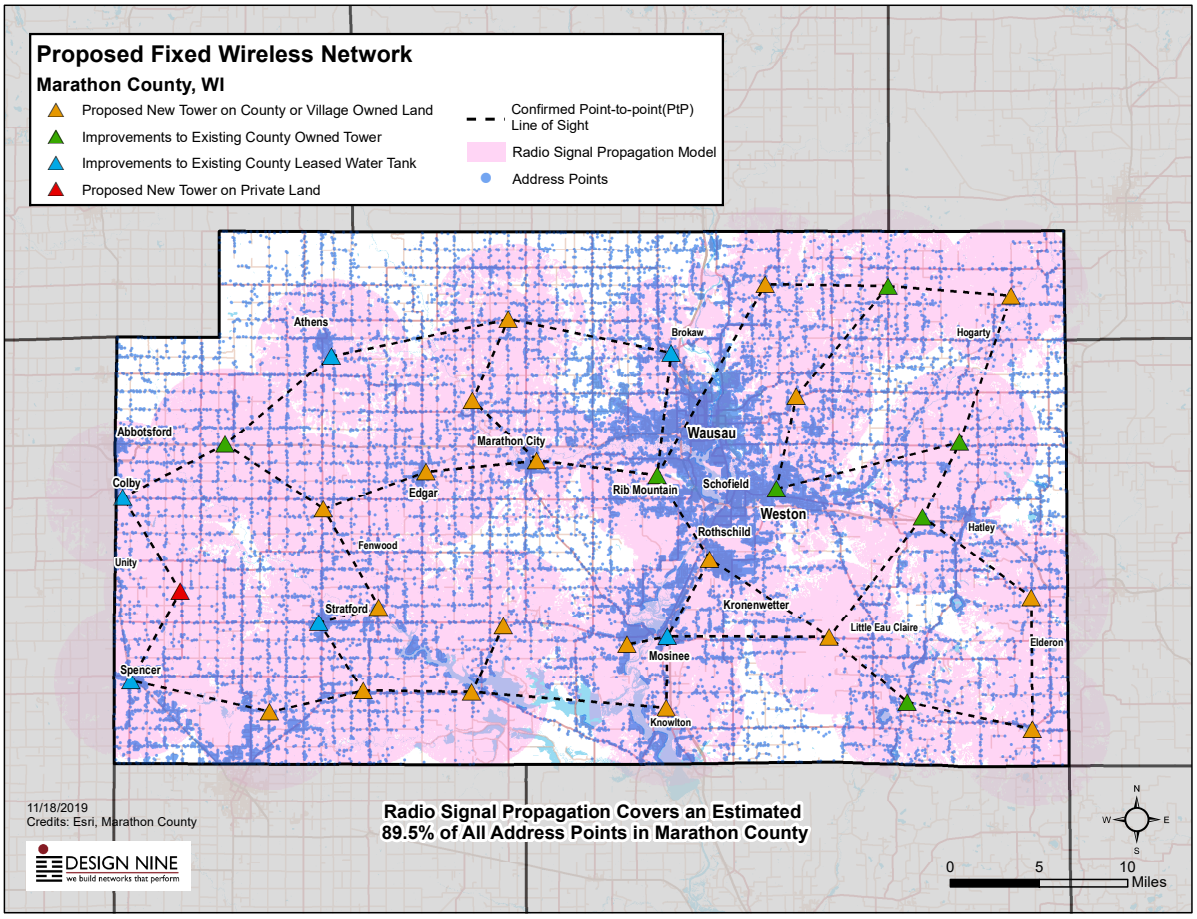
* addresses points within range of fiber routes are also counted as being covered by wireless signal propagation

9.1 SUMMARY OF THE WIRELESS AND FIBER NETWORKS

WIRELESS SUMMARY

Marathon County needs a large number of existing and new towers to achieve adequate coverage. The towers deployments could be phased over a period of three years or more, depending upon what funds are available. All six proposed wireless phases could be completed independently of any fiber projects, and the quickest way to improve broadband service throughout the county would be to expand the number of towers available to WISPs as quickly as possible. The total cost of all six phases is an estimated $5.3M.

Map 9.2: Fixed Point Wireless Broadband Countywide Propagation Study



The existing county-owned towers should be evaluated as part of an initial build out effort. Those towers will require a structural analysis to determine if additional equipment can be added to the tower (a structural analysis generally costs $2,500 to $5,000). Improvements to these existing towers could bring better service quickly to at least a portion of the county, and additional towers and poles could be added incrementally.

This map displays the proposed wireless network, including the proposed point to point links between towers. This design could provide 25/3 wireless broadband service to as many as approximately 89%

of residential address points in the county. To reach 100% of homes and businesses would require as many as ten additional towers at an estimated cost of $2.5M to $3M. Any wireless tower improvements and/or new towers should be sited and developed in consultation with interested (WISPs).

- The wireless propagation models in this document are created to depict an area of potential coverage for the equipment. Wireless connectivity must be evaluated on a case by case basis. Dense tree cover, buildings, and other obstructions can block signal to an individual location. In some cases neighborhood poles, a grain silo, or individual tall masts on homes/businesses may be required to obtain good wireless service.
- Wireless propagation modeling was completed using 5GHz frequencies. The characteristics of other frequencies could be slightly different. Utilizing the 5GHz frequency for the models represents the most conservative example.
- Plans for the wireless phases should be developed in close consultation with local Wireless Internet Service Providers (WISPs). The WISPs will be leasing space on the new and existing towers, and their advice should be solicited to ensure that there is at least one WISP who wants to place equipment on planned towers.
- If all six wireless phases are constructed, an estimated 89% of households in the county could receive service if they have clear line of sight or near line to site to one of the proposed towers.

FIBER NETWORK SUMMARY

This network design is a "lit" network, meaning the cost of all network electronics are included in the financial analysis, including the customer premises equipment (CPE). The three year build out includes construction of the county-wide middle mile network (about 211 miles of distribution fiber) that would pass an estimated 3,400 homes and 450 businesses. The network construction could be financed with twenty year bonds.

An estimated $30M in borrowing would be required to pay the capital costs of construction and to provide an operating fund to support the network for the first several years of operation. In the first three years, 1,600 home and businesses could be connected. In subsequent years, 300-500 additional homes and businesses could be connected per year.

It has been assumed that most of the fiber to the home construction would take place in the smaller towns and villages in the county.

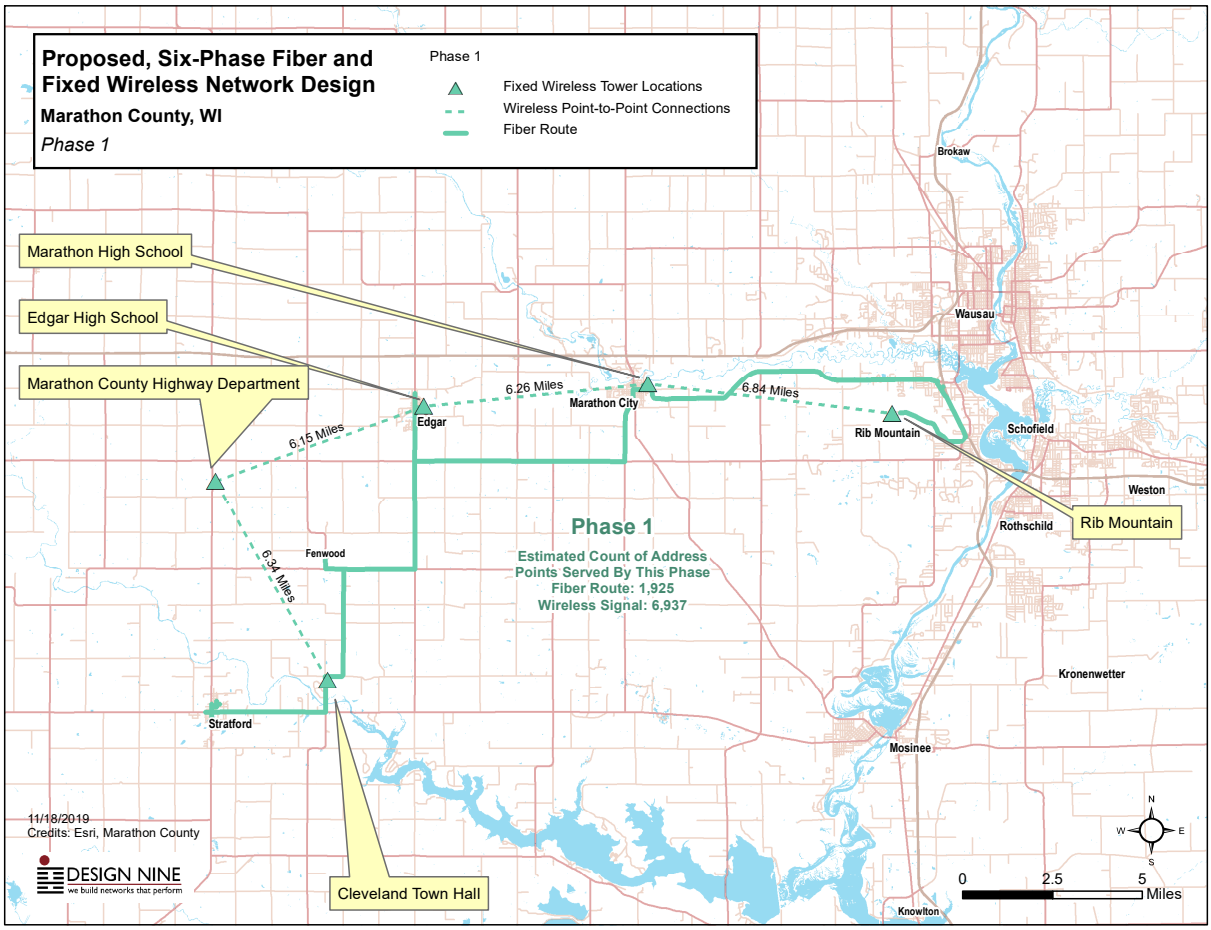
A faster build out would be possible with higher levels of funding.

- The fiber network design utilizes the existing WCAN fiber route in the Wausau area to reduce some of the construction costs. Phases One, Three, Five, and Six all are connected to the WCAN fiber, which would allow demand and political considerations to drive the actual build out schedule.
- The initial construction period is three years. Most of the capital expenditures occur during this time.
- An initial take rate of 40% to 45% is projected for residential connections, projecting about 1,500 homes connected by year three.

- An estimated 450 businesses will be passed in the initial construction, with a projected take rate of 25%, which would be about 110 businesses connected in the first three years.
- Residential customers would pay a monthly Connection Fee of $45 to the network itself for a full Gigabit of symmetric bandwidth on the network. Customers then purchase a package of Internet from a service provider that is offering services on the network (e.g. 100/100 Meg package of Internet, 250/250 meg package of Internet, etc.).
- Business customers would buy service from providers on the network. Service providers pay the network a fee based on the size of the circuit they request to deliver service to a customer. Business class services have a higher quality of service than residential customers.
- The fiber network design creates three redundant fiber rings, which increases network reliability. As some wireless towers are connected to the fiber network, additional redundancy and network resiliency is achieved.
- The network would be operated as an "open access" enterprise, meaning that private sector service providers would offer all retail residential and business services. The Marathon County government would not be an Internet Service Provider (ISP).

9.2 PHASE ONE

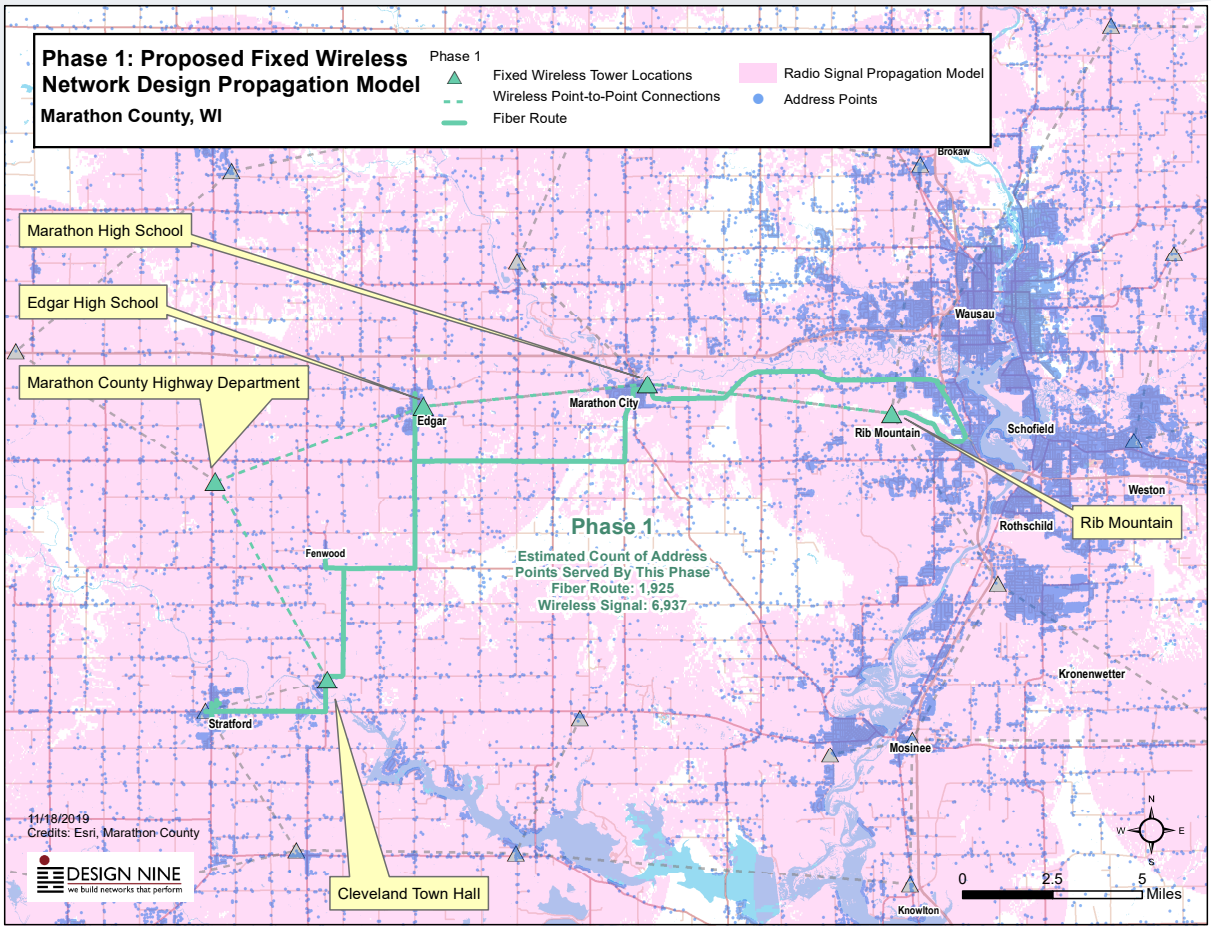
Phase One builds fiber to the west and provides several wireless towers. As noted previously, the fiber construction and the wireless towers do not have be constructed at the same time. However, to achieve some redundancy for the fiber network, the wireless backhaul would have to be constructed as the same time as the fiber network.



Map 9.3: Phase One Proposed Fiber and Wireless

Table 9.1: Phase One Wireless and Fiber Total Estimated Cost

SITE	DESCRIPTION	TOTAL COST
Phase 1 Fiber Construction	Fiber Construction, Phase 1, 5 Cabinets, Calix GPON FTTX Architecture	$5,484,211
Phase 1 Wireless Construction	Four new towers, one existing tower, point to point links	$916,638
		$6,400,849



Map 9.4 : Phase One Propagation Study

PHASE ONE WIRELESS CONSTRUCTION

Four new towers and one tower up fit is included in this phase.

Table 9.2: Phase One Wireless Projected Costs

SITE	DESCRIPTION	TOTAL COST
Proposed: Edgar HS/Edgar	Proposed New Tower on County or Village Owned Land, WISP Provides Access Equip.	$200,425
Proposed: Marathon County Highway Dpt.	Proposed New Tower on County or Village Owned Land, WISP Provides Access Equip.	$200,425
Proposed: Marathon HS/ Marathon	Proposed New Tower on County or Village Owned Land, WISP Provides Access Equip.	$200,425
Proposed: Cleveland Town Hall	Proposed New Tower on County or Village Owned Land, WISP Provides Access Equip.	$200,425
Existing: Rib Mountain Tower	Improvements to Existing County Owned Tower of Already Leased Water Tank, WISP Provides Access Equip.	$52,088
Point to Point: Edgar HS to Marathon County Hwy Dpt	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Marathon County Hwy Dpt to Cleveland Town Hall	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Marathon HS to Edgar HS	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Rib Mountain to Marathon HS	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
		$916,638

PHASE ONE FIBER CONSTRUCTION

Table 9.3: Phase One Fiber Construction Overview

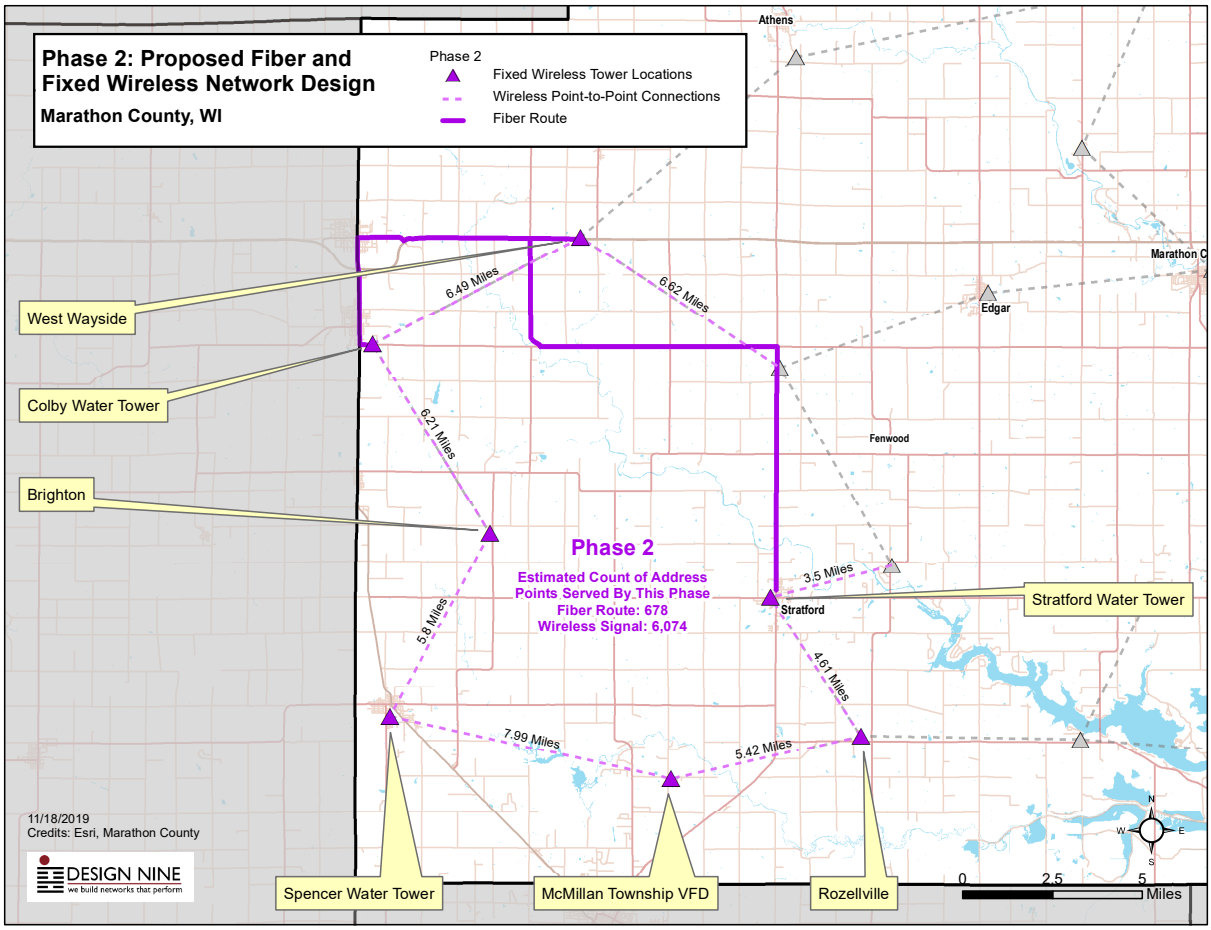
Fiber Construction: Phase One Route Overview		
0	**ITEM/PROJECT**	**VALUE**
1	Miles of Fiber / Conduit Installed	37.91
2	Number of Handholes Installed	251
3	Splice Closures Installed	482
4	Cabinets Installed	5
5	Buildings Passed	1,925
6	Buildings Connected - % of the Buildings Passed who are connected	25%
7	Number of Buildings Connected	482
8	Aerial - Percentage of construction expected to be installed on utility poles.	1%
9	Trenching - Percentage of construction installed by trenching	9%
10	Boring - Percentage of construction installed by horizontal drilling.	20%
11	Slot Cutting - Conduit installed in street by special methods.	0%
12	Rock Saw - Required where rock prevents the use of other methods.	0%
13	Direct Bury - Conduit installed by direct bury methods (plow, vibratory plow)	70%
14	Aerial Info	1% Aerial is estimated to account for water body crossings and other obstacles to construction.
15	Other Notes	Estimated labor rates are based upon common rates seen for recent medium sized rural projects.

Table 9.4: Phase One Fiber Construction Cost Summary

Fiber Construction: Phase One Cost Summary		
0	**ITEM/PROJECT**	**ESTIMATED**
1	Phase One Construction Materials	$924,379
2	Phase One Distribution Labor	$1,950,751
3	Phase One Structures, Cabinets, and Equipment	$361,725
4	Phase One Drop Construction	$805,350
5	Network Construction Subtotal	$4,042,205
6	Project Management, Network Engineering, Integration, and Testing	$404,221
7	Misc Fees, Advertising, Technical Services	$40,422
8	Bookkeeping and Administration	$40,422
9	Engineering, Permitting	$303,165
10	Legal Costs	$20,211
11	Tools and Vehicles	$35,000
12	BSS/OSS/Software	$50,000
13	Other Upfront Costs	$50,000
14	Other Costs Subtotal	$943,441
15	Project Total	$4,985,646
16	Contingency at 10%	$498,565
17	Project Total (with contingency)	$5,484,211

9.3 PHASE TWO

Phase Two continues building fiber to the west end of the county. Several new and existing towers are set up to support WISP services, and combined with Phase One wireless, a wireless ring is created to improve the resiliency of the wireless service in the west end of the county.



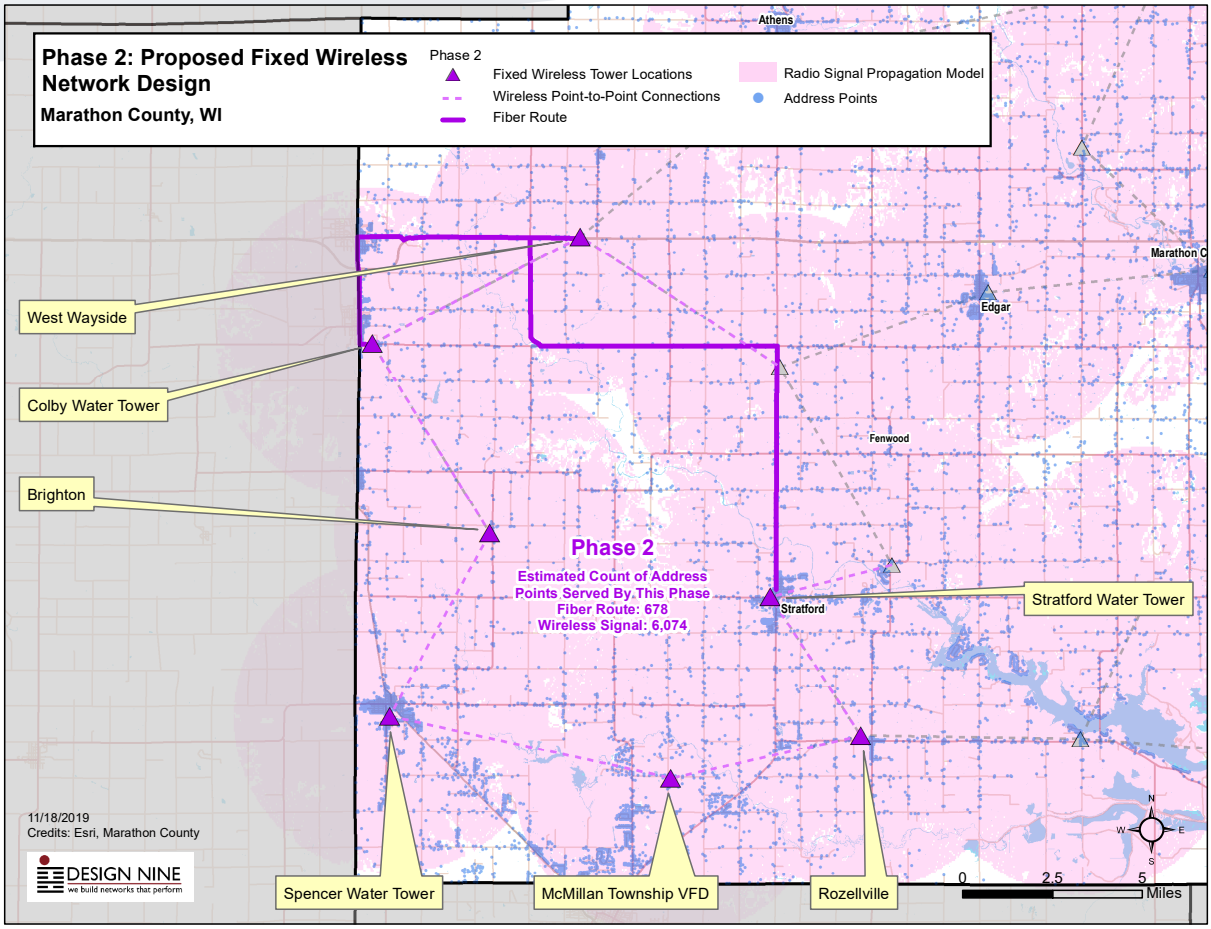
Map 9.5: Phase Two Proposed Fiber and Wireless

Table 9.1: Phase Two Wireless and Fiber Total Estimated Cost

PHASE TWO WIRELESS AND FIBER CONSTRUCTION

SITE	DESCRIPTION	TOTAL COST
Fiber: Phase Two	Fiber Construction, Phase 2, 3 Cabinets, Calix GPON FTTX Architecture	$3,085,733
Wireless Construction Phase Two	Three new towers, four existing county-owned and leased towers, point to point links	$935,325
		$4,021,058

Map 9.6 : Phase Two Propagation Study



PHASE TWO WIRELESS CONSTRUCTION

Table 9.5: Phase Two Wireless Projected Costs

WIRELESS CONSTRUCTION PHASE TWO

SITE	DESCRIPTION	TOTAL COST
Proposed: McMillan Township VFD	Proposed New Tower on County or Village Owned Land, WISP Provides Access Equip.	$200,425
Proposed: Rozellville	Proposed New Tower on County or Village Owned Land, WISP Provides Access Equip.	$200,425
Existing: West Wayside Tower	Improvements to Existing County Owned Tower of Already Leased Water Tank, WISP Provides Access Equip.	$52,088
Existing: Stratford Village Water Tank	Improvements to Existing County Owned Tower of Already Leased Water Tank, WISP Provides Access Equip.	$52,088
Existing: Colby Water Tank	Improvements to Existing County Owned Tower of Already Leased Water Tank, WISP Provides Access Equip.	$52,088
Existing: Spencer Water Tank	Improvements to Existing County Owned Tower of Already Leased Water Tank, WISP Provides Access Equip.	$52,088
Proposed: Town of Brighton	Proposed New Tower on Private Land Near an Existing Cell Tower, WISP Provides Access Equip.	$200,425
Point to Point: Spencer Water Tower to McMillan Township	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Brighton to Spencer Water Tower	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: McMillan Township to Rozellville	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: West Wayside to Colby Water Tower	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Marathon County Hwy Dpt to West Wayside	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Colby Water Tower to Brighton	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Cleveland Town Hall to Stratford Village Water Tower	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Stratford Village Water Tower to Rozellville	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
		$935,325

PHASE TWO FIBER CONSTRUCTION

Table 9.6: Phase Two Fiber Construction Overview

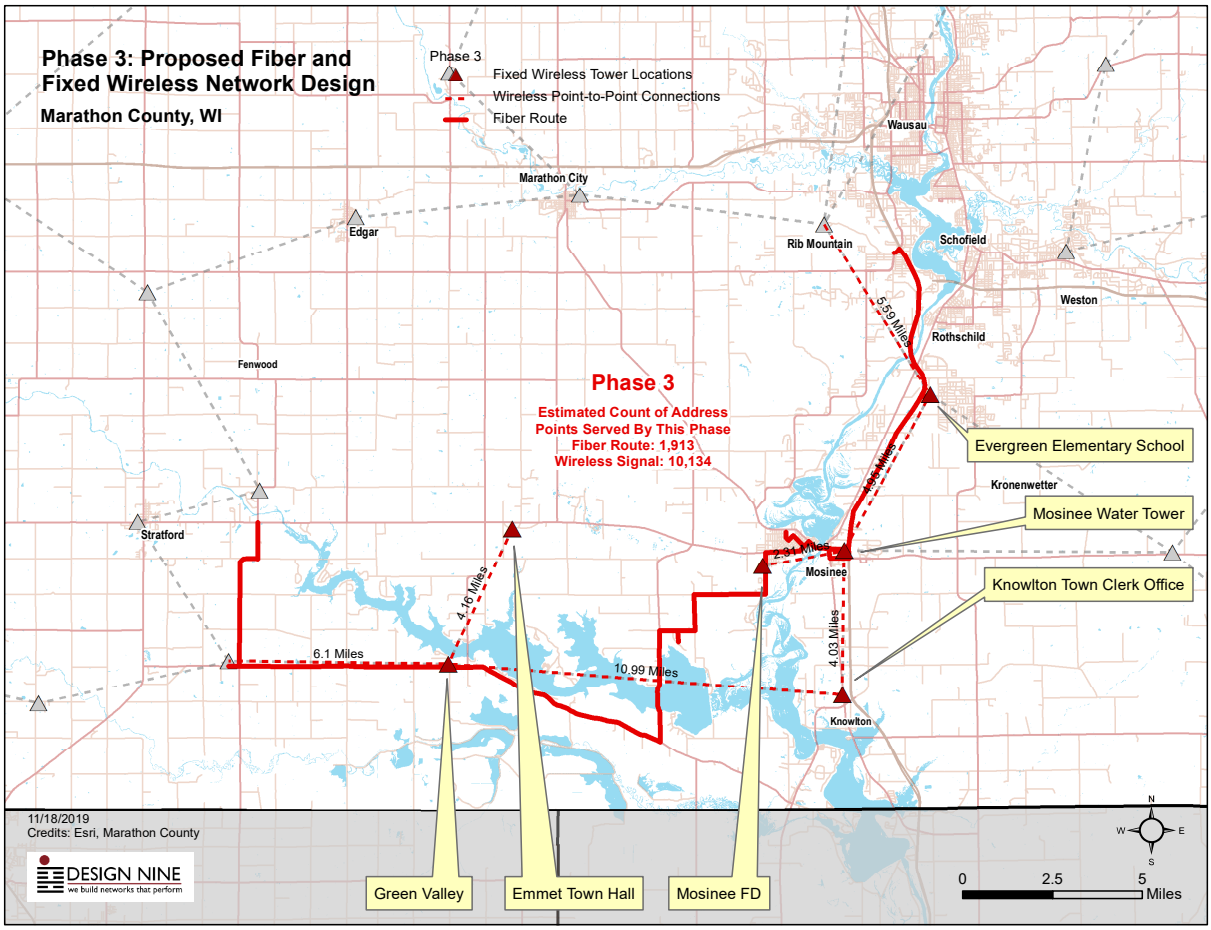
Phase Two Route Overview		
0	**ITEM/PROJECT**	**VALUE**
1	Miles of Fiber / Conduit Installed	26.12
2	Number of Handholes Installed	173
3	Splice Closures Installed	170
4	Cabinets Installed	3
5	Buildings Passed	678
6	Buildings Connected - % of the Buildings Passed who are connected	25%
7	Number of Buildings Connected	170
8	Aerial - Percentage of construction expected to be installed on utility poles.	1%
9	Trenching - Percentage of construction installed by trenching	9%
10	Boring - Percentage of construction installed by horizontal drilling.	20%
11	Slot Cutting - Conduit installed in street by special methods.	0%
12	Rock Saw - Required where rock prevents the use of other methods.	0%
13	Direct Bury - Conduit installed by direct bury methods (plow, vibratory plow)	70%
14	Aerial Info	1% Aerial is estimated to account for water body crossings and other obstacles to construction.
15	Other Notes	Estimated labor rates are based upon common rates seen for recent medium sized rural projects.

Table 9.7: Phase Two Fiber Construction Cost Summary

Phase Two Cost Summary		
0	**ITEM/PROJECT**	**ESTIMATED**
1	Phase Two Construction Materials	$604,896
2	Phase Two Distribution Labor	$1,264,557
3	Phase Two Structures, Cabinets, and Equipment	$163,440
4	Phase Two Drop Construction	$283,950
5	Network Construction Subtotal	$2,316,843
6	Project Management, Network Engineering, Integration, and Testing	$231,684
7	Misc Fees, Advertising, Technical Services	$23,168
8	Bookkeeping and Administration	$23,168
9	Engineering, Permitting	$173,763
10	Legal Costs	$11,584
11	Other Upfront Costs	$25,000
12	Other Costs Subtotal	$488,369
13	Project Total	$2,805,212
14	Contingency at 10%	$280,521
15	Project Total (with contingency)	$3,085,733

9.4 PHASE THREE

Phase Three fiber builds to the south central area of the county, and combined with Phase One, creates a fiber ring. The Phase Three wireless, if connected to Phase One and Two wireless towers, creates a wireless ring for improved service.

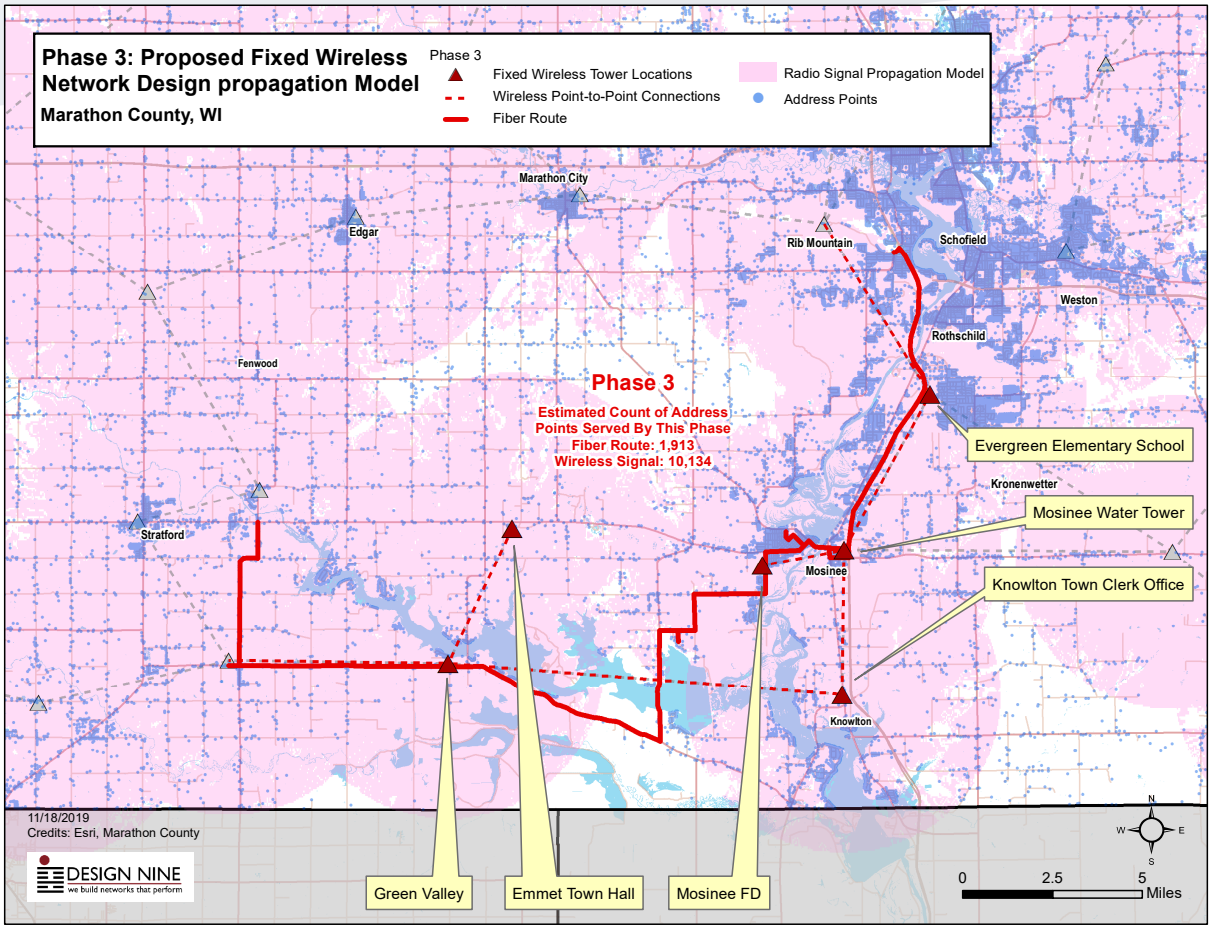


Map 9.7: Phase Three Proposed Fiber and Wireless

Table 9.8: Phase Three Wireless and Fiber Total Estimated Cost

PHASE THREE WIRELESS AND FIBER CONSTRUCTION

SITE	DESCRIPTION	TOTAL COST
Fiber: Phase Three	Fiber Construction, Phase 3, 1 Cabient, Calix GPON FTTX Architecture	$5,176,249
Proposed: Evergreen Elementary School	Five new towers, one existing tower, point to point links	$1,164,200
		$6,340,449



Map 9.8 : Phase Three Propagation Study

PHASE THREE WIRELESS CONSTRUCTION

Table 9.9: Phase Three Wireless Projected Costs

WIRELESS CONSTRUCTION PHASE THREE

SITE	DESCRIPTION	TOTAL COST
Proposed: Evergreen Elementary School	Proposed New Tower on County or Village Owned Land, WISP Provides Access Equip.	$200,425
Proposed: Mosinee FD	Proposed New Tower on County or Village Owned Land, WISP Provides Access Equip.	$200,425
Proposed: Emmet Town Hall/ Hadler	Proposed New Tower on County or Village Owned Land, WISP Provides Access Equip.	$200,425
Proposed: Green Valley	Proposed New Tower on County or Village Owned Land, WISP Provides Access Equip.	$200,425
Proposed: Knowlton Town Clerk Office	Proposed New Tower on County or Village Owned Land, WISP Provides Access Equip.	$200,425
Existing: Mosinee Water Tank	Improvements to Existing County Owned Tower of Already Leased Water Tank, WISP Provides Access Equip.	$52,088
Point to Point: Knowlton to Mosinee Water Tower	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Green Valley to Emmet/Hadler	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Rozellville to Green Valley	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
PtP Mosinee Water Tower to Mosinee FD	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Green Valley to Knowlton	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Rib Mountain to Evergreen ES	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Mosinee Water Tower to Evergreen ES	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
		$1,164,200

PHASE THREE FIBER CONSTRUCTION

Table 9.10: Phase Three Fiber Construction Overview

Phase Three Route Overview

0	ITEM/PROJECT	VALUE
1	Miles of Fiber / Conduit Installed	39.44
2	Number of Handholes Installed	261
3	Splice Closures Installed	479
4	Cabinets Installed	1
5	Buildings Passed	1,913
6	Buildings Connected - % of the Buildings Passed who are connected	25%
7	Number of Buildings Connected	479
8	Aerial - Percentage of construction expected to be installed on utility poles.	1%
9	Trenching - Percentage of construction installed by trenching	9%
10	Boring - Percentage of construction installed by horizontal drilling.	20%
11	Slot Cutting - Conduit installed in street by special methods.	0%
12	Rock Saw - Required where rock prevents the use of other methods.	0%
13	Direct Bury - Conduit installed by direct bury methods (plow, vibratory plow)	70%
14	Aerial Info	1% Aerial is estimated to account for water body crossings and other obstacles to construction.
15	Other Notes	Estimated labor rates are based upon common rates seen for recent medium sized rural projects.

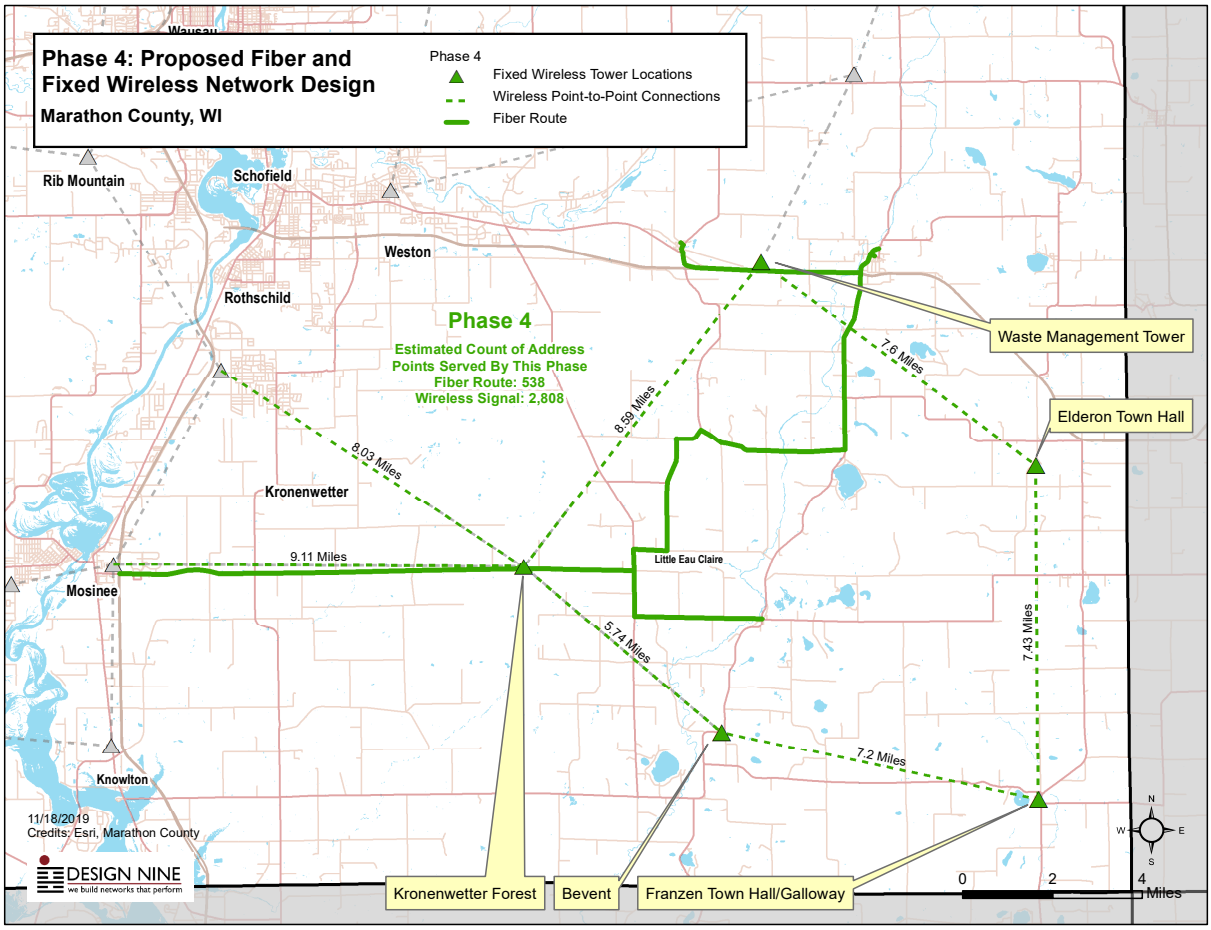
Table 9.11: Phase Three Fiber Construction Cost Summary

Phase Three Cost Summary

0	ITEM/PROJECT	ESTIMATED
1	Phase Three Construction Materials	$957,080
2	Phase Three Distribution Labor	$2,016,107
3	Phase Three Structures, Cabinets, and Equipment	$127,055
4	Phase Three Drop Construction	$800,325
5	Network Construction Subtotal	$3,900,568
6	Project Management, Network Engineering, Integration, and Testing	$390,057
7	Misc Fees, Advertising, Technical Services	$39,006
8	Bookkeeping and Administration	$39,006
9	Engineering, Permitting	$292,543
10	Legal Costs	$19,503
11	Other Upfront Costs	$25,000
12	Other Costs Subtotal	$805,114
13	Project Total	$4,705,681
14	Contingency at 10%	$470,568
15	Project Total (with contingency)	$5,176,249

9.5 PHASE FOUR

Phase Four fiber builds toward the east end of the county, and the proposed wireless infrastructure creates a wireless ring for improved network resiliency.

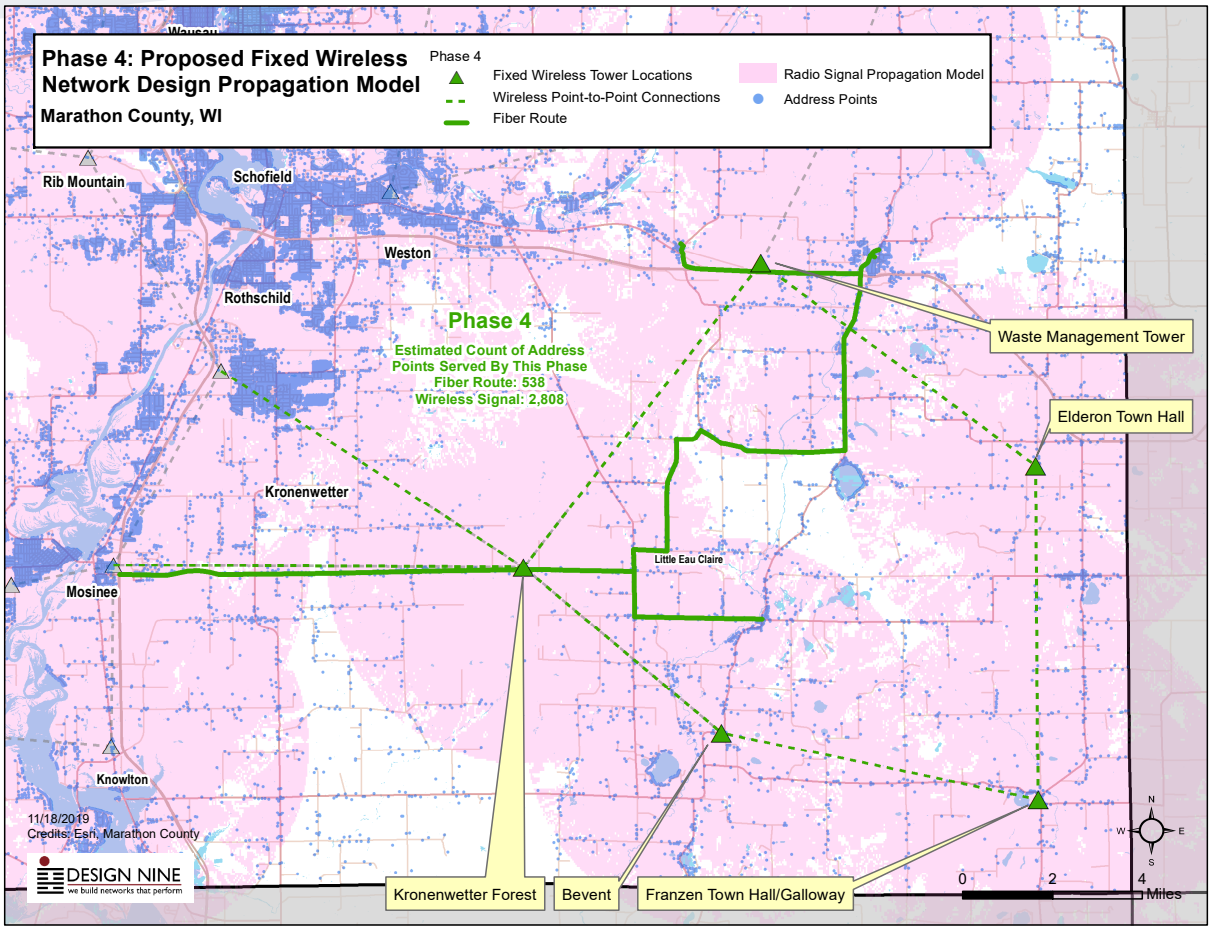


Map 9.9: Phase Four Proposed Fiber and Wireless

Table 9.12: Phase Four Wireless and Fiber Total Estimated Cost

PHASE FOUR WIRELESS AND FIBER CONSTRUCTION

SITE	DESCRIPTION	TOTAL COST
Fiber Construction, Phase 4	Fiber Construction, Phase 4, 3 Cabinets, Calix GPON FTTX Architecture	$3,527,398
Wireless Construction, Phase 4	Three new towers, two existing towers, point to point links	$815,438
		$4,342,836



Map 9.10 : Phase Four Propagation Study

PHASE FOUR WIRELESS CONSTRUCTION

Table 9.13: Phase Four Wireless Projected Costs

WIRELESS CONSTRUCTION PHASE FOUR

SITE	DESCRIPTION	TOTAL COST
Proposed: Franzen Town Hall/ Galloway	Proposed New Tower on County or Village Owned Land, WISP Provides Access Equip.	$200,425
Proposed: Kronenwetter Forest	Proposed New Tower on County or Village Owned Land, WISP Provides Access Equip.	$200,425
Proposed: Elderon Town Hall	Proposed New Tower on County or Village Owned Land, WISP Provides Access Equip.	$200,425
Existing: Waste Management Tower	Improvements to Existing County Owned Tower of Already Leased Water Tank, WISP Provides Access Equip.	$52,088
Existing: Town of Bevent Tower	Improvements to Existing County Owned Tower of Already Leased Water Tank, WISP Provides Access Equip.	$52,088
Point to Point: Franzen/Galloway to Eldron	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Bevent to Franzen Townhall/Galloway	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Evergreen ES to Kronenwetter Forest/Little Eau Claire	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Elderon to Waste Management Tower	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Kronenwetter Forest/Little Eau Claire to Waste Management Tower	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Kronenwetter Forest/Little Eau Claire to Bevent	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Mosinee Water Tower to Kronenwetter Forest/ Little Eau Claire	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
		$815,438

PHASE FOUR FIBER CONSTRUCTION

Table 9.14: Phase Four Fiber Construction Overview

Phase Four Route Overview

0	ITEM/PROJECT	VALUE
1	Miles of Fiber / Conduit Installed	32.55
2	Number of Handholes Installed	215
3	Splice Closures Installed	135
4	Cabinets Installed	3
5	Buildings Passed	538
6	Buildings Connected - % of the Buildings Passed who are connected	25%
7	Number of Buildings Connected	135
8	Aerial - Percentage of construction expected to be installed on utility poles.	1%
9	Trenching - Percentage of construction installed by trenching	9%
10	Boring - Percentage of construction installed by horizontal drilling.	20%
11	Slot Cutting - Conduit installed in street by special methods.	0%
12	Rock Saw - Required where rock prevents the use of other methods.	0%
13	Direct Bury - Conduit installed by direct bury methods (plow, vibratory plow)	70%
14	Aerial Info	1% Aerial is estimated to account for water body crossings and other obstacles to construction.
15	Other Notes	Estimated labor rates are based upon common rates seen for recent medium sized rural projects.

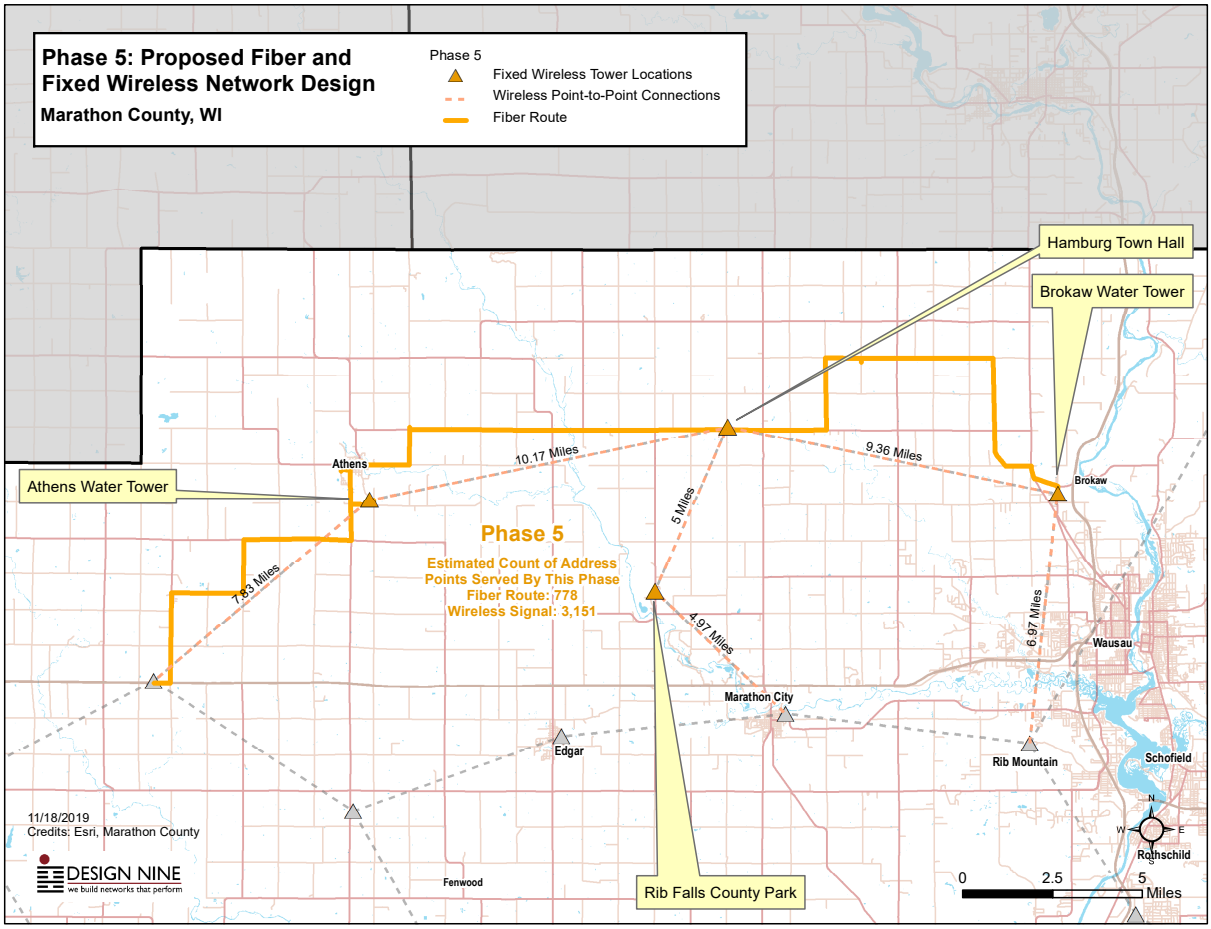
Table 9.15: Phase Four Fiber Construction Cost Summary

Phase Four Cost Summary

0	ITEM/PROJECT	ESTIMATED
1	Phase Four Construction Materials	$738,405
2	Phase Four Distribution Labor	$1,529,518
3	Phase Four Structures, Cabinets, and Equipment	$158,190
4	Phase Four Drop Construction	$225,325
5	Network Construction Subtotal	$2,651,438
6	Project Management, Network Engineering, Integration, and Testing	$265,144
7	Misc Fees, Advertising, Technical Services	$26,514
8	Bookkeeping and Administration	$26,514
9	Engineering, Permitting	$198,858
10	Legal Costs	$13,257
11	Other Upfront Costs	$25,000
12	Other Costs Subtotal	$555,288
13	Project Total	$3,206,725
14	Contingency at 10%	$320,673
15	Project Total (with contingency)	$3,527,398

9.6 PHASE FIVE

Phase Five builds fiber in the northwest area of the county, and connects to the existing WCAN fiber near Wausau. The Phase Fiber wireless towers create two new wireless rings if Phase One and Phase Two towers are already in place.

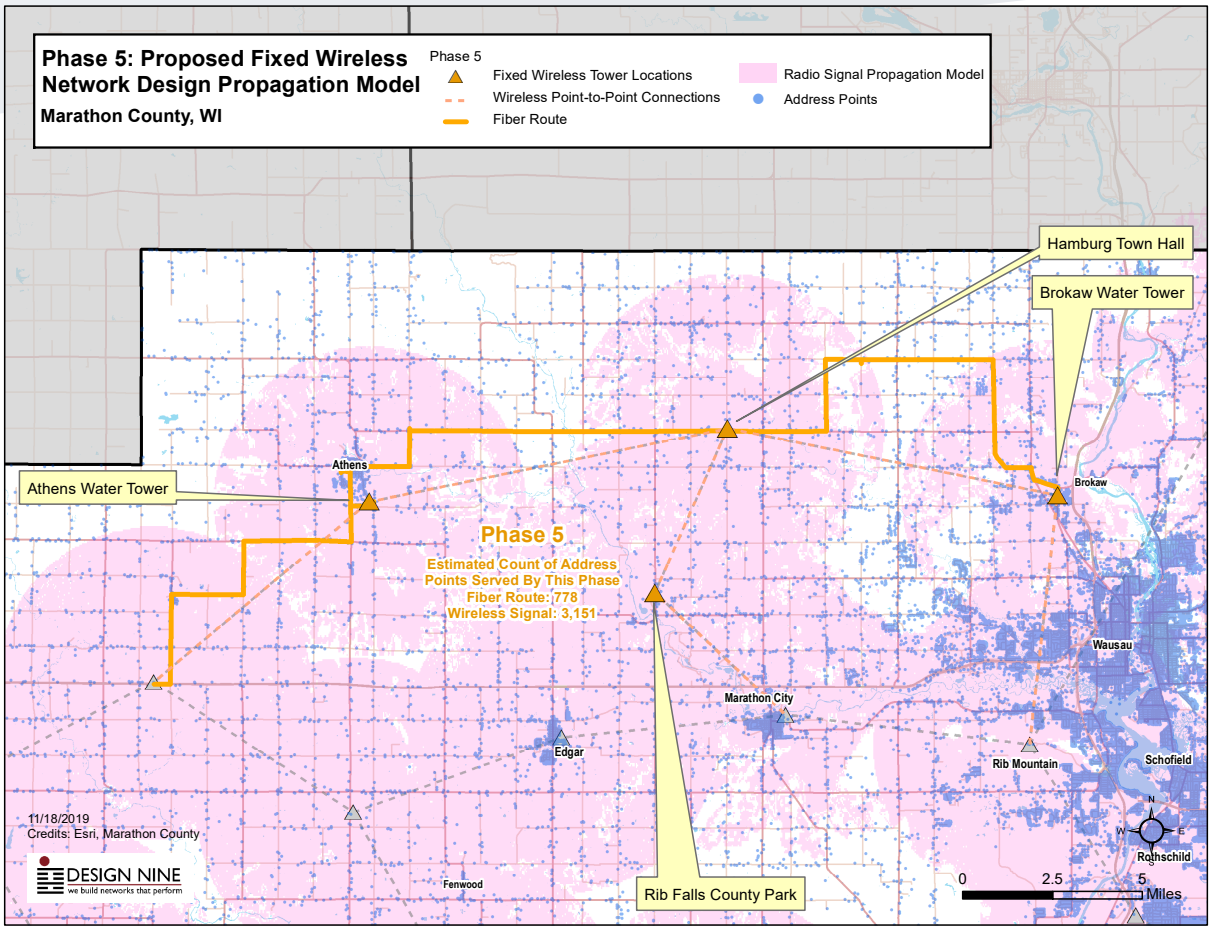


Map 9.11: Phase Five Proposed Fiber and Wireless

Table 9.16: Phase Five Wireless and Fiber Total Estimated Cost

PHASE FIVE WIRELESS AND FIBER CONSTRUCTION

SITE	DESCRIPTION	TOTAL COST
Fiber Construction, Phase 5	Fiber Construction, Phase 5, 2 Cabinets, Calix GPON FTTX Architecture	$4,249,358
Wireless Construction, Phase 5	Two new towers, two existing towers, point to point links	$599,300
		$4,848,658



Map 9.12 : Phase Five Propagation Study

PHASE FIVE WIRELESS CONSTRUCTION

Table 9.17: Phase Five Wireless Projected Costs

WIRELESS CONSTRUCTION PHASE FIVE

SITE	DESCRIPTION	TOTAL COST
Proposed: Hamburg Town Hall	Proposed New Tower on County or Village Owned Land, WISP Provides Access Equip.	$200,425
Proposed: Rib Falls County Park	Proposed New Tower on County or Village Owned Land, WISP Provides Access Equip.	$200,425
Existing: Athens Water Tank	Improvements to Existing County Owned Tower of Already Leased Water Tank, WISP Provides Access Equip.	$52,088
Existing: Brokaw Water Tank	Improvements to Existing County Owned Tower of Already Leased Water Tank, WISP Provides Access Equip.	$52,088
Point to Point: Rib Mountain to Brokaw Water Tower	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Hamburg Town Hall to Athens Water Tower	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Brokaw Water Tower to Hamburg Town Hall	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Marathon HS to Rib Falls County Park	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Athens Water Tower to West Wayside	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Rib Falls County Park to Hamburg Town Hall	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
		$599,300

PHASE FIVE FIBER CONSTRUCTION

Table 9.18: Phase Five Fiber Construction Overview

Phase Five Route Overview

0	ITEM/PROJECT	VALUE
1	Miles of Fiber / Conduit Installed	39.19
2	Number of Handholes Installed	259
3	Splice Closures Installed	195
4	Cabinets Installed	2
5	Buildings Passed	778
6	Buildings Connected - % of the Buildings Passed who are connected	25%
7	Number of Buildings Connected	195
8	Aerial - Percentage of construction expected to be installed on utility poles.	1%
9	Trenching - Percentage of construction installed by trenching	9%
10	Boring - Percentage of construction installed by horizontal drilling.	20%
11	Slot Cutting - Conduit installed in street by special methods.	0%
12	Rock Saw - Required where rock prevents the use of other methods.	0%
13	Direct Bury - Conduit installed by direct bury methods (plow, vibratory plow)	70%
14	Aerial Info	1% Aerial is estimated to account for water body crossings and other obstacles to construction.
15	Other Notes	Estimated labor rates are based upon common rates seen for recent medium sized rural projects.

Table 9.19: Phase Five Fiber Construction Cost Summary

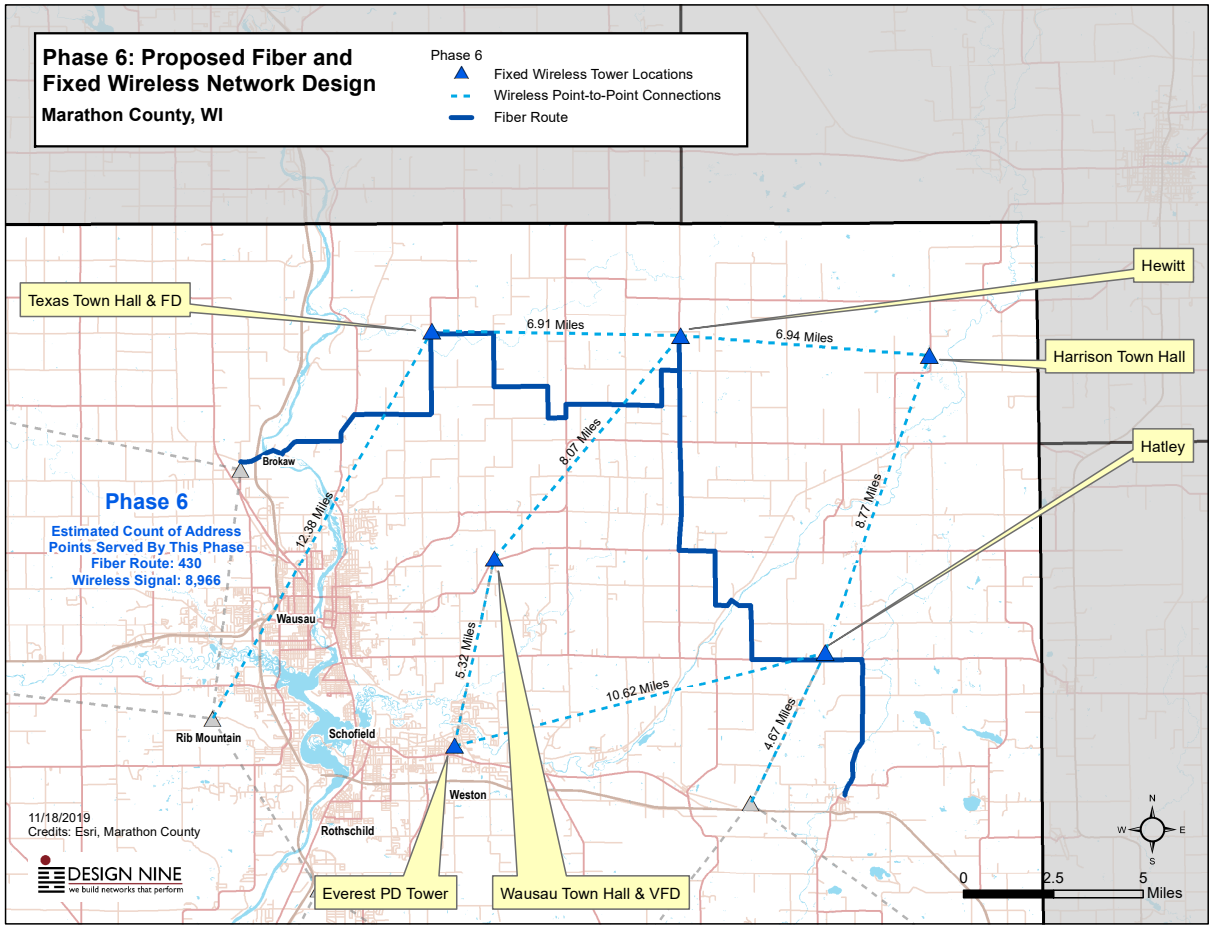
Phase Five Cost Summary

0	ITEM/PROJECT	ESTIMATED
1	Phase Five Construction Materials	$895,296
2	Phase Five Distribution Labor	$1,854,696
3	Phase Five Structures, Cabinets, and Equipment	$122,560
4	Phase Five Drop Construction	$325,825
5	Network Construction Subtotal	$3,198,377
6	Project Management, Network Engineering, Integration, and Testing	$319,838
7	Misc Fees, Advertising, Technical Services	$31,984
8	Bookkeeping and Administration	$31,984
9	Engineering, Permitting	$239,878
10	Legal Costs	$15,992
11	Other Upfront Costs	$25,000
12	Other Costs Subtotal	$664,675
13	Project Total	$3,863,052
14	Contingency at 10%	$386,305
15	Project Total (with contingency)	$4,249,358

9.7 PHASE SIX

Phase Six builds fiber into the northeast section of the county, and if Phase Four and Phase Three fiber is in place, creates a redundant fiber ring for improved network reliability and resiliency. The proposed wireless towers also create a wireless ring.

Map 9.13: Phase Six Proposed Fiber and Wireless



Map 9.14 : Phase Six Propagation Study

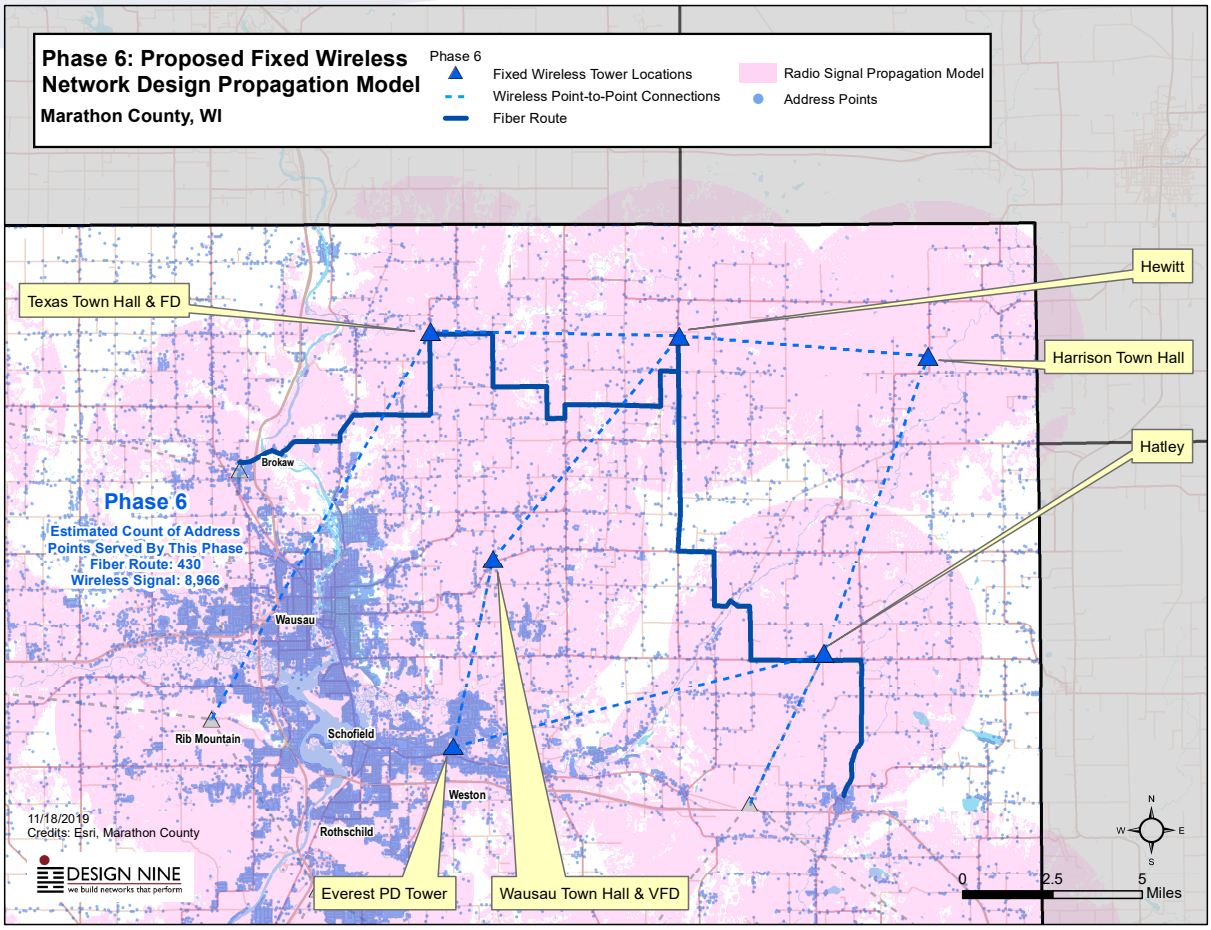


Table 9.20: Phase Six Wireless and Fiber Total Estimated Cost

PHASE SIX WIRELESS AND FIBER CONSTRUCTION

SITE	DESCRIPTION	TOTAL COST
Fiber: Phase Six	Fiber Construction, Phase 6, 2 Cabinets, Calix GPON FTTX Architecture	$3,779,640
Wireless Construction, Phase 6	Three new towers, three existing towers, point to point links	$833,238
		$4,612,878

PHASE SIX WIRELESS CONSTRUCTION

Table 9.21: Phase Six Wireless Projected Costs

WIRELESS CONSTRUCTION PHASE SIX

SITE	DESCRIPTION	TOTAL COST
Proposed Wausau Town Hall & FD	Proposed New Tower on County or Village Owned Land, WISP Provides Access Equip.	$200,425
Proposed: Texas Town Hall & FD	Proposed New Tower on County or Village Owned Land, WISP Provides Access Equip.	$200,425
Proposed: Harrison Town Hall	Proposed New Tower on County or Village Owned Land, WISP Provides Access Equip.	$200,425
Existing: Everest Police Tower	Improvements to Existing County Owned Tower of Already Leased Water Tank, WISP Provides Access Equip.	$52,088
Existing: Hewitt Tower	Improvements to Existing County Owned Tower of Already Leased Water Tank, WISP Provides Access Equip.	$52,088
Existing: Hatley Tower	Improvements to Existing County Owned Tower of Already Leased Water Tank, WISP Provides Access Equip.	$52,088
Point to Point: Hatley to Everest PD	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Harrison Town Hall to Hewitt	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Wausau Town Hall & FD to Hewitt	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Texas Town Hall & FD to Rib Mountain	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Hatley to Harrison Town Hall	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Hewitt to Texas Town Hall & FD	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Waste Management Tower to Hatley	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
Point to Point: Everest PD to Wausau Town Hall & FD	Point to Point Link Installation, Alignment, Configuration, and Testing,	$15,713
		$883,238

PHASE SIX FIBER CONSTRUCTION

Table 9.22: Phase Six Fiber Construction Overview

Phase Six Route Overview		
0	**ITEM/PROJECT**	**VALUE**
1	Miles of Fiber / Conduit Installed	37.2
2	Number of Handholes Installed	246
3	Splice Closures Installed	108
4	Cabinets Installed	2
5	Buildings Passed	430
6	Buildings Connected - % of the Buildings Passed who are connected	25%
7	Number of Buildings Connected	108
8	Aerial - Percentage of construction expected to be installed on utility poles.	1%
9	Trenching - Percentage of construction installed by trenching	9%
10	Boring - Percentage of construction installed by horizontal drilling.	20%
11	Slot Cutting - Conduit installed in street by special methods.	0%
12	Rock Saw - Required where rock prevents the use of other methods.	0%
13	Direct Bury - Conduit installed by direct bury methods (plow, vibratory plow)	70%
14	Aerial Info	1% Aerial is estimated to account for water body crossings and other obstacles to construction.
15	Other Notes	Estimated labor rates are based upon common rates seen for recent medium sized rural projects.

Table 9.23: Phase Six Fiber Construction Cost Summary

Phase Six Cost Summary		
0	**ITEM/PROJECT**	**ESTIMATED**
1	Phase Six Construction Materials	$834,836
2	Phase Six Distribution Labor	$1,719,434
3	Phase Six Structures, Cabinets, and Equipment	$108,160
4	Phase Six Drop Construction	$180,100
5	Network Construction Subtotal	$2,842,530
6	Project Management, Network Engineering, Integration, and Testing	$284,253
7	Misc Fees, Advertising, Technical Services	$28,425
8	Bookkeeping and Administration	$28,425
9	Engineering, Permitting	$213,190
10	Legal Costs	$14,213
11	Other Upfront Costs	$25,000
12	Other Costs Subtotal	$593,506
13	Project Total	$3,436,036
14	Contingency at 10%	$343,604
15	Project Total (with contingency)	$3,779,640

9.8 CONSTRUCTION COST ESTIMATE FACTORS

The costs contained in these estimates represent the best information available, based on similar costs from other projects, from vendor price lists, and/or estimates from contractors and construction firms. These estimates are generally reliable for up to six months. Note also that the time of year that the work is bid out can have a substantial effect on the estimate. We use an average weighted value for most costs to try to compensate for this, but as an example, construction work bid out in spring or early summer may have higher costs than a project bid out in late fall or early winter.

The cost estimates are developed using the the categories below. For each category, the items, labor, and activities associated with that category are calculated, using vendor price quotes, prices for labor and materials from previous construction projects, and other sources of cost information.

BUILDINGS, IMPROVEMENTS, AND PREFABRICATED SHELTERS

This category includes any buildings and shelters constructed as well as improvements to the buildings such as redundant HVAC systems, power improvements, fire suppression systems, security and surveillance systems, etc.

OUTSIDE PLANT CONSTRUCTION MATERIALS

Network construction includes the outside plant materials needed to build the network. Items like conduit, pedestals, cabinets, hand holes, and splice enclosures are all included in network construction.

OUTSIDE PLANT CONSTRUCTION LABOR

Labor is typically included with network construction for the bidding process but is separated here to help identify money that could be saved by leveraging local labor resources. Labor includes the placement of pedestals and hand holes, the underground or aerial placement of conduit, the construction of foundations (pads) for various structures throughout the network, and more. Several material costs such as concrete and gravel are included in labor depending on the type of job to be performed.

NETWORK EQUIPMENT, SOFTWARE, AND RELATED COSTS

Network equipment includes any network electronics that will be used in the network such as routers, switches, and CPE. Network equipment also includes some items that do not use any AC power but fall into a similar category such as patch panels, and patch cables. The equipment cost will vary widely depending on the type of architecture chosen.

ADMINISTRATIVE AND LEGAL

Specialized legal counsel will be required to review contracts with service providers, contractors, and other participants in the project. Legal costs can vary with a particular location and tend to go down over time. The most legal work is needed early in the first construction phase to develop business contracts with service providers, to review construction and vendor contracts, and to broker lease agreements for use of public or private property (where network equipment like cabinets or shelters have to be located).

LEASES, PERMITS, AND RIGHTS OF WAY

Some costs will be incurred based on the permitting requirements of the project. If the county is able to place the colocation facility and any cabinets in public right of way or on county properties at no charge, the cost of leases will be lower. If cabinets or shelters have to be placed on private property, the cost of the land or long term leases will increase. The cost of permits needed for crossing wetlands, streams, other sensitive areas, and WisDOT permits are also included in this category. Formal leases and negotiated lease payments are more desirable than providing some form of free access to services.

PROJECT MANAGEMENT

Project management for a community network build requires thorough and detailed planning, experience in procuring construction materials for the project, and the ability to oversee and convey project information to contractors through the duration of the project, including construction inspection work (ensuring construction contractors have done their job properly).

NETWORK DESIGN AND ENGINEERING

This work include a full design of the outside plant network, cabinet and shelter specifications, and extensive detail (blueprints) that specifies how all fiber cable, towers, buildings, and network equipment is to be installed. These documents have to be completed prior to bidding out any construction work, and are usually included as part of a construction bid package. The detail includes fiber optic cable route determination and size determination, active and passive network equipment selection and placement planning, splicing layouts and documentation, network configuration planning, and all engineering necessary to complete construction.

NETWORK INTEGRATION AND TESTING

Some configuring and testing will take place after the network is built and before it is ready for use. In a dark network this involves labeling and documenting the routes of individual fiber strands, and testing of any other features of the network such as generators, air conditioners, and locks. In an active network the testing and integration includes integration requirements for a dark fiber network plus the configuring and installation of switches, routers, and other network equipment. Work in this category requires a skilled professional who is familiar with the network architecture and the business model (e.g. open access).

MISCELLANEOUS

This category provides a small budget for miscellaneous expenses that will arise during the course of construction (e.g., bid advertisement costs, inventory tags, etc.).

CONTINGENCIES

The Contingency category is included and calculated as a percentage of the total estimated cost (e.g., 10% of total cost) to provide flexibility in managing the overall budget. Equipment costs can and do change between the time an estimate is made and construction commences. Labor costs can vary depending upon the time of year the work starts, the state of the local economy, and the state of the national economy. Material costs and lead times can vary based on demand on certain industries, energy costs, and location.

9.9 FIBER NETWORK ARCHITECTURE

With a compact and highly scalable design the Calix E7 Ethernet Service Access Platform is well suited to provide scalable customer aggregation networks.

The flexibility of the Calix E7 platforms available in either a Chassis or a Virtual (or stackable) Chassis form factor will allow the network to utilize the same logical platform in different environments simplifying service delivery.

- Each of the 20 slots in an E7-20 or the two slots in an E7-2 can support up to 24 point-to-point Active Ethernet subscribers with a 48 port line card in development. That gives each E7-20 the capacity of serving 480 subscribers at 1GB.
- Utilizing a GPON card in any of the 20 slots in an E7-20 can support up to 512 subscribers using a 1:64 split providing a total of 10,240 GPON subscribers. Line cards supporting up to 1024 subscribers is being developed allowing 20,480 subscribers on a single chassis. For this network, a full 1:64 split is possible, but a 1:16 or 1:32 split allowing 128 or 256 customers per card respectively is recommended.
- Active Ethernet and GPON line cards can be mixed and matched in a common chassis – no common control equipment required. This allows the network to serve large business customers with dedicated Active Ethernet connections and smaller businesses and residential customers with PON services in the same chassis or even line card.
- Line cards can be added or replaced without uninstalling/installing power, alarms, or cables – reducing MTTR (mean-time-to-repair) from hours to minutes.
- The network will most likely require multiple E7-20s in the primary shelter location and each of cabinet would be outfitted with 3-5 E7-2 virtual chassis for multi-neighborhood capacity.
- The Calix system already has XGS-PON and NG-PON2 line cards and ONTs available.

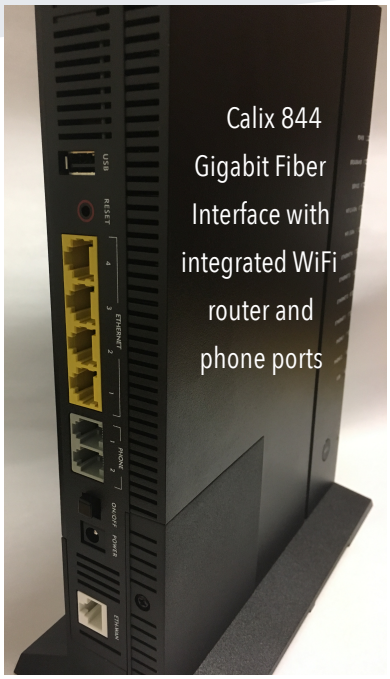
- Subscribers are easily aggregated and network resources efficiently shared across protected trunk facilities.

The Calix E7 platforms allow the flexibility of utilizing GPON line cards and a GPON architecture if some areas require PON architectures due to exiting fiber optic availability or if the low density doesn't justify home runs back to a cabinet location. For MDU or very dense locations, Calix provides VDSL equipment which can be implemented into the architecture.

CUSTOMER PREMISES EQUIPMENT

Calix offers a wide variety of customer premises equipment (CPE) for residential as well as many options for MDU, Office Parks, or large businesses. Residential CPE are available in both indoor and outdoor configurations and can be pre-configured with battery backup. Indoor Residential CPE are available with home gateway, built in WiFi (802.11 a/b/g) and a dual line POTS port (internal SIP controller). Business class CPE are available in indoor and outdoor formats and many options are

available including rack mount and wall mount with multiple GE ports. Additional Business class CPEs are available with multiple synchronous ports (E1/T1) and multiple POTS ports.



All Calix ONT optics in the 700GX and 800GE family are multi-sensing (AE and PON) and auto-attenuating with a maximum range of either 50km (or in some cases 80km). This simplifies deployment as CPE devices do not have to be pre-configured with optics prior to deployment.

Calix GigaFamily ONTs support XGS-PON and NG-PON2 and are available for locations or businesses now or in the future which will require 10Gb services.

CORE SWITCHING EQUIPMENT

The network architecture selected for this network will support the future needs of the project for years to come by implementing a core routed layer. The network core can be any vendor offering standards based interoperability with the distribution layer, however Design Nine has successfully integrated Calix equipment with Juniper in other client networks.

We would recommend a Juniper EX Ethernet switch for the core network. The Ex product line scales up to wire speed 10GbE and 40GbE optics. In the core network the EX (eg. MX4600) will provide dual, redundant handoff points between customers on the network and service providers, and therefore will be less susceptible to failures.

The virtual chassis based EX switches each feature fully redundant cooling systems, power supplies, and switching engines. As an example the EX4600 has a system capacity of 72 wire speed 10GbE ports and 12 wire speed 40GbE ports to meet the immediate and future bandwidth needs of Marathon County.

GPON AND ACTIVE ETHERNET OPTIONS

The recommended Calix architecture will support both Active Ethernet and current GPON options (i.e. XGS-PON, NG-PON2). There are several variants of current GPON offerings that provide significant improvements over previous GPON architectures.

- **XG-PON** (10G down / 2.5G up) – ITU G.987, 2009. XG-PON is essentially a higher bandwidth version of GPON. It has the same capabilities as GPON and can co-exist on the same fiber with GPON.
- **XGS-PON** (10G down / 10G up) – ITU G.9807.1, 2016. XGS-PON is a higher bandwidth, **symmetric** version of GPON. The 'S" in XGS stands for 'Symmetrical,' indicating the ability of this design to deliver symmetric service.

- **NG-PON2** (10G down / 10G up, 10G down / 2.5G up) – ITU G.989, 2015. Not only is NG-PON2 a higher bandwidth version of GPON, it also enables new capabilities like wavelength mobility and channel bonding. NG-PON2 co-exists well with GPON, XG-PON, and XGS-PON and deployments began in late 2017 and early 2018. NG-PON2, like XGS-PON, also supports symmetric service and can by using multiple wavelengths, can achieve total throughput of 40Gig.

The newer PON technical specifications were developed as successors to Gigabit PON (GPON) – which have lower bandwidth speeds of 2.5 Gig downstream and 1.25 Gig upstream for the past decade.

As noted in the previous section, the recommended Calix design can provide both XGS-PON (10Gig down/10Gig up) symmetric service and NG-PON2 (10G down/10G up, 10G down/2.5G up). These two PON designs can deliver ample bandwidth to support virtually any work from home or business from home bandwidth requirements.

The network fiber design for Marathon County would include extra fiber strands allocated to support Active Ethernet circuits where needed.

EQUIPMENT

The network will include a mix of active and passive network items, including conduit, dark fiber, cabinets, patch panels, and network electronics.

Passive Equipment

Passive equipment is equipment that is not addressable on the network, but still plays an important role.

- Fiber patch cables
- FTU - A Fiber Termination Unit is the enclosure mounted to a customer premise where fiber is terminated. ("Wall Box"). The County should allow service providers to install drops and FTUs but those would belong to the network, not the ISP.
- Closures, Splice Cases, or FOSCs are the enclosures in a handhole that protect the splicing from distribution fiber to drop fiber.
- Patch panels (connector types).
- Hand holes and vaults - These are part of the dark fiber core network.
- Cabinets, Shelters - The network will have at least one or two small shelters (e.g. 10' x 16') and/or several additional cabinets for fiber termination and network equipment. These will ideally be located in right of way or County property. Fiber cables serving 1000-2000 homes will be routed back to these enclosures.
- Equipment Racks - The network should offer rack space for provider equipment in one shelter or equipment room where 24/7/365 access is available to providers. A patch panel will be used to cross connect leased fibers as needed. All patch cable installs and cross-connects will be performed by network staff or designated contractors.

Active Equipment

All active equipment, including core switches, access switches, and customer premises equipment (CPE) will be owned by the network and maintained by the network or its third party contractors.

9.10 WIRELESS COST DETAIL

These tables provide the cost estimate detail used to develop the wireless costs contained in Phases One through Six.

EXISTING TOWER IMPROVEMENTS

The cost of improvements to an existing tower can vary substantially based on what is already available at the tower site. Road improvements and a generator may or may not be needed. A structural analysis to determine if the tower can support WISP radios and the point to point microwave network radios will be the first step before any other expenditures.

Table 9.24: Tower site development and improvement costs

ITEM/PROJECT	NO. UNITS	UNIT COST (LOW)	UNIT COST (HIGH)	COST (AVG)
Tower Study / Survey	1	$4,500	$7,000	$5,750
Site Development (Clearing, Road Improvements, etc.)	1	$0	$1,500	$750
Small Telecom Cabinet AMPROD AM47P-2636-24RU OR EQUIVALENT, ALUMINUM CABINET - FRONT AND REAR DOORS-HVAC/HEAT - ADJUSTABLE RACK RAILS 19"	1	$6,000	$7,500	$6,750
10kW Liquid Propane Generator	1	$4,000	$6,000	$5,000
Cabinet Foundation and Installation	1	$2,500	$4,000	$3,250
New Power Service / Installation ASSUMES POWER AVAILABLE ON SITE, New meter placement required to support WISP equipment	1	$1,500	$2,500	$2,000
Power System Installation Labor	1	$300	$500	$400
Generator Installation Labor	1	$1,250	$1,700	$1,475
Propane Service Installation TANK FURNISHED / INSTALLED BY LOCAL GAS PROVIDER	1	$750	$1,250	$1,000
Poject management				$10,000
			TOTAL:	$36,375

NEW TOWER

This estimate is for a 180' guyed tower, and includes site clearing, electric service, foundation work, and a cabinet for electronics. If space is a constraint on a particular piece of property, a self-supported tower can be substituted, and this would add approximately $40,000 to $50,000 to the cost.

Table 9.25: Cost estimate for 180 ft guyed tower

ITEM/PROJECT	NO. UNITS	UNIT COST (LOW)	UNIT COST (HIGH)	TOTAL (AVG)
Labor and Contracting: $82,640				
Site Development (Clearing, Road Improvements, etc.)	1	$15,000	$15,000	$15,000
New Power Service / Installation	1	$1,250	$3,450	$2,350
180' Guyed Tower Construction Labor & Contracting	1	$50,000	$74,750	$62,375
Cabinet Installation Labor	1	$600	$1,150	$875
Power System Installation Labor	1	$300	$575	$438
Generator Installation Labor	1	$1,250	$1,955	$1,603
Materials: $35,735				
180' Guyed Tower Construction Materials	1	$17,500	$27,500	$22,500
Small Telecom Cabinet	1	$4,000	$6,000	$5,000
Cabinet Foundation and Installation Materials	1	$1,000	$1,500	$1,250
10kW Liquid Propane Generator	1	$4,000	$6,000	$5,000
Spare Fuses	1	$10	$20	$15
Power System Installation Materials	1	$20	$40	$30
Samlex 1000W Inverter	1	$350	$450	$400
Samlex SEC1230-UL Battery Charger	1	$200	$300	$250
100ah 12v Non Spillable Backup Battery	4	$250	$350	$1,200
DC Voltage Monitoring Device	1	$40	$60	$50
Unmanaged Rack Mount PDU (6O)	1	$35	$45	$40
			TOTAL:	$118,375
Project Management, Network Design				$37,500
Site Engineering, Surveying, Viewshed Analysis, Etc.				$9,500
Misc Fees, Technical Services				$7,500
Contingency				$11,838
			TOTAL:	$184,713

NEW COMMUNITY POLE

Community (utility) poles are used in locations where there may not be clear line of sight to a larger tower. The pole is placed where line of sight to a nearby taller tower is available. A community pole can provide access to a single customer or to a cluster of customers that are located near the pole.

Table 9.26: Cost estimate for new community pole

1	ITEM/PROJECT	NO. UNITS	UNIT COST (LOW)	UNIT COST (HIGH)	BEST ESTIMATE
2	Site Development (Clearing, Road Improvements, etc.)	1	0	2000	$1,000
3	3x3 NEMA Box	1	$300.00	$600.00	$450
4	New Power Service / Installation	1	$500.00	$1,250.00	$875
5	60' Wooden Utility Pole Construction Materials	1	$2,500.00	$3,500.00	$3,000
6	Unmanaged Rack Mount PDU (6O)	1	$35.00	$45.00	$40
7	60' Wooden Utility Pole Construction Labor & Contracting	1	$2,000.00	$3,000.00	$2,500
8	Neighborhood Pole Coordination and Project Management				$5,000
9				**TOTAL:**	$12,865.00

POINT TO POINT NETWORK

The design includes a high performance Gigabit network between towers, with all towers have two point to point microwave connections and some towers have three point to point connections. This design achieves two goals:

- The wireless network is highly redundant. With every tower site having two data paths, any site can lose a point to point link and still provide service.
- The high performance point to point network can carry county, K12 school, and public safety traffic separately and securely while also providing WISPs reduced costs. WISPs can use the shared point to point backhaul to utilize the network redundancy at much less expense than mounting their own point to point radios on every tower.

Table 9.27: Licensed PTP Link - Ubiquiti Airfiber 11FX

Item	Units	Unit Cost	Total
AF11X Radio	2	$799.00	$1,598.00
AF11-CA Adapter Kit	2	$49.00	$98.00
AF11FX Duplexer	4	$199.00	$796.00
AF11 X Antenna 11GHz, 35dBi	2	$379.00	$758.00
FCC Licensing	1	$2,000.00	$2,000.00
Shipping @ 5%	1		$262.50
Point to Point Link Assembly, Installation, Alignment, and Testing	2	$3,600.00	$7,200.00
Project Management, NIIT	1		$3,000.00
TOTAL			$15,712.50

10 NETWORK OPERATIONS AND MANAGEMENT

With more than a dozen years of operation for a variety of community-owned network infrastructure projects around the country, there is very little "experimentation" that is still necessary. With more than three hundred communities making investments in broadband infrastructure, there is now enough information about what works and what does not work to be able to identify best practice across nearly all areas of operations, planning, management, and finance.

It is now relatively easy to identify the obstacles, challenges, and opportunities that the County is likely to face if it moves forward.

10.1 MANAGING NETWORK INFRASTRUCTURE

There are three approaches to managing broadband infrastructure owned by municipalities or other community-based entities (e.g. nonprofit, coop, IDA/EDA).

IN-HOUSE MANAGEMENT AND OPERATIONS

In this scenario, the network entity that owns the infrastructure (e.g. County, EDC, nonprofit) provides all or nearly all of the staff, services, maintenance and operations support needed to operate and maintain the network. Very few muni networks take this approach because of the high cost of staffing relative to the revenue in the first several years of network operations. Electric cities, which own utility poles, have bucket trucks and other needed equipment, and have trained line crews for repairs, can do this, but few other localities already have the capacity available.

OUTSOURCED MANAGEMENT AND OPERATIONS

In this scenario, most or all of the services, maintenance, and operations support needed to operate and maintain the network are outsourced to qualified private sector firms and/or other nonprofit entities. Nonprofit entities that do provide services are usually focused on administrative services like bookkeeping, fiscal oversight, and related activities. Private sector firms are typically used to provide 24/7/365 network monitoring, routine and emergency maintenance and repairs, and new customer connections.

SHARED IN-HOUSE AND OUTSOURCED MANAGEMENT AND OPERATIONS

A common approach for many muni network projects is to have a limited staff to provide some day to day management and oversight. Network operations, routine and emergency break-fix, new customer connections and related work are outsourced to qualified private sector firms. Outsourcing is financially usually much less expensive for many activities like emergency repairs than trying to support that capacity in-house.

10.2 WISP TOWER LEASE MANAGEMENT

Once existing and/or new towers have space available to lease to WISPs, there are policy and contract decisions that must be evaluated.

- There should be a single public fee schedule for all providers.

- There should be a single tower space agreement that is used for all providers.
- Tower access should be made available in ten foot vertical segments, as high as possible on the tower without interfering with other uses (e.g. public safety antennas). Note that it is unlikely that any tower will have more than two providers on it.
- Leases should be a minimum of two years and should auto-renew if the ISP is meeting performance requirements.
- It may be more effective to have a single lease agreement with access to all towers, and the contract should require the ISP to put equipment on all towers within a certain period of time (e.g. nine to twelve months). This limits ISPs from "cherry picking" towers with more potential customers and ignoring towers in parts of the county with lower population density.
- Monthly tower lease fees should be on the order of $200 to $250 per tower. Higher fees make it difficult for providers to make a business case for the cost of equipment and the extensive marketing required to develop a customer base around a tower.
- If there are two vertical spaces available for lease, the lower segment could be made more attractive to a WISP by offering a reduced lease fee.
- An initial grace period of three to six month should be offered on fees, and/or offer a one year sliding scale of fees (e.g. first three months, fee waived; months four to six, 25% of normal fee; months seven to nine, 50% of normal fee; months ten to twelve, 75% of normal fee). There are many ways to structure the initial fee period, but it is important to recognize that the WISPs incur substantial early costs to develop revenue and customers for a new tower.
- All tower leases should expire on the same date even if started at different times. This allows the regional enterprise to potentially make a smoother transition to a new provider if there are performance issues, and will give the regional entity more leverage and control over the WISPs.
- In contracts, fee reductions should be worded as discounts that can be revoked if performance requirements are not adequately being met.
- There are considerations for ground-space (e.g. WISP cabinets, shelters, H-frames for electric service) that will have to be evaluated at each tower site. If new shelters will be allowed, the regional entity should set minimum standards for new shelters.

TOWER SPACE REVENUE ESTIMATE

Tower revenue opportunities are limited. It takes WISPs many months to acquire enough customers on a new tower to break even, and even longer to begin to show a profit. Fees for tower space need to be modest to attract one or two providers, and it is good practice to offer several months of free service while the WISP markets in the new service area and tries to sign up customers.

Because of interference problems, two providers are the most that are desirable on a tower, and offering towers on an exclusive basis (e.g. an open auction for tower space) could bring in more revenue from a single provider.

Table 10.1: Sample Tower Leasing Revenue Projection

SERVICE ITEM	DESCRIPTION	MONTHLY FEE	MAX NUMBER OF WISPS PER TOWER	PROJECTED ANNUAL REVENUE
Tower Space on One Tower	10 feet of vertical space leased to one ISP	$200	1	$2,400
Tower Space on Three Towers	10 feet of vertical space leased to one ISP	$200	1	$7,200
Tower Space for Six Towers	10 feet of vertical space leased to one ISP	$200	1	$14,400

TOWER SPACE OPERATIONAL EXPENSES

Assumptions include:

- Each provider on a tower will install their own electric service (meter) and pay their own utility costs.
- Site leases on private land can be negotiated for $1000/year with a single up-front payment of $10,000 (for ten years).

If several towers are available (e.g. three, four, or more), there will be some efficiencies gained in costs so that revenue would likely exceed expenses—costs like legal services and insurance will not increase proportionally with more than one tower.

Table 10.2: Tower lease annual expense projections

BUDGET ITEM	DESCRIPTION	ANNUAL EXPENSE
Legal Services	Legal counsel on an as-needed basis for review of construction and service contracts, IRU agreements, and other business documents.	$1,500
Accounting	Part time accounting and bookkeeping services will be required	$2,400

Generator Maintenance/ Fuel	Generators require periodic maintenance and occasional fuel (propane) tank refills.	$950
Site Maintenance	Routine tasks like trimming weeds and grass around the tower.	$600
Site Leases	Some towers may be placed on private property which would require annual site leases. This will vary depending on the availability of local government properties that may be available for tower placement.	$1,000
Insurance	Some insurance is likely to be needed (general liability, unemployment, asset insurance, umbrella policy).	$2,500
	TOTAL Projected annual expenses:	$8,950

10.3 OPERATING A LIT FIBER NETWORK

A lit fiber network requires a series of ongoing daily, weekly, and monthly activities. Most network operations responsibilities can be outsourced to a qualified private sector firm at less cost than taking on full time staff.

- Provisioning – When a new customer is connected, a circuit has to be allocated for that customer. Switch configurations have to be updated.
- Troubleshooting – Occasional faults and problems occur, and the source of the issue must be identified and then corrected.
- Port tracking – As customers and services are assigned, the ports and patch panel assignments have to be recorded and tracked.
- Network security – Network switches and services have to be kept up to date with current software patches and security software.
- Service definitions – As customers request new services, these have to be added to the network switches and core network management server.
- Monitoring – Customers expect the network to be available and operational at all times. Automated monitoring alerts and alarms have to be in place to alert network staff of problems. Someone has to be designated to respond to these alerts (i.e. a network problem) around the clock–24/7/365.
- Bandwidth management – Internet backhaul is purchased in increments, and this has to be monitored to ensure that adequate bandwidth is available to customers.

- Emergency restoration – Radios on towers fail due to the harsh environmental conditions: ice, wind, snow, rain, heat, insects, rodents, and birds. Aerial fiber can be damaged by tree limbs, ice, and rodents. Underground fiber can be damaged by unauthorized digging. A plan has to be in place to address equipment and network failures.

EQUIPMENT INVENTORY

- Periodic audits of the network inventory will be especially important during network expansions.

SPARES MANAGEMENT

- The project will need to store spare equipment, and OSP construction materials in a secure location.
- Non-tagged network inventory such as connectors, patch cables, clamps, and consumables should be included in the spare inventory.

LOCATES

- The budget allocation for locate services must be part of the network's Operations and Maintenance budget. Note that with the purchase of some relatively inexpensive equipment, locates could be done by project staff at significant cost savings.
- The Network will have a membership in the Wisconsin 811 (Call811) locate service.
- The Network should maintain a list of qualified locate contractors and engage at least one to perform regular locate services for the network. Optionally, project staff can perform locates at significantly less cost with nominal training.

FIBER STRAND MANAGEMENT

- Project staff will maintain GIS mapping and documentation of assets for the network.
- If dark fiber has been placed in the conduit network, project staff will track all fiber splices in an appropriate tracking database.
- Project staff can manage break/fix services and procedures with appropriate training and the purchase of a fiber splicing machine.

10.4 NETWORK EXPANSION

If the conduit/fiber network is expanded over time, there will be a period of time when some construction is underway. During a network expansion phase, parts and materials have to be ordered, delivered and stored until put into operation. Shipments have to be reconciled with orders prior to payment. The project will construct new conduit segments through the management of contracts with outside firms and contractors.

CONSTRUCTION AND CONTRACTOR MANAGEMENT ACTIVITIES

- Build new conduit and install dark fiber as needed.
- Inventory and track all significant equipment, parts, and equipment.
- Reconcile shipped items with shipping tickets and purchase orders.

- Maintain and repair existing fiber facilities as needed.
- Ensure all procurement meets local and state procurement rules.

10.5 TYPICAL CONTRACT SERVICES

Contract services may be used or required as needed, with some services starting prior to service provider or lessee use of the network. For many work roles and responsibilities, this approach helps manage cash flow and will help match revenue and expenses better.

- Project management – Expansion of the network may require the use of a firm to manage the construction process (or the project provides this work).
- Conduit network design and strategy – The project may make occasional use of a network planning firm to help develop expansion routes, assist with pricing strategy, help with service provider negotiation, and other related tasks.
- Conduit network build out – The project, as it expands the network, will typically use a qualified construction firm and/or locally trained and qualified workers to perform the construction.
- Legal services – An attorney will assist as needed with lease agreements and IRU contracts.
- Bookkeeping and accounting – Part time bookkeeping and accounting services will be entirely adequate.
- Marketing services – The project may make occasional use of a local ad agency or marketing firm for assistance with marketing materials (e.g. logo design, Web design, brochure design, etc.).

10.6 OTHER MANAGEMENT ROLES

A wide range of high level activities will take place regularly. Some of the items on this list also appear in other sections of this document, but are listed here to provide a high level overview of key business and management related activities.

ACTIVITIES

- Provide continuity of leadership and project management.
- Provide monthly reports to grant agencies and other stakeholders and funding sources.
- Meet as needed with interested parties and stakeholders (e.g Chamber of Commerce, Merchants Association, etc.).
- Monitor network performance and assist with customer dispute resolution.
- Manage leases, right of way agreements, and other real estate-related activities.
- Manage contract and work activities of outside plant repair and maintenance contractor.
- Meet with local groups as needed to promote use of the network.
- Represent the project at state level meetings and hearings.
- Meet with visitors and interested parties from other cities and regions.

The project will have the primary responsibility for ensuring that management and administration of the enterprise is handled appropriately.

10.7 ASSET MANAGEMENT

A primary role of the project will be to manage assets owned directly. These assets will include conduit, fiber, cabinets, network electronics, easements, and right of way use. Additionally, these assets have to be managed and tracked during the construction and build out process prior to being put into operation.

The asset management will consist of two primary areas of responsibility:

- Legal contracts, ranging from simple documents of a page or two for property easements, pole attachment rights, or tower access for an antenna to more complex legal documents that might cover twenty or thirty year leases of significant assets. These longer documents will have payment schedules and fee calculations. Legal counsel and review will be required for many if not most of these documents, at least for the first time they are written. Some documents will become "standard" contracts that will likely not require review for each lease unless significant changes are needed.
- Management of hard assets, which will include fiber cable, conduit, and handholes, and other fiber-related materials.

ACTIVITIES

- Procure and manage leases for access to public right of way, private property.
- Select, purchase, and track location and value of passive infrastructure, including fiber, conduit, cabinets, and other facilities.

The project will need the help of an attorney to assist with creating leases and other legal documents related to asset management. The network may need additional assistance from qualified legal counsel for occasional review of legal documents. The network will have to maintain a complete inventory of all physical items and real property.

A network inventory management process, which could be as simple as a set of spreadsheets or modest database, with an accompanying process to ensure that data is entered and updated in a timely manner. For all major pieces of equipment (i.e. purchases of more than $100, typically), data like vendor, model number, serial number, date put in service, and service notes will need to be maintained.

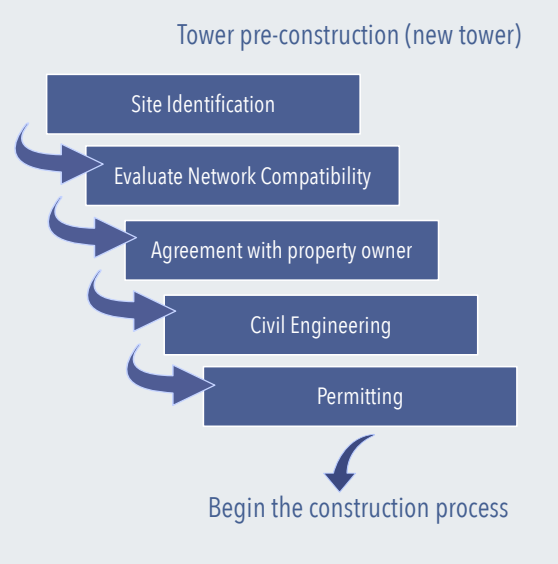
Note that asset management is extremely important, especially fiber strand management. We know of at least one small project that did not maintain adequate strand in-use records and had to install additional fiber cable at significant cost.

10.8 TOWER SITE DEVELOPMENT AND MANAGEMENT

TOWER SITE IDENTIFICATION

When a site for a new tower is being considered for use, the diagram below illustrates the steps that need to be followed. For example, if an existing public safety tower or an existing cellular provider tower may have space for fixed point wireless broadband equipment (i.e. co-location).

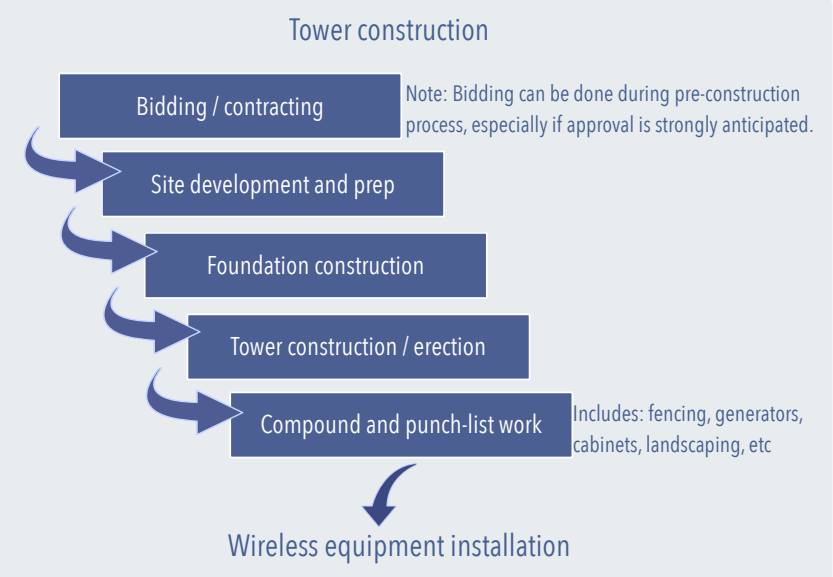
- Site identification – Identify areas of poor service and look for existing towers.
- Network Compatibility – Line of sight to other towers and to key service locations and customers needs to be evaluated. A wireless propagation study and line of sight study will provide the data needed to make this determination.
- Property owner negotiation – A lease has to be negotiated with the property owner. Local government sites (e.g. K12 schools, parks, recreation areas, fire/rescue stations) are candidates for towers because of reduced or no lease fees.
- Engineering – An engineered site plan will be required to as part of the permitting process.
- Leases and permits – A permit to place the tower is required in most localities, and there may be a multi-stage permitting process that can take several months.



TOWER CONSTRUCTION

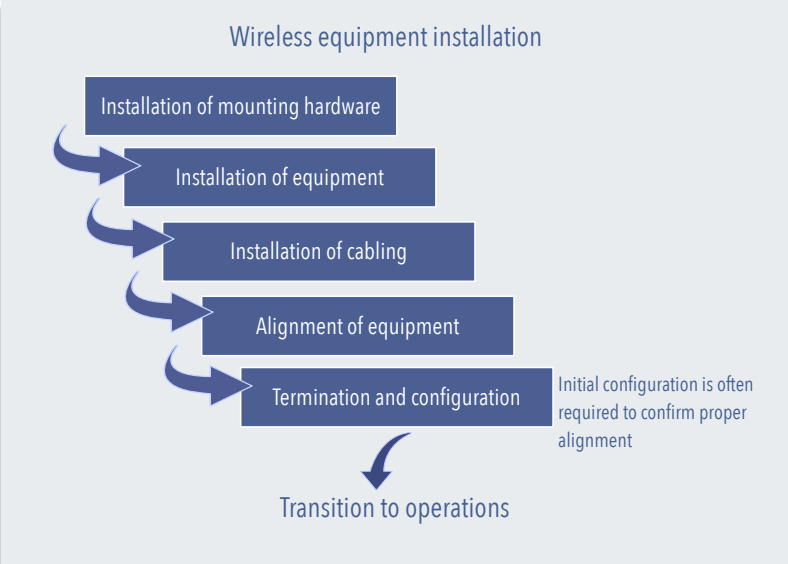
Once the engineering work is completed and a construction permit has been issued, tower construction can proceed. For a typical fixed point wireless tower of 199' feet or less, construction usually takes less than a month, but weather and soil conditions can create delays.

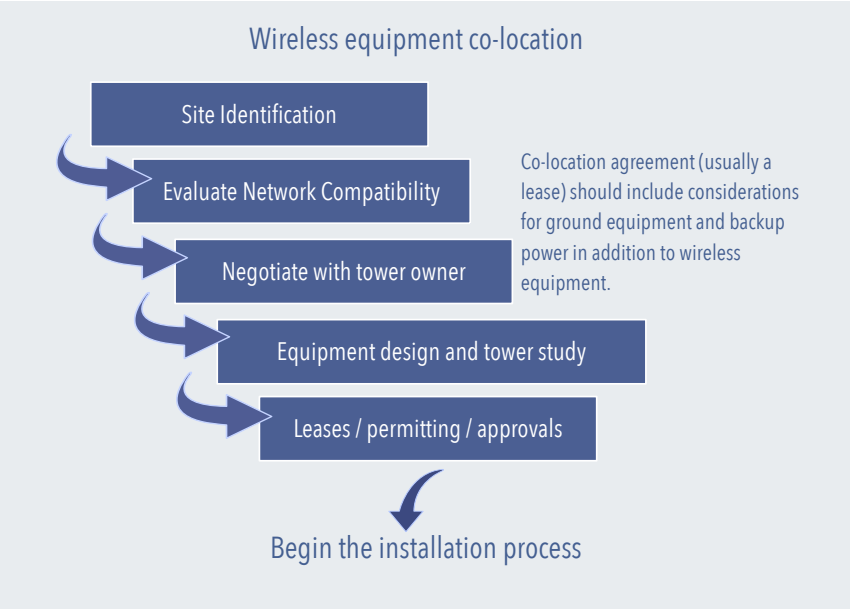
- Bidding and contracting – Bid documents and construction specifications have to be prepared and sent to candidate contractors. Once bids are received, proposals have to be reviewed, and depending upon funding sources, may require review by local government and/or a funding agency prior to awarding a contract.
- Site development – The tower site has to be cleared



of trees, brush, and any other obstructions. The area directly around the tower has to be leveled, and electric service (underground or aerial) has be brought to the site. Depending upon the location a road (usually gravel) may have to be placed.

- Foundation construction – Once site clearing and any road work is completed, the foundation for the tower is installed. If it is a guyed tower, guy wire anchors have to be installed.
- Tower construction – Once the foundation is in place, the tower has to be brought to the site and is erected. For towers of 199' or less, this is usually only two days.
- Final work details – Once the tower is in place, final work items are completed, including fencing, generators, fuel tanks, landscaping, and any site restoration work.





WIRELESS EQUIPMENT CO-LOCATION

When an existing tower is being considered for use, the diagram below illustrates the steps that need to be followed. For example, if an existing public safety tower or an existing cellular provider tower may have space for fixed point wireless broadband equipment (i.e. co-location).

- Site identification – Identify areas of poor service and look for existing towers.
- Network Compatibility – If there are towers in the service area, the first step is to determine if a minimum of ten vertical feet of space is available at an appropriate height for broadband wireless equipment. A wireless propagation study will provide the data needed to make this determination.

- Tower owner negotiation – If the tower is in a suitable location and if space is available at an appropriate height, a lease has to be negotiated with the tower owner.
- Tower study – An engineering study may be required to determine if the tower is able to support the additional weight and wind load of the equipment. Additional electric service and a cabinet for network electronics may also be needed.
- Leases and permits – If new electric service and/or a cabinet or shelter has to be installed at the sight, local government permits and/or construction approvals may be required.

WIRELESS EQUIPMENT INSTALLATION

Wireless equipment installation follows the completion of construction on a new tower or the acquisition of space on an existing tower. Electric power is already in place.

- Mounting hardware – Brackets and other mounting hardware have to attached to the tower at the designated height. This requires a tower climb conducted by a firm with trained tower climbers.
- Equipment installation – Once the mounting hardware is in place, radios are attached to the tower. On the ground, network equipment including switches, powers supplies, battery backup, and other equipment is installed. A backup generator and fuel tank may also be installed and wired into the equipment cabinet or shelter.
- Cabling installation – Cables are connected between the equipment in the cabinet on the ground to the radios on the tower.
- Alignment of radios – Radios on the tower have to be adjusted. Local access radios that provide service to local customers with line of sight to the tower have to be aligned for optimum coverage. If there are also point to point radios on the tower for connections to other towers or locations, these also have to be aligned. Tower climbers are needed to perform these steps.
- Configuration and testing – Once the physical alignment of the radios is complete and all cabling is connected, the new network equipment is integrated into the rest of the network.

10.9 LEGAL AND REGULATORY

Investments in community telecom infrastructure require attention to local, state, and Federal regulatory issues. The management of telecom infrastructure is a business enterprise that requires a variety of legal contracts, service agreements, maintenance and work agreements, procurement and performance contracts, and corporate legal documents of various kinds.

- Identification of state and Federal laws that may affect operations.
- Development of service provider master agreements and service agreement addendums.
- Leases for easements and rights of way.
- Review of work contracts for consultants, contractors, and engineering firms.
- Review of maintenance and operations agreements.

The project will require the services of an attorney with some demonstrable experience with community telecom agreements. Many attorneys are not familiar with community-owned open access networks, and some time and effort should be made to carefully qualify an attorney or firm prior to hiring them.

11 PARTNERSHIP OPPORTUNITIES

11.1 DISTRIBUTED OWNERSHIP

The key to obtaining improved availability of broadband, increased range of service options and competitive pricing is to distribute ownership of infrastructure among a wider range of interested parties beyond the incumbent and competitive providers.

Distributed ownership can take several forms:

- Space can be made available on existing county and state owned towers. Leasing space on an existing tower helps to attract a WISP to a new area by lowering the capital costs associated with developing a new market area.
- Where government-owned towers do not exist, county government or a regional entity can build new towers to expand the available service area for a WISP or WISPs that would lease space on the new towers.
- Empty conduit, ideally with several empty tubes, may also be an option, especially in new rural sub-divisions, where the developer may be willing to make the investment if the county government or a regional entity is willing to take responsibility for it once the construction of the neighborhood is complete. Empty conduit can be leased to private sector providers to generate an ongoing revenue stream. If the conduit is installed concurrently with street repairs, sidewalk upgrades, and/or grinding of streets prior to resurfacing, the construction cost can be lower. The long-term benefits include reduced street maintenance and repairs in the future because providers no longer have to cut streets and sidewalks to install their own conduit. Even in small communities where this is being done, multiple providers show interest in leasing conduit in business areas of the community.
- If a local government installs dark fiber in conduits (while leaving some tubes empty for conduit leasing), the potential revenue is higher than if it only installs conduit. If it installs fiber drops into commercial and retail business buildings, businesses in those building will potentially have more provider options and better (competitive) pricing for internet, voice and other IP-related services.
- Individual property owners can make investments in infrastructure for their own use, including conduit and/or fiber drop cable from the sides of their homes or businesses to the curb. Property owners can also erect wooden utility poles to obtain improved lines of sight to wireless broadband towers.
- A group of property owners (for example, residential subdivisions, homeowner associations or owners along a section of rural road) can pool funds to erect a utility pole to improve wireless access to the entire group or jointly fund conduit and fiber to their homes, using a wireless or fiber backhaul connection to an ISP.
- Commercial property owners (for example, business park owners, commercial building owners or apartment/condo building owners) can provide conduit and fiber or internal cabling for their

properties and make it available to service providers to serve their tenants on a competitive basis.

- Community organizations such as K–12 schools can build infrastructure primarily for their own use and include extra conduit and/or additional fiber for business, community and government use.

Managing conduit and dark fiber networks is practical for even very small communities because there are virtually no day-to-day operational responsibilities for the two systems, unlike an end-to-end "lit" network with fiber switches and customer-premises equipment.

Non-government entities like HOAs, neighborhood associations or nonprofits gain access to public right of way in the same way incumbents and service providers do, by following the local construction permitting process. A network design firm or local engineering firm can manage the paperwork easily.

By owning a pole or tower, residents have more control over how they get service (wireless broadband can be a dramatic improvement over poor copper landline DSL) and from whom they purchase service. Similarly, a neighborhood that provides its own financing for broadband infrastructure ensures that lack of adequate broadband does not depress property values or make homes in the neighborhood more difficult to sell.

As work, school, and leisure activities increasingly require more and more bandwidth, communities that want better internet services, competitive services and better pricing have a way forward: investing in and owning some broadband infrastructure. If the cost of that infrastructure is spread over several years, even small communities can afford world-class fiber and wireless services with a choice of providers and services. The alternative is to continue to see more areas in which a single provider exercises monopoly control over the services offered and ever-increasing prices.

Distributed ownership forces incumbent and competitive providers to pay more attention to their customers because their control has been weakened. Once a provider no longer "owns" the customer infrastructure end to end, it is forced to compete on a level playing field with better services, more kinds of services and competitive pricing.

11.2 PARTNERSHIP OPPORTUNITIES

Broadband efforts in Marathon County will by necessity have to include both public and private partners. Among some public and private entities, the common synergies are:

- The need for more bandwidth,
- The need for more affordable bandwidth, and
- The need for more affordable bandwidth to be more widely available.

Potential project partners include:

LOCAL GOVERNMENT

Marathon County government must play a significant and steady role in this effort because the future economic and community health of the county is at stake. In other parts of the country, some county governments are funding middle mile fiber routes to connect county facilities, (e.g. schools, libraries, pump stations, water tanks, fire and rescue facilities, etc.). This approach often includes significant cost savings by eliminating the expense of leased lines for all connected facilities. The City of Palm Coast,

Florida saved $80,000/year by building its own fiber ring in the City. Other county governments are funding county-wide broadband towers for private sector WISP use, and some are making investments in both towers and fiber.

PUBLIC SAFETY

The Sheriff department, fire, and rescue departments all need better access to broadband and improved wireless voice/data communications. Throughout the United States, public safety voice and data communications systems are being upgraded, often at staggering cost. Many of the upgrades include new towers to eliminate "holes" in the served area where first responder, fire, and rescue radios do not work. Combining public safety needs with community broadband needs can bring new sources of funding and cut costs, sometimes dramatically. Elected officials may need to take the lead in this area to ensure that public safety officials work collaboratively with the broadband efforts.

As additional towers and community pole sites are deployed in the county, first responders will benefit from lower Internet costs. Sharing tower space (WISP access and first responder voice/data) is extremely efficient, and all tower improvement and tower construction activities should be coordinated closely. There are some grants and funding sources available for public safety infrastructure like towers that may be available to help support new tower development.

K12 SCHOOLS

K12 students often lack adequate Internet service at home, and some schools are careful not to assign homework that requires Internet access. Parents consistently report on the burden of having to drive children to a public library or some other WiFi hotspot to get Internet access for school work. Some schools in the county are already setting up WiFi hotspots outside school buildings for student use after school hours, when classroom instruction would not be impacted. It is possible to make this access controlled, so that students would have to a user id/password to use it. The county government should work with the schools to apply for education grant funds to make this available at all rural school locations, and to keep K12 parents informed about broadband activities.

Some school systems have successfully applied for eRate funding to build fiber networks to connect schools together, and the eRate program is now allowing some of that fiber to be used for non-education use (e.g. residential and business fiber services) if the local government contributes a proportional share of the cost.

ISPS AND WISPS

Internet Service Providers (ISPs) and Wireless Internet Service Providers (WISPs) are important partners, as they will be the companies leasing tower space and/or conduit/fiber infrastructure.

County telecom investments will be a public/private enterprise, and service providers are the primary customers of the infrastructure. Service providers cannot be taken for granted. Instead, a fair fee structure, high quality infrastructure, excellent maintenance and operations (where needed), and flexibility on business agreements and pricing will be required to recruit and retain service providers.

See section 10.10 in this report (***Legal and Regulatory Analysis)*** for more information on how to work with providers. For providers that express interest in using community infrastructure, it will be important to meet with them on a regular basis. These companies may also be partners on grant applications, where it may be required to show that the infrastructure being constructed has a service provider already committed to using it.

AREA BUSINESSES

Businesses in the county and the local Chamber of Commerce have an important role to play as advocates for the work of this effort. At both the county and state level, businesses that need more affordable and better broadband should ensure that elected officials understand the urgency. As part of a regional marketing program, ensure that local businesses are kept up to date with work activities, grants, and other efforts (e.g. attend CoC meetings at least quarterly to report on the work of the broadband effort).

ELECTRIC UTILITIES

Electric utilities are natural partners in any municipal broadband venture. Electric utilities own utility poles, bucket trucks, and the equipment needed to install aerial fiber. Chattanooga's fiber to the premises (FTTx) initiative has enabled millions in savings for the city-owned electric service. When power outages occurs from events like ice storms or tree damage, the utility is able to use the fiber network to very accurately pinpoint where the outage occurs, enabling a more rapid repair of the electric network at less cost.

BROADBAND COOP

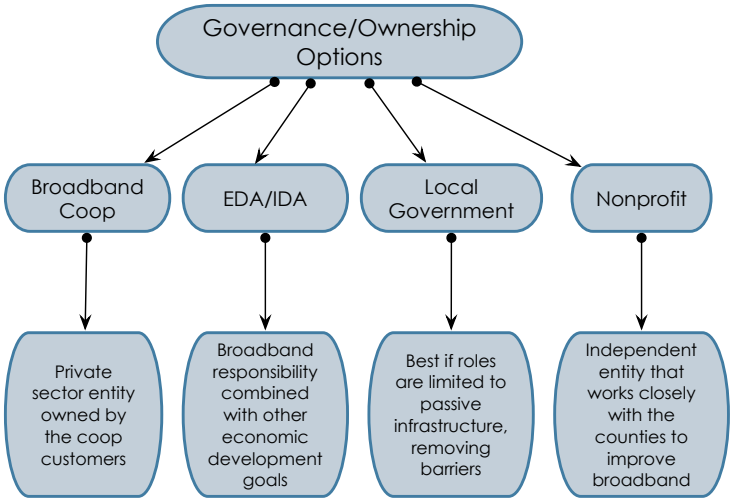
Forming a broadband coop may be one of the most effective ways of creating a partnership with a diverse and robust set of public and private members (partners) that could include residents, businesses, schools, health care providers, public safety, and local government. More information on the coops and how they are formed is contained in the next section ***(Governance and Ownership Options).***

11.3 GOVERNANCE AND OWNERSHIP OPTIONS

For whatever infrastructure improvements may be made by Marathon County, there will be a limited number of essential roles.

Community and county government investments in telecom improvements can be a mix of passive infrastructure like dark fiber, conduit, and wireless towers as well as some network electronics. These assets can be leased out to the private sector.

If the improvements are owned directly by the **county government**, many of the routine responsibilities could be managed by existing locality staff and departments that may include IT, Public Works, and Planning.



Governance and ownership options

An **EDA** or **IDA** (Economic Development Agency, Industrial Development Agency) as a nonprofit, could also own and manage telecom assets.

Another option is to form a **nonprofit**, which would not be subject to the state level restrictions on local government. A number of communities have formed a nonprofit (typically a 501(c)(4) to provide the governance and ownership roles for a community broadband effort.

In the county, a **broadband coop** may also be a useful option to consider. Coops are typically formed as a 501(c)(12) and are owned by the members (who are also the customers of the coop). Coops can receive membership fees in advance of providing the service, which can help raise the funds needed for infrastructure. There can also be more than one type of membership (e.g. residential, small business, large business, government, institutional, etc.), and each membership type can have a different membership fee associated with it.

ABOUT COUNTY GOVERNMENT OWNERSHIP

Many community-owned networks have achieved success with direct ownership by the local government. The primary advantages of county ownership as opposed to other ownership options include:

- The ability to provide long term financing for a high performance "future proof" network by using a very modest utility fee, in much the same manner that water and sewer is typically financed with pass-by and tap fees.
- Working directly with existing incumbent and competitive service providers to assist them in making service improvements and lowering cost of Internet service.
- Better coordination among county departments (e.g. planning, IT, GIS, etc.) to remove barriers, simplify permitting, and track assets (e.g. fiber, conduit, handholes, etc).
- The County fiber infrastructure can support improved delivery of other County services, including public safety initiatives, energy management, and other municipal activities.

Before making a decision, the County should also evaluate these factors:

- Any investments should be supported financially with a well-defined strategy to pay for the improvements.
- The effect on existing County staff work load should be evaluated, and there should be an evaluation of the cost of any additional staff that may be required.

ABOUT NONPROFITS

There are various kinds of nonprofit businesses. The most common is the 501(c)(3), which is limited to strictly charitable efforts. A 501(c)(3), according to IRS rules, must have a well-defined charitable purpose targeted toward a specific need and/or a specific target population. In other words, a 501(c)(3) cannot, according to IRS rules, operate as a nonprofit business that provides services to the general public.

Many of the first community networking projects in the early and mid-nineties were formed as 501(c)(3) organizations; it was common for these entities to offer dial-up Internet access to the general public at a time when Internet service providers were still relatively uncommon. But by 2000, most of these organizations had closed their doors and/or discontinued their Internet access services because of IRS challenges.

Today (2019), we have seen new 501(c)(3) and 501(c)(4) organizations being formed, and the Federal government's 2015 endorsement of both community-owned networks and the open access business

model has removed the uncertainty of using a nonprofit for this kind of effort. The IRS defines one role for 501(c)(4) entities as "*Social welfare organizations: Civic leagues or organizations not organized for profit but operated exclusively for the promotion of social welfare.*"

A 501(c)(3) can accept tax deductible donations, but contributions to a 501(c)(4) are not tax deductible. The advantage of a nonprofit is that they are relatively easy to create and legal fees are usually nominal. Nonprofits are often eligible for certain kinds of grants not available to for profit enterprises, and the nonprofit can provide the needed oversight to manage broadband infrastructure investments.

The advice of legal counsel should be solicited before forming a nonprofit.

ABOUT COOPS

Cooperative business enterprises as formal entities date from the mid-1800s. The first cooperative was set up in England to serve customers unhappy with local merchants. In the United States, the Grange movement began setting up cooperatives in rural areas to sell needed items to members and to help sell produce and other agricultural products that were produced by members. Today, credit unions are the most common form of coop business in the United States, with more than 65 million people obtaining services from over 12,000 credit unions.

Telephone and electric coops continue to be very common in rural parts of the U.S., and in fact, the majority of telephone companies in the United States are coops, but most have very small numbers of customers--often less than a thousand subscribers. Telephone coops serve more than a million subscribes in thirty-one states. The True Value and Ace Hardware chains are actually buying coops that help keep independent hardware stores competitive with the large chain stores.

The U.S. Department of Agriculture (USDA) provides extensive support for existing coops, and also helps communities start coops. One of their publications lists the principles of the coop:

- User-Benefits Principle -- Some purposes of a coop are to help members get services that might otherwise not be available, to get access to markets, or for other "mutually beneficial" reasons.
- User-Owner Principle -- The users of the cooperative own it.
- User-Control Principle -- The owners of the coop (i.e. members) control the coop through voting (annual meetings, etc), and indirectly by electing a board of directors to manage the enterprise. Large users who make high volume purchases of goods or services may receive additional votes.

Because cooperatives are user-managed, control of the enterprise is vested in the community or county where the users reside. Cooperatives also return excess earnings to its members; these refunds are called patronage refunds, and are typically computed at the end of the fiscal year. The expenses and income of the coop are calculated for the year, and any excess is returned to members, based on the percentage paid in by each member (e.g. a member that paid in 1% of total earnings would get a refund of 1% of any excess earnings).

Most cooperatives do not pay dividends on capital. This helps keep outsiders from taking control of the company, which would result in the community losing control over the quality of services and direction of the enterprise.

Coops are organized in part based on the territory they serve, and there are several classifications that may be relevant for community broadband efforts. A local coop serves a relatively small area that may be a single town or county and/or a radius of ten to thirty miles. A super local coop serves two or more counties. A regional coop may have a service area of several counties up to an entire state (or multiple

states). For projects that involve several local government entities that are already trading services like local public safety dispatch, a super local coop may be the most appropriate designation.

Most local and super local coops use the centralized governance structure, which means that individuals and businesses represent the bulk of members.

Cooperatives offer one or more of three kinds of services:

- Marketing coops help sell products or services produced by members.
- Purchasing coops buy products and services on behalf of members.
- Service cooperatives provide services to members, and service coops include credit unions, the electric coops, and the telephone coops.

Equity is typically raised for coops by direct investment from members. In return for an investment, members receive a membership certificate. The member may also receive shares of stock if the cooperative issues stock (some do, and some do not). Once a member has invested, they gain the right to vote in elections. As an example, if the local governments made a large initial investment in the cooperative, they could gain substantial influence in the affairs of the organization by gaining multiple shares and increased voting rights. Property owners (residential property owners and business property owners) who paid an initial connection or pass-by fee would also gain shares in the business, so every property owner that pays the connection fee gains ownership in the enterprise--an important selling point when encouraging property owners to, quite literally, invest in the project.

Although cooperatives are typically constrained by both Federal and state laws to do a majority of business with members, in most cases, cooperatives are able to do business with nonmembers up to some percentage of business income that can be as high as 49 percent. Note that this may be affected by the underlying legal incorporation of the cooperative--if incorporated as a 501(c)(12), the IRS requires that 85% of income must come from members for the purpose of meeting ordinary expenses.

In summary:

- Coops are member (subscriber) owned, meaning they are strongly vested in the community. Any effort by the coop board to dispose of assets or to sell the coop would have to be approved by a majority vote of the members.
- Members play an active long term role in governance by nominating and electing board members. So members have a straightforward way of influencing decision-making by the board.
- Coops generally operate on a cost-plus basis. Income that exceeds some preset level is returned to members periodically as a distribution of funds.
- Broadband coop bylaws must be carefully written, especially if there is an interest in several classes of membership. Each class of membership can be charged a different membership fee, and this can be a valuable source of start up funds, but membership categories are difficult to change later.
- Coops are largely immune to challenges by incumbent telecom providers due to the long history of existing coops and because of special legislation passed by Congress.
- Coops can tap USDA funds, but the application process would be time-consuming and expensive for a start up coop.

Advantages of a Coop

The primary advantages of an Coop as opposed to the county pursuing projects independently include:

- Avoids the strict limitations on local government participation. A coop, as a private sector entity, would have a wider range of infrastructure options, including offering retail wireless and fiber services.
- Coops can raise funds prior to delivering services to its shareholder customers. A broadband coop could solicit memberships from throughout the county (as long as the coop can clearly articulate its mission). Alternately, it could start with smaller "first phase" service areas and only solicit memberships from the initial target areas.
- A coop, with local members as the shareholders and owners, is firmly vested in the community. By comparison, a nonprofit, while easier to set up, does not have the same vesting in the community—the volunteer board of a nonprofit can sell the assets and/or disband it without any input from the community.

A broadband coop would need a carefully selected board of directors with significant business and management experience.

GOVERNANCE QUANTITATIVE EVALUATION

Six factors can be evaluated to provide a quantitative assessment of the governance options. These factors are:

- Transparency - Does the governance structure provide adequate transparency about decision making? Do stakeholders and interested parties have adequate ways to obtain documents, financial reports, and related governance materials?
- Timeliness - How quickly can the governance entity be legally formed? Time may be of the essence.
- Community Oversight - Does the entity have adequate community control and oversight? Do the communities and local governments have adequate representation in the governance structure to ensure that assets are managed properly?
- Legislative Authority to Build/Operate - Does the governance entity have clear legislative approval to build and operate a telecommunications network?
- Financing Options - Are there adequate financing options available to provide the appropriate level of funding over time to meet the long term vision of the county?
- Tax Liability - Does the governance entity incur tax obligations?

OWNERSHIP RECOMMENDATION

If local government participation is primarily limited to investments in passive infrastructure, direct county government ownership is the simplest and most direct route. This also aligns ownership most easily with state and Federal grant opportunities. If public safety tower needs can be combined with improved broadband wireless tower needs in underserved areas of the county, this also supports county government ownership.

If the County elects to pursue the middle mile fiber network as described in this report, a separate entity should be evaluated. A lit fiber network (dark fiber plus network electronics) requires a higher level of day to day responsibility, and the network is managed as a County-owned enterprise, the County IT department would have to be comfortable taking on the responsibility and would require at least one or two additional staff.

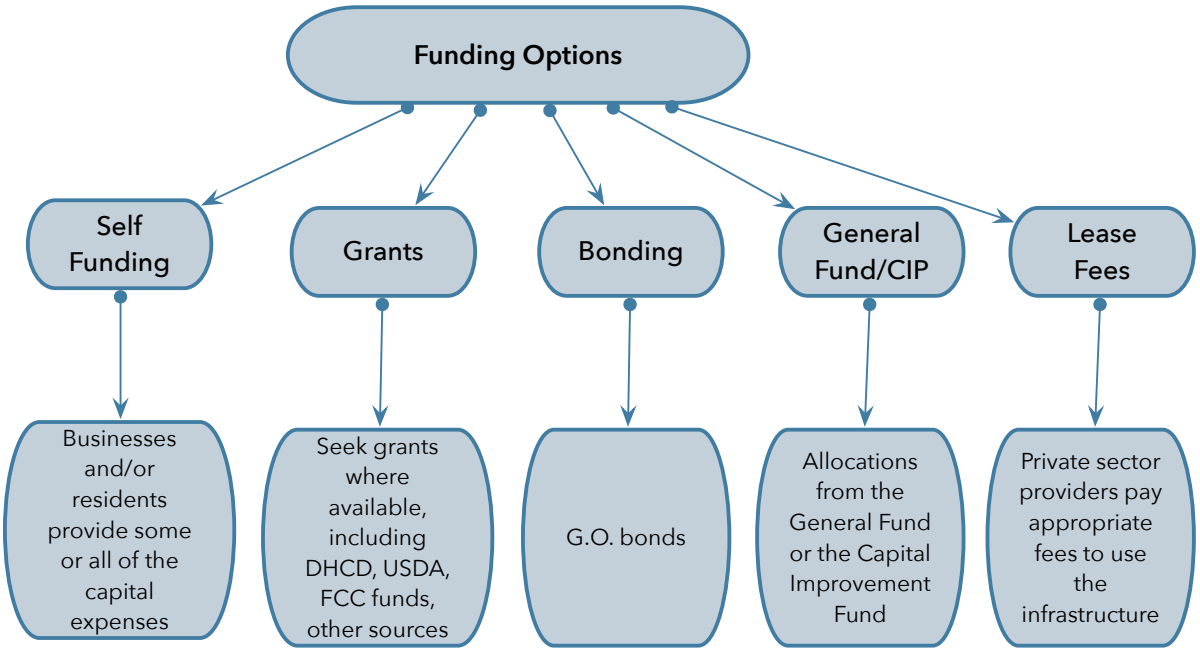
A coop, while requiring more time attention during formation, could provide a durable long term solution to improving broadband in Marathon County, and a broadband coop could apply for loans and grants, especially from USDA, and that could be used to make improvements in an area that includes more than one county.

12 FUNDING STRATEGIES

It is important to note that any investment by Marathon County in broadband infrastructure should be focused on basic infrastructure improvements. The County government should not offer retail Internet services to residents and businesses. Passive infrastructure assets like wireless towers, conduit, and fiber cable have a conservative life span of thirty years or more, and fiber network electronics typically have a useful life of eight to ten years. Wireless towers, properly maintained, have a life span of thirty to forty years or more. Broadband wireless electronics (radios and antennas) have a typical lifespan of four to six years.

Not all funding approaches described in this section may be applicable, but are discussed to provide examples of how other communities are pursuing innovative ways of funding broadband infrastructure. Experienced legal counsel may be needed to advise on what approaches can be utilized.

These types of infrastructure investments create hard assets that have tangible value and can then be leveraged for additional borrowing. The demand for services and the associated fees paid for those services will provide the revenue that will pay back loans over time. There is ample time to recoup not only the initial capital investment, but also to receive regular income from the infrastructure.



The financing of community-owned telecommunications infrastructure faces several challenges with respect to funding.

- Not all local governments are willing to commit to making loan guarantees from other funding sources like property taxes, because the idea of community-owned telecom infrastructure has a limited track record and therefore a higher perceived risk.

- Similarly, citizens are not always willing to commit to the possibility of higher taxes that may be needed to support a telecom infrastructure initiative, for many of the same reasons that local governments are still reluctant to make such commitments: perceived risk and a lack of history for such projects.
- Finally, banks and investors are also more skeptical of community telecom projects because of the relative newness of the phenomenon. By comparison, there are decades of data on the financial performance of water and sewer systems, so the perceived risk is lower.

Somewhat paradoxically, the cost of such a community digital road system is lower when there is a day one commitment to build to any residence or business that requests service. This maximizes the potential marketplace of buyers and attracts more sellers to offer services because of the larger potential market. This is so because:

- Service providers are reluctant to make a commitment to offer services on a network without knowing the total size of the market. A larger market, even if it takes several years to develop, is more attractive.
- Funding agencies and investors that may provide loans and grants to a community network project want to know how the funds will be repaid and/or that grants will contribute to a financially sustainable project. Knowing that the size of the customer base is the maximum possible for a service area helps reduce the perceived risk for providing loans and grants.

12.1 GRANTS

Grant funding is limited and should be viewed as part of a larger basket of funding. Federal funds from sources like the USDA and the FCC are highly competitive and often come with substantial limitations on who can qualify and how the funds can be used. CDBG funds can support telecom infrastructure construction but must be tied to job creation and/or job retention.

WISCONSIN PUBLIC SERVICE COMMISSION BROADBAND EXPANSION GRANTS

In 2020, the Public Service Commission (PSC) will award up to $24 million in Broadband Expansion Grants. Applications are due by December 19th, 2019. Marathon County may wish to begin planning for an application to be submitted for the 2021 grant cycle. Grants are available to public and private entities that meet requirements set forth in Wis. Stat. § 196.504. Eligible applicants include counties, towns, coops, and telecom utilities. Areas that are "unserved" (no ISP) or "underserved" (only one ISP) are eligible. Network infrastructure must be "scalable," meaning that the service area/users can be expanded without reducing service quality. Statute 196.504 has more information on how to qualify for an award.

WISCONSIN TEACH INFRASTRUCTURE GRANT PROGRAM

$3.0M is available in TEACH Information Technology Infrastructure Grants to eligible rural school districts and public libraries. Libraries became eligible for the TEACH Information Technology Infrastructure Grants in 2018. TEACH funds can be used to purchase equipment and related infrastructure. In the past, TEACH funds have been available for curriculum development and teacher training, but those funding areas have been discontinued.

HUD COMMUNITY DEVELOPMENT BLOCK GRANTS

The U.S. Housing and Urban Development CDBG State Program allows the Wisconsin Department of Administration's Division of Energy, Housing and Community Resources to award grants to smaller units of general local government (e.g. counties, towns) that develop and preserve decent affordable housing, to provide services to the most vulnerable in our communities, and to create and retain jobs. In recent years, CDBG funds have been successfully used for broadband infrastructure development where the local government applicant can show the improvements meet the general guidelines of the program—so grant funds have to spent in low and moderate income areas.

Over a 1, 2, or 3-year period, as selected by the grantee, not less than 70 percent of CDBG funds must be used for activities that benefit low- and moderate-income persons. In addition, each activity must meet one of the following national objectives for the program: benefit low- and moderate-income persons, prevention or elimination of slums or blight, or address community development needs having a particular urgency because existing conditions pose a serious and immediate threat to the health or welfare of the community for which other funding is not available. More information is available here (https://www.hud.gov/program_offices/comm_planning/communitydevelopment/programs). Applications for CDBG funds are likely to be due in May, 2020.

USDA RECONNECT PROGRAM

The ReConnect program is a new funding program managed by the USDA Rural Development Office. This program is sometimes called the USDA e-Connectivity pilot program. Grant applications can be a combination of 100% grant, 50% grant/50% loan, or 100% loan. $600 million has been allocated to the program, and a wide variety of entities can apply, including non-profits, coops, and state and local governments. Successful applications will require a very credible business plan that shows the project can be financially sustainable. Up to $25 million is available for a 100% grant application. Applications will be due in the spring of 2020. More information is available here: (reconnect.usda.gov). A mapping tool is available on the Web site to show areas that are eligible. To qualify as an eligible area, households must have less than a minimum of 10 Megabit down/1 Megabit up broadband service.

CAF 2 FUNDS

The FCC Connect America Fund (CAF2) continues to provide funds to incumbent and competitive service providers. The funds must be used in unserved or underserved areas as defined by Federal census blocks. To be eligible, a census block could not have been served with voice and broadband of at least 10/1 Mbps (based on Form 477 data) by an unsubsidized competitor or price cap carrier.

The FCC published the final eligible census blocks for the auction on February 6, 2018. The final areas were based on FCC Form 477 data as of December 31, 2016 (the most recent publicly available FCC Form 477 data at the time). So there is a time lag between the determination of a qualifying census block or blocks and the schedule for submitting a bid to serve those areas.

Because many CAF2 qualifying areas are only served by low performance DSL (e.g. less than 10/1 Mbps service), incumbent carriers use the awards to upgrade DSL switches, which is not a long term solution. More recently, competitive carriers are applying for CAF2 funds to provide higher performance broadband wireless and in some cases fiber to the home. Because the use of CAF2 funds are so restricted, it has not had as much impact as many hoped.

In Wisconsin, less than $500,000 was awarded in the CAF 2 auction, with 80% going to Viasat for improved satellite service.

12.2 GOVERNMENT TAX INCENTIVES

COMMUNITY REINVESTMENT ACT

The Community Reinvestment Act (CRA) was developed forty years ago to encourage banks and savings institutions to help meet the credit needs of their local communities, with a focus on low and moderate income areas of those communities. The Federal agencies that oversee private banks assign a CRA rating to each institution. Banks are often looking for well-planned community efforts that need loans. Such loans can improve a bank's CRA rating.

The CRA was revised in 2016 to encourage banks to support community broadband efforts. A community broadband project may be able to get some loan financing from a local bank that wants to get credit for their CRA work.

OPPORTUNITY ZONES

An Opportunity Zone is an economically-distressed community where new investments, under certain conditions, may be eligible for preferential tax treatment. Localities qualify as Opportunity Zones if they have been nominated for that designation by the state and that has been approved by the Internal Revenue Service. Opportunity Zones are designed to create tax incentives for private investors to make investments that can encourage economic development and job creation in distressed communities. Opportunity Zones would be of most use for Internet Service Providers who could use the tax benefits to make a business case to improve Internet access in a qualifying area (zone).

Opportunity Zones are defined by census tract, and the Census Bureau's Geocoder online tool can provide census tract ID numbers. A link to the list of currently qualified census tracts can be found on this page (https://www.cdfifund.gov/Pages/Opportunity-Zones.aspx). Marathon County has two census tracts that are designated Opportunity Zones.

NEW MARKETS TAX CREDIT

New markets tax credits are a form of private sector financing supported by tax credits supplied by the Federal government. The New Markets Tax Credit (NMTC) Program permits taxpayers to receive a credit against Federal income taxes for making qualified equity investments in designated Community Development Entities (CDEs). The CDEs apply to the Federal government for an allotment of tax credits, which can then be used by private investors who supply funds for qualifying community projects. Substantially all of the qualified equity investment must in turn be used by the CDE to provide investments in low-income communities.

The credit provided to the investor totals 39 percent of the cost of the investment and is claimed over a seven-year credit allowance period. In each of the first three years, the investor receives a credit equal to five percent of the total amount paid for the stock or capital interest at the time of purchase. For the final four years, the value of the credit is six percent annually. Investors may not redeem their investments in CDEs prior to the conclusion of the seven-year period.

Throughout the life of the NMTC Program, the Fund is authorized to allocate to CDEs the authority to issue to their investors up to the aggregate amount of $19.5 billion in equity as to which NMTCs can be claimed.

These tax credits can be quite useful, and there may be some areas that qualify. However, it can take up to a year or more to apply and then finally receive NMTC-related cash. This can be a useful long term source of funds.

12.3 SELF-FUNDING

911 FEES

Improved broadband access in the county can improve household access to 911 services by using broadband Internet to carry 911 voice calls, using one or more strategies to include Wifi calling and nano-cell devices.

A modest increase in the 911 fee to improve 911 access in rural areas of the county could generate funds to support additional broadband towers and community poles. In Wisconsin, there are limits on how much a county can charge in 911 fees, so legislative changes would be needed to utilize this funding approach. Wisconsin currently only charges a 911 fee on landline voice service (cell phones and VoIP services are excluded). This has led to a funding shortfall as the number of landlines has decreased in recent years. There may be an opportunity, if new 911 legislation is under consideration, to allow more flexibility in 911 fees to support broadband infrastructure.

COOP MEMBERSHIP FEES

Coop members pay a one time membership fee to join the coop. For fiber and wireless improvements, this fee could be set at a level that pays for part or all of the cost of building the fiber to the business or residential premises and/or placing the towers and equipment to deliver wireless service. It may also be possible to work with local banks to provide a financing option (e.g. the membership fee could be paid monthly over a period of several years to reduce the financial burden on a household or business).

The coop membership fee offers the area a way to self-finance a substantial portion of the initial network, as well as providing a long term framework for expansion.

UTILITY FEE

Two small cities in Utah are currently evaluating the potential of a $10-12 utility tax levied on every household and business to finance a full fiber to the premises build out, including a modest “free” Internet service that would be adequate for email and light Web use. Most households will probably choose to select a higher performance Internet package from a private provider on the network. A $10/month utility fee or special assessment (the cost of one large pizza) on every household in the county could raise as much as $5 million per year for broadband—enough to take Gigabit fiber to nearly every home and business.

Tables 12.1 and 12.2 below shows the kind of funds that could be generated over several time periods. If ten dollars per month were collected from each household for twenty years, it would easily finance the immediate build out of Gigabit fiber that would pass nearly all homes and businesses in the county.

LOCAL TAX ASSESSMENT

Special Assessment

Special assessments are labeled in different ways depending upon the state and the locality. However, the general concept is to levy a fee (or tax) on businesses and/or residents of a defined geographic area to help pay for the cost of improvements. In Wisconsin, statues section 66.60(1)(a) and (b) provides that any municipality may levy and collect special assessments for "special benefits" conferred from municipal work or improvements. (Mulcahy and Zimet, Impact Fees for a Developing Wisconsin, 1996).

Communities like Bozeman, Montana and Leverett, Massachusetts have been funding broadband infrastructure improvements with special assessments (in Leverett, $600/year for five years), and in Bozeman, TIF (Tax Incremental Financing) is being used in some areas to add telecom conduit, handholes, and dark fiber. In some localities, it is possible to levy a special assessment in a service district designated for a particular utility (like broadband) or other kind of public service.

Charlemont, Massachusetts intends to add an $11/month assessment to every household to build a town-owned Gigabit fiber network that will pass every household in the community. A town-wide vote supported this funding approach. Put in perspective, the average cost of a large, single topping pizza in the U.S. is currently $9 to $12.

Table 12.1: Individual service district property tax assessment revenue

MONTHLY ASSESSMENT AMOUNT	FIFTY HOMES FIVE YEAR ASSESSMENT	FIFTY HOMES TEN YEAR ASSESSMENT	100 HOMES FIVE YEAR ASSESSMENT	100 HOMES TEN YEAR ASSESSMENT
$5	$15,000	$30,000	$30,000	$60,000
$10	$30,000	$60,000	$60,000	$120,000
$25	$75,000	$150,000	$150,000	$300,000
$50	$150,000	$300,000	$300,000	$600,000

A lesser amount (e.g. $2/month over twenty years) would easily finance the immediate build out of a comprehensive wide area wireless tower network in each, as well as some fiber infrastructure.

Table 12.2: Marathon County special assessment revenue

MONTHLY ASSESSMENT AMOUNT	TWENTY YEAR ASSESSMENT	THIRTY YEAR ASSESSMENT
ESTIMATED NUMBER OF HOUSEHOLDS	42,000	
$1	$10,080,000	$15,120,000
$2	$20,160,000	$30,240,000
$5	$50,400,000	$75,600,000
$10	$100,800,000	$151,200,000

PROPERTY TAX FUNDING

While raising taxes can be politically very difficult, a very small incremental increase in property taxes, with the increase clearly earmarked specifically designated for broadband development (.e.g. one-quarter cent) might be possible to sell to citizens and businesses. The table below is adjusted to reflect the cost of borrowing over the listed periods of time.

The table below illustrates a hypothetical example of what funds might be raised for broadband improvements with a sample county-wide assessed property value.

Table 12.3: Individual service district property tax assessment revenue

	SAMPLE ASSESSED PROPERTY VALUE	BROADBAND INCREMENT	ANNUAL BROADBAND FUND	TEN YEAR AGGREGATE	TWENTY YEAR AGGREGATE	THIRTY YEAR AGGREGATE
1/4 of one cent	$10,000,000,000	$0.0025	$225,000	$2,250,000	$4,500,000	$6,750,000
1/2 of one cent	$10,000,000,000	$0.0050	$450,000	$4,500,000	$9,000,000	$13,500,000
1 cent	$10,000,000,000	$0.0100	$900,000	$9,000,000	$18,000,000	$27,000,000

12.4 FEE-BASED FUNDING

Initiatives like tower access and access to local government-owned conduit and fiber can create long term revenue streams from lease fees paid by service providers using that infrastructure. The City of Danville has recovered their entire initial capital investment from lease fees paid by providers on the nDanville fiber network.

CONNECTION FEES

Tap fees, pass by fees, and connection fees are already commonly used by local governments for utilities like water and sewer. The revenue share model can be strengthened from additional sources of revenue, including one time pass by fees, connection fees and sweat equity contributions. It is important to note that the Coop Membership Fee can be treated as a connection fee in whole or in part.

Pass By Fees

Pass by fees could be assessed once the fiber passes by the property, just as some communities assess a pass by fee when municipal water or sewer is placed in the road or street–and the fee is assessed whether or not the premise is connected, on the basis that the value of the property has been increased when municipal water or sewer service passes by. At least one study has indicated that properties with fiber connections have a higher value by $5,000 to $7,000 that similar properties without fiber access.

One Time Connection Fees

A one time connection fee can be assessed to property owners (e.g. residents and businesses) when the fiber drop from the street to the premise is installed. This is similar to the kinds of connection fees that are typically charged when a property is connected to a municipal water or sewer system. The fee is used to offset the cost of the fiber drop and the Customer Premise Equipment (CPE) needed to provide the operational access to the network. The connection fee can be modest (e.g. $100) or it can be a larger percentage of the actual cost of the connection. Fiber CPE may range from $250 to $350 and a fiber drop may cost from $200 for a premise very close to the distribution fiber passing along the property to $1,000 or more if the premise is hundreds of feet from the road. One variant would be to charge a minimum connection fee for up to some distance from the road (e.g. $100 for up to 75′ and $2 for each additional foot).

There is already some data that indicates that residential property values increase by as much as $5,000 to $7,000 if fiber broadband services are available, so pass by fees can be justified on the basis of increased property values accruing to the property owner. Given the novelty of this approach, pass by fees may need more time to become an accepted finance approach, but tap fees (for installing the fiber cable from the street or pedestal to the side of the home or business) may be easier to use, especially for businesses that may need improved broadband access. Tap fees have the potential of reducing the take rate in the early phases of deployment, but as the value of the network becomes established, it is likely that there will be much less resistance to paying a connection fee.

12.5 BONDING

Revenue bonds are repaid based on the expectation of receiving revenue from the network, and do not obligate the local government or taxpayers if financial targets are not met. In that respect, they are different from general obligation bonds. Many kinds of regional projects (water, sewer, solid waste, etc.) are routinely financed with revenue bonds. We believe many community projects will eventually finance a significant portion of the effort with revenue bonds, but at the present time, the limited financing history of most community-owned broadband networks has limited using revenue bonds.

Selling revenue bonds for a start up municipal network can be more challenging because there is no financial or management history for the venture. Bond investors typically prefer to see two or three years of revenue and expenses and a track record of management success. It would be advisable for the County to have an early conversation with qualified municipal bond counsel to assess the viability of this approach.

Obtaining funding using revenue bonds requires an excellent municipal credit rating and an investment quality financial plan for the operation and management of the network. Revenue bonds must be used carefully, and a well-designed financial model is required to show investors that sufficient cash flow exists to pay back the loans.

General obligation bonds are routinely used by local governments to finance municipal projects of all kinds. In Wisconsin, municipalities can only bond for infrastructure (not operations) with a limit of twenty years of the term of the bond—which is usually adequate to repay the bond if revenue and other sources of funding have been matched to the capital expenditures carefully.

G.O. bonds are guaranteed by the good faith and credit of the local government, and are not tied to revenue generated by the project being funded (i.e. revenue bonds). G.O. bonds obligate the issuing government and the taxpayers directly, and in some cases could lead to increased local taxes to cover the interest and principal payments. Some bond underwriters have indicated a willingness to include telecom funds as part of a larger bond initiative for other kinds of government infrastructure (e.g. adding $1 million in telecom funds to a $10 million bond initiative for other improvements).

In discussions with bond underwriters, it has been suggested that it would be easier to obtain bond funds for telecom if the telecom bonding amount was rolled into a larger water or sewer bond, or some other type of bond request that are more familiar to the bond market. Two cities in Utah are both evaluating the use of a per household utility fee, on the order of $10 to $15 per month, to provide the financial support for a bond amount that would allow a full 100% fiber to the home build out. A basic (limited) Internet package is intended to be included so that low and moderate income households could receive Internet access with the utility fee.

12.6 GRANT APPLICATION ACTIVITIES

Applying for grants, especially Federal grants, requires careful planning. Federal grants often require soliciting and assembling a variety of information and endorsements. USDA ReConnect applications may require starting the application process four to six months in advance of the deadline for submission of the completed application.

Table 12.4: Grant application activities

ACTIVITY	DESCRIPTION	DISCUSSION	TASKS
Develop a grant application	The grant application process, from start to award announcement, can be nine to twelve months.	Broadband grant application requirements have become more stringent over time, with more grant agency oversight and review. Careful planning is essential to develop a successful application.	• Once a grant opportunity has been identified, review grant requirements to determine if the project can qualify. For example, some grants require two years of financial history. • Identify appropriate agency that will assist with grant application. • Begin contacting potential ISP partners. • If the project qualifies, identify at least two people to take the lead to prepare application. • Prepare a task list of all grant materials requirements and identify data needed. • Develop a timeline for developing sections of the grant. • Identify requirements for letters of support and matching funds and develop timeline to solicit and collect commitments. • Complete all sections of grant application with assistance from public and private partners. • Submit grant application.

Table 12.5: Grant application timeline

TYPICAL TIMELINE	MONTHS											
TASKS	1	2	3	4	5	6	7	8	9	10	11	12
Determine grant qualifications												
Identify regional council partner												
Identify ISP or WISP partner if needed												
Appoint grant team												
Create grant task list												
Prepare timeline and assign tasks to partners												
Identify matching fund requirements and letters of support to solicit and collect as needed												
Complete all sections of the grant application												
Submit grant												
Grant agency review												
Awards announcement												

13 COMMUNICATIONS AND OUTREACH STRATEGY

13.1 CHARACTERISTICS OF A SUCCESSFUL MARKETING PLAN

A successful marketing plan for the broadband initiative does not have to be expensive or time consuming. The attributes that need attention are:

- Consistent – Use a single, easily recognized logo, tag line, and message consistently across all platforms–paper, Web, social media, and email.
- Ongoing – Regular updates and news postings on the Web site and the Facebook page will keep residents, businesses, and local officials up to date and well-informed about broadband development activities.
- Affordable – Avoid using high priced media consultants, SEO advisers, and over-priced marketing agencies. A simple Web site can be hosted for less than $200 per year, and there are a variety of Content Management Systems (CMS) that allow Web sites to be updated quickly and easily without any programming or coding required. For paper materials like fliers, professionally designed templates are available that can be easily edited for a high quality finished product. Paper materials can be printed easily and quickly on high quality, four color glossy paper formats at very low cost. As an example, an 8 1/2 x 11 four color glossy flier can be printed and delivered in 48 hours for as little as twelve cents a copy.
- Interesting Content – Posted news items should emphasize quality over quantity. One interesting broadband article per week is better than three marginally interesting articles per week.
- Well-defined Distribution – Distribution of news items should be well understood–as an example, most news items should be posted on the Web site news blog at the same time as the Facebook page.
- Well-defined Goals – The project team/county should develop a short list of short term and long term goals that can be described concisely (e.g. one sentence each). Goals should be included as needed and as appropriate on the Web site, on the Facebook page, and on paper media. The goals should also be highlighted in presentations, interviews, and in public meetings.

13.2 DISTRIBUTION

Social Media – A Facebook page should be an important part of the marketing strategy. Regular posting of news items will keep residents and businesses engaged and seeing those items in their news feeds. Occasional use of "boosted" posts is extremely effective in reaching a wider audience. Boosted posts should be reserved for significant and timely news about the project itself.

Instagram and Twitter can be used occasionally for high profile news announcements.

Perhaps the most important feature of Facebook is the interactivity that is possible between the project team and Facebook users. Residents and businesses will be "liking" and "sharing" the page, but they

will also be posting questions. The Facebook page should be visited regularly by a member of team who will review activity, write responses to questions, and pass interesting or important comments on to other team members and/or County staff.

Keyword Optimization – Web site should include keywords that are most likely to be used in search engines (e.g. broadband, Marathon County, wireless broadband, WISP, bandwidth, etc.).

Search Engine Optimization Strategy – To ensure that the Web site shows up near the top of search engine results, the site should have a blog-style news page, with regular updates–at least several items per month, and ideally 1-2 news items per week.

Traditional Media – Local newspapers and local radio stations can be a valuable resource for getting news about the work of the initiative to the wider community, especially for news about work completed (e.g. new WISP coming to the area, new tower completed, etc.).

Web Site – The effort needs a permanent Web site. It does not need to be lengthy and does not need many pages (as few as 10-12 pages may be adequate). A content management system (CMS) should be installed to make updating the site quick and easy. A CMS like Wordpress or Drupal, once configured by an experienced Web developer, will allow fast and easy page updates without any programming or HTML experience. A news blog should be part of the site so that news items can be posted there. A blog that is updated regularly will help the site get a good rating in search engines.

Email – Most Web hosting services will include email and email mailing list support as part their package. Companies like JustHost will provide domain registration, a Web site with CMS support, email addresses, and mailing lists for under $200/year.

Mailing Lists – It will be useful to have one or more "invite only" mailing lists to keep key stakeholders and interested parties informed.

Media Partners – The Web site and the Facebook page should be linked prominently on partner Web sites (e.g. County Web site, Chamber of Commerce site, economic development Web pages, etc.).

13.3 MARKETING MATERIALS

The project needs only a small amount of printed/PDF materials for distribution. These might include a one page **overview** of the project, **vision and project goals**, and **efforts currently underway**. These materials can be distributed to County Supervisors, placed in libraries, or emailed (as a PDF) to people asking for more information.

Regular posting of news items related to broadband generally and postings related specifically to local broadband efforts can be cross-posted to reach a wider audience. The same news item can be posted to the Facebook page and the Web site news blog.

13.4 TARGET AUDIENCE

There are several different groups that should be identified as needing to receive information on a regular basis.

- Residents – Residents can be effectively updated using Facebook and occasional other use of social media. Facebook works extremely well for this kind of project, and residents should be encouraged to "share" and "like" the Facebook page. Facebook "boosts," used sparingly for major announcements, are very effective and are relatively inexpensive.

- Businesses – Businesses are most easily kept informed by regular updates at Chamber and merchants association meetings.
- County Supervisors – The Committee should plan to make a regular quarterly update at a scheduled County Supervisor's meeting.
- County Departments - Regular meetings with planning, GIS, and public works staff in the county (perhaps 2 times per year) will be important, with regular email and phone call interaction in between meetings. Planning staff can provide information on new private towers that have applied for permits, and can identify other opportunities for the initiative to have an impact (e.g. new industrial/commercial areas that might need fiber, new rural residential developments, etc.).
- Public Safety – Regular meetings with public safety officials will be important to ensure that grant funding is coordinated jointly for the most benefit of both groups.
- Healthcare Providers – Health care providers, because of the electronic medical records (EMR) requirements, are big users of Internet access and bandwidth. The use of telemedicine and telehealth services is increasing steadily, and health care providers are often the heaviest users of bandwidth in a county after K12 schools. They can be early customers for expanded service.
- K12 Schools and Higher Education – While schools generally have adequate bandwidth, they are often interested in a second (redundant) Internet connection, so they could be major customers for services being offered by new providers.
- ISPs – ISPs will be the primary users of any infrastructure investments made in the county. It will be very important to give interested providers regular updates on activities.
- State Legislators – Changes in laws and funding opportunities at the state level could accelerate the goals of the effort. Regular updates by email and in-person meetings will be important.

14 POLICY AND PLANNING RECOMMENDATIONS

There are numerous opportunities for Marathon County to make prudent investments in telecom infrastructure without spending large amounts of money, or in some cases, without spending any money at all directly. County and local town policy changes can have a substantial impact on the installed telecom infrastructure in the community over time, if those policy changes are embraced and pursued diligently.

GOVERNMENT POLICY OPPORTUNITIES

Maintain and extend a fiber overlay plan that will take fiber to all critical County, town, and village facilities, including public safety and first responder locations, water and sewer pump facilities, high water and water monitoring locations, parks and recreation facilities, and all key traffic management equipment.

- Action Step: Identify and map all recommended areas for for possible fiber deployment.
- Action Step: Maintain a fiber overlay plan that identifies all major routes for fiber and all needed public safety towers, antenna locations, fire and rescue facilities, and other local government facilities.
- Action Step: As new local government infrastructure projects are developed or improved (e.g. park, fire station, pump station, office building, etc.) determine if fiber connectivity is needed at that location and include the necessary fiber infrastructure in the budget.

Ensure that all underground utility construction in public right of way is permanently documented in the County GIS system.

All private underground construction that places infrastructure in public right of way should be documented and maintained in the County GIS system.

- Action Step: Ensure that both site plans submitted for permits and as-built drawings are provided to the County GIS system.
- Request that all current telecom providers with conduit and/or cable in public right of way provide accurate drawings (e.g. shapefiles or CAD files) to the County. Note that some providers will claim that they do not have to provide "proprietary" company information, but route data does not have to include cable size/capacity and does not have to include any customer information.

Marathon County should have a "dig once" policy that considers installing fiber alongside water and sewer extensions and improvements.

The Wausau Are Metropolitan Planning Commission is already discussing the development of a "dig once" policy. The County has the authority to implement such a policy (in some states, this is more difficult). "Dig once" in practice has more potential with street, sidewalk, and bikeway projects than with certain utilities. Water, sewer, and gas projects usually require that the conduit/fiber be offset by

two or three feet from the primary utility so that there is less risk of fiber damage if utility repairs are required. This requires wider trenches and can increase costs.

Some telecom providers are willing to work with local government on "dig once" projects by agreeing to install extra conduit and/or fiber cable as part of their project.

- Action Step: Develop a policy of evaluating inclusion of telecom conduit in any open trenches, and other public works projects when the work matches routes in the fiber overlay plan.
- Action Step: If traffic signals are being updated with fiber connectivity to improve traffic management, place extra conduit in intersections. Intersections often have underground congestion, and "dig once" with extra conduit can reduce costs substantially for both private fiber and community fiber that may be installed later.

The County, Towns, and Villages should have a pandemic emergency plan in place that would allow employees to work from home in the case of an epidemic that requires long term quarantines (e.g. 40 days or more).

- Action Step: The IT departments should review the capacity of their IT infrastructure to have most or all employees have the ability to access servers and data from home. Dependencies on data, security issues, and backup strategies should be evaluated for robustness.

Marathon County should discuss utilization of a next generation network to support shared public safety and government communications goals.

- Action Step: County planning and IT staff should meet to discuss how a next generation network could improve response and management of public safety emergencies (e.g. pandemics, weather catastrophes, etc.).
- Action Step: The County should consider taking fiber to all County and County radio towers to provide better support for wireless communications and to provide better support for Emergency Communications.
- Action Step: The County and Towns should explore FEMA and Homeland Security funding options for using fiber for redundant emergency communications routes and for improved wireless communications.
- Action Step: Any public safety broadband infrastructure (fiber, wireless towers) should be designed to support any planned business/residential broadband infrastructure development. Critical public safety data can be completely and securely separated from being mixed with commercial and residential data traffic.

NON-GOVERNMENT OPPORTUNITIES

Numerous opportunities exist to improve the living and work spaces in Marathon County, especially when new construction is underway. Remarkably, many builders and architects still fail to include adequate network cabling in their residential and commercial building designs. The County can play a leadership role by encouraging stepped up private sector investment in telecom infrastructure.

All new commercial and retail buildings constructed in Marathon should have appropriate "Internet ready" structured cabling from a Building Distribution Frame (BDF) to all office and workspaces.

- Action Step: County planners should meet regularly with developers, builders, and architects to encourage adding appropriate telecom facilities in all new buildings.

All new commercial buildings in the County should include appropriately designed telecom facilities (e.g. telecom closet(s), cable trays in the ceilings, 4" risers between floors, etc.). The building spaces become more valuable, and when the appropriate infrastructure is designed in, the cost to the tenants is lower.

All new commercial and retail buildings constructed in Marathon should have a minimum of two 4" ducts from a pedestal or hand hole in the public right of way to the telecom closet or BDF (Building Distribution Frame) area.

- Action Step: All new commercial buildings in the County should have telecom conduit installed from the structure to a County-designated demarc point in the right of way. Property owners would be responsible for the conduit to the County demarc point. The County would take ownership of the conduit in the right way (pedestal to pedestal conduit) after the building construction has been completed.

All new residential developments in Marathon County should have conduit from each home to a pedestal or hand hole, and conduit from each pedestal or hand hole back to a neighborhood demarcation point for network electronics and/or optical splitters.

- Action Step: All new homes in the County should have telecom conduit installed from the home to a County-designated demarc point in the right of way. Homeowners would be responsible for the conduit to the County demarc point. The County would own the conduit in the right way (pedestal to pedestal conduit).
- Action Step: County staff and planners should begin meeting with local builders and developers to encourage the inclusion of structured cabling (Ethernet cables) in all new residential single family homes, rental units, and condominiums.
- Action Step: A short handout should be prepared that describes the adequate level of structured cabling needed in new homes. This should be circulated to County planners, local builders, developers, and real estate agents.
- Action Step: County planners should begin meeting with developers to discuss this initiative and to help educate developers and builders on the enhanced value that accrues from this investment.
- Action Step: County planners should amend the County land division ordinance to require installation of high speed Internet infrastructure as part of final plat approval and work with local cities and villages to complete similar amendments to their local land division ordinances.

The cost of adding structured cabling to a new home is a tiny fraction of the cost of construction (typically less than $500). At least three Cat 5e/6 cables should be pulled to every living space in the

home (with the exception of bathrooms) to provide for complete voice, video, and Internet access in every room. All cables should be run back to a structured cabling panel on an outside wall, near the building entrance for utilities. A recent study showed that homes with fiber to the premise sell for $5,000 to $7,000 more than homes without fiber.

All new residential developments in the County should have telecom conduit installed by the builder. Conduit would be routed from the side of the home where other utilities enter the home to a nearby pedestal or handhole. Conduit from the handhole should run back to a neighborhood cabinet or optical splitter location for network aggregation. The cost of this work is typically only $200-300 per home.

Ensure that the businesses of Marathon County have adequate and redundant electric power.

- Action Step: Meet with the electric utility to discuss developing a strategy to upgrade facilities to provide dual sub-station power feeds to key commercial and business areas of the County.
- Action Step: County planners should encourage commercial developers to design redundant electric feeds to major commercial projects (i.e. electric service from two different substations).

Many businesses now conduct online commerce 24 hours a day, and electric power interruptions can be costly in terms of lost revenue. In other areas of the country, some business park managers are aggressively working with local electric providers to ensure that business and industrial parks have electric power from two different substations. Data server operations and data backup facilities are being relocated to areas with reliable and redundant electric power.

APPENDIX A: GLOSSARY

Active network: Typically a fiber network that has electronics (fiber switches and CPE) installed at each end of a fiber cable to provide "lit" service to a customer.

Asymmetric connection: The upload and download bandwidth (speed) are not equal. Cable Internet and satellite Internet services are highly asymmetric, with upload speeds typically 1/10 of download speeds. Asymmetric services are problematic for home-based businesses and workers, as it is very difficult to use common business services like two way videoconferencing or to transfer large files to other locations.

Backhaul: Typically refers to a high capacity Internet path out of a service area or locality that provides connectivity to the worldwide Internet.

Colo facility: Colo is short for Colocation. Usually refers to a prefab concrete shelter or data center where network infrastructure converges. A colo or data center can also refer to a location where several service provider networks meet to exchange data and Internet traffic.

Conduit: Inexpensive plastic (typically HDPE or PVC) pipe that is often installed for underground fiber routes. Fiber cable is pulled through the conduit after the conduit has been placed in the ground. The conduit provides extra protection against damage to the fiber cable. Conduit is also referred to as duct.

CPE: Customer Premises Equipment, or the box usually found in a home or business that provides the Internet connection. DSL modems and cable modems are examples of CPE, and in a fiber network, there is a similarly-sized fiber modem device.

Dark fiber: Dark fiber is fiber cable that does not have any electronics at the ends of the fiber cable, so no laser light is being transmitted down the cable.

Duct: See **Conduit**.

Fiber switch: Network electronic equipment usually found in a cabinet or shelter

Fiber Optic Splice Closure: See **FOSC**.

FOSC: Fiber Optic Splice Closure. Typically a water and air tight cylindrical container where fiber cable is split open to allow splicing (connecting together) of fiber strands for a drop to a premises.

FTTH/FTTP/FTTx: Fiber to the Home (FTTH), Fiber to the Premises (FTTP), and Fiber to the X (FTTx) all refer to Internet and other broadband services delivered over fiber cable to the home or business rather than the copper cables traditionally used by the telephone and cable companies.

Handhole: Handholes are open bottom boxes with removable lids that are installed in the ground with the lids at ground level. The handholes provide access to fiber cable and splice closures that are placed in the handhole. Handholes are also called **pull boxes**.

IP video: Video in various forms, including traditional packages of TV programming, delivered over the Internet rather than by cable TV or satellite systems.

Latency: The time required for information to travel across the network from one point to another. Satellite Internet suffers from very high latency because the signals must travel a round trip

to the satellite in stationary orbit (22,500 miles each way). High latency makes it very difficult to use services like videoconferencing.

Lit network: A "lit"network (or lit fiber) is the same as an active network. "Lit" refers to the fact that the fiber equipment at each end use small lasers transmitting very high frequency light to send the two way data traffic over the fiber.

Megabits/second: A measure of transmitted Internet dat a– one million bits per second.

Middle Mile Network: A high capacity fiber or microwave (wireless) network that typically provides data connectivity between just two or a few locations. Middle mile networks usually do not offer any retail residential or small/medium business services.

MST: Multiport Service Terminals are widely used in fiber to the home deployments to connect individual home drop cables to larger distribution cables on poles or in handholes. Pre-connectorized drop cables snap into the MST ports and do not require any splicing.

Passive network: Refers to infrastructure that does not have any powered equipment associated with it. Examples include wireless towers, conduit (plastic conduit), handholes, and dark fiber.

Pull boxes: Pull boxes (also called handholes) are used to provide access to fiber cable and splice closures. They are called pull boxes because they are also used during the fiber cable construction process to pull the fiber cable through conduit between two pull boxes.

Splice closures: Splice closures come in a variety of sizes and shapes and are used to provide access to fiber cable that has been cut open to give installers access to individual fiber strands. Splice closures are designed to be waterproof (to keep moisture out of the fiber cable) and can be mounted on aerial fiber cable or placed underground in handholes. Also called **FOSC**s.

Splicing: The process of providing a transparent joint (connection) between two individual fiber strands so that laser light passes through. A common use of splicing is to connect a small "drop" cable of one or two fiber strands to a much larger (e.g. 144 fiber strand) cable to provide fiber services to a single home or business.

SCADA: Supervisory Control and Data Acquisition. Used by the electric utility industry and some other utilities (e.g. water/sewer) to manage their systems.

Symmetric connection: The upload and download bandwidth (speed) is equal. This is important for businesses and for work from home/job from home opportunities.

Virtual Private Network: A VPN creates a private, controlled access link between a user's computer and a corporate or education network in a different location. VPNs are often encrypted to protect company and personal data. VPNs usually require a symmetric connection (equal upload and download speeds) to work properly.

Wausau Area Community Network:

APPENDIX B: SERVICE PROVIDER PRICING AND SERVICE OFFERINGS

Table B.1: Wireline Internet service provider comparison for Marathon County, WI

Provider	Monthly Cost	Promo Rate & Contract Length	Other Monthly Fees	Down-load Speed (Mbps)	Upload Speed (Mbps)	Data Cap (GB/ Month)	One-Time Fees	Services & Incentives
Amherst Communi-cations DSL	$74.99			10	n/a			
Frontier DSL	$27.99	1-year promo	$10 (modem)	6	n/a	None	$9.99 (equipment delivery) $75 (optional install) Free self-install	$200 Visa reward card for online purchases
Frontier DSL	$34.99	1-year promo	$10 (modem)	25	n/a	None	$9.99 (equipment delivery) $75 (optional install) Free self-install	$200 Visa reward card for online purchases
Frontier DSL	$44.99	1-year promo	$10 (modem)	25	n/a	None	$9.99 (equipment delivery) $40 (install)	$200 Visa reward card for online purchases
Packerland Broadband	$39.00	1-year promo		50	n/a	None		
Packerland Broadband	$62.00	1-year promo		100	n/a	None		
Spectrum	$99.97	1-year promo		100	10	None		Internet, TV Select, Home Phone
Spectrum	$119.97	1-year promo		100	10	None		Internet, TV Silver, Home Phone
Spectrum	$139.97	1-year promo		100	10	None		Internet, TV Gold, Home Phone
Spectrum	$89.98	1-year promo		100	10	None		Internet, TV Select
Spectrum	$44.99	1-year promo; reg. rate $65.99		100	10	None	$9.99 (self install) $49.99 (professional install)	Spectrum Internet (only)
Spectrum	$64.99	1-year promo; reg. rate $90.99		400	20	None	$9.99 (self install) $49.99 (professional install)	Spectrum Internet Ultra (only)

Provider	Monthly Cost	Promo Rate & Contract Length	Other Monthly Fees	Down-load Speed (Mbps)	Upload Speed (Mbps)	Data Cap (GB/ Month)	One-Time Fees	Services & Incentives
TDS	$29.95	1-year promo; reg. rate $60.95	$8.00 (modem)	6-15	0.768	None	$100 (processing) $14.95 (equipment handling)	Turbo Internet
TDS	$29.95	1-year promo; reg. rate $65.95	$8.00 (modem)	18-25	1.5-5	None	$100 (processing) $14.95 (equipment handling)	Mach Internet
TDS	$29.95	1-year promo; reg. rate $65.95	$8.00 (modem)	36-50	1.5-10	None	$100 (processing) $14.95 (equipment handling)	Warp Internet
TDS	$29.95	1-year promo; reg. rate $55.95	$8.00 (modem)	2-5	0.512	None	$100 (processing) $14.95 (equipment handling)	Express Internet
TDS	$29.95	1-year promo; reg. rate $65.95	$8.00 (modem)	75-100	15	None	$100 (processing) $14.95 (equipment handling)	WarpX Internet
Wittenberg	$91.50			5			None	
Amherst Communi-cations Fiber	$99.99	1-year contract		120			None	Internet and phone

Table B.2: Wireless Internet service provider comparison for Marathon County, WI

Provider	Monthly Cost	Promo & Contract Length	Other Monthly Fees	Down-load Speed (Mbps)	Upload Speed (Mbps)	Data Cap (GB/ Month)	One-Time Fees	Incentives & Notes
Cellcom	n/a			0.7				
Kings Street Wireless	n/a			0.7				
Cirrinity	n/a			25				
Airrunner	$48.95			6	1	None		
Airrunner	$67.95			10	2	None		
Airrunner	$89.95			15	2	None		
Airrunner	$125.93			25	4	None		
Arris	$48.52			4	1	None	$130 (setup)	

Provider	Monthly Cost	Promo & Contract Length	Other Monthly Fees	Down-load Speed (Mbps)	Upload Speed (Mbps)	Data Cap (GB/ Month)	One-Time Fees	Incentives & Notes
Arris	$59.07			6	1	None	$130 (setup)	
Arris	$69.62			10	2	None	$130 (setup)	
Beltram	$59.95			5	n/a	None		
Beltram	$74.95			10	n/a	None		
Beltram	$89.95			15	n/a	None		
Beltram	$149.95			25	n/a	None		
County Wireless	$32.00	2-year contract		1	1	None	None	Free installation including equipment
County Wireless	$41.00	2-year contract		2	0.512	None	None	Free installation including equipment
County Wireless	$64.99	2-year contract		5	2	None	None	Free installation including equipment
County Wireless	$74.99	2-year contract		7	2	None	None	Free installation including equipment
Network Professionals	$39.99		$4.99 (modem)	5	1	None	$199 (setup)	Bronze Package
Network Professionals	$59.99		$4.99 (modem)	10	2	None	$199 (setup)	Silver Package
Network Professionals	$89.99		$4.99 (modem)	15	3	None	$199 (setup)	Gold Package
Network Professionals	$129.99		$4.99 (modem)	25	4	None	$199 (setup)	Platinum Package

Table B.3: Satellite Internet service provider comparison for Marathon County, WI

Provider	Monthly Cost	Promo & Contract Length	Other Monthly Fees	Down-load Speed (Mbps)	Upload Speed (Mbps)	Data Cap (GB/Month)	One-Time Fees	Incentives
Hughes-net	$59.99	2-year contract, up to $400 ETF	$14.99 (modem)	25	3	After 10 GB (speeds drop to 1-3 Mbps)	$99 (setup)	50 GB/mo data in off-peak hours
Hughes-net	$69.99	2-year contract, up to $400 ETF	$14.99 (modem)	25	3	After 20 GB (speeds drop to 1-3 Mbps)	$99 (setup)	50 GB/mo data in off-peak hours
Hughes-net	$99.99	2-year contract, up to $400 ETF	$14.99 (modem)	25	3	After 30 GB (speeds drop to 1-3 Mbps)	$99 (setup)	50 GB/mo data in off-peak hours
Hughes-net	$149.99	2-year contract, up to $400 ETF	$14.99 (modem)	25	3	After 50 GB (speeds drop to 1-3 Mbps)	$99 (setup)	50 GB/mo data in off-peak hours
Viasat	$50.00 (promo) $70.00 (regular)	3-month promo 2-year contract	$10/month (modem)	12	3	After 40 GB(priority drops)	$150 Setup Fee	
Viasat	$70.00 (promo) $100.00 (regular)	3-month promo 2-year contract	$10/month (modem)	25	3	After 60 GB (priority drops)	$150 Setup Fee	
Viasat	$100.00 (promo) $150.00 (regular)	3-month promo 2-year contract	$10/month (modem)	30	3	After 100 GB (priority drops)	$150 Setup Fee	