Enhancing Cellular and Broadband Deployment: A Strategic Report

Prepared for

Warren County, Pennsylvania

2007

Prepared by

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Abstract

Warren County is experiencing the same connectivity problems felt by rural areas across the nation. The scarcity of advanced connectivity and poor cellular telephone coverage leads to a rural digital divide for residents and businesses and discourages tourism and new business development.

One of the greatest challenges of universal broadband access and cellular telephone coverage is the provision of service in low population density areas. Service providers need to commit to thousands of dollars per customer to deploy service. Yet because their investment may take many years to recoup it makes a deployment project unlikely. A coordinated County-wide initiative creates an infrastructure asset that is capable of supporting a number of public or private sector communications initiatives and brings with it the many benefits of an enhanced communication infrastructure.

For example, a coordinated effort can:

- Provide a platform for service providers to quickly and affordably enter the market.
- Enhance rural digital inclusion by facilitating affordable access to the World Wide Web.
- Facilitate economic development by:
  - Enabling small business, including home-based business, creation and growth.
  - Enabling job creation and the enhanced economic activity that accompanies it.
  - Supporting businesses with high bandwidth needs, such as medical uses.
  - Attracting and retaining businesses of all sizes.
- Raise the attractiveness of the area for tourists and new residents.
- Support current and future public safety and government communications systems and facilitate interoperable communications between agencies.

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1. Executive Summary

The Commissioners, businesses, and residents of Warren County experience significant gaps in cellular telephone coverage. The coverage gaps are not unique to the County; rural areas across the United States are experiencing the same issue. In the event of a public health or safety emergency, gaps in cellular telephone and public safety radio coverage are a threat to area security. In addition, the lack of comprehensive cellular telephone coverage hinders economic development and resident quality of life.

Cellular telephone coverage is not the only issue – access to affordable and reliable broadband connectivity is no longer a luxury. To maintain the quality-of-life and enhance the economic viability of the region, improvements in availability, reliability, and affordability of broadband connectivity are essential.

1.1 Report Purpose and Methodology

To address the above concerns, the County Commissioners engaged Columbia Telecommunications Corporation (CTC) to evaluate strategies and provide a blueprint for development of communications infrastructure — with the intention to address cellular telephone coverage gaps and also look beyond cellular telephone coverage to other critical communications avenues in both voice and data transport areas.

CTC prepared this Report in late 2006 and early 2007. The Report develops an infrastructure blueprint and strategy with the primary objective of encouraging the expansion and enhancement of cellular telephone and broadband connectivity services in Warren County. Specifically, the Report provides an analysis of the following areas:

- Availability gaps of high-speed Internet services.
- Current use and future needs for advanced connectivity services in the County.
- Methods to coordinate local government broadband service objectives.
- Components needed to create an environment where affordable and accessible broadband technology is used to support and enhance citizen and business interactions and economic development initiatives.
- Approaches to facilitate interoperable communications among County agencies and bridge rural digital gaps that threaten area residents' access to electronic information.

To prepare this Report, CTC's staff of engineers and analysts undertook the following tasks:

- Conducted briefings and meetings with County officials and representatives of other County, municipal, regional, and Commonwealth agencies.
- Met extensively with County stakeholders, including first responders, schools, libraries, economic development authorities, the Chamber of Business and Industry, and other interested parties.

- Met with private sector entities that may participate in long-term infrastructure deployment in the County, including:
    - Dobson Communications
    - Verizon
    - WestPA.net
- Participated in meetings in Harrisburg with Commonwealth agencies regarding potential strategies for co-deployment of communications.
- Met with the Northwest Commission regarding their infrastructure efforts in the Commonwealth and the County.
- Attended the regional meeting hosted by Warren County in the wake of the "Bucky" Phillips affair to evaluate communications aspects of the experience.
- Met with owners of potentially-useful assets for development of communications networks, such as Warren County Electric Cooperative.
- Conducted extensive data-gathering in Warren County including visits to communications facilities and a field review to survey and inventory existing communications assets.
- Conducted research regarding existing communications providers in the County to determine the existing availability of services and to assess the factors that prevent or delay further private sector deployment of communications.
- Conducted field-review and a detailed engineering review and analysis of the area including tower locations, and prepared a technical blueprint for consideration.
- Researched emerging rural broadband technologies.

1.2 Three Core Hurdles with Infrastructure Deployment in Warren County

Warren County and communication providers face three core infrastructure hurdles in ensuring the availability of affordable state-of-the-art connectivity. The resolutions for these three hurdles are interdependent upon each other. By this we mean that connecting end-user premises (hurdle 2) is dependent upon aggregating traffic (hurdle 1) and ensuring connectivity outside of Warren County (hurdle 3) is dependent upon the success of connecting end-users (hurdle 2). In Section 5 of the Report, CTC develops a phased approach that seeks to overcome the infrastructure hurdles and provides costs associated with each phase. The hurdles are:

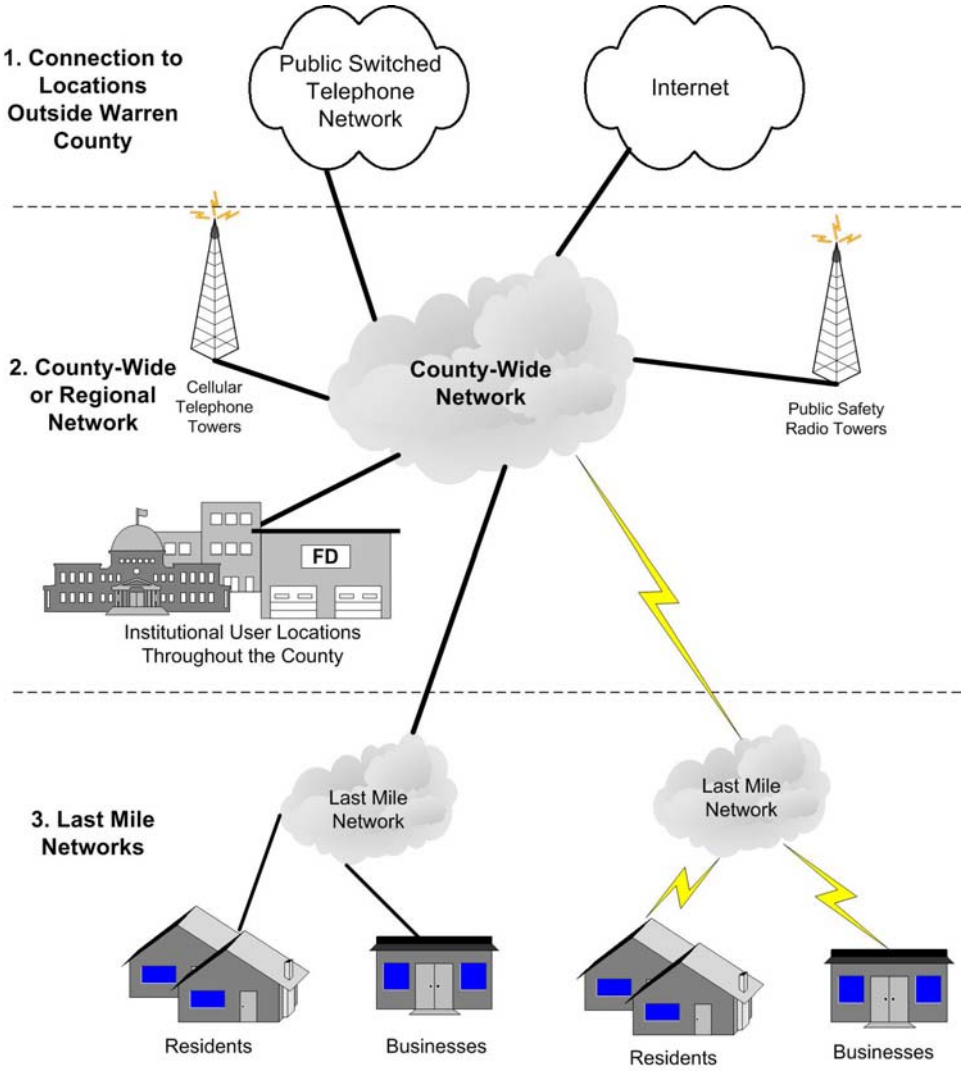
1. The connectivity infrastructure used to aggregate traffic throughout the County. Section 5 of this Report provides specific details on developing a County-wide network that addresses this core problem.

2. The connectivity infrastructure connecting the end-user premises – or last mile network. Section 6 of this Report discusses emerging last-mile technologies for rural areas. These technologies increase use of connectivity infrastructure and make the market more attractive for service providers.

3. The connections to locations outside Warren County. Aggregating traffic through a County-wide network and connecting end-user premises significantly increases the likelihood that a service provider will extend services beyond Warren County. Continued discussions with the Tier 1 provider is one of the first steps in improving these connections for the County.

These networks and connections are shown in Figure 1-1.

Figure 1-1: Connectivity Services Overview



Connectivity Status in Warren County

Limited affordable County-wide connectivity options restrict the abilities to expand cellular telephone coverage, deploy alternative last-mile technologies, and aggregate traffic. Last mile

connectivity options vary widely across Warren County. For example, in the City of Warren, most residences have a choice of DSL, T1, and other options from Verizon; however, they are provided at a disproportional cost relative to other Commonwealth communities, and service availability gaps still exist. In smaller communities and rural areas of Warren County, last-mile options are often limited to expensive satellite services that do not support interactivity such as Voice over Internet Protocol (VoIP) or high bandwidth applications. In addition, CTC found that connectivity options to locations outside the County are expensive and have limited capability.

1.3 Summary of Recommendations to Address the Core Hurdles and Next Steps

The recommendations and strategies in this Report offer a variety of perspectives and action items that Warren County can pursue to expand connectivity to meet the needs of current residents and businesses and potential new broadband users by addressing the core hurdles. The success of the connectivity project hinges on the ability to guarantee anchor tenants on the proposed network, secure grants to reduce implementation costs, and form partnerships to increase the attractiveness of the market. In addition, obtaining grant and other alternative financing sources along with obtaining commitments for aggregation of demand – are essential to reach the County's vision and meet the identified objectives.

The scope of the proposed connectivity project is as one expects – huge. To deploy a communications infrastructure in Warren County is a large undertaking. The recommendations and technical blueprint provided in this report are dependant upon active participation of the County, other institutions, and major businesses. The next step in the process is to initiate a work session with selected County staff and decision makers. The purpose of the work session is to refine and tailor the recommendations and considerations presented in this Report.

We recommend consideration of the following issues during the work session:

1. The role the County plays in direct financial support of the network.

2. The role the County plays in seeking grants and funding from the Commonwealth and the Federal government.

3. The role the County plays in infrastructure (tower and fiber) ownership.

4. The role the County plays in promoting the network including assistance with sales and marketing support, and seeking anchor tenant commitments from area businesses.

5. The role the County plays in leading each tasks and assignments of responsibilities.

6. The projected time-lines needed for each phase of the connectivity project and coordination with other infrastructure projects.

Following the work session, the recommended action items include:

1. Expand, refine, and adopt the vision and policies for connectivity asset use and ownership (see Section 1.3.1).

2. Investigate and seek alternative funding sources such as grants to reduce the County's implementation cost (see Section 1.3.5.1).

3. Pursue increase of public safety radio coverage with additional towers and equipment additions (see Section 1.3.2).

4. Meet and negotiate with cellular telephone providers to encourage deployment of towers that may expand coverage (see Section 1.3.3).

5. Continue working the local agencies and businesses to aggregate service demand (see Section 1.3.6.1).

6. Work with local jurisdictions in the County to establish policies for conduit and other connectivity infrastructure (see Section 1.3.5.2).

7. Continue efforts to attract a Tier 1 provider to expand available connectivity services in Warren County (see Section 1.3.6.2).

8. Seek commitments from local agencies and businesses to acquire services from providers which participate in the County's efforts to improve connectivity (see Section 1.3.6.3).

9. Pursue construction of the Core Backbone Ring (Phase I, see Section 1.3.4.1) which supports initial government needs. The Core Backbone Ring provides a foundation for aggregation of demand and providing an anchor tenant for connectivity providers (see Section 1.3.6.1).

10. Expand the core fiber ring to distant townships (see Section 1.3.4.2).

11. Increase the fiber network redundancy (see Section 1.3.4.3).

These action items are further described in the following primary recommendations:

1.3.1 Adopt Vision and Policies Guidelines for Expansion of Connectivity Assets

The identified vision for connectivity in Warren County is:

> "To ensure that Warren County residencies, businesses, and institutions have at least equivalent if not superior connectivity options in regards to

performance, availability, affordability, and reliability when compared to other regions (United States and globally)."

The initial guidelines for policy development include:

- Ensure end-users and value-added sellers have equal-access to connectivity facilities and assets.
- Promote activities that encourage aggregation of services to increase the attractiveness of the Warren County marketplace.
- Pursue County-ownership which maximizes grant or other funding alternatives which do not compromise the range of public safety to private carriage uses.
- Balance the "core-competitives" of the private and public sectors.
    - Private: Offer competitive end-use services and support.
    - Public: Ability to own and finance infrastructure that ensures retail providers have unfettered access to the recommended fiber and tower facilities.

1.3.2 Construct New Public Safety Radio Sites

CTC recommends that the County seeks to improve public safety radio coverage. The communications demands on public safety agencies continue to increase. Enhancing the wireless communications infrastructure in Warren County reduces service gaps and is a critical first step toward ensuring that public safety agencies have the ability to communicate to each other from any location. To accomplish this objective, we recommend that the County install new towers with public safety radio equipment near Dunham Corner, Eldred Hill Road, Grand Valley and Tidioute to expand the public safety radio coverage. We also recommend adding public safety equipment on the Bull Hill and Swede Hill towers.

Section 5.1.2 and Section 5.1.4 provides details on the costs and methodology used to determine new tower site locations. The approximate cost for improving public safety radio coverage is $490,000.

1.3.3 Construct New Cellular Telephone Tower Sites

CTC recommends that the County build communications towers to reduce the cost for commercial and non governmental agencies to provide communication services. Cellular telephone providers cannot justify the low return-on-investment to build towers in low population density areas. If enhanced cellular service is a desired objective; supplying towers for the service providers to use reduces the provider's required investment to expand coverage. CTC identified 21 locations[1] where construction of additional communications towers could significantly improve commercial wireless service coverage (Appendix A2 and Appendix A3). In addition to these locations CTC found that nine of the public radio sites are suitable locations for cellular telephone sites (see Section 5.1.3). These sites may need upgrades before they can effectively act as a cellular telephone site. They are: Bull Hill, Dunham Corner, Eldred Hill,

[1] Includes the four towers identified in Section 1.3.2 to expand public safety radio coverage.

Grand Valley, Jake's Rocks, Scandia, Swede Hill, Tidioute, and Watson (see Section 5.2.3). The cost for the recommendations to expand cellular coverage is approximately $975,000.

1.3.4 Construct a Fiber Optic Network to Support Government Needs and Encouragement of Aggregation

CTC recommends that the County construct a robust[2] fiber optic network to meet current communication demands and provide additional capacity for future needs. CTC met with several Warren County agencies to assess current and future needs. All agencies expressed a critical need for connectivity either between agencies, between their organization and the Internet or between their agency and either a branch facility or field worker. Section 2 of the Report describes their responses.

The detailed conceptual fiber optic network design (Figure 5-15) is described in Section 5.2.3 and Section 5.2.4. Given the size and low population density of the County, and the cost of the project, the fiber optic network design is divided into phases. The estimated cost of the three-phase fiber optic network is approximately $15,400,000.[3,4]

1.3.4.1 Phase One – Construct a Core Backbone Ring to Support Government Needs

The first phase of the three phase project constructs a fiber optic backbone ring to serve stakeholders and wireless communications facilities in the central portion of the County. In addition the first phase connects[5] 45 stakeholder facilities and 4 tower sites. Figure 5-13 shows the phase one logical networking map. The cost of this phase is $3,600,000.

1.3.4.2 Phase Two – Expansion of Backbone to Distant Townships

The second phase of the project builds secondary fiber optic rings through Tidioute and Scandia, and provides a fiber optic spur to Sheffield. This project provides connectivity to 45 stakeholder facilities and 22 communications towers in the vicinity of the fiber and creates additional backbone rings for increased redundancy. The cost for this phase is $8,400,000.

1.3.4.3 Phase Three – Increase Network Redundancy

The final phase increases the redundancy of the network and connects four stakeholder facilities and four communication towers on the fiber optic network. It is also designed to provide fiber optic connectivity to additional tower sites. Figure 5-16 depicts the logical topology of this phase. The cost for this phase is $3,400,000.

[2] Meets availability, reliability and redundancy demands for first responder and other critical communications.
[3] The cost estimate assumes 90 percent of the fiber is aerial and 10 percent is underground.
[4] The cost estimate does not include the electronics to light the fiber.
[5] Please see Appendix B for a complete list of towers and facilities connected in each phase.

1.3.5 Pursue Strategies to Reduce Costs

The CTC technical blueprint (Section 5) provides the design for a stable, robust, and reliable communications network. However the costs are high and the immediate return-on-investment for service providers is low. To attract partners in this project the County must reduce project costs. CTC developed the following cost-reduction strategies for consideration.

1.3.5.1 Explore Connectivity Grants

CTC recommends exploring connectivity assistance grants to offset the high costs of a rural backhaul deployment project. This is the most effective measure to reduce project costs. To balance the low immediate rate-of-return on this project providers need an infusion of cash from other sources. The County or other government agencies have access to public funds that support rural broadband initiatives. Current Federal opportunities may include the **Improving America's Security Act of 2007** which passed the Senate in mid-March of 2007. Pennsylvania has rural broadband assistance grants for the 2007 budget year.

In Appendix D, we have included a list of potential grant sources for consideration.

1.3.5.2 Prepare Assets for the Future Fiber Projects

CTC recommends that Warren County coordinate with member communities regarding future public safety radio or other communications projects. Every County/Commonwealth/municipal project has the potential to provide long term cost savings on communication infrastructure. Specific action items to consider include:

- Add to the connectivity infrastructure at every opportunity. This is achieved by inter-jurisdictional collaboration on construction projects. These projects range from road, sewer, and water main repair to installation of sidewalks, cellular or radio towers, pathways and underground relocation of facilities.
- Establish a policy to install conduit during road improvements and other Capital Improvement Projects (CIPs). Conduit provides the connectivity "road" and holds the key to a reduction in the cost of future communications deployment. Leverage the low incremental cost to install conduit during roadwork or utility installation (sewers, electrical) to entice commercial carriers to offer services in the County or to build municipal networks by offering a "free" connectivity path. The cost of pulling fiber through existing conduit is $6,000 to $12,000 per mile. The cost of new underground fiber construction often exceeds $100,000 per mile.
- View every private sector project in the right-of-way as an opportunity for partnerships. Develop uniform requirements and procedures for using commercial carrier construction to simultaneously install fiber or conduit. Negotiate for conduit or dark fiber during permitting discussions, and look for construction partnerships during infrastructure projects.

1.3.6 Increase Market Attractiveness

Reducing project costs must accompany an increase in market attractiveness. Providers have their choice of areas to deploy services; Warren County's challenge is to make the market attractive enough for a provider to make the investment. CTC developed the following measures to increase market attractiveness:

1.3.6.1 Leverage Public Demand and Aggregate Services

CTC recommends that Warren County aggressively aggregate service demand. Combining County-wide demand for services provides a better business case for service providers. Aggregation of demand is a critical factor in attracting providers to make an investment in the area. Aggregation efforts work hand-in-hand with educating consumers on connectivity benefits. Consumers need to believe that the cost of advanced broadband service is worth paying reoccurring monthly charges. If there is a lack of consumer interest there is little demand to aggregate.

Pennsylvania enacted Act 183 that created an aggregation program called the Bona Fide Retail Request (BFRR) program. In accordance with this Act, the Northwest Commission's Technology Advisory Group[6] meets to develop approaches to regional technology initiatives in northwest Pennsylvania. CTC recommends that Warren County expand upon this advisory committee's broadband aggregation efforts by creating a stakeholder group to assist with Warren County broadband aggregation efforts. Committee representation from all key County decision-makers is critical. The following categories need representation:

Administration: This includes County, municipal, and regional staff.

Business Sector: This includes small business owners and home-based businesses as well as higher-end broadband users such as commercial and industrial businesses.

Economic Development Agencies and Business Liaisons: This includes the Chamber of Business and Industry, local real estate professionals and the Commonwealth, Warren County and other regional economic development commissions.

Education/Training Institutions: This includes schools, libraries and job training facilities.

Public Safety and Healthcare Agencies: This includes police, fire, and first responders, as well as hospitals and medical clinics.

Utility Providers: This includes telephony, cable, cellular, and electric providers who are either in the position to provide assets or deploy service.

[6] Warren County is a member of the Northwest Commission Technology Advisory Group.

1.3.6.2 Explore Private Public Partnerships

CTC recommends considering public entity collaboration with one or more private companies to deploy backhaul network and provide services. The partners can act as an Internet Service Provider (ISP), build the backbone or provide assets such as fiber, conduit, and cellular towers. Elements that are commonly used to develop business models for collaborative infrastructure are discussed in Section 7.4. The County also must review existing assets (Section 4) that have the potential to encourage private investment by reducing the costs associated with the investment.

1.3.6.3 Seek Anchor Tenants

A provider's decision to invest in an area is based on their projected return-on-investment and the ability to obtain financing. If Warren County is able to acquire anchor tenants on the system, it encourages private provider investment by guaranteeing a fixed revenue stream. The anchor tenant model is commonly used in city-wide WiFi deployments. Section 7.4 details the benefits of the anchor tenant model.

1.4 The Need for Communications Infrastructure

The benefits of connectivity range from attracting and retaining businesses, to providing educational opportunities for students, to improving the quality of life. Expanding connectivity increases the residential and visitor attractiveness of the area, improves efficiencies in the business arena and brings new businesses to the County. Detailed needs by specific agency are described in Section 2 of the Report. The potential public benefit by category of user is illustrated in the following paragraphs.

1.4.1 Schools and Libraries

Schools across the nation use digital technology to enhance the learning environment. The world is a "digital world" and it is important to prepare students to use technology at their place of employment, to pay bills, use online services and to seek information on the World Wide Web. The schools play a critical role in preparing students for the future. Warren County Schools can benefit by high speed Internet access from each school. This permits distance learning programs and downloading video intensive educational materials to the classrooms.

Libraries are public gathering areas and an optimal place to provide public Internet access to those who are without access at their home or business. The Library Association is interested in high speed connectivity to all of its branches. High speed connectivity enables deployment of voice over IP (VoIP) to library branches and provision of Internet-based patron services.

1.4.2 Economic Development

A Warren County goal is to increase the amount of good paying jobs to the area. These are jobs that pay a "living wage". One of the factors relocating companies look for is a solid, reliable

communications infrastructure. Companies will not relocate to an area with limited communications access. They rely on traditional,[7] Internet Protocol (IP), electronic and cellular-based technologies to keep connected with in-field staff and to remote facilities. In addition, high speed Internet access is needed to transfer files and documents to satellite facilities and other businesses across the nation.

1.4.3 Public Safety

The major needs for public safety connectivity are connections to local agencies and other jurisdictions. Connectivity greatly maximizes the ability to exchange information and results in efficient management of resources. Up-to-date information on criminal activity, road closures, forest fires and other public safety events is critical.

1.4.3.1 Case Study: Ralph "Bucky" Phillips Manhunt and Capture

In 2006, Bucky Phillips escaped from the Erie County jail. He had spent 20 of his last 23 years in jail and because of his past history and the fact that he was heavily armed he was placed on the FBI's Most Wanted List. The five-month manhunt for Ralph Phillips ended with his surrender in Warren County, Pennsylvania on September 8, 2006. Mr. Phillips, 44, was captured near the town of Akeley, Pennsylvania. Phillips was finally caught when four members of the New York-New Jersey Regional Fugitive Task Force spotted him hiding in the woods. While the Task Force and local agencies did a phenomenal job of working around communication limitations their job would have been much easier with a reliable, robust County-wide communications infrastructure.

1.4.4 Tourism

Although some out-of-town visitors enjoy the lack of connectivity, most want cellular communications in case of an emergency or to call home. According to the Warren County Visitor's Bureau one factor that affects tourism, especially in terms of young urban visitors, is the lack of cellular communications in the County. The Visitor's Bureau sees cellular coverage as a requirement for today's business traveler and recreational visitor.

1.4.5 Hospitals and Medical Uses

Sharing information among hospital departments, satellite clinics, rural medical facilities and medical offices is an essential quality of care component and contributes to cost containment. Telemedicine requires transmission of large images and files. Hospitals, clinics, and assisted-living facilities need access to high capacity, high speed Internet in order to securely share patient information between each other. Field workers such as social workers and visiting nurses need to access agency files from the field and also rely on cellular telephone coverage to communicate with their clients and administrative staff.

[7] Traditional communications includes voice and data circuits using the Public Switched Telephone Network (PSTN).

2. Communications Needs Analysis

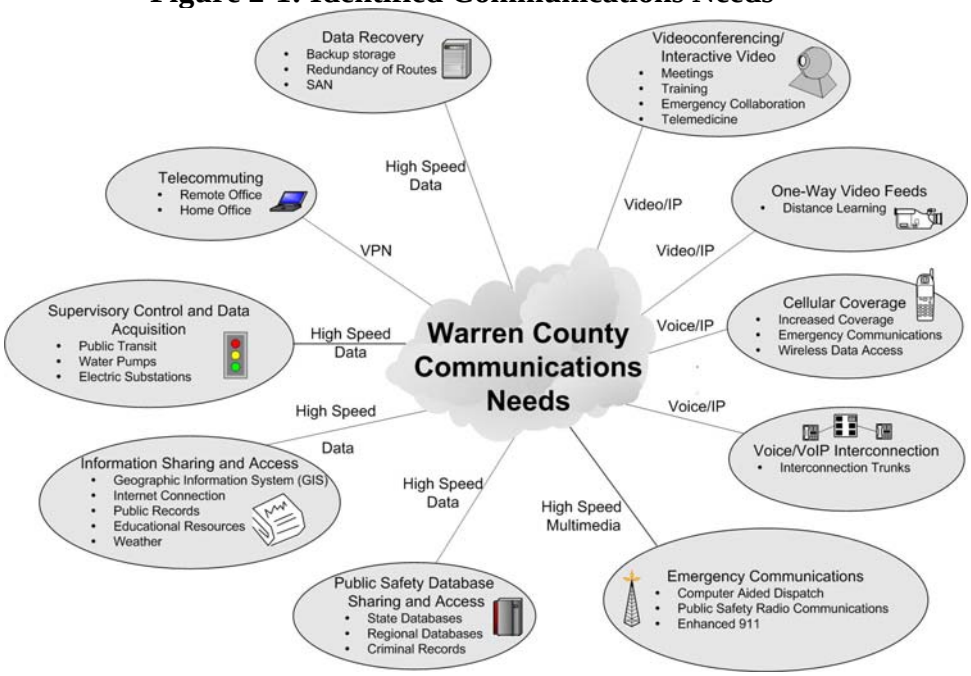
This section of the Report identifies areas or applications that may be improved or expanded with access to broadband connectivity. High-bandwidth applications include videoconferencing, voice, Internet access, and GIS mapping system access.

To assist in identification of communications networking needs, CTC conducted strategy meetings with Warren County representatives.

The key network connectivity needs (Figure 2-1) identified from interviews with these agencies are:

1. Increased performance networking for existing and emerging technology applications
2. Increased connectivity speed to support new applications (video, homeland security, intelligent transportation systems)
3. Maintenance of reliability standards (especially for public safety and security monitoring applications)
4. Reduction of recurring monthly access fees
5. High speed connectivity to additional locations and to mobile users
6. Universal cellular coverage

Figure 2-1: Identified Communications Needs



2.1 Warren County Government

2.1.1 Warren Fire Service and Emergency Management Services

Nineteen volunteer fire departments operate within Warren County. The departments also serve as EMS first responders. The departments use the County's public safety radio system and the Public Switched Telephone Network (PSTN). There is no data communications network between fire stations. In fact, only seven of the 19 fire stations have broadband connections.[8]

The main data exchange between fire stations is written management reports that are re-entered in the computer for archival purposes. Reports are written at the fire stations and loaded to the records management system using File Transfer Protocol (FTP) over the Internet, or hand delivered on media disks (floppy drives, CDs, flash drives). Once a month, the County's reports are sent to the State of Pennsylvania for addition to their database. Data connectivity and universal broadband access reduces the time spent entering reports into the system and the lag time between date of occurrence and entry into the state database.

The Fire Service also needs data connectivity to enable remote access, including access from fire stations, to the Computer Aided Dispatch (CAD) system and mapping software located at the 911 Center. Access to these systems enables first responders in-the-field to access critical dispatch data to supplement information received over voice communications. Increased connectivity also provides the opportunity to install Mobile Data Terminals (MDTs) in Fire and EMS vehicles for wireless remote access to the 911 Center and its databases.

2.1.2 Warren Public Safety Dispatch

2.1.2.1 Existing Dispatch

The Warren County 911 Center runs the Public Safety Answering Point (PSAP) from the County Sheriff's Office. The 911 Center dispatches police, fire, and EMS personnel using Computer Aided Dispatch (CAD) software. The CAD system also includes a records management system that maintains a database of incident reports. The 911 Center operates a geographic information system (GIS) based mapping software to display incident locations based on information from the CAD system.

The 911 Center works closely with public safety officials in neighboring jurisdictions. Fire and EMS vehicles are often dispatched to other jurisdictions under mutual aid agreements. Currently communications between jurisdictions occurs over the public safety radio system or the PSTN. All communication is voice-based with no ability to exchange written data using the Internet. A critical need of the 911 Center is Enhanced 911 (E911). E911 provides the PSAP with location information for callers not on the PSTN, namely cellular phones and VoIP. 911 Center staff desire expanding GIS, CAD, and mapping system to include more information, such as fire

[8] CTC interviewed Rich Barrett, Warren Fire Service.

hydrant and hazardous materials locations. Remote access disseminates this vital information to the fire stations and emergency vehicles in-the-field.

2.1.2.1.1 911 Center Upgrade

To improve response to public safety calls and implement advanced public safety features such as E911 and improved public safety radio, this May, the County is moving the 911 Center from the Warren County Sheriff's Office to the Rouse Building. Although PSAP operations will change, not all public safety features and functions are relocating to the new 911 Center.

Ideally the County wants redundant services between the County Courthouse and the new 911 Center. The County is exploring leasing a 100 Mbps Transparent LAN Service (TLS) circuit from the County Courthouse to the new 911 Center.

The Commonwealth places their connection to the State's databases at one location in the County. The County has to provide backhaul from the County Courthouse back to the 911 Center for access from the 911 Center to the State and Federal criminal databases.

The major needs for public safety connectivity are connections to local Police Departments, Sheriff's Office, Fire Departments, Forest Service, State Departments, County Jail and connectivity from the public safety radio towers to the PSAP. The City of Warren and the Sheriff's records management system is very bandwidth intensive and needs a high capacity connection to the new 911 Center.

2.1.2.2 Public Safety Radio

The County operates six radio tower sites for the low band VHF and UHF public safety radio system. Equipment is located at Stone Hill, Watson, Stillson Hill, Cobley's, Jake's Run, and the Sheffield Cable TV tower. There are also repeaters to improve coverage. The radio sites receive connectivity either through copper pairs (circuits) or point–to-point microwave.

Currently the County's public radio system does not have remote system monitoring capabilities. The public safety personnel consider system monitoring a critical feature for [9]managing and maintaining the radio system.

The public safety radio system covers approximately 30 percent to 40 percent of the area. The limitations in the system are attributed to the geography of the County, lack of available towers and lack of funds for additional radio equipment and towers. Several additional locations for additional towers are identified; however, there is no funding for the expansion.

The regional EMS provider, EMMCO West performed a propagation study for the Northwest PA region. They identified a need for new towers at: Scandia,[10] Tidioute and Grand Valley Route

[10] The recommended tower at Scandia haw been installed.

27 corridor near Tionesta. Coverage will never reach 100 percent due to the proximity of Allegheny National Forest. The recently installed Scandia/Fitzsimmons Tower provides improved coverage for the Kinzua Beach area. Public Safety personnel report that there is very little other land in the Kinzua Beach area to build a tower.

When the County performed their licensing for the public safety radio system, each site was licensed for an abundance of frequencies. This allows the County to quickly add radio equipment without the need for frequency coordination and license approval.

Public Safety personnel stated that it difficult to envision transitioning to 800 MHz. The cost of upgrading from the current system to 800 MHz is substantial and equipment-related factors such as line-of-sight requirements add to the complexity of the project.

2.2 Non-County Agencies

2.2.1 Hospitals and Medical Facilities

Hospitals nationwide are seeking to fulfill increasing data communications needs in a cost-effective manner. A secure network providing seamless access and sharing of data between medical agencies is critical.

Telemedicine is revolutionizing the medical field; however, it requires transmission of large images and files. Magnetic Resonance Imaging (MRI) files are a minimum of one to two Giga Byte (GB) files and multi-slice Computed Axial Tomography (CAT) scan files exceed 20 GB.

Many hospitals are implementing remote diagnosis from the hospital to a clinic or physician's office and to coordination of pharmaceutical needs between physicians, hospitals and pharmacies. These services require substantial bandwidth over a secure network. Radiology, out-patient clinics, long-term care facilities and rural medical centers could use secure fiber connectivity to support remote diagnostics and sharing of patient files.

2.2.2 Northwest Commission

The Northwest Commission is a local Development District serving an eight-County region of Northwest Pennsylvania. One of the strategic goals adopted by the Commission is to promote high quality, affordable telecommunications infrastructure to foster future economic and community development and job creation/retention across the region. The Commission works with the region's Technology Advisory Group (TAG) and County broadband task forces to aggregate broadband demand in underserved rural communities.[11]

The bi-monthly Technology Advisory Group (TAG) meetings work to attract affordable broadband service and assist with local government Internet connections. The Commission also hopes to encourage the region to increase the use of GIS/GPS tools.

[11] CTC interviewed Chris Beichner, Director Community Development and Planning.

One of the issues the commission ahs identified is the lack of "last mile connectivity" to support the needs of the residences and businesses. Further, the commission has encountered difficulty in encouraging investment since a given single user does not have enough demand to justify the required investment. To assist in justifying the investment aggregation of demand is required.

2.2.3 Pennsylvania Department of Conservation and Natural Resources (DCNR)

The DCNR launched Pennsylvania Wilds (PA Wilds) a major conservation and tourism project in the 12-County north central region of Pennsylvania. The project involves the Commonwealth, local municipalities, tourism industries, and the Allegheny National Forest. A major goal of PA Wilds is to promote the region as an ideal tourism area for conservationists and nature enthusiasts. Warren County is an active participant in the PA Wilds project.

Part of the PA Wilds project is promoting economic development in the Counties that make up the Wilds. Communications infrastructure is seen as a critical component of tourism and economic development. The PA Wilds has initiated a communications study that focuses on communications planning for the region.[12]

2.2.4 Pennsylvania Emergency Management (PEMA)

PEMA is agency responsible for assisting and helping fund Commonwealth 911 Centers. They reported that there are approximately 70,000 VoIP subscribers in the Commonwealth and that many of those subscribers are not completely E-911 functional. A similar problem occurs with satellite phones. PEMA is working to deploy E-911 in all jurisdictions in Pennsylvania. The completion of the 911 "addressing phase" is scheduled for this year. Addressing is one component of updating the 911 Center for compatibility with E-911. Standards-based addressing assists in relaying mapping and addressing information to other jurisdictions. PEMA also reports that the cellular providers feel the cellular demand and market in rural areas is too little to justify the expense of adding additional coverage.

2.2.5 Pennsylvania Office of Public-Safety Radio Services

Beginning in 1996, the Commonwealth of Pennsylvania began deploying a statewide 800 MHz public safety radio system. The increased awareness of public safety over the past five years had lead to the expansion of the public safety radio program that includes a mandate from the Governor for 95 percent coverage within each County. The Commonwealth partnered with First Energy to deploy a radio system capable of supporting both entities. This agreement provides the Commonwealth with space on First Energy's towers, installation of radio equipment in the right of way and power for radio equipment deployment.

[12] CTC met with Michael Krempasky, DCNR and Dan Glotz, County Planning and Zoning Director.

The program was initiated in heavily populated areas of Pennsylvania. The Commonwealth initially constructed or used existing 150 foot to 300 foot towers, also known as high profile towers, to provide coverage over a large area. This concept worked particularly well in the southeastern portion of the Commonwealth, where the terrain provided coverage over a large area with a single tower. The Commonwealth controls about 50 percent of the approximately 200 high profile towers that they use. The other towers belong to other Commonwealth agencies, local jurisdictions, or third party providers. In many instances, the Commonwealth partnered with local governments to collocate 800 MHz radio equipment on towers. These collocation agreements are on a tower by tower basis. In general, the Commonwealth does not permit cellular carriers or other third party entities to use their towers. The justification for not allowing other entities on their towers is to reserve tower space for future public safety needs and decrease the complexity of tower management.

As the public safety radio system has expanded out to the Northwestern Pennsylvania, the geography changed the method of deployment needed to provide optimal coverage. The Commonwealth has started looking at leasing space on existing third party provider towers as well as deploying 140-foot monopole towers to meet new needs.

2.2.5.1 Warren County 800 MHz Deployment

The planned 800 MHz deployment uses a mix of high profile and low profile towers to provide the majority of the coverage needed. As of September 2006, the Commonwealth estimates approximately 50 percent operational coverage in Warren County. The Commonwealth operates three high profile towers in Pittsfield, Youngsville and the Kinzua Dam. The State Police plan to continue use of the existing VHF radio system until the 800 MHz system is fully deployed and tested in Warren County.

The high profile tower sites are designed for 24-hour runtime Uninterrupted Power Supply (UPS) and a seven-day runtime generator. Point-to-point microwave links provide backhaul for the high profile towers.

The Commonwealth plans to deploy 800 MHz radio equipment at approximately five more existing high profile towers within Warren County. The majority of the sites are third party tower leasers such as American Tower and SBA properties.

The Commonwealth intends to use “micro cells” to provide localized coverage in difficult to cover areas. These micro cells are attached to 80 foot utility poles and provide pocket coverage. The micro cells are attached to the tops of the utility poles that are installed and powered through an agreement with First Energy. The cells communicate back to the base stations located at the high profile towers through a leased data connection or unlicensed wireless Ethernet.

Through other rural deployments, the Commonwealth has found that the 95 percent coverage mandate leaves portions of major roadways uncovered due to mountain terrain and the serpentine nature of the roadways. Public Safety believes that the state mandate needs to be modified so that the 95 percent coverage applies to roadways in the Northern rural counties.

The Commonwealth uses preexisting contracts for radio, microwave and backhaul for the public safety radio system. These contracts are available to the County through the Commonwealth's Department of General Services. Unfortunately, a microwave backhaul of public safety radio towers is not eligible for funding out of the Commonwealth 911 fund.

2.2.5.2 Commonwealth Plans for Future Connectivity

Once the public safety radio system is fully implemented and tested in each jurisdiction, the Commonwealth plans to switch the State Police and other organizations over to the new radio system. Lancaster County is the first County where the State Police have switched to the 800 MHz radio system.

The Commonwealth is also exploring using the point-to-point microwave system implemented for backhaul for the public safety radio system as method for data connectivity to support various state and local connectivity needs.

2.2.6 Warren County Chamber of Business and Industry

Among the areas the Chamber is focusing on for 2007 is redevelopment of Brokenstraw Area Industrial Park, expansion of rail/freight service and tourism attraction initiatives. These areas of focus tie into building communications infrastructure by providing new business with access to expected levels of connectivity and by addressing existing businesses' growing communications needs.

Warren is experiencing an explosion in growth. Wal-Mart and Lowells are opening stores and restaurants have announced plans to locate to the City. Other potential new businesses are: a hotel and shopping strip mall.[13]

Warren General Hospital is opening a new ambulatory surgery center. Services offered at the new center include: general surgery, orthopedics, endoscopy and podiatry. It is being built on a 98 acre parcel that in the future may include assisted living and independent senior housing.

Communications needs are difficult to quantify; however, it is reasonable to conclude that the demand for connectivity is rapidly rising. This is particularly the case with more health care uses being developed and new and existing businesses seeking Voice over Internet Protocol (VoIP) services. New developments need connectivity. While connectivity options are expanding the progress is slow. A significant need exists; and this need is not being met by current providers. People migrating from urban areas expect access to high bandwidth. Level 3 is hoping to fulfill business needs with the roll out of their new service and perhaps in the future they can also offer a retail model to fill connectivity gaps in this area.

[13] CTC interviewed Jim Decker, CEO Warren County Chamber of Business and Industry.

2.2.7 Warren County Electric Cooperative

Formed in 1939 to bring electricity to Warren County, Warren County Electric Cooperative passes 9,000 homes in Northwestern Pennsylvania. The Cooperative foresees several applications that benefit from increased connectivity including: electric system load monitoring; automatic meter reading; Supervisory Control and Data Acquisition (SCADA); communications backhaul; and remote monitoring and switching.

2.2.8 Warren Library Association

The Warren County Library Association operates five public libraries within the County. The main branch is located in Warren with four other branches in Sheffield, Sugar Grove, Tidioute, and Youngsville. The Library Association leases a wireless T1 Internet connection from West PA.Net to the Warren Branch. For connectivity to the other branches, the Library Association leases frame relay circuits from Verizon. The Library is exploring receiving last mile connectivity from West PA.Net. Youngsville TV Corporation and the Youngsville Library have access to cable modem service and receive free cable television from the cable company. The Library Association received a grant from the Bill and Melinda Gates Foundation to purchase the networking equipment to connect the libraries.

Applications over the frame relay system include Internet access, a digital catalog system, virus updates, and web filtering. The Library Association desires expanded connectivity and applications, but higher bandwidth circuits are too costly for the Association and there is a lack of alternatives for connectivity. The Library Association is interested in high speed connectivity to all of its branches. [14] The Association also has expressed an interest in using the libraries as a location where citizens can use broadband connectivity for distance learning and other educational applications.

2.2.9 Warren School District

The Warren School District is responsible for public education in the majority of Warren County. The School District is currently operating a 768 kbps frame relay network to connect each of the District's schools back to the District for database and Internet access. The school has a six Mbps Internet connection.

Using educational funding, the School District released an RFP for upgraded network connectivity between facilities. WestPA.Net received the contract and is constructing a 53 mile fiber optic network that provides 100 Mbps connectivity to 13 School facilities. The School District is also upgrading their Internet connection to 10 Mbps. WestPA.Net will manage the 100 Mbps connections, the Internet connection and the fiber optic network. The School District plans to apply for E-rate funding to supplement the cost of management and maintenance of the

[14] CTC met Barbara Tracey, IT Manager.

network.[15] The school needs high speed connectivity to offer digital-based learning programs including distance-learning and electronic sharing of materials between schools.

2.2.10 Warren County Visitor's Bureau

The Visitor's Bureau is charged with promoting tourism within the County. In their 2006 Comprehensive Plan the Bureau includes comments by a firm that they commissioned to study tourism needs. The Report discussed the lack of broadband connectivity. They report that Warren County's tourism businesses must have access to broadband connectivity in order to compete in the modern tourist economy.

Excerpt from Warren County Comprehensive Plan, Tourism & Character of Pace, 2006 Report, "…First, Warren County's tourism businesses themselves must have access to broadband connectivity in order to compete in the modern tourist economy. Second, visitors must know that if they wish to or must they can make a cell phone call, check email on a portable device, or get on the Internet to access and exchange data. We have heard the argument that if the attractiveness of places like Warren County, or the Pennsylvania Wilds, lies in large part in their unspoiled natural character and isolation, then it is perfectly appropriate for those places to be outside the reach of modern communications, which is even seen by some as an undesirable intrusion into the peacefulness of the place. But that point of view is radically out-of-step with reality, and it drastically limits the attractiveness of a place if connectivity is not available.…"

The Bureau believes that a lack of cellular communications in the County negatively affects tourism. The Visitor's Bureau sees cellular coverage as a necessity for both today's business and recreational traveler.[16]

Many of the members of the Visitor's Bureau do not have broadband Internet access at their establishments; although some are migrating to use of the Internet for reservations and other e-commerce applications.

The Visitor's Bureau reports a lack of connectivity in the wire line broadband industry in Warren County. The Visitor's Center sits on a major route through Warren County just outside the City of Warren; however, is not able to receive DSL service. The Visitor's Center uses an expensive fractional T1 connection to receive broadband Internet service.

[15] CTC met with Amy Stewart, Director of Technology.

[16] CTC met with Diane Shawley, Executive Director.

3. Connectivity Assessment by Market and Technology

This section of the Report provides an overview of available voice, video, and data services in Warren County, and a comparison of costs and technical capacity of the provider's systems.

In evaluating the broadband market, it is not sufficient to just consider current services and demand. The providers' capacity to improve their networks and products, as well as the providers' commitment to meet expanding needs for performance, mobility, and reliability are important parts of the equation.

Based on CTC discussions with providers, the availability of cable modem and DSL service in Warren County is similar to many communities across the nation. DSL has availability gaps[17] in many areas, and while cable modem service is available to most residents in the larger communities, it is not always available for businesses.[18]

Many businesses and public entities rely on point-to-point connectivity, such as T1 lines to support bandwidth needs. There is a growing demand for new services to fill the need for greater bandwidth and speed. Large users are forced to connect 100 Mbps Local Area Networks (LAN) together with expensive 1.5 Mbps T1[19] circuits. The limited performance of the T1 circuits restricts the types of applications these organizations can deploy. When the providers are asked for larger capacity circuits, often they either claim that they are not available or the price they propose is exorbitant.[20] The interviews conducted by CTC confirm this situation in Warren County. In addition, Verizon does not lease dark fiber within Warren County. Youngsville Cable TV Corp. will lease dark fiber; but it has a limited footprint.

We also find that sometimes availability and performance gaps are perceived rather than real. In some cases, business and residences report that their Internet connection for downloading and uploading data files is not fast enough. Sometimes it is the application that causes the bottleneck rather than the speed of their Internet service. A file size limit on their email service can delay or deny a transfer of an email. Education regarding options for data and file transfer often alleviates perceived performance issues.

[17] DSL coverage is difficult to project for a given location. A residence or business could be in an area where DSL is offered but is not available at their location due to the quality of the existing circuit or all DSL capacity is allocated.

[18] In most communities, the cable provider has concentrated on providing residential cable modem service, and has not made business services a priority.

[19] The cost of T1 circuits can exceed $500 per month, two to three times more than urban regions.

[20] Verizon reports availability of a switched Ethernet service which provides 10 Mbps, 100 Mbps, and 1 Gbps connectivity speeds. The service starts at $1,200 per month for 10 Mbps, $2,400 per month for 100 Mbps, and $4,000 per month for 1 Gbps. In addition, the customer is responsible for construction costs to build fiber from Verizon facilities to their premises.

3.1 The County Lacks Competition in Provision of Broadband "Pipe"

It is important to distinguish between "pipe" and "services." These two distinct categories are frequently lumped together. "Pipe" or "broadband network" refers to the medium over which one sends and receives information over the Internet or private networks. "Services" are the various types of voice, video, and data transmissions that one can send or receive, such as Voice over IP from Vonage; email from Yahoo; and streaming video from Disney. It is helpful to visualize "pipe" as the "Information Superhighway" and to view "services" as vehicles. Without the road, the cars are useless.

The current American market precludes true broadband competition because of the impracticability of constructing multiple broadband networks. While in many areas there is significant competition in provision of programming and services there is not enough competition in provision of "pipe." In a context in which network owners have been permitted by the Federal Communications Commission (FCC) and the courts to "close" their networks to competition,[21] competitors can reach customers only by building their own facilities. The prohibitive cost precludes emergence of multiple competitors. In a best case scenario the result is a broadband monopoly or duopoly of incumbent cable and telephone companies. However, in a rural or less-populated area even this scenario is not practical.

Even using this closed model, the incumbents do not plan to build or upgrade their networks in Warren County. At best, these incumbent providers will move incrementally to expand capacity, but they are constrained in their investment by the high cost and the relatively low immediate return-on-investment.

3.2 Existing Networks Do Not Meet All Broadband Needs

Incumbent communications carriers offer a number of products in parts of Warren County that meet the FCC's definition of "broadband" or "high speed." The FCC defines "high-speed" as "connections that deliver services at speeds exceeding 200 kilobits per second (kbps) in at least one direction." The FCC defines "advanced services" as "connections that deliver services at speeds exceeding 200 kbps in both directions."[22] These definitions are inadequate and widely rejected – for example, broadcast quality streaming video requires at least 700Mbps - 2 ½ times greater than the FCC definition.

Even accepting the FCC's definition, it is clear that such speeds present problems for many broadband users. Most mass-market broadband products offer reasonable download speeds but

[21] Under recent rulings, the owners of DSL, cable broadband, and FTTP systems have been permitted to close their networks to competitors – a departure from the common carrier rules under which the telephone networks have long operated and under which numerous competitive Internet Service Providers (ISPs) offered service over dial-up modems. As a result, many of these ISPs have ceased to offer Internet service – because they cannot access the distribution networks, at any price.

[22] "Federal Communications Commission Releases Data on High-Speed Services for Internet Access," FCC Website, http://www.fcc.gov/Bureaus/Common_Carrier/Reports/FCC-State_Link/IAD/hspd0705.pdf, accessed October 3, 2005.

much slower upload speeds. This asymmetry makes it very hard for a business or home-office to function adequately because it is difficult to send large files or conduct video-conferencing. The asymmetry suits the providers because it offers the opportunity to sell a higher-priced service for businesses desiring increased capacity. Asymmetrical speeds are functional only for those consumers who primarily use their broadband connection to download information or stream video.

3.2.1 The Cable Companies

Atlantic Cable, Armstrong Cable, and WestPA.net (through Youngsville Cable TV) offer cable services to parts of Warren County.

The cable company traditionally has serviced the residential market and has a very limited footprint with respect to the business areas of the County. Their limited commercial impact has not made an appreciable competitive impact on the availability or price of higher quality and higher speed broadband products for business. In addition, the cable television companies generally do not serve the smaller communities or rural residents.

3.2.2 The Telephone Company

Verizon is the incumbent local exchange carrier in Warren County. They offer Digital Subscriber Line (DSL) services to some portions of the County.

DSL represents a relatively low-bandwidth form of broadband — a network of roads, not superhighways. DSL runs on telephone network copper wires that cannot handle the same capacity as fiber. As capacity requirements increase, DSL is likely to fall further behind cable modem.

Verizon offers a suitable Ethernet service offering connectivity speeds up to 1 Gbps.[23] Unfortunately, the service has a limited footprint and the monthly recurring fees are cost prohibitive for most businesses.

3.2.3 Satellite Services

In many areas of Warren County, satellite service is the only broadband option. Satellite technology is a competitor for delivery of one-way video, radio, email and web browsing, but it is significantly inferior to cable modem or DSL service for interactive services. Satellite broadband exhibits latency and delay issues that make interactive services such as Voice-over-Internet Protocol (VoIP) difficult.

[23] Verizon reports availability of a switched Ethernet service which provides 10 Mbps, 100 Mbps, and 1 Gbps connectivity speeds. The service starts at $1,200 per month for 10 Mbps, $2,400 per month for 100 Mbps, and $4,000 per month for 1 Gbps. In addition, the customer is responsible for construction costs to build fiber from Verizon facilities to their premises.

3.2.4 Summary of Available Services

In Table 3-1 and Table 3-2, we provide a summary of cable modem, DSL, wireless, and satellite services for residential users.

Table 3-1: Residential Cable and DSL Services

Common Provider	Cable			DSL
	Atlantic Cable	Armstrong Cable	WestPA.net (Through Youngsville Cable TV)	Verizon
Broadcast Video	Yes	Yes	Yes	No
High Speed Data Download Rate/Upload Rate	Up to 5Mbps/512Kbps	Up to 10.0 Mbps/ 1.5 Mbps	Up to 1.4 Mbps/400Kbps	Up to 3 Mbps/768 Kbps
Data Pricing (Residential)	Up to 320Kbps/320Kbps: $22.95-$29.95, Up to 3Mbps/320Kbps: $34.95-$45.95, Up to 5Mbps/512Kbps: $44.95-$55.95	256 Kbps/256 Kbps: $26.95, 5 Mbps/512 Kbps: $39.95, 10 Mbps/1.5 Mbps: 59.95	450 kbps/100 kbps: $32.00, 700 Kbps/200 Kbps: $42.00, 900 Kbps/300 Kbps: $62.00, 1.4 Mbps/400 Kbps: $82.00	$14.95 for 768 Kbps/128 Kbps, $29.95 for 3 Mbps/ 768 Kbps
"Always On"	Yes	Yes	Yes	Yes
Network	HFC	HFC	HFC	DSL
Infrastructure Needed	Hybrid Fiber-Coaxial Cable, Coaxial wiring indoors.	Hybrid Fiber-Coaxial Cable, Coaxial wiring indoors.	Hybrid Fiber-Coaxial Cable, Coaxial wiring indoors.	Proximity to Central Office, Twisted Pair Wiring Indoors
Mobile Use	No	No	No	No
Voice	No	No	No	Verizon Telephony
Home Network	Yes	Yes	Yes	Yes
Video On Demand	No	No	No	No
Widely Availability	Partial Coverage of Warren County	Partial Coverage of Warren County	Partial Coverage of Warren County	Partial Coverage of Warren County

Table 3-2: Residential Wireless and Satellite Services

Common Provider	Wireless Broadband	Satellite		
	WestPA.net	**Hughes and DirecTV (formerly DirecWay**)**	**EarthLink**	**Megapath**
Broadcast Video	No	Yes	No	No
High Speed Data Download Rate/Upload Rate	Up to 4096 Kbps/4096 Kbps	Up to 1.5 Mbps/200 Kbps	Up to 1.5 Mbps/128 Kbps	Up to 1 Mbps/192 Kbps
Data Pricing (Residential)	Up to 256 Kbps/96 Kbps: $23.95, Up to 512 Kbps/256 Kbps: $33.95, Up to 768 Kbps/384 Kbps: $43.95, Up to 1024 Kbps/192 Kbps(dedicated): $80.00, Up to 4096 Kbps/4096 Kbps (dedicated): varies	$59.99 for home (700 Kbps/128 Kbps), $69.99 for professional (1 Mbps/200 Kbps), $79.99 for proplus (1.5 Mbps/200 Kbps)	$69.99 for 1.5 Mbps/128 Kbps	150 Kbps/64 Kbps: $94.95, 500 Kbps/128 Kbps: $149.95, 1.0 Mbps/192 Kbps: $249.95
"Always On"	Yes	Yes	Yes	Yes
Network	Wireless Ethernet	Satellite	Satellite	Satellite
Infrastructure Needed	Near line of sight to wireless Ethernet antenna	Need clear line of sight to the South, Satellite dish for DirecWay HSD	Need clear line of sight to the South, Satellite dish for DirecWay HSD	Need clear line of sight to the South, Satellite dish for DirecWay HSD
Mobile Use	No	No	No	No
Voice	No	No	No	No
Home Network	Yes	Yes	Yes	Yes
Video On Demand	No	Yes, and Digital Video Recorder is offered	No	No
Widely Available	Partial Coverage of Warren County	Virtually all Warren County is covered	Virtually all Warren County is covered	Virtually all Warren County is covered

Table 3-3: Business Cable Modem Services

Common Provider	Cable		
	Atlantic Cable	**Armstrong Cable**	**WestPA.net (through Youngsville Cable TV)**
High Speed Data Download Rate/Upload Rate	Up to 5 Mbps/ 512Kbps	Not Listed	Up to 1400 Kbps/ 400 Kbps
Pricing (Commercial)	Up to 320 Kbps/ 320 Kbps: $22.95-$29.95, Up to 3 Mbps/320 Kbps: $34.95-$45.95, Up to 5 Mbps/512 Kbps: $44.95-$55.95	Not Listed	450 Kbps/100 Kbps: $32.00, 700 Kbps/200 Kbps: $42.00, 900 kbps/300 Kbps: $62.00, 1.4 Mbps/400 Kbps: $82.00
"Always On"	Yes	Yes	Yes
Network	HFC	HFC	HFC
Infrastructure Needed	Hybrid Fiber-Coaxial Cable, Coaxial wiring indoors.	Hybrid Fiber-Coaxial Cable, Coaxial wiring indoors.	Hybrid Fiber-Coaxial Cable, Coaxial wiring indoors.
Mobile Use	No	No	No
Voice	No	Few Areas	Not Listed
Video On Demand	Yes	Yes	Not Listed
Widely Available	Partial Coverage in Warren County	Partial Coverage in Warren County	For Warren County

In Table 3-3 through 3-6, we listed available data services for Warren County businesses. Please note that with the exception of schedule, these services are only available in populated areas.

Table 3-4: Business Ethernet, T1, and DSL Services

	Dedicated Ethernet	T1	DSL
Common Provider	**Fisk Internet Services**	**Fisk Internet Services**	**Verizon**
High Speed Data Download Rate/Upload Rate	Up to 10 Mbps Dedicated	~1.5 Mbps	Up to 3 Mbps/768 Kbps
Pricing (Commercial)	Quote Required	Listed as "Price Protected Rate"	768 Kbps/128 Kbps: $24.95, 3 Mbps/768 Kbps: $39.95 (dynamic IP) $79.95 (static IP), 7.1 Mbps/768 Kbps: 149.95
"Always On"	Yes	Yes	Yes
Network	Fiber or Copper	T1	DSL
Infrastructure Needed	10 Mbps Fiber Backbone (Ethernet handoff)	Private Leased T1 Line	Proximity to Central Office, Twisted Pair Wiring Indoors
Mobile Use	No	No	No
Voice	Yes	Yes	Verizon Telephony
Video On Demand	No	No	No
Widely Available	In Pa	In PA	Yes

Table 3-5: Business Wireless Services

Common Provider	Wireless Broadband	
	Fisk Internet Services	**WestPA.net**
High Speed Data Download Rate/Upload Rate	Up to 512 Kbps/512 Kbps	Up to 4096 Kbps/4096 Kbps
Pricing (Commercial)	Quote Required	256 Kbps/96 Kbps: 23.95, 512 Kbps/256 Kbps: $33.95, 768 Kbps/384 kbps: 43.95, 1024 kbps/192 Kbps(dedicated): $80.00, 4096 Kbps/4096 Kbps (dedicated): varies
"Always On"	Yes	Yes
Network		
Infrastructure Needed	"No telecom loop, wireless to Ethernet handoff"	
Mobile Use		No
Voice	Yes	
Video On Demand	No	No
Widely Available	Partial Coverage in Warren County	Partial Coverage in Warren County

Table 3-6: Business Satellite Services

Common Provider	Satellite		
	Hughes and DirecTV (formerly DirecWay)	**EarthLink**	**Megapath**
High Speed Data Download Rate/Upload Rate	Up to 1.5 Mbps/200 Kbps	Up to 1.5 Mbps/128 Kbps	Up to 1 Mbps/192 Kbps
Pricing (Commercial)	$59.99 for home (700 Kbps/128 Kbps), $69.99 for professional (1 Mbps/200 Kbps), $79.99 for proplus (1.5 Mbps/200 Kbps)	69.99 for 1.5 Mbps/128 Kbps	150 kbps/64 Kbps: $94.95, 500 Kbps/128 kbps: $149.95, 1.0 Mbps/192 Kbps: $249.95
"Always On"	Yes	Yes	Yes
Network	Satellite	Satellite	Satellite
Infrastructure Needed	Need clear line of sight to the South, Satellite dish for DirecWay HSD	Need clear line of sight to the South, Satellite dish for DirecWay HSD	Need clear line of sight to the South, Satellite dish for DirecWay HSD
Mobile Use	No	No	No
Voice	No	No	No
Video On Demand	DVR is offered		
Widely Available	Yes	Yes	Yes

3.3 Connectivity Provider Summary

3.3.1 Verizon

Verizon announced that they plan to deploy Fiber-to-the-Premises (FTTP) to the Pittsburgh area; however, this fiber network is not currently scheduled for Warren County anytime in the immediate future.

According to Verizon, they have approximately 175 strand miles of fiber optic plant within the County. The strand miles do not include additional fiber optic links through the County that Verizon uses for additional redundancy. Verizon stated that their fiber optic footprint covers most of the County.

In areas such as the Kinzua Beach, Verizon has fiber optic cable in the vicinity and also has an OC-3 multiplexer. The Pennsylvania Public Utilities Commission defines tariff rates and Verizon adds additional charges for construction, special features and added redundancy.

Verizon also stated that their policy is to provide any service, where available, to any customer who requests the service. Services are obtained by calling the business office and requesting the type of service desired. The business office either quotes a price or, if the request is too complex, it is forwarded to other departments for their action. Once the quote is accepted and the order placed, Verizon works to provide user connectivity.

According to Verizon approximately 38 percent of the County is currently DSL-capable. Verizon has plans to increase the capability to 47 percent in the near future. Verizon reports that there are instances where a customer may reside in a DSL-capable area where DSL is not available due to capacity limitations. Verizon's policy is to increase capacity in those areas where DSL is not available rather than waiting for another subscriber to discontinue their DSL service to free up service. By 2015 Verizon plans to provide at least 1.54 Mbps downstream and 128 kbps upstream to every access line within Warren County.

Verizon reported that the Verizon map of DSL coverage can be misleading about the actual coverage area. The maps show DSL-capable Central Offices (CO); however, DSL coverage may not be available in the entire area serviced by the Central Office. Verizon offers a phone number lookup database for consumers to determine if their location is DSL-capable.

Verizon reports that there are six COs in Warren County:

- Grand Valley;
- Russell;
- Sugar Grove;
- Tidioute;
- Warren; and
- Youngsville.

Every Central Office is DSL-capable except for Grand Valley. Verizon plans to make Grand Valley DSL-capable in the near future.

Verizon's cellular broadband services are limited to those areas where subscribers receive RF coverage. The location of cellular towers is often dependent on population, usage density and traffic. Verizon does not offer EVDO data services in Warren County

3.3.2 West PA.Net

WestPA.Net is a local ISP that provides Internet access, website hosting, and other Information Technology (IT) related services. Their central office is located in Warren, although they offer services throughout the County. The majority of WestPA.Net residential customers use dial-up access to connect to the Internet. WestPA.Net also offers wireless T1 services to City of Warren businesses and cable modem service as part of a joint venture with Youngsville TV Corporation.

As part of a contract with the Warren School District, WestPA.net is deploying a fiber optic network that allows WestPA.Net to provide advanced network connectivity to other portions of Warren County. The planned fiber optic network runs from Warren to Sugar Grove, Russell, Youngsville, and Sheffield.

One of the biggest hurdles WestPA.Net experienced with the project was the cost and time associated with the make ready for fiber optic deployment. Make ready is the pole survey and physical work necessary to accommodate the additional cables on a utility pole. WestPA.Net found that the costs for make ready exceeded their budgetary estimates and the process to get the pole owners to complete pole upgrades was arduous. The high cost of pole attachment fees constrains WestPA.Net. According to them the cost for Penelec and Verizon pole attachments was about twice the cost of attaching to Warren Electric poles.

WestPA.Net mentioned that the lack of Internet connectivity within Warren County, translates to a higher cost for aggregated Internet access. WestPA.Net pays approximately $900 per month for a T1 connection to the Internet. According to WestPA.Net staff the Central Office (CO) in Warren is at or near its circuit capacity. They were unable to contract for a partial DS-3 circuit and were forced to lease more costly multiple T1 circuits instead.

WestPA.Net stated that Coudersport, Pennsylvania is the closest Internet point of presence (POP) to Warren County. An Internet POP is a location where large internet providers collocate and sell Internet access to smaller entities. Other regional POPs include Erie and State College.

3.3.3 Youngsville TV Corp

Youngsville TV Corporation operates a small cable system in Youngsville, PA. The corporation is a non-profit cable system serving Youngsville, Pittsfield, and Irvine. The cable system offers an analog channel line up and cable modem service in a joint venture with West PA.NET. The system has approximately 1200 cable subscribers and 200 data subscribers. The cable system is a hybrid fiber coaxial cable system that was rebuilt in 2001. Youngsville TV Corporation also leases dark fiber to several organizations in its service area.

Youngsville TV Corp offers four levels of cable modem service from 450 kbps to 1.2 Mbps downstream, 100 kbps to 400 kbps upstream respectively.

Youngsville TV Corporation’s cable system expansion plans are limited by three factors: the cost to build, low population density and high pole attachment rates.

3.3.4 Level 3

Level 3 began a project in November 2006 to investigate the potential for adding a ring to the Level 3 infrastructure from Coudersport to Erie along the Route 6 corridor. The projected route passes through Sheffield, Warren, and Youngsville. The potential design calls for a high count fiber optic backbone with smaller rings to serve the cities passed along the way. Level 3 envisions a local Sonet-based loop ring for Warren that serves larger businesses, government needs, cellular carriers, and ISPs in the area.

As part of their internal market and feasibility study, Level 3 is conducting meetings with potential bandwidth users in the region to determine the demand for additional network connectivity in Northwestern Pennsylvania. Level 3 explained new network deployment is based on reconciling the cost of constructing fiber with the demand for bandwidth.

Level 3 is currently working with local ISPs to negotiate partnerships as well as meeting with major corporations to secure potential bandwidth users.

3.3.5 Dobson Communications/Cellular One

Dobson Communications is one of the two widely deployed cellular communications companies within the County. Dobson specializes in rural communications markets and has deployed approximately 17 cell towers that provide coverage to Warren County.

Dobson partners with CellularOne to provide extended coverage and wireless voice and data services. Dobson uses GSM based cellular technology for both voice and data services.[24]

Dobson has an interest in expanding cellular coverage but states that the cost is prohibitive. They estimate that 10 additional towers (for a total of 27) are needed for complete County coverage. Dobson is willing to consider adding cell sites but will not construct towers on their own.

[24] Provides dial-up speeds, under 50 Kbps.

4. Existing Infrastructure and Assets

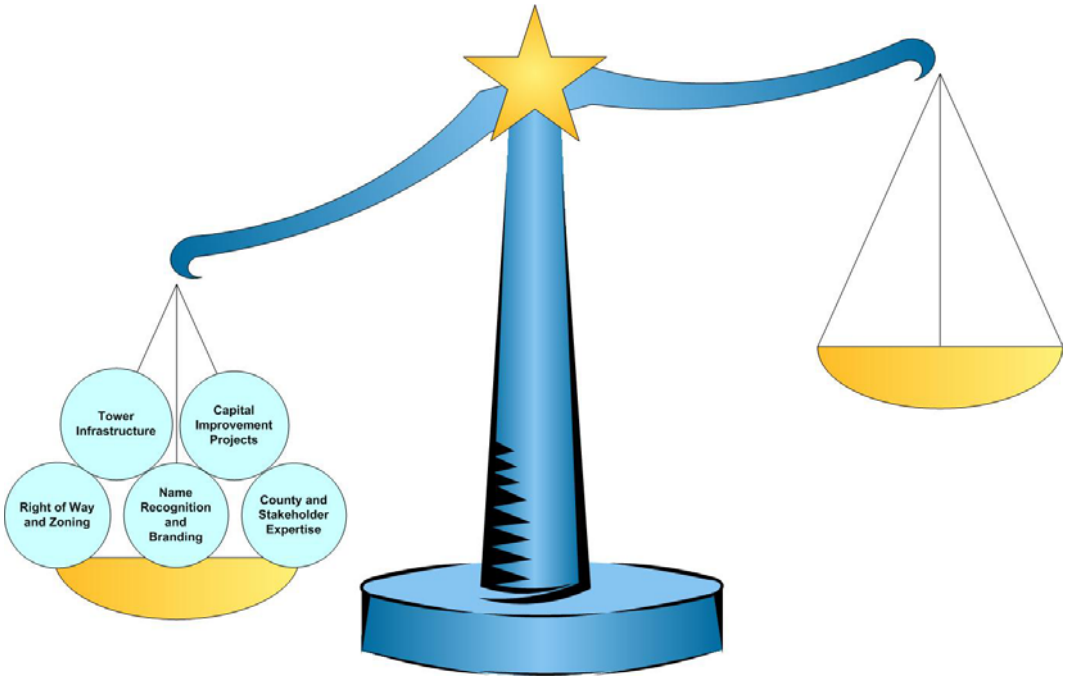
This section of the Report provides County decision-makers with suggested approaches and considerations that may encourage a private investment in Warren County. In particular, this section provides a discussion on how leveraging existing County assets improves financial projections for a County-wide communications backhaul deployment.

To help encourage investment, it is important to examine assets from a business perspective. These assets include any available community resource that increases operating margins by:

1. Reducing operating costs such as pole attachment fees, energy fees, customer acquisition, and maintenance.
2. Reducing the required investment to deploy the County-wide networks.
3. Increasing the number of anticipated consumers without lowering per customer margins.

This section also provides methods to explore leveraging assets. The examples are by no means an exhaustive list.

Figure 4-1: County and Stakeholder Communications Assets



4.1 Reducing Operating Costs

4.1.1 Reduce Customer Acquisition Costs

Name recognition and product branding are essential considerations when entering a new market place. Obtaining market recognition requires expensive advertising and marketing programs – a company whose name is not recognizable often spends hundreds of dollars – for a small monthly gross revenue stream. Warren County, through press releases, public education forums, and existing communication channels can substantially reduce the provider's cost of obtaining credibility and name recognition. Another consideration is to use County brand name or endorsement for the new service offering.

Promotion of rural digital inclusion efforts assists the provider in capturing market share. Other potential avenues include placing project information in mailings, newsletters, access channel and other citizen communications and providing access to water billing and other records which provide potential customer contact information. The County can also facilitate involvement with the Warren County Chamber of Business and Industry of Commerce, local real estate professionals and other private organizations and promote service availability with the Visitors and Convention Bureaus, and with entertainment and tourism venues.

4.1.2 County Staff Resources/Expertise

County personnel can leverage their experience with Warren County residents and businesses and relationships with municipalities to plan and guide a communications project. Staff's familiarity and working relationships with area agencies are huge assets to any deployment project.

In addition, the County and its stakeholders have extensive experience overseeing capital improvement projects such as utility installations, street repairs, and facility construction projects such as the new 911 Center. These skills and expertise are critical to ensuring that the needs of the County and its stakeholders are met.

4.1.3 Pole Attachments

The Warren County Electric Cooperative owns 16,000 poles and has over 1,000 miles of lines in their service area. The Cooperative recently completed make ready for WestPA.net's fiber optic network. Warren Electric estimates that it cost approximately $1,600 per pole for make ready on their poles. Approximately 40 percent of poles have no other attachments other than electric lines.

The Cooperative operates nine electric substations in Warren County. Warren Electric is currently using leased Verizon lines or unlicensed wireless microwave links. The microwave system provides seven T1 lines of capacity, of which the Coop is only using 1.5 lines. In the event of a power outage, each microwave site has battery and generator backup to maintain connectivity. To operate their microwave and radio communications network, the Cooperative

owns one 100-foot tower and leases space on another tower in the County. The Cooperative is currently using their data connectivity for backhaul for their radio system and status monitoring of their electric system.

If costs of fiber optic construction were shared by other organizations the Cooperative could deploy fiber to substations. Warren County Electric Cooperative expressed an interest in collaborating with the County on communication projects in a private public partnership. The Cooperative is piloting fiber optic connectivity to its substation in Pittsfield.

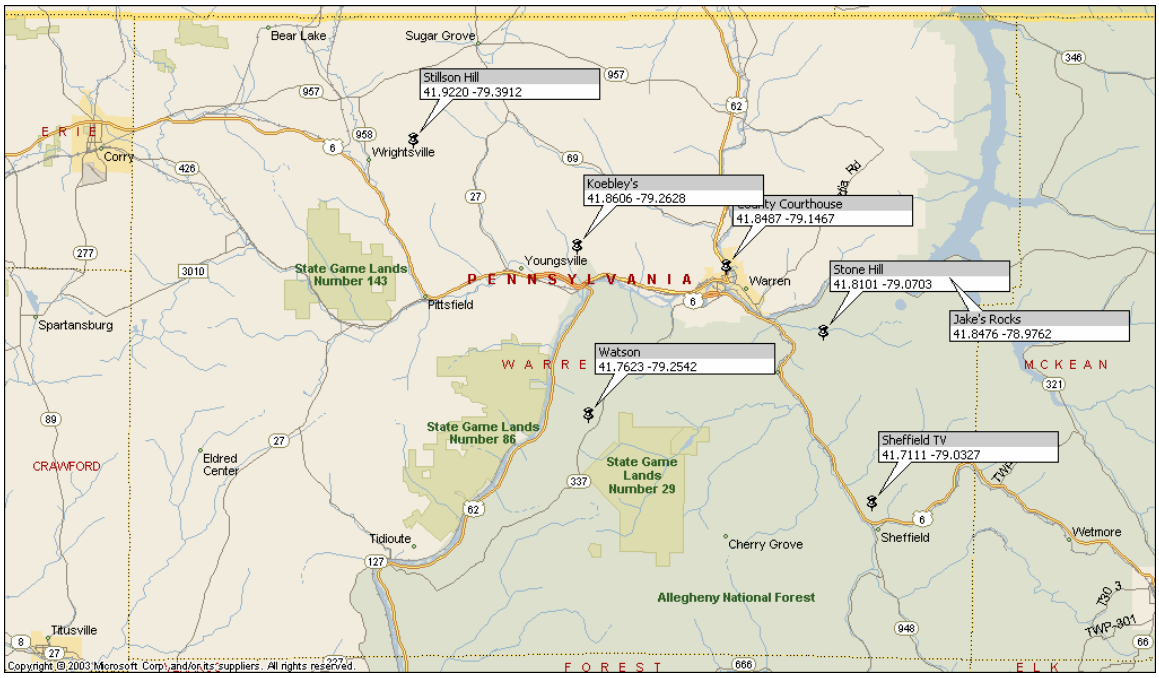
4.2 Reducing the Required Investment

4.2.1 Infrastructure

4.2.1.1 Towers

The County operates radio communications equipment at six towers within the County at Stone Hill, Watson, Stillson Hill, Koebley's, Jake's run, and the Sheffield Cable TV tower. Figure 4-2 depicts the County's public safety radio communication sites.

Figure 4-2: Existing Public Safety Radio Tower Locations



Jake's Rocks Tower has no access in the winter and no generator therefore it is classified as a summer only tower. The Forest Service used to have equipment at the Jake's Rocks tower site, but they have since removed their equipment.

With the exception of Jake's Rocks, the remaining sites are road accessible. All sites receive electrical power on aerial poles and are physically secured by locked fences or locked communications shelters.

4.2.1.2 Rights Of Way

The County has a zoning ordinance that covers 13 of the 27 municipalities. In the zoning ordinance, tower structures over 120 feet require a Special Exception to the zoning ordinance. All other tower structures are permitted provided they meet the requirements of the ordinance. The County Zoning staff stated that they have worked in the past with communications providers and other tower permit applicants to obtain the required zoning permits for tower deployment. CTC does not foresee zoning requirements as a hurdle to tower deployment within the County.

4.2.1.3 Planned Capitol Improvement Projects

The City of Warren is undertaking a Main Street beautification program. This project includes under grounding all utilities on Main Street. There may be an opportunity during the beautification program to install communications conduit for County/municipal use. The County is investigating a similar street beautification program for the downtown areas of Tidioute, Sheffield, Sugar Grove, and Youngsville.

Sheffield Township is also considering expanding the existing sewer system. This construction project provides the opportunity to install communications conduit during sewer system installation.

4.2.2 Access to Grants and Other Funding Mechanisms

Grants reduce the amount of financing required. Public partners bring access to different funding mechanisms to the table. Public Safety agencies have access to Federal and State Homeland Security Funds, while schools and libraries have access to both public funds and private foundation granting sources. County and Municipal entities have access to financing mechanisms such as Community Development grants, general obligation bonds and special assessment area funds.

4.3 Increasing Subscriber Participation

Hand-in-hand with efforts to reduce customer acquisition costs is increasing the size of the market (number of households acquiring services) and the market share (percent of total market using services).

Examples of increasing market size include: working with schools to encourage students to obtain access and with the Warren County Chamber of Business and Industry of Commerce and other agencies to encourage use of the service by all members.

5. Technical Blueprint for County-wide Communications Infrastructure

The following section provides a technical strategic guide for deploying communications infrastructure within Warren County. This guide is one part of an overall economic development and wireless communications enhancement strategy. The first part of this technical plan includes a system-level design for enhancing wireless communications infrastructure to increase public safety radio coverage and reduce the cost barriers for increasing commercial cellular coverage within the County.

The second part of the technical strategy includes a conceptual backbone fiber-optic communications network to provide connectivity for key County facilities, interconnect the wireless communications facilities, and reduce the cost for commercial and other non-governmental entities to provide services in the County.

5.1 Wireless Communications System Level Design

CTC suggests a two-pronged approach for enhancing wireless communications, comprised of:

- Construction of new public safety radio sites to eliminate existing broad coverage gaps within the County; and
- Construction of additional tower facilities to enable commercial carriers to improve their service coverage area with reduced costs for initial infrastructure.

5.1.1 Existing Wireless Communications Landscape

There is a significant need to expand the communications infrastructure in Warren County. Many geographic areas within the County, in particular Grand Valley, Kinzua Dam, Sheffield, and Tidioute, do not have public safety radio and cellular communications coverage. This lack of connectivity is a public safety risk that increases as more people enter the areas.

Residents, business people and visitors to the area rely on their cell phones for routine and emergency communications. In some areas, first responders must delay communicating with the County's public safety officials to request assistance because they are in an area without adequate communication infrastructure. Motorists involved in automobile accidents and "lost" travelers are forced to drive miles (often out of their way) before reaching a location where there is adequate communication access to place a call for assistance.

This section presents solutions to increase the availability of wireless communications facilities that are needed to support additional public safety radio and cellular equipment.

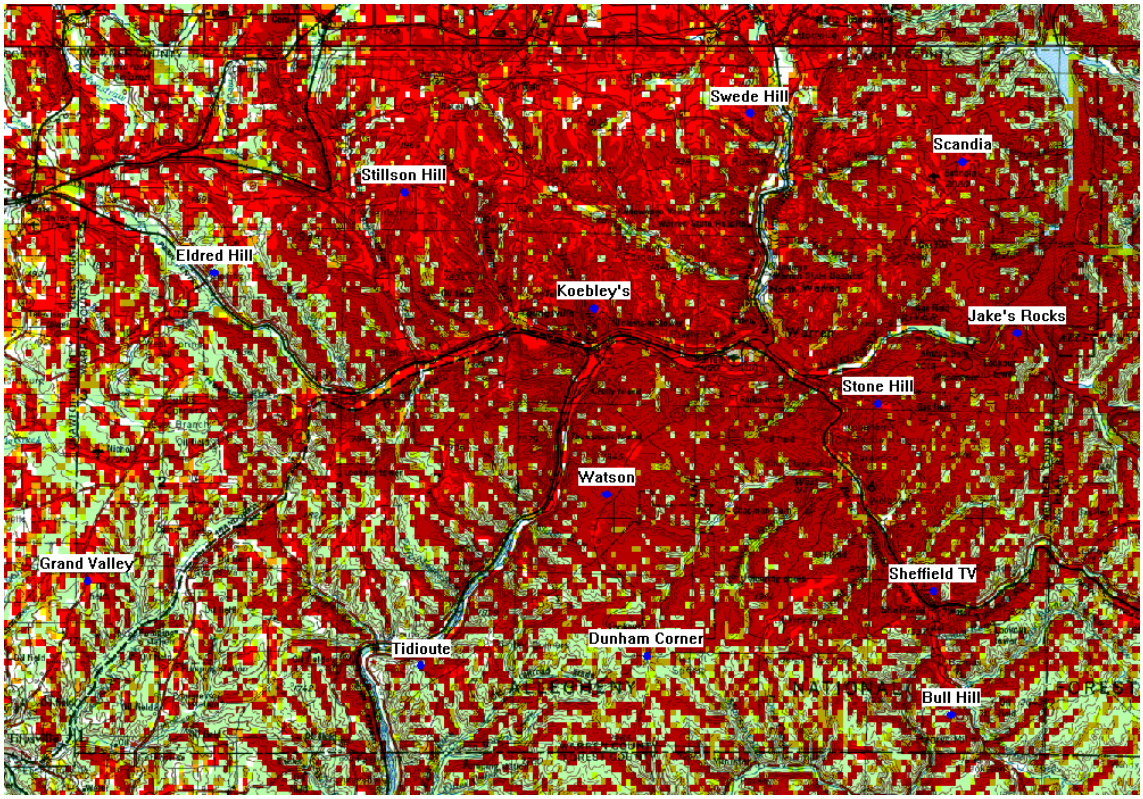
The recommended approaches are:

1. Increase public safety radio coverage with new public safety radio sites and upgrades to existing sites, and
2. Increase commercial wireless coverage with new commercial wireless sites, potentially coordinated with public safety sites.

5.1.2 Increase Public Safety Radio Coverage

The County continues to build communication infrastructure to support increased public safety radio coverage and improve first responder communication capabilities. Figure 5-1 shows the County's predicted existing public safety radio coverage (red regions represent areas of good coverage).

Figure 5-1: Predicted Existing Public Safety Radio Talk Back Coverage



A public safety radio site was built in Scandia. This improved radio coverage for the Kinzua Dam region of the County.

The County has designated Grand Valley and Tidioute as potential locations for public safety radio towers. These new towers would provide additional public safety radio coverage for the southwestern portion of the County.

In conjunction with this public safety radio project, CTC recommends that the County consider making the facilities available for non-public-safety wireless communications facilities.

CTC also recommends that the County consider adding public safety radio equipment at the Bull Hill and Swede Hill tower locations.

CTC also recommends that the County consider new towers near Dunham Corner and Eldred Hill Road to provide expanded and redundant public safety radio coverage (Appendix A2). Section 1.1.2.1 describes the methodology for determining the locations for additional public safety radio coverage.

In addition to increasing the number of public safety communications facilities, CTC recommends the following upgrades to improve the availability of the existing public safety radio locations:

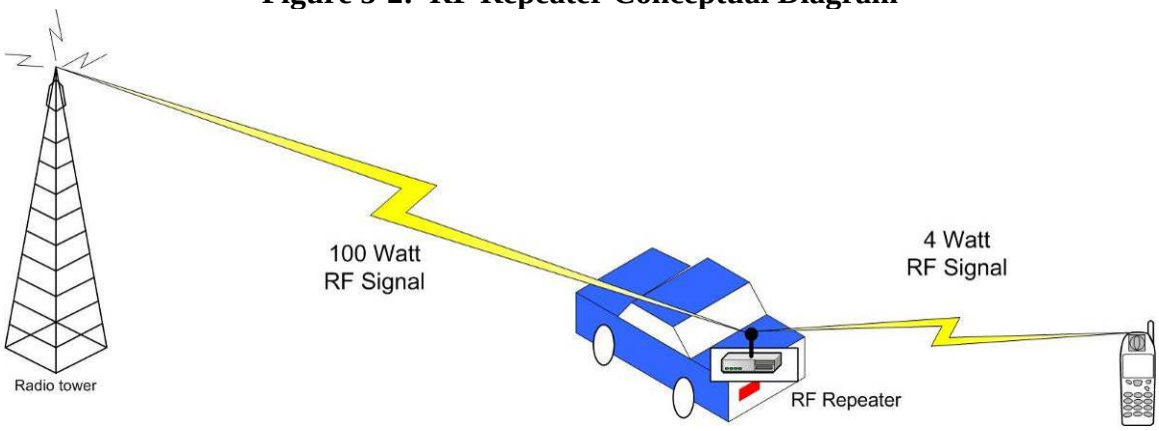
- Installing uninterruptible power supplies (UPS) and backup generators with automatic transfer switches at each radio site;
- Improving road access to remote public safety communications facilities, such as Jake's Rocks, to improve routine and emergency maintenance response time;
- Establishing a remote monitor and control system capable for each public safety device; and
- Using public safety vehicles as repeaters for in-field portable radios.

5.1.2.1 Public Safety Radio Coverage Methodology

To determine the areas of existing inadequate public safety radio coverage, CTC generated computer-generated prediction models. Prediction models are a tool for basic system level design. Although they cannot perfectly model actual coverage because foliage, interference, and other factors affect coverage, they provide a solid foundation to build upon.

Coverage was modeled based on the County's UHF system using a 450 MHz signal. CTC assumed each RF transmitter operated at a maximum allowable Effective Radiated Power (ERP) as defined by the County's FCC license, and that omni-directional antennas were used to provide uniform coverage. As the basis for determining coverage gaps, CTC modeled talk back coverage, which is the ability of a mobile transmitter to communicate to the nearest tower. Talk back coverage was modeled based on a 100-watt (W) repeater in each public safety vehicle using roof mounted omni-directional antennas. Repeaters extend the reach of portable units carried by public safety personnel by receiving radio signals from the user and amplifying the signal back to the tower.

Figure 5-2: RF Repeater Conceptual Diagram



The Longley-Rice propagation model was used to model the talk back coverage based on the geographic terrain of Warren County, as well as the assumptions stated above. RF performance levels were based on TIA/EIA TSB-88A[25] for analog FM radio systems. CTC assumed a receiver sensitivity of 0.35 microvolts (-116 dBm) at 12 dB signal-plus-noise-plus-distortion to noise-plus-distortion ratio (SINAD). A delivered audio quality (DAQ) of 3.0 was used as the minimum threshold for accepted received audio quality. DAQ 3.0 is "Speech understandable with slight effort. Occasional repetition required due to noise distortion."[26] Based on a minimum of DAQ 3.0, CTC used the following thresholds for determining the public safety radio coverage:

Description	Coverage Color	RF Received Power
DAQ 4.0 - Speech easily understood.		>-93 dBm
DAQ 3.4 – Speech understandable with repetition only rarely required.		<-93 dBm and >-100 dBm
DAQ 3.0 – Speech understandable with slight effort.		<-100 dBm and >-103 dBm
Unacceptable Performance		<-103 dBm

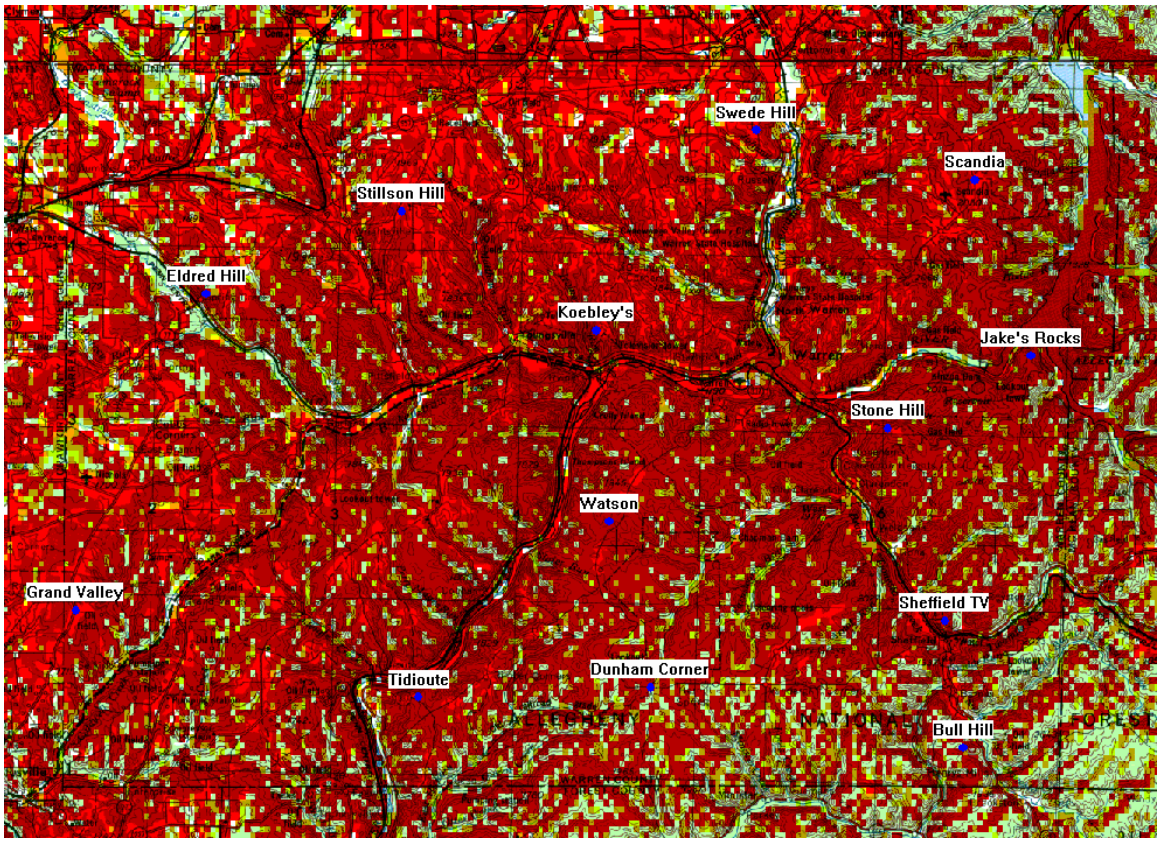
5.1.2.2 Proposed Public Safety Radio Coverage

Figure 5-1 on the preceding page shows the predicted existing public safety radio coverage of the County's UHF system. The map shows that public safety radio provides coverage throughout

[25] "Wireless Communications Systems - Performance in Noise and Interference-Limited Situations - Recommended Methods for Technology-Independent Modeling, Simulation, and Verification," TIA/EIA TSB 88-A.
[26] "Wireless Communications Systems - Performance in Noise and Interference-Limited Situations - Recommended Methods for Technology-Independent Modeling, Simulation, and Verification," TIA/EIA TSB 88-A.

the highly populated areas of the County, yet there are portions the Tidioute and Grand Valley area that do not have adequate coverage. These gaps were also noted by County Public Safety personnel, who determined locations in Tidioute and Grand Valley for wireless communications facility siting. Figure 5-3 illustrates CTC's model of the increased theoretical coverage achieved by adding the Grand Valley and Tidioute sites.

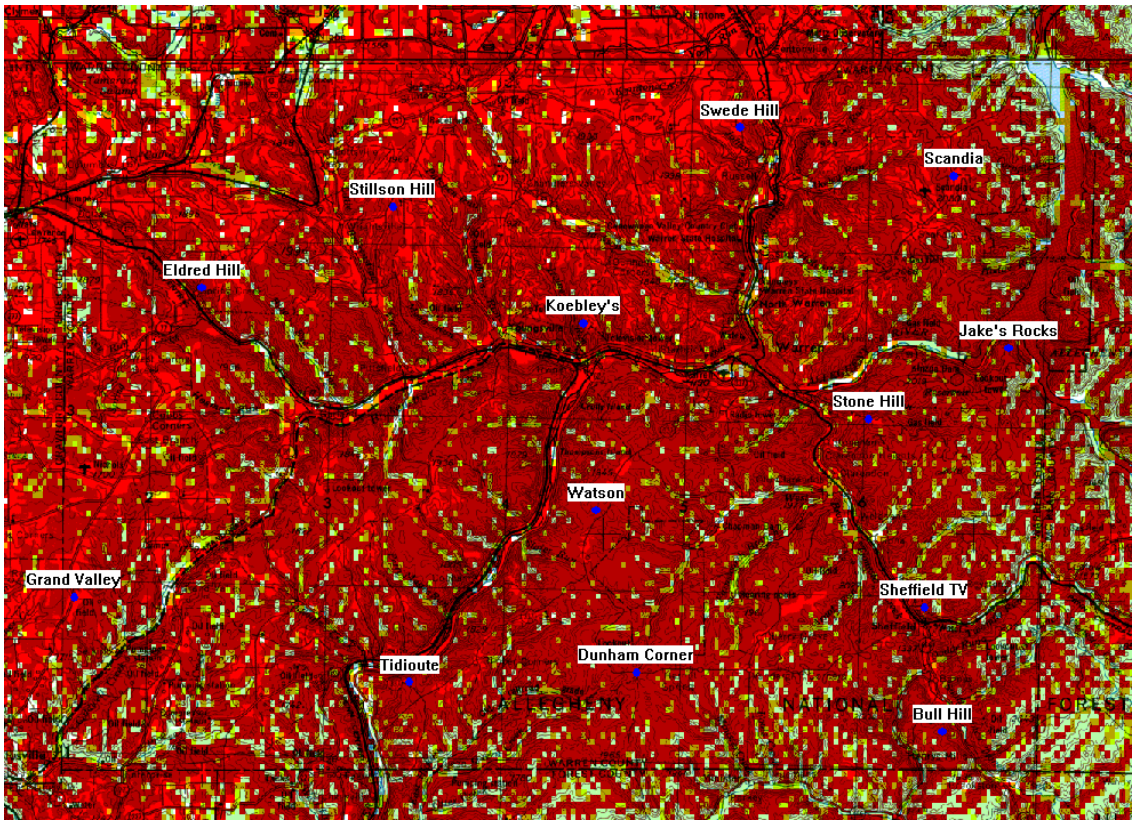
Figure 5-3: Predicted Coverage with the Tidioute and Grand Valley Sites



The two additional sites provide increased coverage along Route 62 and Route 27. After reviewing the County's findings, CTC agrees that constructing wireless communications facilities at both the Grand Valley and Tidioute sites will significantly improve coverage.

The County is also licensed to operate their public safety radio system from Swede Hill and Bull Hill, although public safety base station equipment does not currently exist there. By adding base station equipment at those sites, the County can improve roadway coverage along Route 62 and Route 948. CTC also identified locations near Dunham Corner and Eldred Hill for additional RF coverage within the Allegheny National Forest and along Route 6. These four additional sites provide the predicted coverage shown in Figure 5-4.

Figure 5-4: Conceptual Public Safety Coverage Map



These proposed sites are only a basis for further RF and tower siting analysis. As sites are added to the public safety radio system, field RF measurements should be performed to determine the actual performance of the radio system. The County's public safety radio personnel should log user experiences with coverage in order to determine additional areas for increased facilities.

5.1.3 Increase Commercial Wireless Coverage by Constructing Wireless Communications Facilities

A technical approach to decrease barriers to market entry and provide enhanced coverage for commercial wireless providers includes building assets that can be shared for County and commercial wireless communications purposes. Based on the existing communications tower locations in the area, there are significant portions of the County where commercial wireless coverage is not available. In conjunction with public safety radio projects, the County should consider constructing communications towers for use by wireless communications providers. CTC identified 21[27] locations where construction of additional communications towers could

[27] Includes the four recommended towers in Section 5.1.2 (Appendix A2).

significantly and strategically improve commercial wireless service coverage within Warren County (Appendix A2 and Appendix A3).

The following sections describe CTC's methodology for modeling existing commercial coverage, and CTC recommendations for additional communications towers.

5.1.3.1 Commercial Coverage Modeling Methodology

In order to model coverage for wireless carriers in Warren County, CTC used several industry standard modeling tools and assumptions to predict coverage. Our model is based on typical digital cellular telephone technologies and systems.

CTC modeled each base station using a three sector antenna array, which is common for cellular providers. Each sector would contain one or more cellular antennas that cover approximately 120 degrees per sector. The antenna height was approximated at 100 feet. Given the rural topology and demographics of Warren County, each tower would provide coverage for a three to five mile radius. A 20-watt base station transmitter was assumed, along with a 16 dB panel antenna for an approximate ERP of 400 W. A two degree down tilt was assumed to provide far reaching coverage. A one-watt unity gain cell phone was assumed for predicting talk back coverage (note that although some mobile phones can exceed three watts in output power, newer technologies typically target an ERP of less than one watt).

Given these assumptions the Longley-Rice propagation model was used to predict talk-back coverage. The following sensitivity thresholds are based on industry standards.

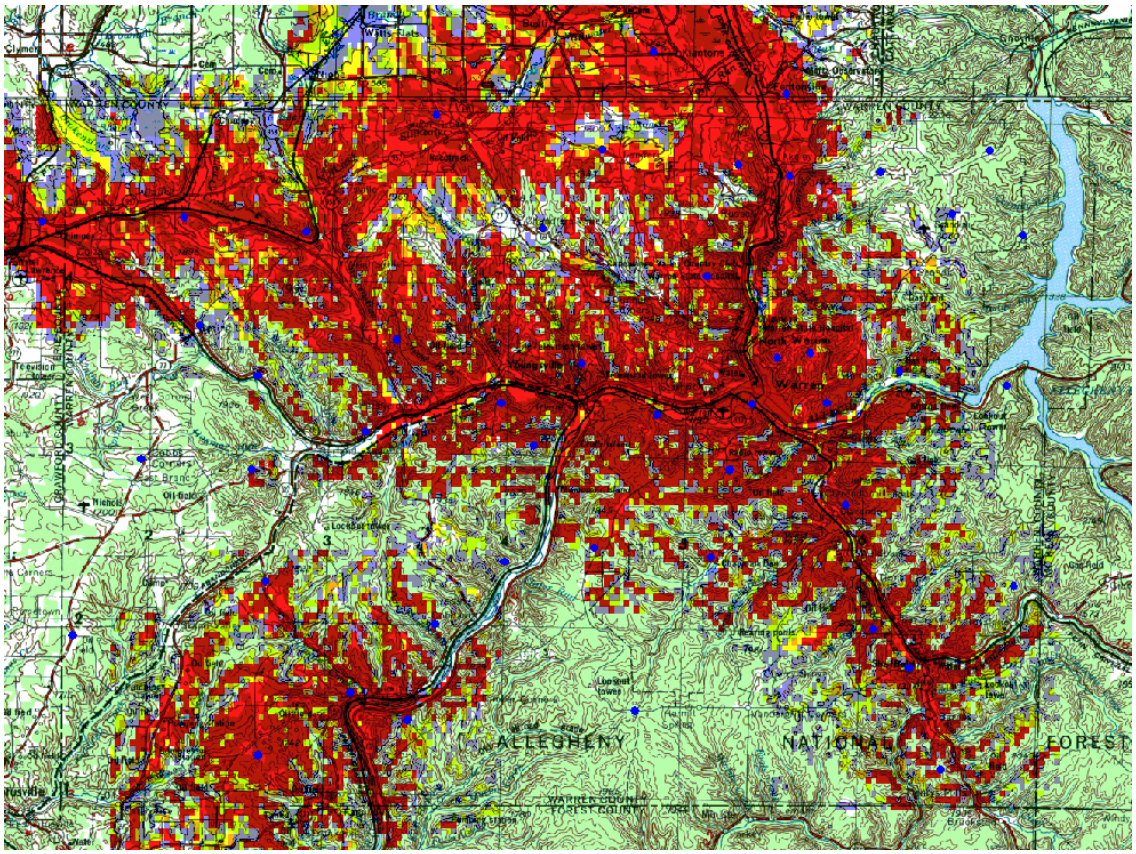
Description	Coverage Color	RF Received Power
Good cellular reception		>-80 dBm
Industry design standard for successful handoff between base stations		<-80 dBm and >-85 dBm
Acceptable cellular reception; increased likelihood of dropped calls.		<-85 dBm and >-93 dBm
Poor cellular reception; difficulty handing off calls.		<-93 dBm and >-103 dBm
Unacceptable Performance		<-103 dBm

5.1.3.2 Commercial Coverage Enhancement

Existing cell phone coverage in the County is based on the locations of existing communications towers designed for cellular communications. Within Warren County, the majority of the cellular towers are owned by third party tower providers: American Tower Corporation and SBA Communications. Third party tower providers own and maintain communications towers and lease tower space back to cellular providers. CTC identified 21 third-party towers within or

directly adjacent to Warren County (Appendix A1). Using the methodology described above, CTC predicted the existing cellular coverage available in Warren County (Figure 5-5).

Figure 5-5: Predicted Existing Cellular Coverage Available in Warren County



The coverage map shows that the highly populated areas, such as the City of Warren and major roadways, are currently being served by existing commercial carriers. This corresponds with the high traffic areas where other providers are looking to establish connectivity. The most underserved areas are the ANF, Bear Lake, Grand Valley, Scandia, and Route 62 between Tidioute and Youngsville.

Dual Use of Public Safety Radio Sites

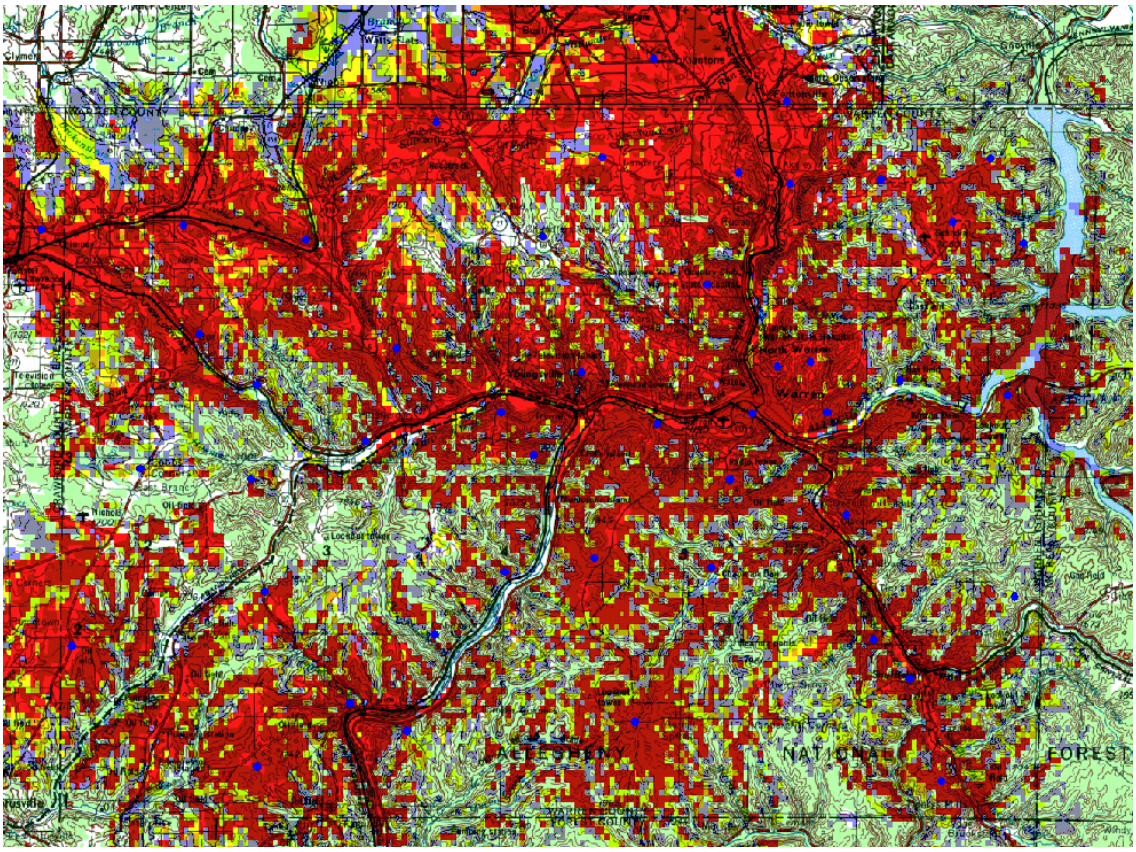
Using the existing cellular towers as a basis for coverage, CTC analyzed additional locations for tower siting. Of the 13 public safety radio sites identified in Section 5.1.2.2, CTC suggests that nine of the sites are suitable locations for cellular towers. The following sites have been identified as dual use locations, supporting both additional public safety radio and commercial mobile coverage:

- Bull Hill

- Dunham Corner
- Eldred Hill
- Grand Valley
- Jake's Rocks
- Scandia
- Swede Hill
- Tidioute
- Watson

However, the existing wireless communications facilities at Scandia, Jake's Rocks, Watson, Swede Hill, and Bull Hill, may need site upgrades and improvements to support the additional requirements of a commercial carrier. For example, road improvements are required at Jake's Rocks to facilitate access to the site and make it accessible to cellular carriers. Figure 5-6 shows the predicted potential coverage, assuming commercial carriers located base stations at each of the nine suggested public safety radio locations.

Figure 5-6: Predicted Cellular Coverage with Public Safety Radio Sites

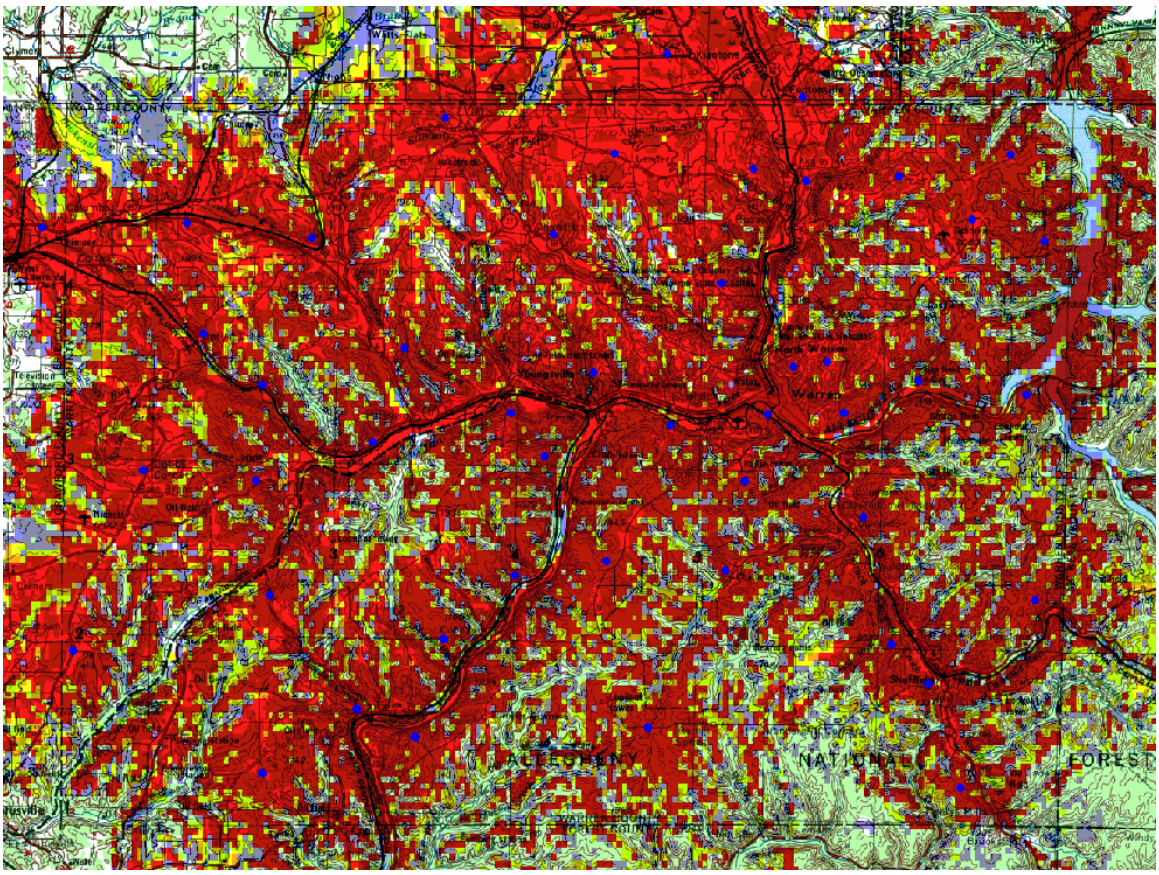


Collocation with the public safety radio system would also minimize the number of new towers needed in Warren County to support both public safety radio and cellular communications. Minimizing the number of towers decreases construction costs and minimizes the aesthetic and environmental impact of tower construction.

Additional Coverage

CTC identified 17 additional locations where wireless communications facilities would improve coverage along roadways, population centers, and major recreational areas, such as the ANF, Chapman State Park, and Kinzua Dam (Appendix A). These facilities would provide space for multiple cellular carriers to collocate and could be used to expand public safety radio coverage in the future. Figure 5-7 illustrates the predicted total potential coverage, including the additional 17 tower locations.

Figure 5-7: Predicted Cellular Coverage with New Tower Construction



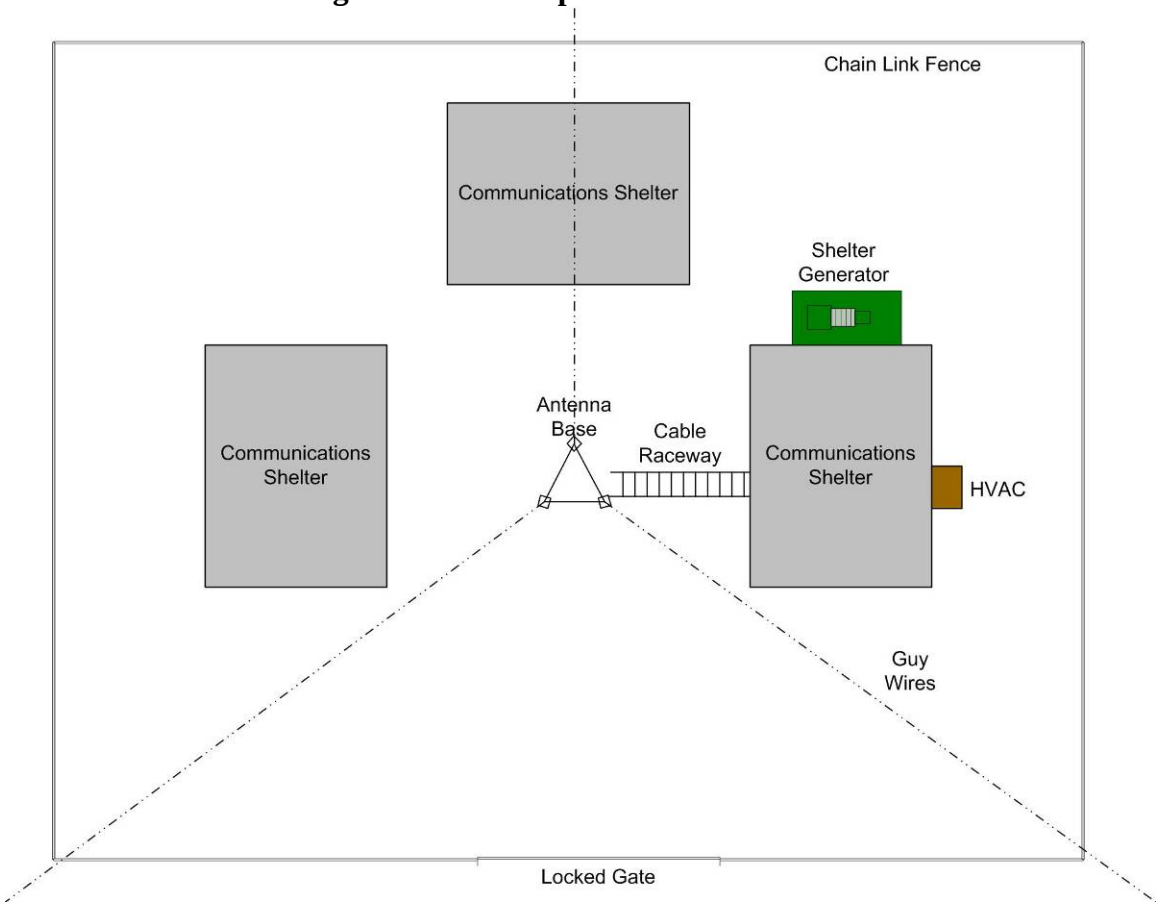
Further RF analysis and tower siting analysis would be required to determine the optimal locations for additional wireless communications facilities.

5.1.4 Wireless Communications Facility Model

At each location where new wireless communications facilities are required, CTC recommends that the County consider constructing facilities that can accommodate multiple cellular providers, public safety radio, and future wireless technologies that may emerge. Key concerns when choosing a site location and designing a wireless communications tower include land, tower type, shelter, power, security, and backhaul.

The Section outlines the technical specifications and recommendations for a tower site (Figure 5-8) with a 120-foot guyed communications tower capable of supporting multiple cell providers and public safety radio. The estimated construction cost for the tower, tower site work, and one communications shelter would be approximately $100,000. Note that this estimate does not include the radio equipment or installation.

Figure 5-8: Conceptual Tower Site Plan

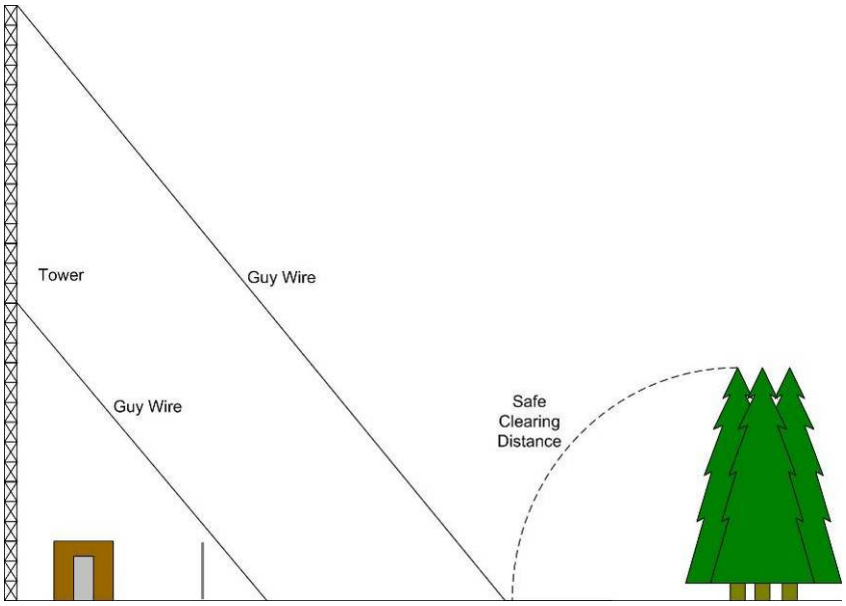


5.1.4.1 Siting Requirements

To construct a wireless communications facility, the County will need a parcel of land to construct the tower and house the communications shelters. The base of the tower and the area

needed to house the communications shelters would be approximately 100 feet by 100 feet, to include sufficient space for separate shelters each for multiple communications carriers. In addition to the base of the tower, space is required to mount the guy wires to support the tower structure. The area near the guy wires should be cleared of any obstructions, such as trees, that could potentially fall on and damage the guy wires.

Figure 5-9: Guy Wire Clearance Example



The approximate area needed to be cleared for a 120 foot tower would be from one-half to one acre of land. Space needs should be taken into consideration when choosing a site for additional wireless communications facilities. Where the necessary clearance for a guyed tower is not possible, more costly self-supporting structures can be installed with very little surrounding clearance.

In addition to space, road access to the site is also a critical feature of any wireless communications facility. Easy access facilitates tower installation and response times during an outage or maintenance.

Other factors important in site selection include access to electrical lines, telecommunications providers, and the aesthetics of the tower.

5.1.4.2 Tower Description

At each location where new communications antennas are installed, one approach for supporting the County's telecommunication initiatives would be the construction of a 120-foot guyed lattice tower. Guyed towers support a wide range of heights and tend to be less expensive than self-supporting towers or monopoles. A guyed tower typically has six guy wires that support the

tower and its attachments. Guyed towers require more ground space than monopoles and self-supporting towers, which is not typically a limiting factor in rural areas.

Guyed towers are typically assembled in sections with guys at the top and midway point of the tower. During the site design phase, sections may be added or removed to achieve the desired height of the tower at an incremental cost to the tower construction. Guyed towers can be designed as high as 1,500 feet, although these towers are not capable of supporting heavy loads.

A 120-foot guyed tower would be capable of supporting at least two cellular providers and public safety radio. Several guyed tower manufacturers include Rohn, Fort Worth Towers, Valmont, and Trylon.

Tower design is typically based on height requirements and the number, height, and type of attachments that the tower is designed for. Tower design is standardized by the ANSI/TIA/EIA 222 standard.[28] The latest revision of the standard, Rev G, requires a tower in Warren County to withstand a maximum wind loading of 90 mph and a 3/4-inch ice loading.

CTC estimates the cost of fabrication and installation a 120-foot guyed tower to be approximately $40,000.

5.1.4.3 Communications Shelter

One or more communications equipment shelters would be required at each tower location. The communications shelter provides a secure and environmentally controlled housing for the communications equipment at the base of the tower. At most new communications towers, pre-fabricated communications shelters are delivered fully constructed on site. Typically a concrete foundation is poured and the shelter is bolted to the foundation. Shelters can range in size and cost depending on the features selected. At a minimum, the shelter should include a locking door and port manifold to allow transmission lines into the shelter. Common pre-installed features include lighting, security alarms, cable raceways, power receptacles, HVAC units, generators, and UPS. In addition to the shelter, a cable bridge should be purchased to protect transmission lines from the tower base to the shelter.

[28] ANSI/TIA/EIA-222-G "Structural Standard for Antenna Supporting Structures and Antennas."

Figure 5-10: Example Communications Shelter

CTC estimates the cost of an eight feet by 15 feet communications shelter, with pre-installed electrical circuits, HVAC, security system, and other features, to cost approximately $30,000. In most tower leasing situations, a cellular provider will provide its own communications shelter at the base of the tower. Alternatively, the County could install larger shelters with subdivided space and multiple exterior doors to facilitate leased space for a range of carriers and governmental entities.

5.1.4.4 Physical Security and Monitoring

Physical site security is an important aspect of tower construction in order to protect the wireless communication assets and to prevent injury those who access the site. At a minimum, the base of the tower and the communications shelters should be enclosed by a chain link fence with a locking gate sized to allow vehicle access into the site. Fencing limits access to the tower and the communications shelters and minimizes the risk of injury to unauthorized individuals.

Where possible, the entire tower site, including guy anchors, should be fenced in to protect the site. Where fencing the entire site is impractical, the guy anchors should be fenced separately to protect the mounts and lower portion of the cable.

An alarm system should be installed in the communications shelter to remotely monitor site conditions. Standard alarm features include door opening, high and low temperature, high humidity, loss of power, generator and HVAC functions. Remote monitoring will allow the County to monitor all sites remotely 24x7. Provided sufficient backbone network capacity is available, security cameras can also provide remote site monitoring.

5.1.4.5 Power

A highly reliable power supply is a requirement of critical wireless communications services. As part of the tower siting process, access to electrical power is an important site consideration. CTC recommends checking with FirstEnergy or Warren Electric Coop about the availability of commercial electrical service at potential sites.

For the County's own public safety needs, a generator and battery system should be installed at each base station. The generator will provide power in the event of a commercial power outage. Given the rural nature of the proposed communication facilities and the existing propane generators in use by the County, CTC recommends a liquid propane style generator. The generator should be equipped with an automatic transfer switch capable of automatically starting the generator once commercial power is lost. The generator should also have status monitoring capable of monitoring the generator remotely. The generator and fuel capacity should be sized to provide power to the shelter for five or more days. Based on the expected load of the public safety radio system and potential future growth, CTC recommends a minimum of a 10 kW generator for each communications facility.

Figure 5-11: Example Liquid Propane Generator

Uninterruptible power supplies (UPS) condition electrical power and provide standby power during a power failure, typically sized to support equipment during the short time frame (usually less than a minute or two) between an outage and the start of backup generator power. A UPS or battery backup system is important in providing clean and consistent power to the communications equipment. CTC recommends an uptime of one to three hours in the event that the generator does not start automatically upon commercial power outage, increasing the

likelihood that support personnel can be dispatched to remedy the backup generator failure prior to a total outage.

For each communications facility where backup power is needed, CTC estimates the cost for generator, battery backup, and installation to be approximately $20,000.

5.1.4.6 HVAC

Sufficient heating, ventilation, and air conditioning are critical for maintaining the life of network electronics. Although most wireless communications electronics are designed to withstand large temperature ranges, temperature extremes increase the likelihood of equipment failure. Given the temperate weather conditions in Warren County and the minimal power draw of the radio, CTC recommends at a minimum one, two-ton HVAC unit per shelter. The price of the HVAC system is included in the price of the communications shelter.

5.1.4.7 Backhaul

From each wireless communications facility, backhaul[29] will be required to transmit wireless communications and site monitoring information. Section 5.2 discusses wired connectivity solutions for providing backhaul to the wireless communications facilities.

In the tower siting process, it is important to ensure that wired communication services are available for backhaul of the wireless systems. Cellular carriers typically use multiple T1 lines to support rural communications towers. Wireless backhaul options, such as point-to-point microwave, may provide another alternative for wired communications.

5.1.4.8 Site Overview and Cost Summary

The proposed wireless communication will support a multitude of wireless communication applications from cellular to public safety radio to emerging wireless technologies.

Given the tower design described above, CTC estimates an approximate cost of $100,000 to construct each wireless communications tower including, one shelter for the County's use. This cost does not include the cost of the land, which would be negotiated with the property owner, or consist of existing County property. Table 5-1 provides a breakdown of the cost associated with a wireless communications facility construction.

[29] Backhaul is a communications medium for transmitting data back to a central network. In the case of cellular telephony, backhaul connects cellular phone users to the public switched telephone network.

Table 5-1: Wireless Communications Tower Site Estimated Cost Summary

Description	Cost
120 foot Guyed Tower and Site Installation	$40,000
Communications Shelter	$30,000
Fencing	$ 9,000
Propane Generator	$15,000
UPS	$ 5,000
Site Total	$99,000

CTC estimates that using the design for additional public safety radio and cellular towers provided in Sections 5.1.2 and 5.1.3, the cost of enhancing wireless communications infrastructure within Warren County to be approximately $1,465,000. Our cost estimates assume that site modification at existing public safety radio sites to support cellular carriers would be approximately $25,000, $15,000 would be required to equip each tower with public safety radio equipment, and cellular sites without public safety radio would cost approximately $50,000.

Table 5-2: Summary Cost Estimate for Enhancing Wireless Support Infrastructure

Description	Quantity	Cost	Subtotal
Cellular only towers (1.3.3)	17	$50,000	$850,000
New public safety and cellular towers (1.3.2)	4	$100,000	$400,000
Public safety tower modifications (1.3.3)	5	$25,000	$125,000
Public safety equipment (1.3.2)	6	$15,000	$90,000
		Total	$1,465,000

These costs do not include backbone communications, discussed in Section 5.2. In addition we do not include any costs for land use for the new towers or backhaul, assuming existing County property could be selected in most cases. Table 5-2 provides a breakdown of the cost to expand wireless connectivity in Warren County.

5.2 Wired Communications System Level Design

As a second critical technical component of the communications enhancement strategy, the County should consider the construction of a fiber optic network that meets the demands of the County stakeholders as a whole, and provides additional capacity for future needs and users. The fiber network would have a role both in support of expanded wireless coverage and for wireline connectivity purposes.

Various County stakeholders have explored public-private partnerships for meeting their own connectivity demands. CTC recommends that the County explore these and other opportunities for collaboration with private telecommunications providers to aggregate the needs of the various stakeholders within Warren County and leverage the purchasing power of the stakeholders as a whole to maximize the resources obtained by the County.

CTC developed a conceptual fiber optic network design based on the existing stakeholder facilities and needs, and on the potential wireless communications facilities presented in the previous section. Given the size and low population density of the County, the fiber optic network design is divided into several phases, which can be deployed based on opportunity, need, time, and cost of each phase.

Initially, CTC proposes constructing a core backbone ring through the central part of the County, which would connect a large portion of the stakeholder facilities and provide a survivable backbone for extension of other future fiber optic builds. Additional phases of fiber optic construction would expand connectivity to other distant facilities and provide additional redundancy to the network.

Based on similar fiber optic construction projects, we estimate that the three-phase fiber optic network would cost approximately $15,400,000.

5.2.1 Existing Wireline Overview

County stakeholders frequently find that they cannot get the bandwidth or reliability they need from existing wireline services. DSL and frame relay circuits are available for Internet access and site-to-site connectivity; however, availability is often limited within the County and the bandwidth of these types of circuits is low relative to the needs of most users and compared to many other wireline technologies.

As bandwidth demands have increased, stakeholders, such as the Warren County School District, have developed their own fiber optic networks to provide the capacity, availability, and scalability needed to meet their needs. The School District's fiber optic network is a public-private partnership, in which the School District became the anchor tenant for a fiber optic network constructed by WestPA.net. Other stakeholders in the County are exploring similar partnerships to meet connectivity needs.

As communications demands increase, CTC recommends that the County aggregate the stakeholders' needs for connectivity, both to increase economies of scale and to create an entity with greater purchasing power. For example, the various County stakeholders may wish to join with the School District initiative or develop a new initiative that draws in the School District and other high bandwidth users.

5.2.2 Network Design Approach

The following sections outline an approach for fiber optic construction to replace and enhance wireline communications throughout the County. The fiber optic design provides additional capacity, redundancy and connections to stakeholders, including support for backhaul of wireless communications within Warren County.

CTC recommends the use of fiber optic technology as the preferred solution for inter-facility interconnection. Where it can be cost-effectively built, fiber optic cable has several advantages compared to copper or wireless technologies:

- Sufficient bandwidth for multiple channels of full-motion video, as well as the enhanced data and voice requirements of the future;
- Flexibility to increase bandwidth and change services over the fiber, without a need to change the physical plant or renegotiate with a service provider;
- Improved reliability, due to the greater inherent stability of a fiber optic network, the ability to build a fail-safe, redundantly-routed architecture over a backbone ring, and the ability to operate the fiber parallel to backup microwave or leased lines to key facilities; and
- Immunity to electrical noise interference, such as lightning, because it is constructed without metallic parts.

Once fiber is in place, there are several ways to increase capacity without additional construction, such as operating several wavelengths of light over the same fiber using Wave Division Multiplexing (WDM) technology or migrating to higher capacity electronics and optics.

The disadvantage of fiber optics is the cost of construction to distant areas of the County. In these areas it may be worth considering wireless or leased options.

A fiber optic backbone network is capable of supporting a variety of networking applications indicated in the needs assessment as well as unforeseen future applications such as:

- Increased bandwidth between facilities;
- Fiber optic backhaul for public safety radio and cellular communications;
- Expanded broadband access to municipal applications such as GIS and public safety applications (CAD, WebEOC, etc.); and
- Increased Internet capacity.

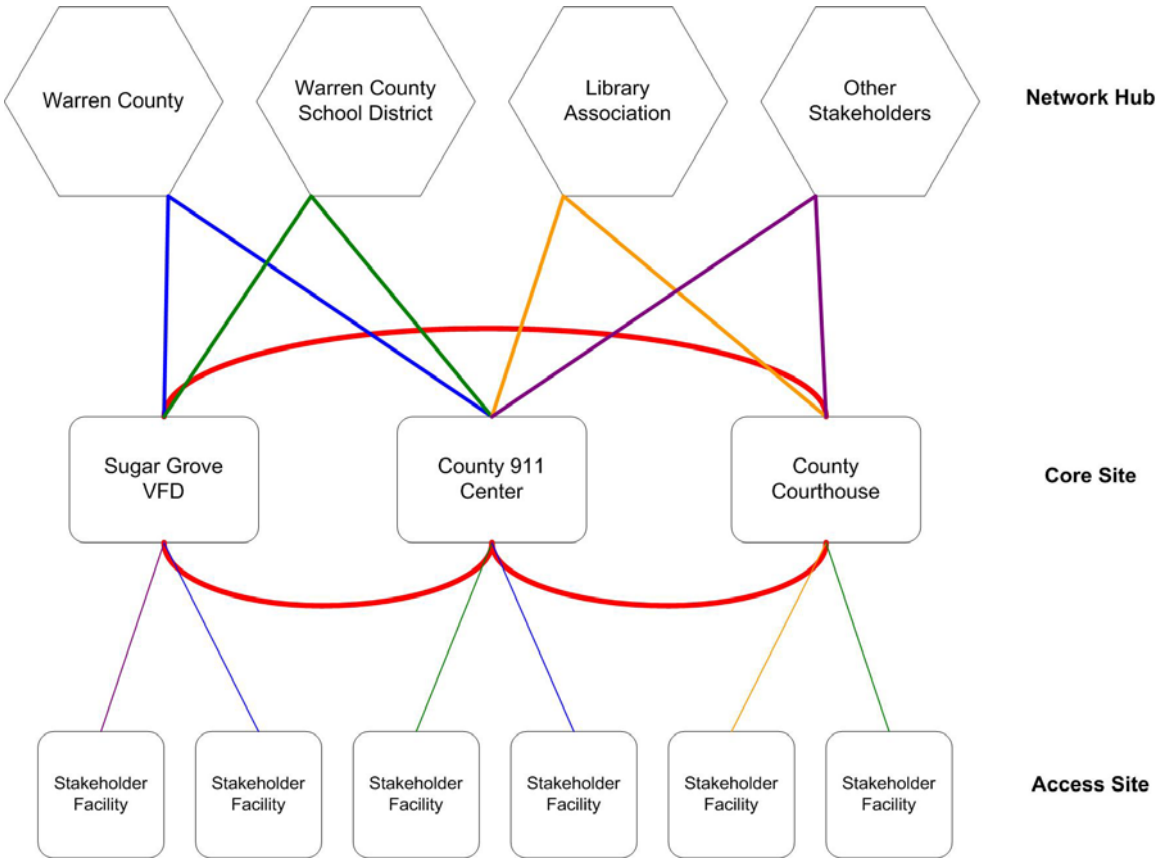
5.2.3 Construct a Fiber Optic Ring to Support Government Needs (Phase I)

CTC recommends constructing a fiber optic backbone ring to serve stakeholders and wireless communications facilities within the central portion of the County as an initial phase of fiber optic construction. Figure 5-12 and Figure 5-13 depict the backbone ring topology provides redundancy to core facilities and scalability to support additional sites in future phases.

Due to the large distances involved in ring construction and the relatively dense aggregation of sites within townships, CTC recommends core sites at the County Courthouse, 911 Center and Sheffield Volunteer Fire Department. Each core site would be connected to the backbone ring with diverse fiber routing entrances to provide redundant routing around the backbone ring. From each core site, stakeholder facilities such as schools, libraries, senior centers, police stations, fire stations, and municipal buildings are connected to the nearest core site to provide connectivity into the fiber optic network. Core sites act as link aggregators and minimize the construction of fiber necessary to provide connectivity to each stakeholder facility.

CTC envisions incorporation of major networking hub facilities for each stakeholder (Warren County, Warren Library, Warren School District Office, etc.) into the backbone ring. Each major networking facility would connect to two core ring sites to provide redundant connectivity to the core networking equipment (or to enable the core ring to be logically "extended" to an entity's hub location). The core networking equipment would provide connectivity from each stakeholder facility to its networking facility. Figure 5-14 shows one potential conceptual logical ring plan.

Figure 5-12: Phase One Logical Network Connectivity



CTC recommends constructing diverse entrance points within each core site and network site. Ring topologies, when constructed with diverse points of entry to facilities and without physically "collapsed" portions sharing physical paths, prevent disruption of network services in the event of a single fiber break. In conjunction with properly configured network electronics, data traffic is re-routed around fiber breaks using physically redundant fiber paths.

A high count fiber optic backbone provides flexibility and scalability for future applications and networking technologies. In the past few years, the price of fiber optic cable has declined, creating a situation where the incremental cost of additional fiber strands is marginal in regard to the overall cost of fiber optic construction. CTC recommends a fiber optic backbone of at least 72 fibers for future scalability.

The proposed backbone design for this study is a 144-count fiber optic ring with path diversity into each of the core sites. Of the 144-count fiber, 24 fibers would be used in support of the logical network described above. For stakeholder network sites, CTC recommends constructing 12-count fiber to the backbone ring with 6 fibers splicing into each direction of the ring. Figure 5-13 shows the proposed ring design, encompassing approximately 42 miles of fiber optic cable construction.

Figure 5-13: Conceptual Fiber Optic Backbone Ring

From the backbone ring and core sites, fiber optic laterals are constructed to provide connectivity to the remaining sites. Laterals are connected to the nearest splice enclosure or core site to minimize the distance of the lateral. Minimizing lateral length has two benefits: (1) it decreases construction costs by decreasing the amount of fiber optic plant needed; and (2) it increases the average reliability of the network by shortening the single points of failure for fiber optic cuts.

Lateral fiber optic connections are small-count fiber optic cables that provide connectivity back to core sites and central networking equipment. CTC recommends a minimum of six fiber strands to each site to provide network connectivity.

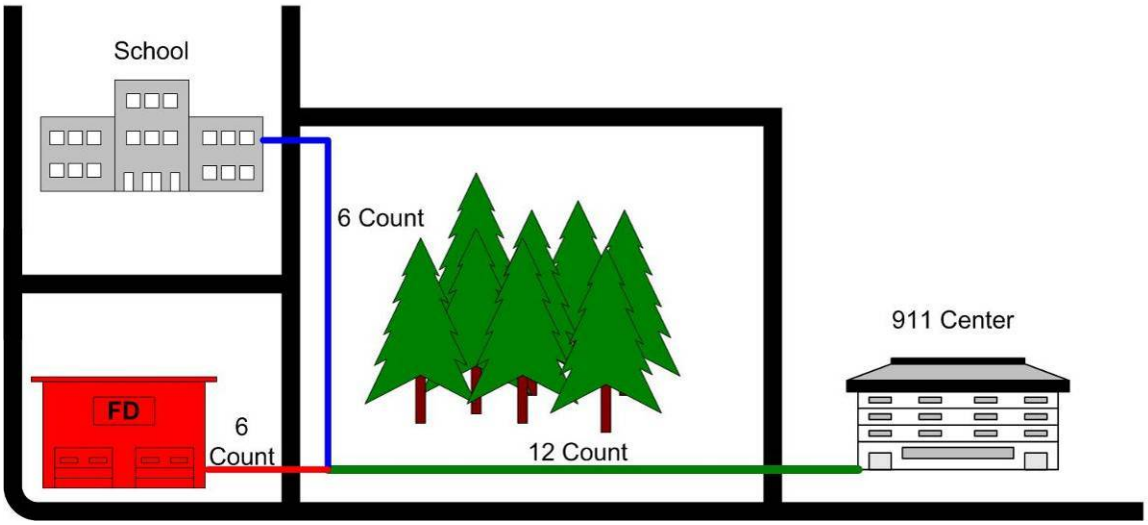
CTC recommends minimizing the number of splice enclosures necessary to connect additional sites, because splices reduce the distance over which fiber optic equipment can communicate.

The number of splice enclosures is minimized by constructing fiber from several network sites back to the same splice enclosure or hub location.

To minimize construction costs, common fiber optic construction paths are used for multiple links to minimize the amount of conduit or stand required for construction. Figure 5-14 illustrates this method, using the same routing to minimize the total construction necessary.

In addition, it is possible to delay constructing the last portion of the fiber lateral to a given site until that particular site chooses to activate its connection to the network. This approach has advantages and disadvantages. The advantage is that a site without a certain or immediate need does not necessarily need to be constructed or financed, but can be added at a later date. This is especially advantageous if the site is far from the rest of the network or requires an especially costly build. The disadvantage is that there is a significant economy of scale in construction, and an advantage in completing a project while crews are in the area.

Figure 5-14: Shared Fiber Routing



In the example illustrated in Figure 5-14, constructing the connection for the school along the same path as the Fire Department connection reduces construction cost by sharing the same path along the green route.

For the initial fiber optic loop, CTC identified 45 potential stakeholder sites for connectivity to the fiber optic network during the first phase of construction, based on information gathered during the needs assessment. The list of sites is provided in Appendix B. On average, each stakeholder site was approximately 0.2 miles from the backbone ring for a total of approximately 7 miles of lateral construction.

5.2.3.1 Backhaul for Wireless Communication Facilities over the Fiber Optic Backbone

In addition to providing connectivity to stakeholder facilities, the fiber optic backbone link would provide backhaul to the public safety radio sites and the wireless communication facilities proposed in Section 5.1 that are in the vicinity of the fiber optic backbone ring. Lateral fiber optic connections would provide connectivity from the tower sites back to nearest core site. CTC recommends constructing a minimum of 12 fiber optic strands from each tower site to the backbone ring. For this study, our design includes 24 fibers from each tower site to the backbone ring.

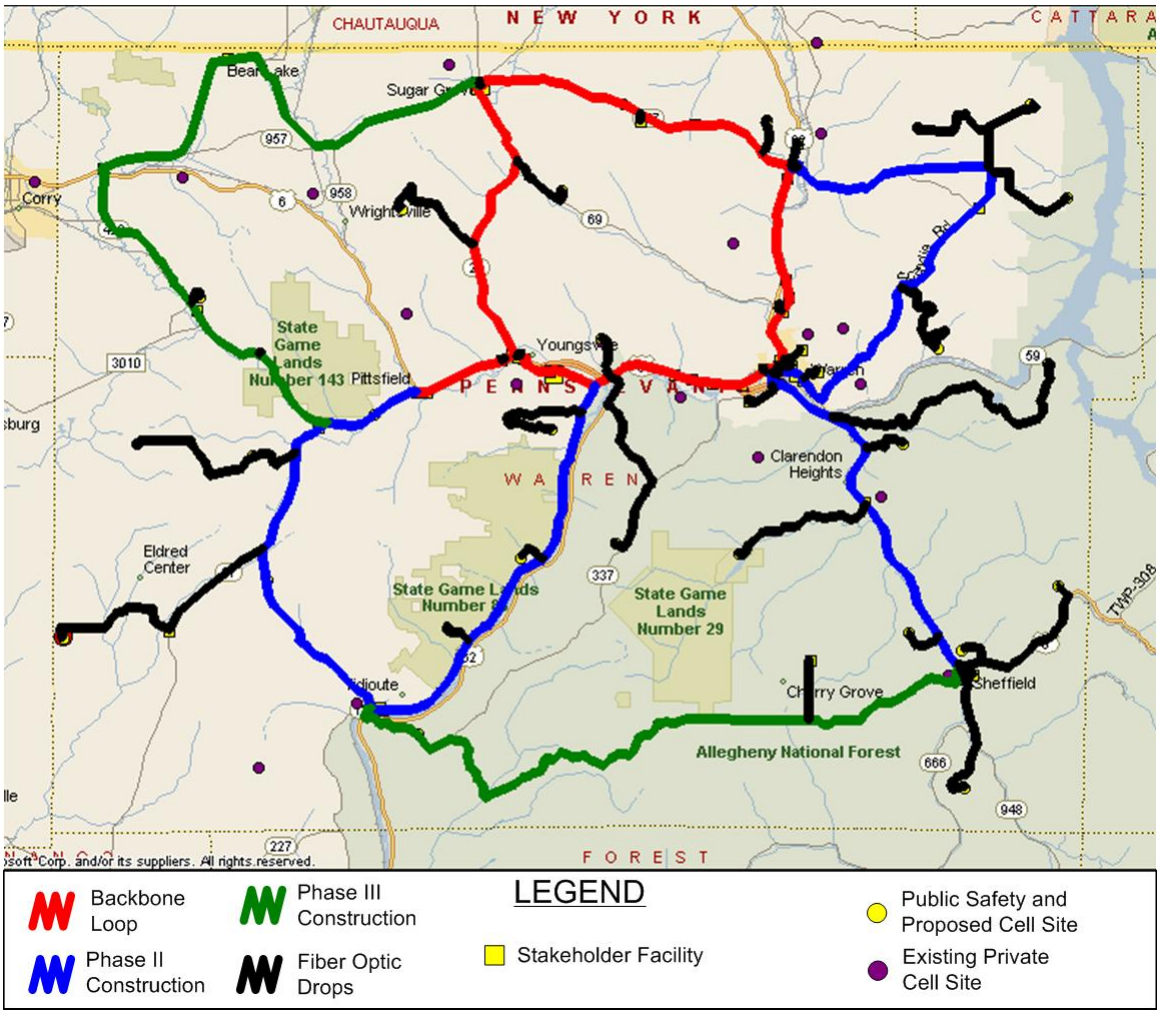
CTC identified four tower sites[30] that are in the vicinity of the initial backbone ring as listed in Appendix B. The average lateral distance was 2.0 miles for a total of approximately 8.1 miles of lateral construction.

5.2.4 Expand Fiber Optic Ring to Support Other Communities and Wireless Communication Facilities (Phase II and Phase III)

CTC recommends constructing additional fiber optic plant in phases as part of the initial fiber optic backbone loop or as part of a future project. Construction of additional fiber would expand connectivity to distant townships, such as Grand Valley, Scandia, Sheffield, and Tidioute, and to provide connectivity to additional public safety radio and proposed cellular wireless communication facilities. Figure 5-17 shows the overall fiber optic design proposed in this study.

[30] Includes Chandler's Valley, Lander, Koebley's, and Stillson Hill.

Figure 5-15: Conceptual Network Fiber Optic Routing



5.2.4.1 Phase II – Expansion of Fiber Optics to Distant Townships

CTC proposes a second phase of fiber optic construction that would build secondary fiber optic rings through Tidioute and Scandia, as well as provide a fiber optic spur to Sheffield. The fiber optic rings and spurs would provide connectivity to the stakeholder facilities in the vicinity of the fiber and create additional backbone rings for increased redundancy.

For this study, CTC designed the Phase II fiber optic rings and spur using 144 count fiber, and 6 count fiber optic laterals to each stakeholder facility. In addition to fiber optic construction, we recommend creating three additional core sites as part of the Phase II fiber optic construction at Sheffield Police Department, Tidioute Police Department, and the Russell Volunteer Fire Department. Phase II consists of approximately 62 miles of fiber optic backbone construction.

CTC identified 16 stakeholder facilities that could be connected in the second phase of fiber optic construction, listed in Appendix B. The average lateral distance was 0.5 miles for a total of 8.4 miles of fiber optic lateral construction.

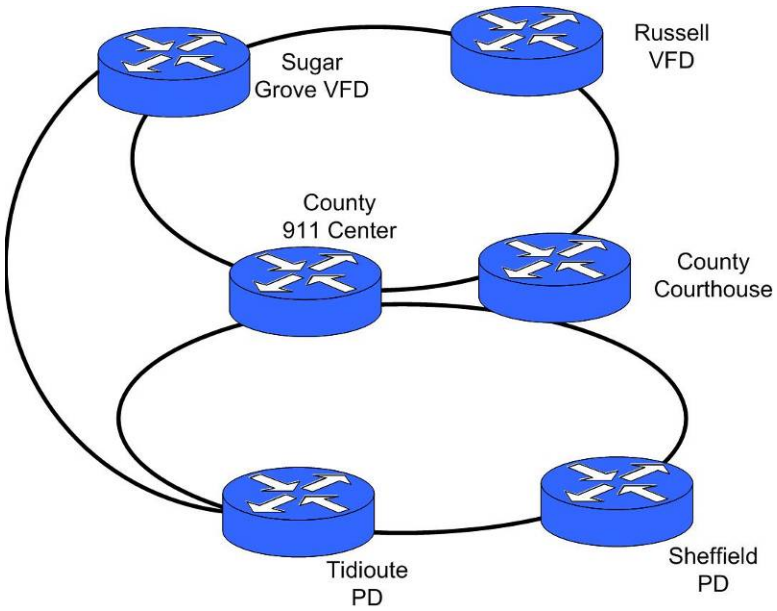
In addition to the stakeholder facilities, CTC identified 22 wireless communication towers (both existing and candidate new towers defined in Section 5.1) in the vicinity of the Phase II fiber optic construction that could be connected to the fiber optic network for backhaul connectivity. These locations, listed in Appendix B, are an average of 3.3 miles from the fiber optic backbone loop for a total of 71 miles of lateral construction.

5.2.4.2 Phase III – Construct Fiber Optic Rings to Distant Townships and Increase Network Redundancy

The proposed third phase of fiber optic construction would be to increase the redundancy of the network by constructing fiber optic rings between Sheffield and Tidioute, and Tidioute and Sugar Grove. The fiber optic construction would also increase the number of stakeholder facilities on the fiber optic network and provide fiber optic connectivity to additional tower sites.

Phase III of the fiber optic construction would eliminate the spur to Sheffield and provide redundancy to Sheffield sites in the event of a fiber cut along the spur. The fiber optic spur will also provide a ring from Tidioute to Sugar Grove and provide fiber optic connectivity to Columbus and Bear Lake. Figure 5-16 shows the logical ring topology upon completion of Phase III.

Figure 5-16: Phase III Logical Ring Topology



Phase III consists of approximately 54 miles of fiber optic construction. CTC identified four stakeholder facilities to include during Phase III construction as listed in Appendix B. The average lateral distance was 0.6 miles for a total of 2.3 miles of lateral construction.

In addition to the stakeholder facilities, four tower sites (both existing and candidate new towers defined in Section 5.1) could be added to the fiber optic network for backhaul connectivity. The average lateral distance is approximately 0.3 miles for a total of 1.1 miles of lateral construction.

Other sites that are not included in this study, but are potential future considerations include:

- Private cell tower sites;
- Public works facilities;
- Private health care facilities;
- Non-profit/charitable organizations; and
- Parks and recreation facilities.

Sites may be added to the fiber optic network at an incremental cost if deemed necessary by the Warren County network stakeholders.

5.2.5 Core Facility Site Recommendations

In order to facilitate multiple entities operating separate networks over the fiber optic infrastructure, the following section outlines CTC's recommendations for core facility site recommendations. By creating facility space that allows multiple providers to access the fiber network and house their equipment, the fiber optic network will be more attractive to potential third party users, including private corporations, wired telecommunications providers, and wireless carriers.

Each core site will require physical security, space, power, and HVAC that allows multiple providers to operate network electronics. Two potential approaches for creating core site facilities involve modifying an existing room within an existing municipal building to provide the adequate space, or construct a communications shelter on the property.

The six candidate core sites: County Courthouse, County 911 Center, Sugar Grove VFD, Russell VFD, Tidioute PD, and Sheffield PD were chosen as because they represent geographically disperse points on the network, and all are relatively physically secure sites. Public safety sites often make ideal locations for core sites, as they are often staffed 24 hours a day, facilitating better physical security and enabling access to equipment for repair. If these locations are deemed unacceptable from an equipment support standpoint, another facility or parcel of land for a prefabricated communications shelter in the vicinity could serve the same purpose.

For both modified buildings and communications shelter, an external locking entrance should be provided to allow authorized users into the core facility 24x7. By separating the core facility operations from the rest of the building it minimizes the burden on the staff of the core site facilities and allows network staff to respond immediately in the event of an outage.

CTC recommends a core site facility with similar standards as the communications shelter, which includes:

- Space for multiple racks of equipment;
- Generator and UPS backed power system;
- Redundant HVAC system (dedicated for the core site if a modified room);
- Cable raceway and/or raised flooring; and
- Status monitoring of the door, power systems, HVAC, and network equipment.

CTC estimates the cost of a communications shelter or modification to an existing building to support the core network facility to be approximately $60,000.

5.2.6 Alternatives to Wired Backhaul Communications

If new fiber construction costs become prohibitive or connectivity is needed in a timeline that does not correspond to fiber construction, wireless access to remote sites is an alternative consideration. Wireless technologies may provide a cost-effective alternative to a fiber backbone if permitted by the terrain and if there is access to appropriate structures for mounting antennas. Given that Warren County has existing antenna structures and this report proposes additional antenna structures, there may be opportunities to use these towers to extend high-speed network connectivity.

5.2.6.1 Overview of Technology and Available Frequencies

Various wireless technologies provide a high-capacity links on a point-to-point or point-to-multipoint basis at data rates ranging from 11 Mbps to 1,000 Mbps. Depending upon the specific technology used, the range and specific requirements for Line-of -Sight (LOS) vary. LOS can be achieved through the use of towers, tall buildings, or water towers where existing.

The IEEE 802.11a/b/g standards specify wireless transmissions in the 2.4 GHz and 5 GHz unlicensed frequency bands and can cover distances of several miles using directional antennas. The standards provide data throughput of up to 54 Mbps (depending on distance between sites and signal strength), with equipment costs ranging between $1,500 and $3,000. Using directional antennas extends the range of the transmission, improves bandwidth and reduces interference; however, this solution is more susceptible to RF interference from other unlicensed wireless devices. Security over this type of wireless link also requires encryption that may reduce the capacity of the link by introducing additional overhead.

An alternative is to use point-to-point license-exempt microwave transmission. Microwave Ethernet bridging equipment operates in both licensed and unlicensed frequency bands at speeds as high as 480 Mbps. Given the use of existing towers, the typical cost of equipment capable of providing 50 to 100 Mbps data throughput with license-exempt direct Ethernet interfaces ranges between $8,000 and $10,000 per link. In addition to point-to-point systems, new point-to-multipoint systems are now available. These provide a bulk bandwidth over the air (e.g., 50

Mbps) that can be shared among a number of remote nodes. Point to multipoint technologies may be suitable within townships, such as Sheffield, Tidioute, and Sugar Grove, where the majority of stakeholder facilities are located near each other in the downtown area.

With microwave systems, using licensed frequencies eliminates the risk of interference with other RF systems and devices and provides higher availability and reliability, though these systems are typically much more expensive to implement. Warren County may have access to selected portions of the frequency spectrum that are set aside for government use. This may eliminate some of the licensing costs. An example of a high bandwidth, microwave system is the FibeAir™ 1500I/1528I Digital Radio[31] system from Ceragon, which provides both Ethernet and DS-1 connectivity over the same microwave link. Other vendors, including Proxim and Terabeam, offer similar products.

Free Space Optics (FSO) systems are another option. FSO transmit infrared light between transceivers and are in many ways comparable to fiber optic transmission without the fiber optic cable. FSO equipment does not require FCC licensing and is not susceptible to electromagnetic interference. The typical range of these systems is very short (for reliable performance), though they may be suitable for interim connectivity prior to fiber construction. Equipment of this type can be re-used to provide redundant connectivity to critical sites already connected by fiber. For short distances, FSO equipment could cost in the range between $8,000 and $20,000, and provide links of 100 Mbps or greater between sites.

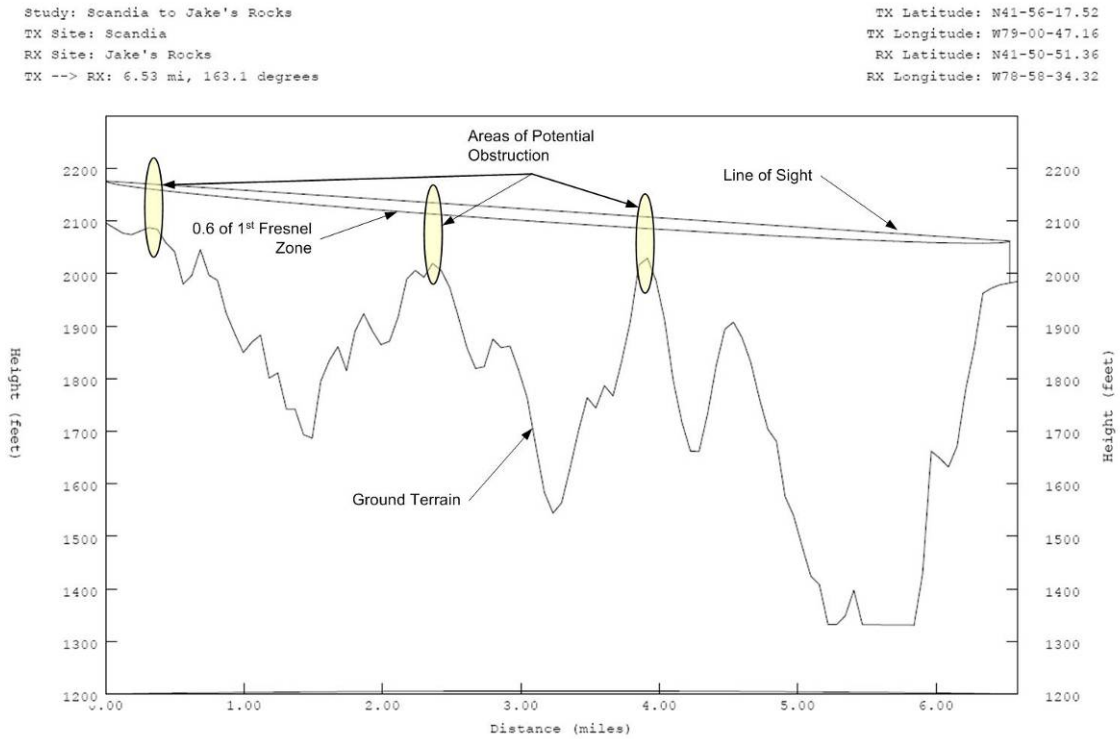
5.2.6.2 Potential Wireless Sites

Due to the high availability requirements of public safety radio, CTC analyzed point to point wireless technology for providing backhaul between public safety radio tower locations. CTC examined the existing LOS between each neighboring public safety radio tower to determine the feasibility of using point to point wireless technology for backhaul.

By modeling the locations and heights of the towers and the terrain between two locations, it is possible to determine whether line of sight is feasible. For the purposes of this study, each point to point wireless backhaul antenna was set at a height of 80 feet on the tower. The higher the antenna is placed on the tower the more likely LOS can be achieved, although greater heights equal greater cable length and therefore greater power loss. Thus, this tradeoff must be balanced to meet the requirements of the terrain. Each wireless device was modeled at a frequency of 6 GHz, which is a common licensed point to point microwave frequency, and is also similar in RF properties to unlicensed 5 GHz technologies. As the frequency of the backhaul link increases, the radiation pattern of the signal, called the Fresnel Zone, gets smaller. If more than 60 percent of the Fresnel Zone is blocked by obstructions, the link will be unreliable or not achievable. Figure 5-17 shows an example LOS profile.

[31] FibeAir 1500I/1528I product description from Ceragon (www.ceragon.com/site/ Products_Products.asp?ID=18)

Figure 5-17: Example Line of Sight Profile



The LOS profile shows that there are areas along the path of the signal where the ground terrain rises close to obstructing 0.6 of the Fresnel Zone. As the profile only models ground terrain, other obstructions, such as trees, tall buildings, and other towers may interfere with the signal at these locations. A good rule of thumb for LOS analysis is any location where there is less than 100 feet between the Fresnel Zone and the ground terrain may be an area of potential obstruction, as tall buildings and trees might reach this height.

Once the LOS profiles have been run to determine the feasibility of point to point wireless links, it is important to do field testing on the links to determine their actual feasibility. This is often done by climbing the tower to the point and visibly observing if there any obstructions and also testing the link with a test transmitter and receiver.

Once LOS is determined, a point to point microwave link can be designed to determine the proper power levels and antenna types needed to achieve the desired bandwidth capacity and reliability.

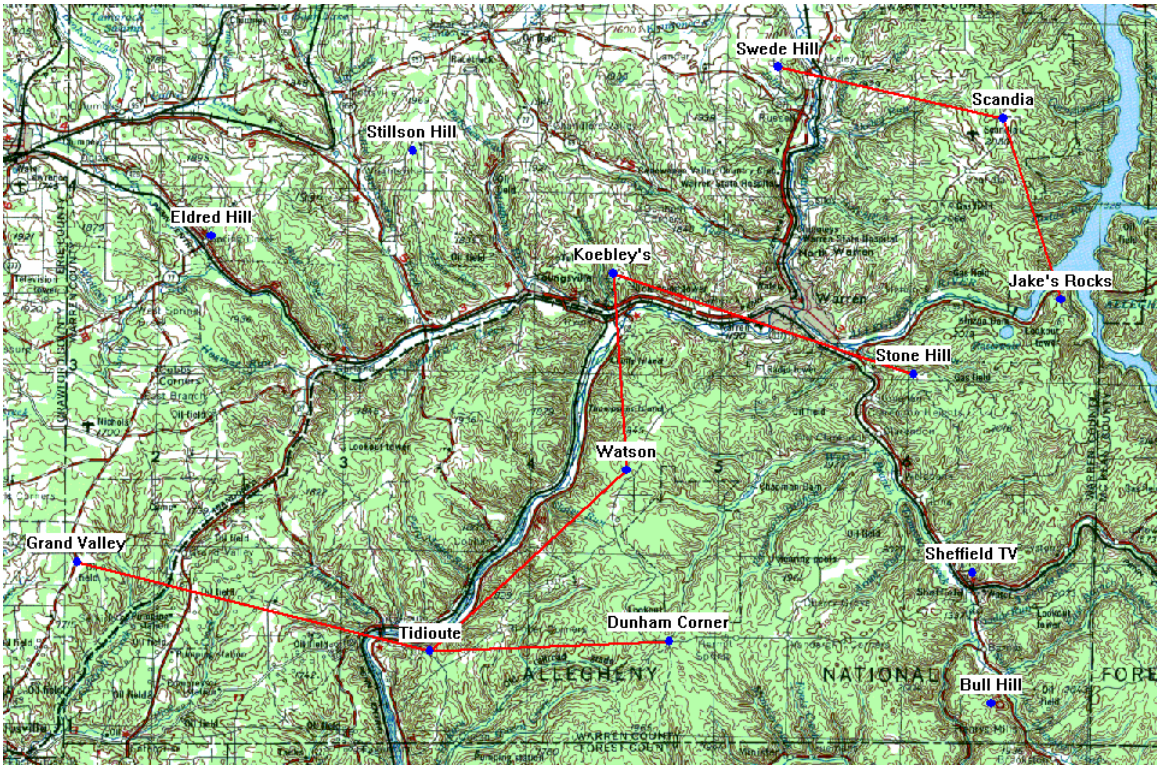
Between the 13 public safety radio tower sites identified in this report, CTC identified seven potential links for point to point connectivity depending on the height of the tower and any potential obstructions in the path. The profiles are provided in Appendix C and include:

- Koebley's to Stone Hill;
- Scandia to Jake's Rocks;

- Swede Hill to Scandia;
- Tidioute to Grand Valley;
- Tidioute to Dunham Corner;
- Tidioute to Watson; and
- Watson to Koebley's.

Figure 5-18 shows the potential links for connecting the public safety radio towers by point to point microwave links.

Figure 5-18: Potential Point to Point Wireless Links in Warren County



Public Safety Radio Wireless Backhaul Cost Example

Assuming that the seven links identified above are capable of supporting point to point wireless connectivity, an interim point-to-point wireless solution may provide broadband connectivity until fiber optics could be constructed to each tower facility.

One approach would be to construct fiber to a public safety radio site that requires the least amount of fiber optic construction. The fiber would provide backhaul to the point-to-point wireless network.

Given that fiber could be constructed to Koebley's and Swede Hill, an unlicensed wireless Ethernet backhaul network could be implemented for approximately $70,000 or $10,000 per link. In comparison, $70,000 is approximately ½ mile of underground fiber optic construction.

Other Potential Wireless Sites

Point-to-point links for backhaul connectivity may also be feasible to the proposed cellular sites within Warren County. Once the siting process has been completed, line of sight analysis can be performed to determine which sites lend themselves to wireless connectivity.

In addition to the point-to-point links, the tower locations may be suitable candidates for the deployment of point-to-multipoint wireless technologies for providing wireless broadband access in the nearby vicinity. Several facilities within Warren County may benefit from point-to-multipoint wireless connectivity including:

- Parks and other recreational facilities;
- Utility stations; and
- Any sites where fiber optic cost construction may be prohibitive.

Ideally, groupings of several wireless sites could be served from the same antenna locations to maximize labor and engineering expenses associated with installation, either using a point-to-multipoint wireless technology, multiple point-to-point links (operating at different frequencies), or with a single wireless connection shared by a cluster of remote sites interconnected by local fiber.

There may be terrain factors that prohibit the use of high-capacity wireless technologies to connect these facilities, such as elevation variations, tall buildings and vegetation. A more detailed analysis is required to ascertain the viability of wireless connectivity to remote sites. Also, there may be other sites that may be more economically served by wireless technologies, even as a short-term interim solution prior to fiber construction.

CTC recommends that the County and its stakeholders perform a point-to-point wireless communications analysis during the tower siting process and as communication towers are constructed.

5.2.7 Wireline System Overview and Cost Summary

Based on CTC's experience with other municipal fiber optic construction projects and our meetings and surveys within Warren County, CTC estimates the cost of constructing the three phases of fiber optic construction and connecting the 95 stakeholder facilities and tower sites in Appendix B to be $15.4 million, exclusive of the cost of the electronics.

The following section describes the costs associated with the construction of fiber optic infrastructure. One of the disadvantages of fiber optic construction is the cost and time

associated with constructing fiber in the right of way, although the overall flexibility and lifetime of fiber optics often outweighs these costs.

As part of our field work in Warren County, CTC observed that the vast majority of the County is served by aerial utility lines. Existing utility poles provide the opportunity to install fiber aerially, which can significantly reduce the overall cost of construction. For this study, CTC estimated that 90 percent of the fiber could be constructed aerially.

The exact percentage of aerial versus underground is determined after a network design and walk out of the fiber optic network. Depending on the availability of space on existing utility poles and the cost of make ready, some areas may require additional underground construction, although this will increase the cost of the overall network. Where economically feasible, CTC recommends constructing underground.

Table 5-3 shows the total cost estimate to construct the proposed fiber optic network.

Table 5-3: Overall Fiber Optic Construction Cost Estimates

Description	Mileage	
Phase I Backbone Loop	42	
Connect 45 Stakeholder Facilities	7	
Connect 4 Tower Sites	8	
Phase II Backbone Extension	61	
Connect 45 Stakeholder Facilities	8	
Connect 22 Tower Sites	71	
Phase III Complete Backbone Ring	54	
Connect 4 Stakeholder Facilities	2	
Connect 4 Tower Sites	1	
Total Mileage	255	
Pre-Construction Cost Estimates	Cost per Mile	Cost Estimate
Pre-Engineering	$450	$114,750
Pole Attachment Applications	$1,200	$306,000
Make Ready and Permitting	$15,000	$3,825,000
Fiber Construction Cost Estimate	Cost per Mile	Cost Estimate
Aerial Construction Cost Estimate	$33,309	$7,644,316
Underground Construction Cost Estimate	$126,211	$3,218,391
Facility Entrance Cost Estimate	Cost per Facility	Cost Estimate
Building Entrance Cost Estimate	$5,000	$325,000
	TOTAL	$15,402,857

It is important to note that the total construction cost per mile includes rough make-ready cost estimates. Make-ready is the process of physically modifying utility poles or re-arranging existing cable attachments on utility poles, as required to facilitate a new cable attachment and meet all applicable codes. Make ready costs are difficult to estimate in a fiber optic construction project for a non-utility pole owner, such as Warren County.

The greatest financial impact on underground construction costs is the cost of installing the conduit. An increase in the amount of boring and street cuts necessary increases the cost of construction. Costs such as street and sidewalk restoration also contribute to the high cost of underground construction. Based on other similar projects, CTC estimates a $15 per foot cost for excavation associated with underground fiber optic construction. From our analysis we estimate an average construction cost of $126,211 per mile for underground fiber optic construction, about four times the cost of aerial construction.

5.2.7.1 Equipment for Institutional Needs

The fiber optic design proposed in this report was designed to facilitate many potential networking technologies, including Gigabit Ethernet, MPLS, and SONET. With a high count fiber optic backbone it is feasible for the County to offer dark fiber, wavelengths over fiber using Wave Division Multiplexing (WDM), or managed network services. This flexibility allows many different network and operations models, and facilitates maximizing the number of stakeholders on the network.

In order to provide a budgetary number for the cost of network electronics to serve the institutional users, this section provides one possible network equipment strategy. The network strategy chosen for cost estimates is Gigabit Ethernet due to its prevalence in wide area networking and the relative simplicity in terms of maintenance and operations compared to other technologies.

For the Core site networking equipment, CTC recommends Gigabit Ethernet equipment that is highly redundant and capable of 10 Gigabit Ethernet backbone traffic around the ring. The core equipment should also have high density Gigabit Ethernet ports to aggregate traffic from the stakeholder sites. In the event of a fiber or equipment outage, the core equipment should be able to route traffic in the opposite direction around the ring to maintain connectivity. CTC estimates the cost for core networking equipment to be approximately $180,000 per site.

At key networking facilities, CTC envisions gigabit Ethernet equipment capable of connecting to two core facilities for added redundancy to these sites. The Ethernet equipment should be scalable to provide additional bandwidth capacity as needed, and provide the ability to support application servers and other hardware needed to support the network. CTC estimates the cost for key networking sites to be approximately $28,000 per site.

At each stakeholder facility and each public safety radio tower site, an access switch is needed to provide connectivity back to an adjacent core site. The access switch would provide a Gigabit

Ethernet uplink and multiple 10/100 Mbps Ethernet ports to attach networking devices. CTC also recommends purchasing access switches that provide power over Ethernet (PoE) to support systems such as Voice over IP in the future. CTC estimates the access site equipment to be approximately $18,000.

Given the assumptions above, the following table provides a budgetary estimate of networking equipment to support the stakeholder sites and public safety radio tower locations.

Table 5-4: Budgetary Equipment Cost Estimate

Description	# of Sites		
Core Sites	6		
Key Networking Sites	4		
Stakeholder Facilities	65		
Public Safety Radio Sites	13		
Site Type	QTY	Cost	Subtotal
Core Sites	6	$180,000	$1,080,000
Key Networking Sites	4	$28,000	$ 112,000
Access Sites	74	$18,000	$1,530,000
		Subtotal	$2,722,000
Ancillary Equipment (Firewalls, Additional Fiber Transmitters, etc.)			$ 100,000
Network Equipment Total			$2,822,000
(30% Equipment Discount)			$ (846,600)
Estimated Equipment Cost			$1,975,400
Installation and Integration Cost (25%)			$ 493,850
Total Equipment Cost Estimate			$2,469,250
Annual Maintenance Contract (15%)			$ 296,310

5.3 Potential Support of Emerging Wireless Technologies

This section describes some of the emerging wireless technologies that may facilitate communications in the future, and describes how the infrastructure components proposed in this report facilitate their deployment within Warren County.

5.3.1 WiFi

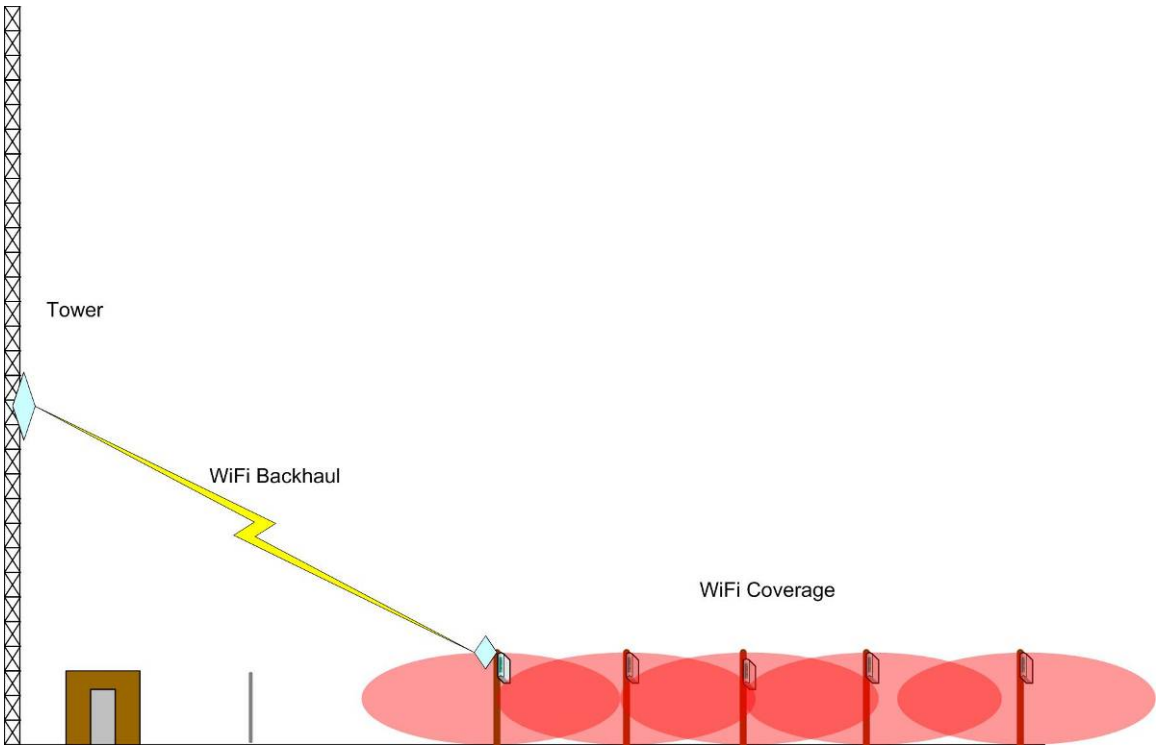
Municipalities and private telecommunications providers are deploying and operating WiFi networks, providing broadband access to multiple users. The fiber optic backbone network and towers proposed in this Report provide infrastructure that can be leveraged to support WiFi in Warren County.

WiFi products comply with one or more of the Institute of Electrical and Electronics Engineers (IEEE) 802.11 standards and operate in the United States within specific frequency bands allocated by the FCC for unlicensed operation near either 2.4 GHz or 5 GHz. The FCC regulations for operation within these bands include limitations on transmission power and specific channel assignments, which limits the range and capacity of WiFi networks.

Given the limitations of WiFi, many WiFi access points (WAP) are deployed in an area to provide coverage in a given area. In a WiFi mesh network, data travels through multiple, interconnected WAPs with routing capability. This is in contrast to a regular wireless LAN network, where every user has a dedicated path to a WAP directly connected to the backhaul network. The mesh network has one or more connections to the backhaul network.

The proposed fiber optic network and wireless communications towers are suitable for providing backhaul to a WiFi mesh network. Point-to-multipoint microwave links, such as WiMAX, can be used for backhaul to WiFi network, where fiber is unavailable. The proposed wireless communications facilities may be utilized to house network electronics and to establish line of sight with the WiFi mesh network to provide backhaul. Figure 5-19 provides a conceptual wireless backhaul for a WiFi network.

Figure 5-19: Wireless Backhaul for Meshed WiFi



WiFi access points attached to buildings, poles, and lampposts provide connectivity to residents and businesses using off-the-shelf network electronics, which lowers the cost of network

deployment. WiFi provides a fairly inexpensive method of delivering broadband connectivity to end users.

A third party provider, municipality, or the County could set up a WiFi network in a town or part of the County. WiFi projects are often used by municipalities as part of downtown economic development projects, such as the Main Street Beautifications projects in place in Warren County. Municipalities such as Mesa, AZ and Northbrook, IL are using their fiber optic networks to support WiFi deployments in their downtown districts.

5.3.2 WiMax

WiMax is an emerging wireless technology that could provide fixed point-to-multipoint wireless backhaul to Warren County stakeholder sites, residents, businesses, and other wireless networks, such as WiFi. WiMax standards are also in development for providing mobile wireless coverage.

IEEE standard 802.16, known as "WiMax," is designed to provide wireless broadband connectivity with similar data rates as those provided by LAN technologies. WiMax is intended to improve upon WiFi technologies by supporting greater range, mobility, and QoS.

The first 802.16 standard was developed for fixed wireless services, meaning for stationary users in homes and businesses. It was designed for data rates of up to 120 Mbps in the frequency range of 10-66 GHz. However, in this frequency band, communication requires direct line-of-sight between antennas.

The 802.16a standard uses frequencies between 2-11 GHz. The bandwidth in this frequency range is lower, but direct LOS transmission is not as critical at these lower frequencies. 802.16a supports long-distance transmission of wireless data at high bandwidths to stationary users.

The WiMax standards could be applied to a variety of different frequencies depending on the application. Within the 2-11 GHz range, there are several frequencies at which Warren County could operate a WiMax network. The unlicensed bands may be one approach to offering WiMax service. Another would be the use of the 4.9 GHz public safety spectrum, although it is not currently approved for WiMax. Such networks would be more like WiFi hotspots due to the power restrictions and would require more access points than a public safety radio system or wireless carrier solution.

Wireless carriers are also exploring using the local multipoint distribution services (LMDS) spectrum (28 & 31 GHz)[32] for WiMax, or some future frequency not yet defined to provide wireless data connectivity. High frequency WiMax networks would be deployed like point-to-

[32] LMDS is a point-to-multipoint wireless solution for high-speed data communications over ranges up to three miles. It was deployed by wireless data service providers including Teligent and Winstar. It is no longer in wide use.

point microwave systems, with the base station requiring LOS for antennas at fixed user locations.

WiMax may also be implemented at frequencies below 2 GHz. At the moment, 802.16 is not designed for use in the 700 MHz or other bands occupied by television broadcasters, but future versions may enable carriers or local governments to use lower frequencies for WiMax or other wide area networking technologies. At lower frequencies, WiMax deployments would be more like cellular or public safety radio deployments, with several antennas providing coverage over a large area without the need for line of sight. There are already proprietary broadband deployments using 802.16-like technologies.

The original WiFi standards were developed for stationary deployments, but the WiMax community is also developing 802.16e, a standard for both mobile and stationary users. 802.16e is intended to operate in the 2 GHz to 6 GHz frequency range in licensed bands for users traveling at speeds up to 75 mph. The optimal range for 802.16e is four to six miles, though in sparsely developed areas, the carrier or operator can deploy fewer antennas operating at higher power, and may be able to achieve a larger coverage area.

Mobile WiMax networks will have similar network architecture to a cellular network for broadband data applications. Wireless carriers will most likely deploy WiMax from their existing base stations and deploy a wireless data network in parallel to their existing cellular network. The wireless communications infrastructure and fiber optic backbone proposed in this report would provide backhaul and equipment and antenna siting for any type of WiMax technology deployed.

5.3.3 3G and 4G Wireless Technologies

Third generation (3G) and fourth generation (4G) are names associated with cellular provider wireless data systems. 3G systems are currently in deployment in most major cellular markets, such as Harrisburg, Pittsburg and Philadelphia, whereas 4G networks are in the conceptual and trial phases.

3G technologies gained their name as upgrades from earlier wireless data technologies. For CDMA based carriers such as Verizon Wireless, the 3G technology being deployed is EvDO, and for GSM based carriers like Cellular One, 3G technologies include EDGE and W-CDMA. 3G technologies typically provide between 200 and 700 kbps of throughput continuously depending on RF signal strength and the number of other users on a particular base station.

3G technologies are deployed typically by upgrading the base stations and mobile devices used on a network and are generally compatible with earlier 2G technologies. For a 3G deployment in Warren County, at a minimum the cellular communications infrastructure described in this report would be needed to deploy a 3G solution throughout the County. More than likely, additional tower locations would be needed to provide the capacity needed in a 3G network.

Many wireless technologies are in the conceptual or trial phases as 4G wireless technologies, including WiMax and upgrades of EvDO and W-CDMA. As trial systems are deployed and the 4G technologies are deployed in major markets, more information will be learned as to the exact deployment strategy necessary to upgrade form 3G to 4G.

From trends in the cellular industry and other projects CTC has overseen, it is assumed that the need for wireless communications facilities and fiber optic backhaul will not decrease as new technologies are deployed. In fact, the newer technologies are often implemented at higher frequencies with a denser deployment of radios. The scarcity of available RF spectrum and the capacity demands of new wireless technologies will likely lead to additional tower sites needed to provide capacity over the network, while decreasing RF output power to minimize the number of users on a single base station.

Given these national trends, there will clearly continue to be the need for infrastructure improvements, such as tower and fiber optic construction, to support and reduce cost barriers for advanced wireless services. Communications infrastructure, including towers and fiber optic cable, remains independent of wireless technology and has a much longer life cycle than equipment or wireless technology that uses it. Thus, investments made today can provide multiple decades of benefit to the community.

6. Emerging Technologies for Rural Broadband Access

This section discusses two additional technologies for delivery of broadband connectivity in rural areas- Broadband over Powerline (BPL) and 700 MHz wireless. For each of these technologies we highlight characteristics of each technology and the potential of each technology from a business case perspective.

Please note that although these technologies are appropriate for residential, small business, and remote asset monitoring, they do not replace the need for expanded fiber assets. In fact, in most cases both of these technologies require fiber in the network backbone and in order to connect the backbone to the Internet.

BPL is not recommended as a broadband solution in a rural area. While it has the advantage of using the most widely-available utility (power) for transport, it is costly to deploy in an actual rural environment on a per-customer basis. Furthermore, only one of the BPL manufacturers has optimized its equipment for the densities of rural areas, the rest focusing on urban and suburban builds.

BPL is limited in bandwidth relative to cable and DSL options. It has not been proven to scale to large networks, and is not standardized between vendors. Most BPL vendors are relatively small, further increasing the risk of investing heavily in a particular solution.

In contrast, there are wireless options which appear to be more promising for the type of population density, terrain, and population distribution in Warren County. We discuss as examples the 700 MHz technologies.

Using 700 MHz technologies, service providers in rural areas and small towns have obtained licensed spectrum at the top end of the former UHF television allotment, located infrastructure at towers, and cost-effectively served a thousand or more customers in the surrounding ten mile area with speeds comparable to or greater than DSL. The technology is well-suited to serving customers outside the DSL and cable service areas and could also be a competitor to those technologies where they exist. Prices are competitive with cable and DSL, and substantially lower than satellite. The cost to deploy the network is substantially lower than a wired infrastructure, and there are techniques to scale the network capacity to provide greater speeds or serve more customers as needed.

The challenge in deploying broadband in rural areas is not a question of getting a technology to work, but one of economics. Aggregation of needs, sharing of network resources, applying cost-effective technologies, and seeking benefits from a range of application is critical. Providers that do not consider the unique characteristics of the rural areas are likely to have difficulty in recovering sufficient revenues to finance the required investment.

High-speed Internet service is available from satellite companies, such as Dish Network and HughesNet, at speeds similar to DSL links (although pricing is considerably higher). These

services are an alternative for rural users who cannot obtain service from any other vendor. With a nationwide footprint for services, satellite-based connectivity technology has a substantial potential market. However, latency induced by distance to the satellite, limits the ability to support interactive application such as VoIP.

6.1 Broadband over Powerline (BPL)

Electric utilities have a potential to provide connectivity services using broadband power line (BPL) technologies. The potential is unleashed by leveraging the electric utilities' substantial existing infrastructure by installing BPL technologies which will support a wide range of connectivity services. BPL can support a range of useful applications that may justify the cost of installing the service: broadband Internet, Webcam security, automated meter reading, demand management and other services.

6.1.1 Technical Characteristics

Not all BPL is the same. The term BPL does not have a universal definition. The term BPL is used differently by consultants, vendors, and utilities. For this report, when we refer to BPL we refer to Medium Voltage Broadband over Powerline (MV-BPL)—the type of BPL used to provide Internet and data services in the United States over outside power distribution plant.[33]

BPL operates on the medium voltage (typically 12,500 volts) distribution system to deliver data services to residences or businesses. Characteristics of BPL include:

- Transmits low-power radio frequency (RF) signals – typically from 2 MHz to 50 MHz.
- Requires amplification (repeater) or regeneration of signals every 1,000 to 2,500 feet.
    - Amplification does not remove noise and does not add significant propagation delays.
    - Regeneration removes noise, but adds propagation delays (in milliseconds).
    - The number of times signal can be repeated/regenerated varies from vendor-to-vendor, and by application.
- Solutions are vendor proprietary. No standards are in place for the BPL network; discussions and development of standards center on interfaces into the proprietary networks.
- BPL has limited installations. In the United States, we estimate that less than 10,000 users are served by MV-BPL access systems (either in a trial or a commercial installation).

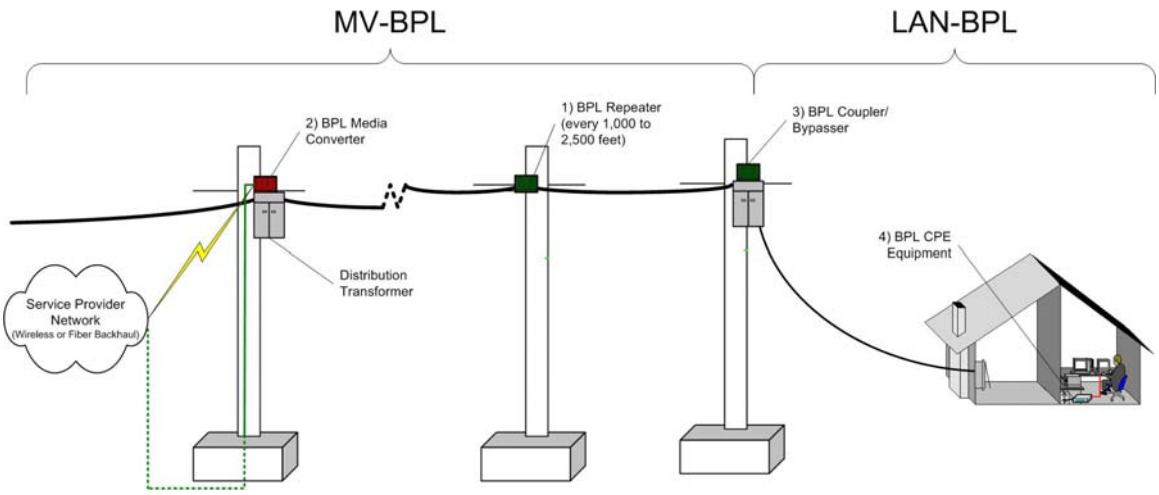
[33] There is also a version of BPL used in indoor electrical wiring, and versions used in Europe and Asia—these have different technical characteristics and business cases and are not potential service provider solutions in Warren County.

- Because transformers act as low-pass filters blocking high-frequency data signals, European and Asian power distribution systems are better suited to provide BPL. Because more customers are served by each transformer, a BPL system requires fewer traversals of transformers by the data signal.

In Figures 6-1, we have included a BPL deployment. This configuration is typical and includes:

- A customer premises LAN (LAN-BPL or wireless) (4)
- A bypass/coupler at each distribution transformer (3)
- A repeater/regenerator every 1,000 to 2,500 feet (1)
- A media converter (BPL to fiber or radio) in each neighborhood (2)

Figure 6-1: BPL Solution



The debate regarding interference from BPL technology continues. The most active opponent is the ARRL, the National Association for Amateur Radio.[34] The concern that is raised by BPL opponents is that BPL generates a high-frequency signal in the range of 2–30 MHz and, because it is transmitted through an unshielded cable, it may create significant radio interference.

The debate is not whether noise or interference is created but how far away from the BPL device interference will be seen and whether it will interfere with the use of a radio frequency (RF) band or channel. The Federal Communications Commission (FCC) responded by enacting rules that require a BPL operator to cease operation or modify its equipment if it were found to interfere with another user. However, concerns with potential interference continue, even with the FCC regulations.

[34] Please see http://www.arrl.org/tis/info/HTML/plc/ for additional information.

While it is proven that BPL will "work" technologically for deployments of thousands of customers, it is not clear that the type of service it provides will justify its expense. The issues of concern are:

1. Limited service speed per customer—typically comparable to lower-speed varieties of DSL service.
2. Lack of standardization and interoperability between vendor solutions.
3. Survival of equipment manufacturers.
4. Ability of product to compete where DSL and/or cable are present.
5. Scalability of BPL to large service areas has not been demonstrated in the United States.

With the exception of IBEC,[35] the BPL products[36] are designed for the urban or suburban markets, typically the areas served by both Digital Subscriber Line (DSL) and cable modem broadband access. Equipment manufacturers are not gearing their products to serve rural users or to address the "digital divide" between rural and suburban/urban areas.

From our review of the BPL industry, it appears that the lack of commercial implementation is a result of:

1. BPL vendors in the early stages of product development, so ISP's and other potential customers appear to be leery of being early adopters.
2. The business model for BPL access has proven difficult.[37]
3. Vendors and BPL ISP's need support from the electric utility beyond simple pole attachments. Trained line-persons need to install and maintain the MV-BPL equipment attached to the electric distribution system.

These conditions have driven the BPL vendors to look for other potential benefits – electric utility applications, new revenue streams such as video and voice services, and new business models.

6.1.2 BPL Business Models

The initial push for the BPL vendors was to convince electric utilities, such as investor-owned utilities (IOUs), municipals and rural electric cooperatives (RECs), to become the retail ISP. This push has had limited success. This has initiated the vendors to discuss a range of business models. The most common business models pursued today include:

[35] BPL vendors include: Ambient, Amperion, AskaUSA, BPLGlobal, COMTEK, Current Technologies, IBEC Inc., Intellon, Main.Net communications, Mitsubishi, Motorola, Samsung, and Telkonet, Inc.
[36] Samsung has reported some testing of BPL in rural China.
[37] Given the need for hardware to be installed at each distribution transformer and the required number of repeaters/regenerators, payback of the investment requires a substantial number of Internet subscribers, and expansion into voice and video services.

Landlord Model: The electric utility allows service provider to have BPL equipment installed and operated on the electric system, while the ISP owns BPL equipment and delivers retail services.

Service Provider Model: The electric utility installs, operates, owns the BPL network, and becomes the retail ISP.

Wholesale or Developer Model: The electric utility installs and operates the BPL networks and owns the network, solely or in partnership with another provider. A third party ISP provides the retail Internet services.

With each of the above models, more and more emphasis is being placed on potential benefits to the electric utility. For example, BPL vendors promote the use of their networks for:

- Automatic Meter Reading.
- Automatic tampering and theft avoidance.
- Dispatch and Control of Dispersed Generation.
- High-Impedance Fault/Downed-Conductor Detection.
- Outage prevention.
- Power System Equipment (capacitors, transformers) monitoring.
- Remotely controlled substation feeder load balancing.
- Supervisory Control and Data Acquisition (SCADA).

The proposed value propositions for use of BPL include improved power network efficiency and capability, reduced capital outlays for peak capacity conditions, reduced time and spending on truck rolls, avoidance of unplanned outages, and overall reduction in capital and operating costs.

These claims raise several questions:

1. Although the above utility applications are beneficial to an electric utility, don't electric utilities do many of these applications today?
2. What portion of the electric utility application is supported by the BPL system and what portion is a new investment (What portion of the investment is for meters, head-end software, and other equipment and what portion of the investment is for the media [BPL, fiber, wireless, PLC, other])?
3. Don't some of the Advanced Metering Infrastructures (AMI) vendors support these applications today?
4. If the cost of installation and operations of a BPL network requires funding beyond the anticipated retail ISP sales, is it a wise investment?

It is our opinion that **a BPL network needs to stand on its merits for delivery of services to end users, i.e., retail Internet services.**

6.2 700 MHz Wireless Systems

Wireless systems have become a very popular form of connectivity technology. Fixed wireless, Local Area Network (LAN)–based wireless used in the external environment, and mobile wireless (mainly cellular telephone–oriented systems) will continue to revolutionize the way businesses and their customers communicate. Fixed wireless systems continue to expand at a rapid pace, and prices have dropped on the most common 802.11 WiFi systems to the extent that an access point costs under $40 and an interface card costs $20. We anticipate similar price performance trends for equipment that uses newer fixed wireless standards to provide increased speeds, increased distances and additional functionality (such as equipment supporting the proposed 802.16 WiMax standard). The early LAN-based wireless systems used by many can be expected to adopt the newer standards-based approach that is optimized for the external environment.

Cellular telephone providers are beginning to implement connectivity technology, allowing for data transfer at higher speeds. The five largest vendors are implementing mobile, data-oriented networks that will provide Internet connectivity that offers throughput in the range of 300–400 Kbps. This will be followed by equipment supporting the proposed 802.20 standard for mobile communications. End user equipment can be expected to support multiple fixed and mobile approaches to connectivity, providing the greatest speed based on the services it senses at a particular location.

Although the wireless technologies above are evolving for subscriber markets, rural use is likely to be cost-prohibitive for some time. The 700 MHz band offers the opportunity for cost-effective solutions in rural areas today. To demonstrate this potential, we have outlined two uses, one for retail offerings, and the next for asset management.

6.2.1 Gardonville Cooperative Telephone Association, Brandon Minnesota[38]

Gardonville Cooperative Telephone Association (GCTA) is an aggressive cooperative serving its consumer members throughout western Douglas County and eastern Grant County in Minnesota. GCTA provides service for 4 exchanges in west central Minnesota, serving the towns of Brandon, Erdahl, Evansville, Garfield, Leaf Valley, Melby and Millerville. GCTA also offers traditional landline telephone and DSL service in Garfield, Evansville, Brandon, Millerville, and the west side of Alexandria

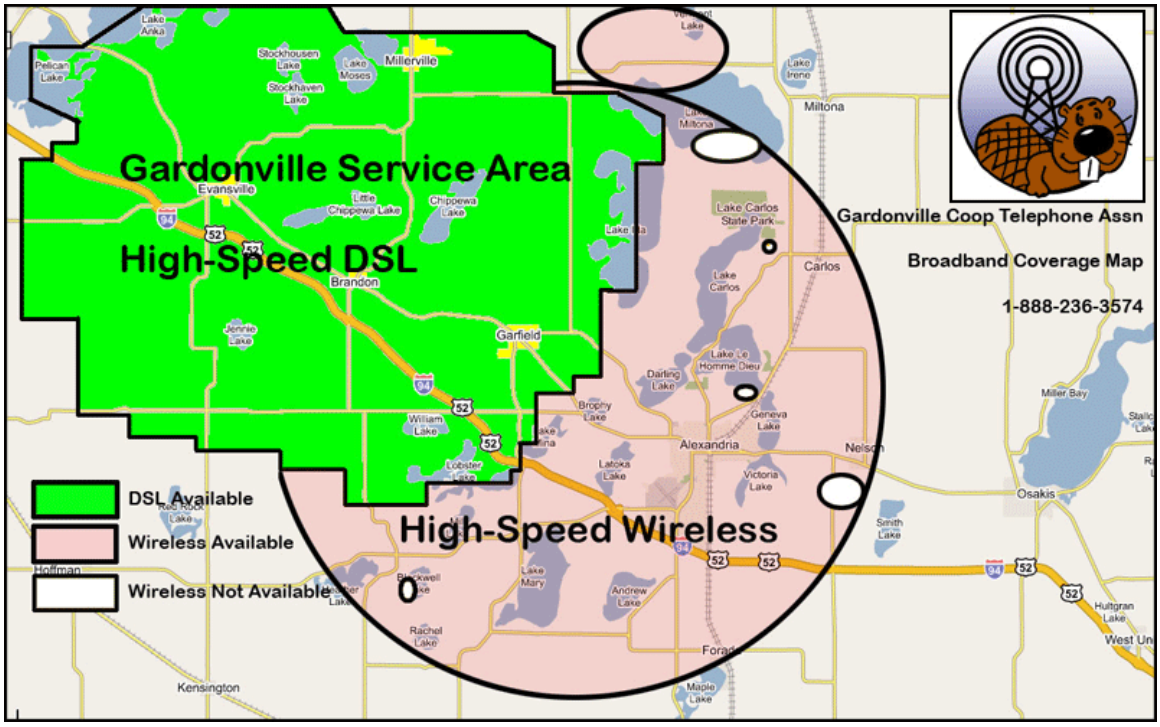
GCTA is a cooperative telecommunication system that was formed in the early 1940's by a group with a desire and understanding of how important telecommunications would be in the future. GCTA was started primarily from the formation of consolidation of small farmer-owned

[38] Information for this summary are from interviews with Andy Erickson of Technical Support and Kathleen of Customer Service, GCTA, March 16, 2007 and GCTA's web sit - www.gctel.com.

rural line systems, which were consolidated at that time into offices in each town that it currently serves.

GCTA continues to strive to meet its mission to provide state of the art telecommunication services to its members. GCTA has gone beyond traditional telephone services. GCTA offers a complete line of affordable Internet services including dial-up, DSL, and web & e-mail hosting to its consumer members. In February of 2006, GCTA expanded its Internet service – adding wireless. The wireless addition allowed GCTA to expand its high-speed Internet services beyond DSL footprint. The expanded service area is shown in Figure 6-2.

Figure 6-2: DSL and 700 MHz Coverage Area



Wireless Internet system operates in the 700 MHz licensed spectrum and is encrypted. The system tower is located in Garfield (seven miles Northwest of Alexandria) and pointed at the Alexandria area. A new tower will be going up in Nelson (five miles east of Alexandria) soon. This flexibility offers GCTA to offer Internet and VoIP services GCTA is presently testing VoIP telephony on the wireless system, and plans for system rollout at a later time.

System uses Vyyo headend equipment, wireless access points (WAPs), and customer premises equipment (CPEs) or modems. The system has a Vyyo CMTS and customers are provided with a Vyyo 280 Plus modem. Customers are provided with GCTA-owned modem, transceiver, and a mounted antenna at no extra charge as part of the service.

As shown in Table 6-1, multiple speed and packages available for Internet service. Prior to an installation, technicians test the location to determine if service is available. Foliage and other factors can prevent signal from being available.

Table 6-1: 700MHz Internet Service Offering

Speeds – Download/Upload	Price	Equipment	Installation Fee
256 kbps/256 kbps	$29.95/mo.	Vyyo 280 modem, external 700 MHz transceiver and house-mounted antenna	$40 install fee for one computer.
512 kbps/512 kbps	$34.95/mo.	Vyyo 280 modem, external 700 MHz transceiver and house-mounted antenna	$40 install fee for one computer.
1 Mbps/1 Mbps	$49.95/mo.	Vyyo 280 modem, external 700 MHz transceiver and house-mounted antenna	$40 install fee for one computer.

The above pricing is lower than satellite, for a service that does not have latency issues.

6.2.2 Arcadian Networks[39]

Another use of 700 MHz is for monitor and control of dispersed assets. In November of 2006, Arcadian Networks announced an agreement for deployment of a 700MHz network with Great River Energy (GRE) - a wholesale power cooperative which serves 28 distribution cooperatives in Minnesota. Arcadians' 700MHz solution will be primarily used for ongoing Supervisory Control and Data Acquisition (SCADA), security surveillance, Voice over Internet Protocol (VOIP), control area operations, automatic meter reading (AMR) and workforce management.

Arcadians' plan is based upon aggregating needs for companies with dispersed assets such as electric utilities in rural areas. Arcadian Networks approach is to provide a secure two-way private licensed broadband radio spectrum to substations, feeders and meter sites, allowing utilities and other dispersed assets industries to monitor mission-critical assets in real-time, detect problems proactively and respond to the growing security requirements of their facilities and assets.

It appears that Arcadian Networks is not looking to offer retail services over the 700 MHz network. Arcadian feels that industries that will use the network include electric, gas and water utilities, oil producers, public safety, mining, transportation, and other business or government agencies with dispersed critical infrastructure and assets.

[39] Information in this section is from the Vyyo Wireless website, www.vyyo.com and Arcadian Networks website, www.arcadiannetworks.com.

7. Developing Partnerships and Technology Selection Strategies

This section discusses the need for collaboration between users and providers in order to advance available infrastructure in Warren County. The section also presents capacity needs and appropriate technologies for different types of consumers, a phased connectivity strategy, and summarizes potential business model elements.

7.1 Collaboration and Aggregation

Economics are the reason that cellular coverage and advanced connectivity options are limited in Warren County today. To justify cost, proposed County-wide connectivity assets such as fiber infrastructure and tower sites must support other traffic, services, and applications. In addition, to reduce the cost of financing, grant sources are likely required.

Section 5 provided details of the antenna tower and fiber backhaul requirement needed to expand cellular telephone coverage. The proposed plan and cost estimate included construction of 21 towers (four shared with public safety) and 255 miles of fiber. The total implementation cost estimate is $17 million. If the implementation cost is financed over a 20 year period at six percent interest, the resulting principle and interest (P&I) payment is $123,000 per month. In addition to the P&I costs, ongoing maintenance and fiber repair add approximately $100,000 per year.

If a 20 year lease was developed to capture the entire cost deployment and maintenance, the required monthly lease payment from the carrier is $132,000. Based upon the 18,000 households located in Warren County, this represents a monthly cost of over seven dollars per household. This cost does not include the cellular carriers required investment for networking electronics and radio equipment at each tower. These investments can easily exceed $6 million, and have a shorter lifetime (five to seven years) than the 20 year fiber and tower investment. Adding these costs (a P&I payment of $89,500 per month if financed over seven years) increases the average monthly cost per household to over twelve dollars. These economics do not work if the network is solely supporting cellular coverage expansion.

The challenge for connectivity providers in Warren County is one of collective consumer use and the resulting revenue streams. There are not enough consumers for multiple providers to set up networks. Although the collective revenues might be sufficient to justify the required rate-of-investment (ROI) for a private investment in a County-wide infrastructure upgrades – there are not sufficient revenue streams to support uncoordinated County-wide infrastructure upgrades. For example, today each provider has their own closed infrastructure that is used to connect consumers and distribution locations within and between communities. It is unlikely any of the providers can obtain a sufficient ROI to justify upgrading or expanding the footprint of their County-wide infrastructure on their own. Further, new potential providers are discouraged by the high-cost of deploying County-wide and last-mile networks.

To counter economic obstacles, we recommend that Warren County seek partnerships and alliances with consumers and providers to collaborate on infrastructure upgrades and to aggregate consumer use. Some may conclude that consolidation and aggregation leads to fewer competitors and higher prices; however, we believe the opposite actually results. In today's model, consumers are paying for duplicate infrastructures and lack choice in connectivity option since each provider operates closed networks. Collaboration and aggregation encourages existing providers to offer enhanced services and new providers to enter the market place.

In addition, grant funds are needed to offset revenue stream shortages. Without grant funding, it is likely that the performance and coverage of essential public safety communication will continue to lag behind requirements (see September 8, 2006 manhunt and capture case study).

Whether Warren County is negotiating with potential partners or creating alliances it is important to remember that creating and operating a fiber, wireless, or BPL network is a strategy, not a goal. In order to assess whether or not a given partnership or technology strategy makes sense, it is necessary to identify and agree upon the overall goals, objectives, and other measurements before making the determination to proceed.

In Section 7.4 we present various elements of business models for Warren County's consideration. Of the elements presented, CTC recommends: identification of anchor tenants including cellular carriers and public safety users; analyzing operation efficiencies; expanding economic development opportunities through advanced connectivity; encouraging open access to networks to facilitate new provider entrants to marketplace; and public-partnerships to leverage core competencies.

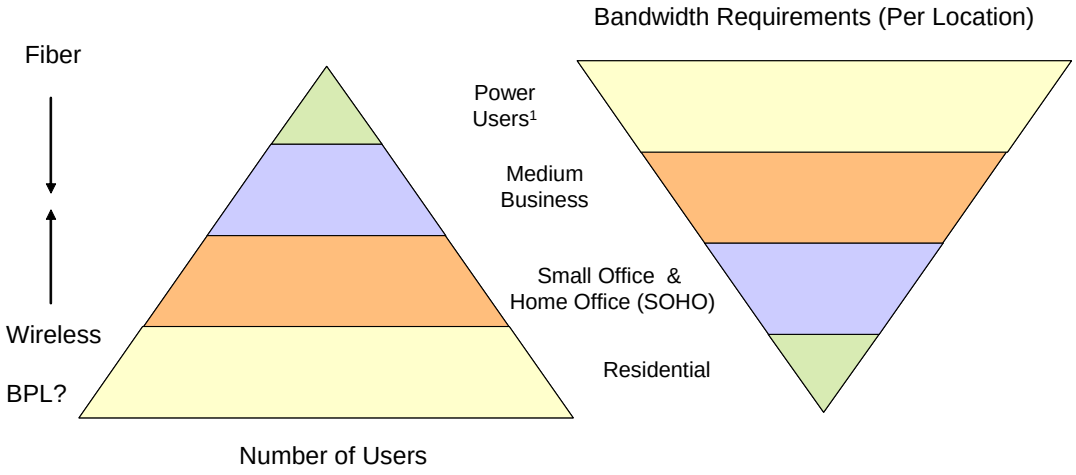
7.2 Balancing Consumer Needs and Technology

The driving force behind the technology solution is the desired level of service, the types of services available, projected revenue streams, and cost-effectiveness. It is also important to remember that the technology selection is not always an either/or choice: a combination of technologies is required in order to effectively meet service goals and objectives.

7.2.1 Consumer Needs and Technology

In Figure 7-1, we show the balance of bandwidth requirements at a given location to the total number of users.

Figure 7-1: Hierarchy of Consumer Needs and Technology



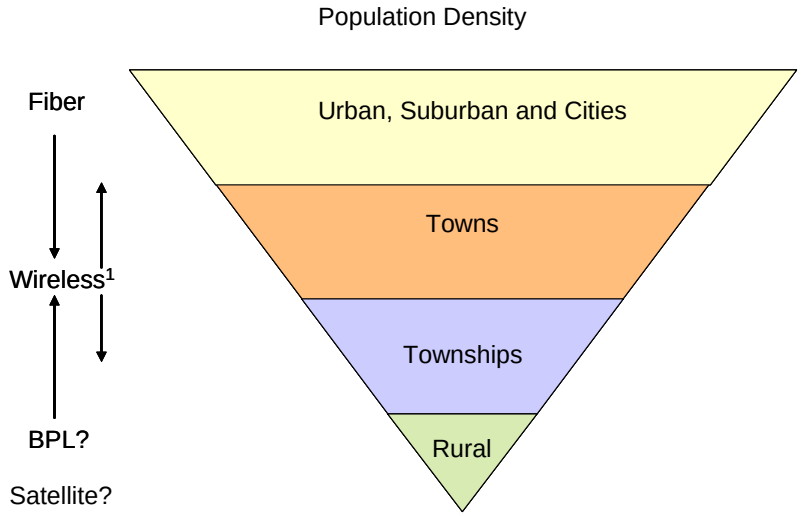
[1] Includes Institutions, Education Facilities, and Large Offices

As seen, today's requirement for bandwidth at a residential location is substantially lower than in a medium business or a "power user" location such as a school. The appropriate technology selection depends upon the positioning, goals, or "future-proofing" objectives of the investment. Further, it is appropriate to consider a mix of technologies. For example, if a goal is to ensure that business have access to state-of-the art services for economic development, and you want a affordable high speed data services for residences, Fiber-to-the-Business and a wireless combination is a potential approach.

7.2.2 Population Density and Technology

Both fiber and wireless are more cost effective in areas with higher population density. Wireless, however, will eventually run into capacity constraints, and require more and more transceiver sites to serve the number of users. As shown in Figure 7-2, today's wireless or fiber alternatives are not cost effective in the rural areas.

Figure 7-2: Hierarchy of Population Densities & Technologies

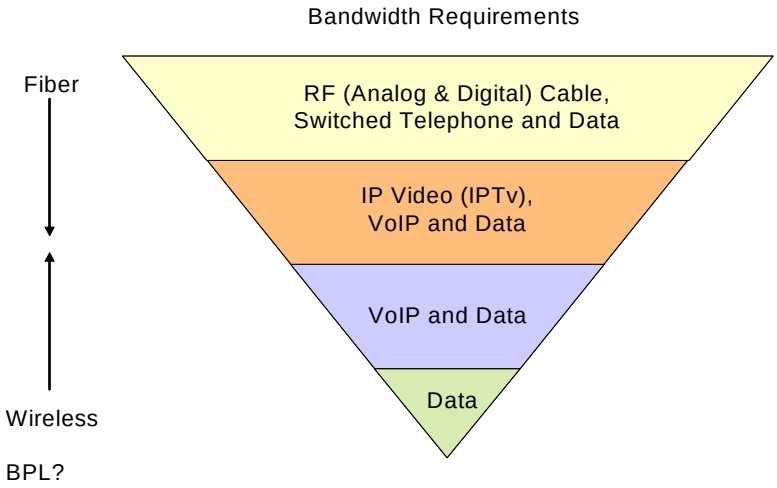


[1]Terrain, foliage and other objects impacts the viability of wireless.

7.2.3 Service and Technologies

The required bandwidth is directly related to the types of service you are considering; this is shown in Figure 7-3. As seen in Figure 7-3, traditional cable television service leads to the need for FTTP. If your goal is to provide high-speed data connectivity and support applications such as VoIP, wireless may have adequate capacity. Finally, if your goal is to provide Internet Protocol (IP) based video applications (IPTV), then FTTP is the most appropriate solution.

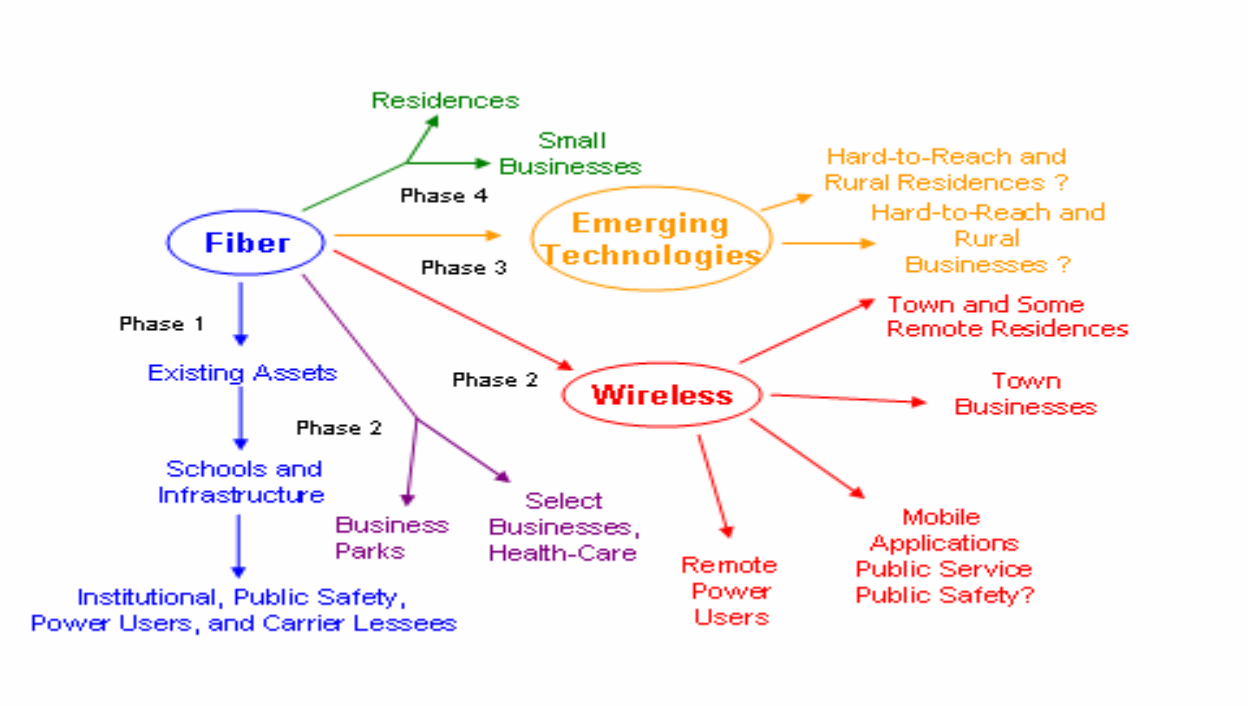
Figure 7-3: Hierarchy of Services and Technologies



7.3 Phased Technology Deployment

We recommend consideration of a phased infrastructure deployment as shown in Figure 7-4. The starting point is seeking alliances and partnerships that provide the momentum for Phase 1 – expanding the County-wide fiber connecting communities, strategic sites, and institutional users.

Figure 7-4: Potential Technology Deployment Strategy



Phase 1 consists of deployment of a County-wide network, expanding the reach and capability to connect communication towers, City, County, school, hospital, and other institutional users with fiber (enhances performance of available connectivity, enables expansion of cellular coverage, provides cost containment, and enables aggregation of regional use).

Phase 2 expands the County-wide fiber network to selected business parks and select businesses (further enhances performance of existing connectivity, economic development and revenue streams).

Phase 3 encourages deployment of last-mile wireless technologies throughout the cities in Warren County (maximizes use of high-speed Internet access, improves public safety communication, increases affordability and enables IP based video with voice alternatives).

Phase 4 deploys emerging last-mile BPL[40] and wireless technologies to serve hard-to-reach and rural areas (expands availability and affordability of connectivity options).

Phase 5 deploys an FTTP network to all residences and businesses (enhances performance of available connectivity, provide full range of traditional voice and video services).

[40] Deployable BPL technologies today are limited to technologies that create a LAN on the low-side of the distribution transformer. BPL technologies that are designed to propagate on the medium voltage distribution system are in the "experimental" stage.

7.4 Summary of Potential Business Model Elements

Business models are based upon objectives, legislative considerations, risk aversion, financial objectives and other considerations. A successful model examines the unique needs and objectives to develop an approach that works for each of the potential partners.

The following paragraphs detail elements that are commonly used to develop business models for collaborative infrastructure (anchor tenant, community branding, community operations, digital inclusion, economic development, ISP competition, open access, private enterprise, public-private partnerships, and universal access). The elements are not mutually exclusive, and in practice, the actual business models use a combination of these elements.

Anchor Tenant: The government entity (Warren County in this case) encourages a private entity to build, operate and maintain the network by agreeing to purchase capacity for public service and some public safety applications.

- Principles: The County can fulfill internal needs using an enhanced network but does not want to own or operate the network. In addition, the County may also desire that residences and businesses have an alternative low-cost high-speed Internet access option.
- Financing: The Anchor Tenant element uses general operating budget funds to meet tenant obligations. Grants are likely required in rural areas to assist in required infrastructure deployment and to enable some of the public safety functions.
- Primary Objective: To assist the provider with financing by guaranteeing an investment in the system and providing a fixed-source revenue stream. Given the magnitude of the financial commitment, the County is allowed to own, control, or influence some aspects of the network such as capacity, coverage, and performance.

Community Branding: For new market entrants, one of the highest expenditures a company expects to make is the creation of name recognition and branding. In this element, the County or other entity allows a private provider to use the public name to market the service.

- Principles: Obtaining market share is very expensive for new market entrants, and becomes a barrier to market entry for companies – especially in sparsely populated areas. Community branding may increase market share, reduce initial marketing expenses, raise the projected rate-of-return and lower the market entry barrier for new provider entrants into the market.
- Financing: This element often does not require resources over and beyond allocating space in existing publications and communications. Issuing targeted or specialized communication requires covering incremental costs with existing or expanded operating budgets.
- Primary Objective: Provide familiarity and credibility with the service provider to raise the consumers' comfort–level with contracting for the service. With public entity support, the provider can reduce marketing expenses and increase net contribution margins. Ensuring that the public entities brand image is maintained is critical if this element is used in the business model.

Community Operations: The County builds the network to increase or expand upon services and programs. The network provides voice and data service to municipal employees for use during the work day. Although the network is not marketed to residents, it is possible to allocate spare capacity for residential access.

- Principles: The County or other public entity implements a last-mile network to provide cost-effective communications support for day-to-day operations. Remote access to files, report writing programs and GIS applications increases efficiency. The public entity is able to improve upon and/or expand services by permitting employees in-the-field access to databases.
- Funding: Funding for this initiative is generally allocated from general operating budgets or grants for development of the applications.
- Primary Objective: To maximize efficiency, reduce the need to re-enter handwritten field reports into the computer, permit field personnel access to GIS information and municipal databases and to reduce overall staffing costs. The public entity is also able to expand upon services and programs that rely on in-the-field digital access (building permit approvals, occupancy permit processing, Fire Department inspections, social service files, etc).

Digital Inclusion: The County or other entity provides access in a city-wide or selected geographic area to assist in closing the Digital Divide. This element also requires attention to the other components of the Digital Divide including education, training, and equipment. Many agencies (schools, job training agencies, etc.) provide computer training. To reduce duplication of efforts coordination between other community agencies is important.

- Principles: Affordable high-speed access is an essential service to citizens. Those with high-speed access can participate in online services and programs; those without high-speed access are left behind.
- Financing: Digital inclusion programs are funded through traditional revenue sources as well as through grants and Community Development Block Grand Fund (CDBG) funds.
- Primary Objective: To provide a means to ensure equal access to the electronic world. Equipment costs have decreased and educational initiatives that provide computer training are on the increase. The Divide is increasingly seen as resulting from the consumer's inability or reluctance to pay monthly access fees; therefore, newer Digital Divide initiatives focus on reducing or eliminating monthly access fees.

Economic Development: An investment in the future is the focus of this model element. The County builds the network (County-wide and/or last-mile) to provide affordable access for residents and businesses. The difference between this attribute and the Universal Access attribute is the inclusion of the small business sector and an emphasis on job creation and economic growth.

- Principles: The County seeks to encourage both businesses and residents to relocate to the region by providing an essential service at an affordable cost. Upgrading the

communication infrastructure is important to attracting "cutting edge" or "high tech" businesses to the area.

- Financing: Revenue sources are similar to Universal Access including grants, assessment funding, general obligation bonds, user-based fees or allocations from the general fund. In addition, depending on the project, special assessments with incrementally-based payoff period are a potential financing source.
- Primary Objective: The project promotes community growth and development of both traditional and new businesses. A projected increase in tax revenues offsets the initial network investment and on-going day-to-day operational costs.

ISP Competition Model: The County builds the last-mile network and markets the service. They act as a utility provider and increase staffing levels to cover technical, sales, operational, and maintenance functions. In order to insure sufficient market share is obtained to reach a break-even cash flow, marketing the service is critical. Network performance, supplemental services and degree of technical support are established and clearly defined. Residents judge the system by the degree of network reliability and customer service support.

- Principle: Since existing high-speed and broadband options are not meeting the needs of all residents and businesses in the community, the County steps in to provide a cost-effective service.
- Financing: The County makes an initial investment to build the system and market the services. The revenue stream from customers of the service pays for the maintenance and further system enhancements. Financing the network deployment is likely to require use of general obligation bonds.
- Objectives: To bring universal high-speed access to the community and promote competition in the marketplace. The County realizes at least a breakeven cash flow sufficient to support continued operation and development of the system. Customers are satisfied with the service – its reliability and speed. More residents and businesses switch to high-speed and prices for access decline.

Open Access: The County or other public entity deploys a ubiquitous broadband network to connect residences and businesses. The public entity then leases the network to private sector service providers that in turn deliver retail services to the residences and businesses.

- Principles: Reducing the barriers to entry entices businesses to invest in the region. Retail providers are constrained by the high initial investment needed to build a broadband network. If the County or other entity provides the network, private retail providers are able to focus on a retail service model rather than network investment and operation.
- Financing: The Open Access Model can consider use of grants, special assessments, general obligation, revenue or other bonds or general operating funds. Financing payments are offset by lease fees charged to the retail providers.
- Primary Objective: Provide competitive choice in high-speed service for all residents and businesses by removing a formidable barrier to entry. New retail providers enter the marketplace, offering greater customer choices.

Private Enterprise: Broadband accessibility is determined by private companies responding to their perceptions of the market. Warren County adopts a "laissez faire" approach and relies on private companies to build systems.

- Principles: Public entities should not compete with private companies for the provision of goods and services.
- Financing: The financing is completely covered by private companies.
- Primary Objective: Let the market determine the availability of goods and services in a community.

Public/Private Partnership: The County or other public entity collaborates with one or more private companies to build the network and/or provide services. The partner either supports components of the ISP or acts as a network leasing agent.

- Principles: A public/private partnership makes sense when both sides of the partnership have significant items to contribute to the project. This element leverages each party's core competencies. Municipalities focus on infrastructure and the Internet Service Providers devote attention to delivery and support of retail services.
- Financing: The financing for this model depends upon the contributions of the public entity. For instance, for little-to-no-cost, the public entity provides access to poles, conduit and facilities. In addition, the public entity builds the network and contracts with a private company to operate and maintain the network in exchange for a portion of the revenues. In this case, funding the network infrastructure is from grants, general obligation, revenue or other bonds.
- Primary Objective: To provide ubiquitous network coverage by capitalizing on the assets each partner brings to the project. It relies on the strengths of each partner to integrate operations.

Universal Access: This element provides free ubiquitous access to residents. A subset of universal access is deployment connectivity in targeted (hot spots) in outdoor or indoor public areas. The hot-spot approach is the lowest cost and is currently the most popular municipal approach.

- Principles: The general public is beginning to view universal high-speed access as an essential service. In the past, local government played a role in bringing essential services such as roads, water, and sewer to the community. Pooling or aggregating resources from citizens to provide essential services takes advantage of economies of scale and reduces costs paid by citizens for connectivity access. This business model stimulates the local economy by assuming that these citizens will use savings to acquire other goods and services.
- Financing: Revenue sources include assessment funding, General Obligation bonds, user-based fees or allocations from the general fund.
- Primary Objective: To provide the residents of the community with free access to high-speed access so that they can take advantage of online resources, pursue opportunities in

education, commerce, etc. The project facilitates citizen's future success in the 'new digital economy'.

- Secondary Objective: Provide access to area visitors so that the County is a more attractive destination for those needing online access. An increase in numbers of visitors means an increase in purchase of goods and services and a boost for the local economy.

The elements of the business models are not mutually-exclusive. The model that ultimately addresses Warren County's unique goals and objectives needs to contain elements from more than one model.

Appendix A: Tower Locations

Appendix B: Fiber Optic Site Listing

Appendix C: Line-of-Site (LOS) Profiles

Appendix D: Potential Funding Sources

