Clarke County Planning Department

101 Chalmers Court, Suite B
Berryville, Virginia 22611
(540) 955-5132

TO: **Board of Supervisors**

FROM: **Brandon Stidham, Planning Director**

RE: **Special Board of Supervisors Meeting – Tuesday, November 29**
Presentation of Telecommunications Infrastructure and Broadband Study by George Condyles (Atlantic Group)

DATE: **November 22, 2016**

Enclosed you will find two documents prepared by George Condyles (Atlantic Group) for presentation to the Board of Supervisors at a special meeting scheduled for **Tuesday, November 29 at 7:00PM** in the Government Center Main meeting. The first is the *Telecommunications Infrastructure and Broadband Study 2020* – an update of the previously distributed Draft #1 revised following receipt of comments from Planning Staff and members of the Planning Commission's Telecommunications Subcommittee. The second document is the *County Organizational Structures and Funding Strategies.* This document outlines specific recommendations from the consultant to facilitate the advancement of broadband in the County. Copies of both documents are also being sent to the Planning Commission and they have been invited to attend the special meeting.

Staff recommends that if the Board has no outstanding questions or concerns with the study documents and finds that the consultant has effectively addressed the requested Scope of Services, a motion should be adopted to formally accept the study. If there are questions or concerns, we encourage the Board to provide those to Mr. Condyles so that he may address them either verbally or through additional edits to the study documents.

If you have any questions or concerns in advance of the meeting, please do not hesitate to contact me.

Telecommunications Infrastructure

And

Broadband Study

2020

November 22, 2016

Performed by

THE ATLANTIC GROUP OF COMPANIES, INC.

"Navigating the Seas of Technology"

6260 Pine Slash Road
Mechanicsville, Virginia 23116
(804) 559-6004
www.atlanticgroup.us.com

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Board of Supervisors

David Weiss, Chair (Buckmarsh Election District)
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Mary L. C. Daniel (Berryville Election District)

Planning Commission Telecommunications Subcommittee

Robina Bouffault
Douglas Kruhm
Jon Turkel

Staff

Brandon Stidham, Director of Planning
Ryan Fincham, Senior Planner/Zoning Administrator
Len Capelli, Director of Economic Development and Tourism

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1. Executive Summary

November 22, 2016

To the Board of Supervisors of Clarke County,

This study focused on the deployment of Telecommunications Infrastructure in relationship to Broadband technology growth within Clarke County, Virginia. The Atlantic Group studied several technical and geographic areas and has determined that Clarke County is progressing in a positive direction in this subject area. While improvements need to be made in the infrastructure planning and application review, the residents of Clarke County are using broadband for home and business uses and will continue to seek greater speed, reliability, and choice of service providers.

There is an explosion of Broadband services and applications that concern all areas of a community. Clarke County is making positive progress in all spectrum areas of simple internet access such as applications for education, commerce, telemedicine, entertainment, business applications, economic development and many more. The demographics of Clarke County and the high demand for Broadband services have led to the next phase of Broadband technology and the infrastructure to address this evolutionary growth. The focus time period for this study is the year 2020 and what will be required to address the "needs" for broadband.

There are several "truths" that must be reinforced when discussing Broadband and its future in a community environment. They are:

1. *There will not be a "one technology wins all subscribers" that will make other technologies obsolete in the digital age.*
2. *Networks will continue to be "hybrid" in nature with various delivery systems, transport technologies, transmit frequencies, device access and infrastructure requirements.*

3. *Service equipment will migrate toward "generic" technologies with speeds that will provide faster "uplink and downlink" to the subscriber.*

4. *The consumer/subscriber will "shop" for services that they can afford but have multiple service providers that they contract. There will be less "one stop shop" service single providers. "My device will subscribe to the services I want, when and where I need them. The technology is irrelevant to me."*

While many of the delivery systems for broadband cannot be discussed in great detail because of proprietary research and development, the providers make known what the emerging technologies are. There are "common" elements of the delivery systems that will address many of the technologies. These "common" elements are communications infrastructure such as towers, fiber optic cable (feeder/distribution), and location of telco central offices, cable provider nodes, Air Space availability, NEPA requirements, and Section 106 requirements.

The important point is not to believe that there will be "one technology" that will define broadband, but look at the technology that has a "hybrid" component that may deploy various speeds and volumes of data at affordable cost depending on the usage and speed required. Remember, not all "users" have the same requirements.

The Atlantic Group's assessment is that Clarke County has progressed "marginally" with Broadband services. The largest deficiency is "infrastructure placement" most notably wireless communications facilities or "towers." While approximately 75 % of the County is covered with acceptable levels of "voice" service, there is a large gap in "data" service levels. Most of the towers that transmit and receive wireless data are located on the County borders or just slightly outside of the County. This creates "perimeter" coverage with only limited "interior" coverage.

The Atlantic Group has worked with many counties over the years where the county may have a "deficiency" in broadband. Counties tend to address this issue from various points of view. Some counties take a "hands-off" approach because they believe that it is not the place of local government to promote a commercial venture. While on the other extreme, many counties have created a "Broadband Authority" which has become a service provider with the ability to impose "fees" under the laws of The Commonwealth of Virginia. Most counties are somewhere in the middle of the involvement spectrum.

The Broadband Committee may seek to "collaborate" with broadband service providers for greater broadband services. They periodically meet with service providers and hold open dialog to assist the unserved and underserved portions of the County.

Occasionally, a local Broadband "Authority" will seek to place a fiber-optic cable or build a communications tower to assist the smaller providers thru a "Public/Private" venture.

Working with the Center for Innovative Technology or "CIT" early in 2016, the County Broadband Committee received various indicators from the Survey performed by CIT concerning the current status of broadband to the various communities but also valuable feedback on the types of applications of broadband such as educational, commercial, and leisure uses.

In addition to other efforts, Clarke County has included space on the County web site to all Broadband providers that facilitates information about who is providing such services and in what general technology platform. Clarke County has collaborated with the community and the providers for antenna space on existing water tanks.

The Atlantic Group was engaged in August of 2016 to study the existing status of Broadband and to make recommendations for its growth within the County that will provide this service to as many residents as possible. The outcome of this study determined that a "wireless" link or "Last Mile" to the home would be the most expedited method of service delivery. In addition, the study revealed that an addition of eleven (11) 120' monopole towers would be required to "fill-in" the existing gaps in wireless Broadband service delivery. These eleven (11) towers were pre-positioned in various parts of the county with a radius of ½-mile for a final "sitting" plan. These locations are known as "Permitted Commercial Tower Development Areas" or "PCTDAs".

The next recommendation is to categorize communications towers by height into "Classes" of towers and their association with various Zoning categories and requirements on where they would be placed. Upon this review, it is recommended that some of these could be "by-right" if all Administrative requirements are met.

With the completion of this study concerning the status of broadband and the efforts to expand this service within the county, The Atlantic Group would like to make the following recommendations:

1. Implement preplanned tower locations (plan known as Permitted Commercial Tower Development Area-PCTDA) to 120' Above Ground Level heights.

2. Seek to place these Permitted Commercial Tower Development Areas near or on County, State, or Federal properties if available.

3. Seek to "stream line" tower Application Process by approving a "By Right" system for the wireless industry to meet market growth demands by approving the tower "Class" system.

4. Continue to encourage co-location on existing towers and structures such as water tanks and rooftops. Seek to streamline the review process for these Applications.

5. "Collaborate" with private fiber optic facility owners, Broadband providers and tower development companies to facilitate the deployment of fiber optic cable and towers to areas that are unserved or underserved.

6. Have all co-location and new tower build applications reviewed by an independent Third Party to ensure all technical information is reviewed, and that the Planning and Zoning guidelines are adhered to.

Clarke County is well positioned to continue growth in the broadband technology sector in its quest to meet the needs of its residents.

George N. Condyles, IV

President & Chief Operating Officer

2. Glossary of Terms

AGL – Above Ground Level – the height above ground as measured from the ground to the top of the structure.

Amateur Radio Service – Also known as "Ham Radio", the service is designated for personal use, but may assist the local community in cases of emergency and disaster communications. Amateur radio is not permitted for commercial use or for profit. All frequencies are shared. No frequency is assigned for the exclusive use of any amateur station. Millions of amateur radio operators are capable of communicating with each other worldwide.

AMSL – Average Mean Above Sea Level – equal to the sum of the above ground level (AGL) and ground elevation (GE).

Analog Service – Modulating radio signals that carry information such as voice or data.

Antenna – An exterior apparatus designed for telephonic, radio, or television communications through the sending and/or receiving of electromagnetic waves.

Backhaul- The ability for a radio signal transmitted by a "user" to a receive antenna located on a communications tower to have the ability to be transported to a switched telco network for access to the World Wide Web. This is typically accomplished with a fiber optic cable or point to point microwave link.

Bandwidth – The range of signal frequencies, expressed in hertz (Hz) that can pass over a given transmission channel, and that a medium will respond to without excessive attenuation (loss of signal strength). The bandwidth determines the rate at which information can be transmitted through a circuit.

Broadband – Broadband generally refers to high-speed internet access. It's the ability to transfer large amounts of information at a fast rate of speed. The FCC defines broadband service as data transmission speeds exceeding 20 Megabits per second (Mbps), in at least one direction: downstream (from the Internet to the user's device) or upstream (from the user's device to the Internet)

Cell – The basic geographical unit of a cellular communications system. Service coverage of a given area is based on an interlocking network of cells, each with

a radio base station (transmitter/receiver) at its center. The size of each cell is determined by the terrain and forecasted number of users.

Cellular Communication – Communication via low power transmitters to service geographical areas or cells (see Review of wireless technologies).

Co-location – The sharing of space on a structure to support multiple carriers.

Digital Service – The method of encoding bits of information using a binary code of 0s and 1s. In digital service the analog voice signal is converted into a series of 0s and 1s allowing more channels within a given bandwidth thus greater efficiency.

Downlink – Also known as "talk-out" is the radio frequency path from the cell site antenna to the receiver at the subscriber unit, i.e. mobile phone.

FAA – Federal Aviation Administration

FCC – Federal Communications Commission

Fixed Wireless Network – The operation of wireless devices or systems used to connect two fixed locations, such as a point-to-point microwave system used for transporting backhaul communications. Wireless backhaul connections typically replace a T-1/T-3 line(s) and is used to transport a company's internal infrastructure, both voice and data communications.

GE – Ground Elevation

Guyed Lattice Tower – Lattice tower that is supported vertically by wire cables.

Handoff – A frequency channel will be changed to a new frequency channel as the vehicle moves from one cell to another without the user's intervention.

Internet - An electronic worldwide network of computers and servers providing access to millions of resources worldwide.

Interoperability – The ability for subscriber equipment to access various wireless networks and have the ability to transmit and receive messages and data.

Last Mile- Term used for the last link for a radio signal to reach its destination to a home or structure for the delivery of Broadband Service. This can be accomplished with copper or fiber optic cable or through a wireless medium such as Wi-Fi, Point to Multipoint or other various technologies.

LEC – Loop Exchange Carrier – a communications company licensed to provide local exchange service for telephony service providers.

Mini/Micro Cell – Small structure, typically not greater than 80' AGL, used to fill "holes" in coverage.

Monopole – Cylindrical, self-supporting structure, erected vertically, used to mount antennae.

Multimedia – In the context of mobile communications, a service that may combine voice, data, graphics, and video information.

Multiple Band – A phone that has multiple-band capabilities and can switch frequencies.

Multiple Modes - A phone that can switch back and forth between "modes" or the type of transmission technology being used.

MW Link – Microwave Link – Digital service licensed by the FCC for the transmission and reception of compressed voice and data. Microwave systems are used to transmit large amounts of data, from point to point, over greater distances than traditional broadcast systems (see Review of Wireless Technologies).

Propagation – The physical principle of the energy emitted through broadcasting a frequency as it relates to transmission, power, ASML, antenna gain and transport loss.

PCTDA – Permitted Commercial Tower Development Area. Pre-Planned location areas where commercial towers can be erected to provide for commercial wireless carriers. These are plotted at a road intersection with a 1/2-mile radius for location of a Tower.

Radio Frequency (RF) – Generally, a frequency from approximately 50 kHz to 3 GHz. RF is usually referred to whenever a signal is radiated through the air.

Rx – Receiver – A wireless radio device that receives a broadcast from a transmission device allowing the broadcast circuit to be completed.

Self-Supporting Structure – Either a monopole or lattice design tower that is free-standing and requires no additional support.

Spread Spectrum (SS) – A common technique that spreads a signal bandwidth over a wide range of frequencies for transmission and then de-spreads it to the original data bandwidth at the receiver.

Stealth Technology (Stealth) – A technology used by the cellular industry to hide or shield a wireless communications facility from view. A system to disguise and blend into the existing topography and not be detected or recognized.

Subscriber – The consumer of a telephony service such as broadband, cellular, etc.

Topographic Study – How the terrain and other land forms and natural features impact the transmission and receipt of radio waves.

Tower – Vertical structure made of steel that is designed to hold communications antennas and electronics for the transmission and reception of radio signal. These come in three main varieties: Self-supportive Lattice, Guyed Lattice and monopole structures. Heights and structure strength vary and are designed using EIA/TIA 222-G specifications.

TX – Transmitter - a wireless radio device that broadcasts a signal to be received by a specific receiver device.

Uplink – Also known as "talk-back" is the radio frequency path from the subscriber unit, i.e., mobile phone to the receiver at the cell site.

Wireless Communications Facility - A facility used for the transmission and reception of radio, satellite and/or microwave signals for the transmission and reception of communications. The Facility includes but is not limited to a communications tower, equipment shelter or cabinets, cables, antennas, microwave dishes, satellite dishes, commercial power transformers and power distribution panels with meters, telephone communications/fiber optic "backhaul", standby power generator(s), fuel tanks, fencing that provides security for the tower, and ground equipment.

Wireless Internet –The provision of internet services through specialized devices over a wireless network. Also known as "Broadband."

Wireless Internet Service Provider – (WISP) a provider of wireless internet that is typically using unlicensed FCC frequencies as part of the broadband initiative.

3. Broadband….What does it mean?

"Broadband" has evolved as the generic term for "internet access" for most localities in the United States. Simply put, the "user" or "subscriber" seeks to have a fast and broad ability to upload or download data for use. Hence the term "Broadband" has come to symbolize a term that has two dimensions, *volume and speed*.

In 2016, volume and speed are measured in Megabits per Second of service for a subscriber.

Megabit per second (symbol Mbit/s or Mb/s, often abbreviated "Mbps") is a unit of data transfer rate equal to: 1,000,000 bits per second.

The FCC, tasked with overseeing the rules that govern the Internet, raised the standard for broadband to **25 megabits per second** from 4 Mbps, while raising the upload speed to 3 Mbps from 1 Mbps on Jan 29, 2015.

As internet access has evolved over the last several decades, the speeds, bandwidth, equipment, and delivery technology has taken this service from a luxury to a necessity.

Below is a chart provided by the FCC concerning Home Broadband services defined by usage. The FCC has developed a spectrum of use from data tabulated from their internal studies.

They are:

1. **Light Use**
2. **Moderate Use**
3. **High Use**

These "usages" are also defined by the number of "users" or "subscribers" within a household. As a result, the more "users" the greater "bandwidth" is required to serve them.

(See FCC Charts Below: Household Broadband Guide & Broadband Speed Guide)

Federal Reference Standards Set for Broadband

Federal Communications Commission

Home / For Consumers /

Household Broadband Guide

Use the chart below to compare minimum download speed (Mbps) needs for light, moderate and high household use with one, two, three or four devices at a time (such as a laptop, tablet or game console).

You can also compare typical online activities with the minimum Mbps needed for adequate performance for each application by using our Broadband Speed Guide (/guides/broadband-speed-guide).

For more information on broadband speeds, see our Measuring Broadband America report (/measuring-broadband-america).

	Light Use (Basic functions only: email, web surfing, basic streaming video)	**Moderate Use** (Basic functions plus *one* high-demand application: streaming HD, video conferencing, OR online gaming)	**High Use** (Basic functions plus *more than one* high demand application running at the same time)
1 user on 1 device (e.g., laptop, tablet, or game console)	Basic	Basic	Medium
2 users or devices at a time	Basic	Basic	Medium/Advanced
3 users or devices at a time	Basic	Basic/Medium	Advanced
4 users or devices at a time	Basic/Medium	Medium	Advanced

Basic Service = 1 to 2 Mbps*

Medium Service = 6 to 15 Mbps

Advanced Service = More than 15 Mbps

*Mbps (Megabits per second) is the standard measure of broadband speed. It refers to the speed with which information packets are downloaded from, or uploaded to, the internet.

Federal Communications Commission

Home / For Consumers /

Broadband Speed Guide

Compare typical online activities with the minimum download speed (Megabits per second, or Mbps) needed for adequate performance for each application. Additional speed may enhance performance. Speeds are based on running one activity at a time.

For household broadband needs, use our Household Broadband Guide (/guides/household-broadband-guide) to compare minimum Mbps needs for light, moderate and high household use with one, two, three or four devices at a time (such as a laptop, tablet or game console).

For more information on broadband speeds, see our Measuring Broadband America report (/measuring-broadband-america).

Activity	Minimum Download Speed (Mbps)
Email	0.5
Web browsing	
Job searching, navigating government websites	0.5
Interactive pages and short educational videos	1
Streaming radio	Less than 0.5
Phone calls (VoIP)	Less than 0.5
Watching video	
Standard streaming videos	0.7
Streaming feature movies	1.5
HD-quality streaming movie or university lecture	4
Video conferencing	
Basic video conferencing	1
HD video conference and telelearning	4

Gaming

Game console connecting to the Internet	1
Two-way online gaming in HD	4

Example: 4 people in a home:

2 parents + 2 children = 4 users

-All have their device on and checking e-mails… 4 x .5 Mbps = 2.0 Mbps

-All Surfing the Web/Facebook……. 4 x 1 Mbps= 4.0 Mbps

-Son Gaming with person in Germany……..1 x 4 Mbps = 4.0 Mbps

- Daughter video Streaming a Movie……..1x1.5 Mbps= 1.5 Mbps

-Mom Video Lecture/Distance Learning……1x4 Mbps = 4.0 Mbps

-Dad working on Office Report……1 x 2 Mbps = 2.0 Mbps

Total Mbps required……17.5 Mbps

Historical Telephony Speeds

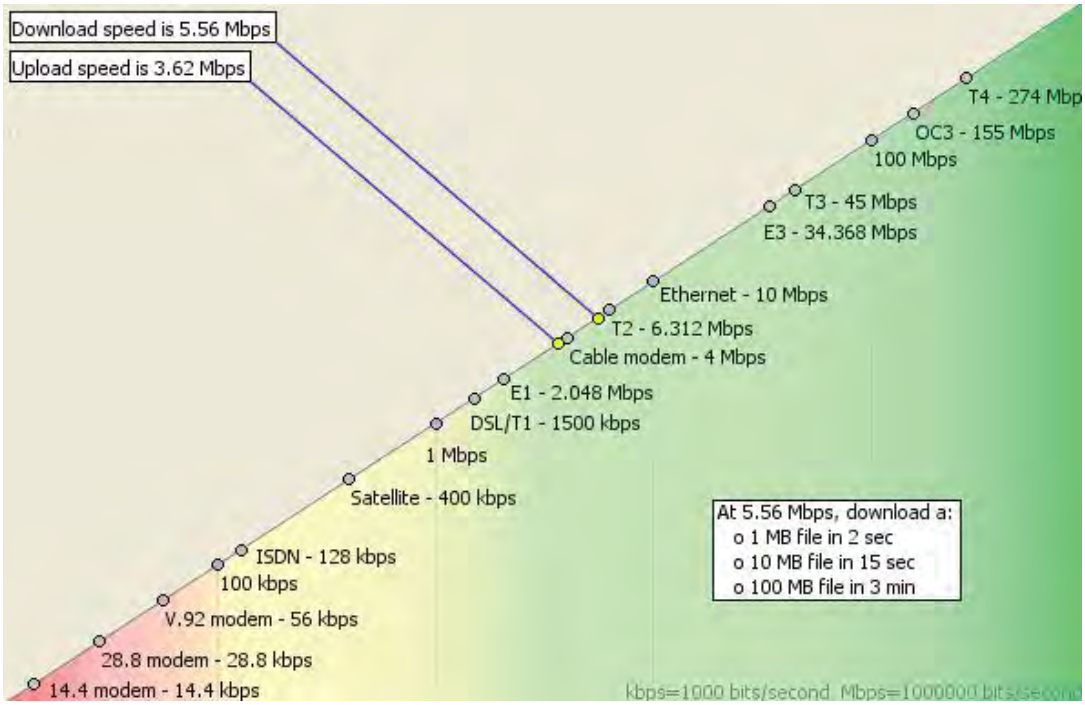
On Diagram #1 below, historical usage was limited to the delivery system of the local telephone company switched network that primarily was developed for voice service. As new and improved devices such as modems, microchip design, laptop computers and servers providing a "portal" of access to records and data files, the speeds have risen significantly. The telephone company or Loop Exchange Carrier (LEC) upgraded their "switching" equipment from analog to digital data format and then upgraded to higher speeds of data. In conjunction with deployment of fiber optic cable, the LEC continued to deploy Optical Remote Modules in the network to provide for more reliable and higher speeds.

With the demand of multiple accesses to the internet from multiple devices at one single location, access and usage has become an issue. Past usage of access upon demand has now evolved into unlimited access and unlimited usage for most subscribers. This principle alone is changing the usage patterns and the ability for a subscriber to meet the network demands.

By observing the bottom left of the Speed vs. Data Usage Chart below, you may observe the type of service with the speeds associated with that service.

Today, Clarke County citizens demand service speeds approaching 25Mbps.

Diagram #1: Speed vs. Data Usage Chart



The Federal Response

The Federal Communications Commission (FCC) has the responsibility for all communications that are produced or received within the boundaries of the United States by the Code of Federal Regulations (CFR).

The FCC provides for the citizens to have representation of communications issues. The federal government has jurisdictional responsibility to ensure that business providers of such voice and data services are acting within prescribed practices and technologies that ensure a level and fair playing field for those companies within the telecommunications industry to serve the public.

The FCC manages the providers of telecommunications within the United States by regulating the technology, radio frequencies and the equipment used to provide transmission and receiving of signals for these technologies.

As the incumbent telephone company providers known as “Loop Exchange Carriers” or “LECs” are regulated for voice services, also Cable companies and other providers of voice and data services are “non-regulated” by state tariffs and can charge what the market will bear for their services. The incumbent telephone company can do the same for data services. The services are considered “Non-Tariffed” in their classification.

Clarke County, Virginia- Telephony

In the case of Clarke County, the incumbent telephone company, *Verizon,* has a telephony network in place currently, however because of limited Central Office "switching" and limited fiber optic "feeder" cables, there is limited fiber optic "distribution" cable into the populated areas. Verizon provides "Plain Old Telephone Service" or "POTS" which is regulated by the Virginia State Corporation Commission. Any service faster than this speed is considered a "Special Service" which Verizon can price to meet its corporate objectives. In comparison, the cable provider, *COMCAST,* also deploys fiber optic cable and makes its decision for fiber optic cable deployment on a subscriber per mile threshold. For Comcast to provide broadband service, it also looks at capital expense and operational cost, and also prices its services to corporate goals and objectives. Because of these two dynamics between the LEC and a cable provider, many of the citizens of Clarke County are underserved or unserved in most high speed networks. Towns such as Berryville and Boyce have sufficient broadband service with several choices of providers. Citizens located in the County typically have limited access to more than one service.

Provider Service Cost/Technology Trend

The cost of providing one (1) wireless circuit for broadband verses one (1) wire line broadband circuit is approximately one tenth (1/10) the cost. Meaning a Wireless broadband connection capital cost would be only 1/10 the cost of a land line connection.

This is why "Wireless Broadband" is the current and future wave of technology.

The **"Last Mile"** providers in Clarke will most likely be of wireless mode for the majority of County residents and businesses. The capital cost that would be required to place broadband landlines throughout the County to the home would be astronomical in price.

Wireless "Last Mile"

Wireless communications have evolved over the last fifteen years. The networks have developed into three (3) distinct types:

1.) Licensed

2.) Unlicensed

3.) Satellite Wireless Networks

They are described as follows:

1. Licensed Wireless Networks

The FCC has opened radio frequency for both licensed and unlicensed networks. Typically the "Licensed" networks are what are known as "LMR," "Cellular," or "Mobile" networks. These are typically owned and operated by the large cell companies such as:

1. AT&T
2. Verizon
3. Sprint
4. T-Mobile

These companies operate within Clarke County. The *industry* identifies these companies internally as "Land Mobile Radio" providers or "LMR."

The FCC has designated "Blocks" of frequencies that each of these companies "bid" upon by "frequency block" and geographic area to engineer and develop a "LMR" network. These areas are known as "Basic Trading Areas" or BTAs. Clarke County is in the "Winchester" BTA. The LMR providers must adhere to USC CFR 47.*

*Note

(The Federal government is managed and regulated by what are known as "Codes." These Codes are authored and designed to ensure a well-run federal government. In the case of communications and specifically "wireless communications," the Federal Communications Commission was established to ensure oversite and regulatory administration of conduct within the communications' industry and the use of frequencies and equipment. To meet this challenge, the FCC has been placed with responsibility to perform this function with a series of "regulations." In this specific case, the "CFR" or Code of Federal Regulations is referenced under Title "47" of the United States Code.)

The typical "LMR" bands are 800 MHz, 1.9 MHz and 2.1 GHz frequency.

Basic Radio Transmission and Receive Theory

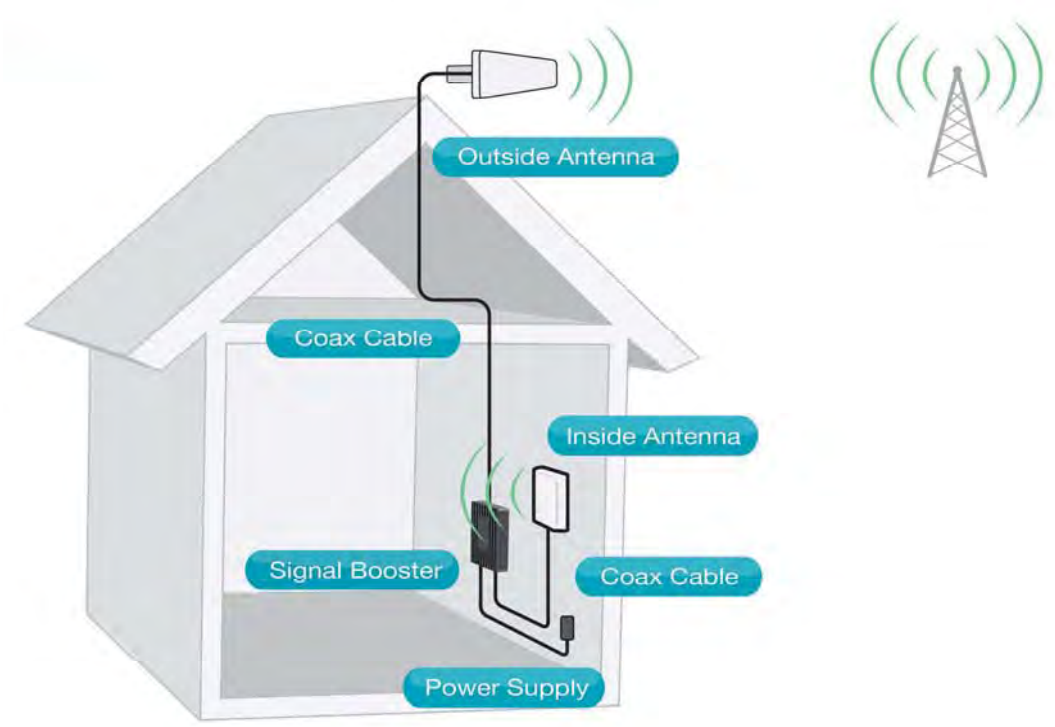
Each LMR company designs and deploys their individual networks to meet the growing customer coverage needs. The usage of a "LMR" subscriber is one of "mobile" use. The tablets and mobile phones such as "Smart Phones" known as "IPhones" or "Droids" must have the ability to travel to work, school, the office, shopping, recreational events and any place that the individual subscriber is "standing." The subscriber demands coverage not just outside but also inside a building or a facility. Inside a facility is known as "Indoor Penetration." This is a positive aspect for the active person. Where ever they are, they are connected to a wireless network.

As the "***Generations***" of cell networks have evolved from an analog signal format to a digital format, the wireless equipment manufacturers have developed 2^{nd}, 3^{rd} and 4^{th} Generation of equipment and devices. Hence, a "Device" such as a Tablet, IPhone or Droid can do multiple applications from sending and receiving e-mails and text messaging to actual Video and Audio Synchronous transmissions on a local and global scale. Because the newer devices have multiple capabilities and what now is known as "Applications" the devices have become a necessity for a subscriber.

Applications can be as simple as "Alerts" to major file sharing, transmission and receiving major data packets or a functional automated system. "Apps" have linked the home, school, commerce, and other sectors of technology and data to integrate networks together. In summary, with the innovation of data services, broadband signaling over a wireless mode is absolutely necessary.

What is next: Fifth Generation or "5-G" for the LMR Providers.

Example of LMR Home Service Network: Outside Antenna pointed at nearby Tower



5th Generation or 5-G will focus on Network <u>"interoperability"</u> with various subscriber hand held devices. For example: "My AT&T phone will receive and transmit data networks that have "alliances" with AT&T."

List of Strengths and Weakness of the "Licensed" LMR Networks

Strengths	Weakness
Well-Funded – Public Companies Annual Budgets and Stock Funding	Budgets must Conform to Sarbanes/Oxley Act, Security and Exchange Commission etc.
Large Budgets for Research and Development with Proprietary Technology	Budgets are set to geography and year
Deployments are planned and engineered	Rigid criteria for deployments no alternatives
Deployment Planning is programed and is typically on a 3 year cycle.	Good projects that "miss" the budget/planning cycle cannot be inserted without Executive Approval
Contracts with National tower companies	Difficult for local tower companies to receive consideration
Retail outlets for Device/service sales	Retail outlets are mostly "Franchised" relationships
Large Corporation with many employees	Most "employees" are contractors/1099 and are "rotational" or temporary
Communications Company	Consumer has very little ability to contact LMR Engineers or technical people for solutions
Equipment of high quality and complexity	Equipment must be maintained strictly and often
Standard deployment: 199' tower with equipment shelter or cabinets	Resist shorter towers and stealth technology integration
Equipment features allow greater ability to provide a wide and various amounts of services	Very rigid in the replacement mode of obsolete equipment

FCC License based on geographic area	**Must maintain that broadcast area or face FCC violation**
Subscriber equipment very expensive with long contract periods	**Less flexibility to negotiate or move to another carrier**
Technology : Evolving constantly	**Speed of Removal of Obsolete equipment**
Original Networks designed for "Outside" service	**Current uses and applications are for "Inside the building" service**
Voice service requires "fewer" towers	**Data services (Broadband) requires more towers with antennas closer to the device**
Services are "Measured" as to usage	**Service providers can "hike" data plans**
Services is provided for in "Plans"	**Subscriber must "shop" plans and negotiate cost**
Various types of Subscriber equipment	**Subscriber "Lost" as to the type and installation**
Subscriber "integrates" his equipment into his house. (Electric, Gas, broadband etc.)	**Subscriber wants to place equipment and not have to change once it is in place**
Subscriber wants "interoperable" abilities to take his equipment and use	**Now, AT&T phone must be used on AT&T Network, etc.**

2. Unlicensed Wireless Networks

Unlicensed "carriers or providers" have strategically directed their frequency base to the FCC provided frequency bands that are able to be used by providers without having to buy or lease a license for a fee. These frequencies were released by the FCC to help stimulate Broadband growth in areas that are unserved or underserved by the LMR service providers. Clarke County is an excellent example.

These service providers must adhere also to USC CFR 47 that pertains to their networks. The FCC requirements limit these providers with the type and power of their equipment, however gives greater latitude in the deployment of their networks with fewer Federal requirements such as NEPA and Section 106 requirements.

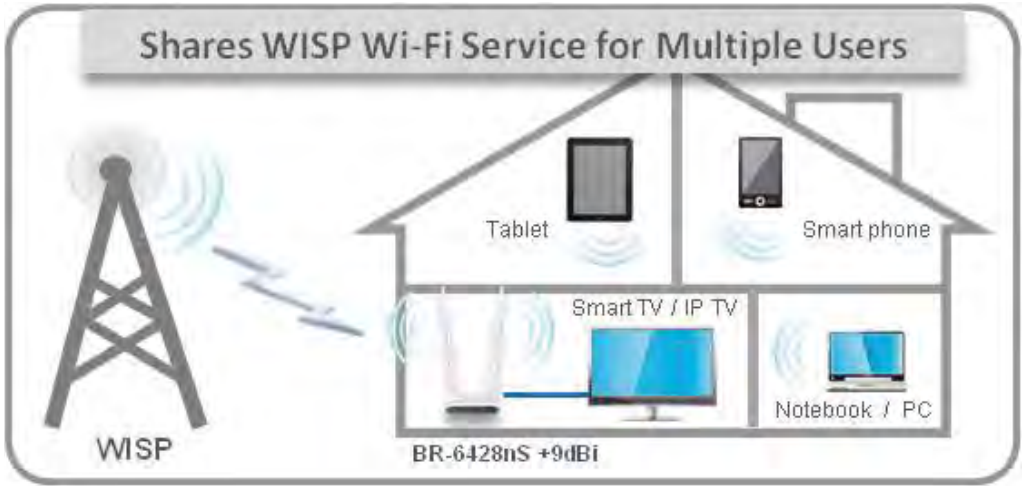
The frequency bands are typically the 900 MHz, 2.4 GHz, and the 5.8 GHz bands.

These service providers are known in the industry as "WiSP" defined by their technology platform "Wireless Internet Service Provider."

Clarke County has approximately 4 major players currently. They are:

1. ***All Points Broadband***
2. ***Winchester Wireless***
3. ***Visual Link Internet***
4. ***Wave 2Net***

Example of a WISP Service: Interior or Exterior antenna pointed at a tower



The following short list of potential strengths and weakness that may be expereinced with un-liscensed wireless networks.

Strengths	Weakness
No FCC "License Compliance" rules **Must follow "Guidelines"**	**Must locally coordinate with other WiSP to prevent interference and intermodulation**
Locally Owned and Operated	
Typically provide "private" financing	**Limited "Debt" financing**
Employ local people	
Equipment not a "sophisticated" as Licensed LMR	**Not as many "features"**
Equipment can be purchased "Off the Shelf"	**Equipment is not as interchangeable. Must be ordered**
Ability to get "off the ground" with one site	**Network must cover 90% of populated areas and geography**
Channels can be added	**Subscriber "logs on and never logs off"**
Lower Power levels	**Shorter Transmission and Receive distances from Tx/Tx site**
Equipment physically lighter and can **be mounted to many types of structures**	**Typical Commercial Tower rent locations on the tower and reserves lower levels for WISP, not "Prime" sites**
FCC allows waiver of Federal requirements such as NEPA and Section 106	
These sites can be mounted on wooden poles sunk into the ground or lightweight towers	**Can "Pop up" anywhere**
Subscribers many times "Evolve" between various providers	
WiSP requires "backhaul" services	**Subscribers can just stop paying their**

Fiber Optic or "Unlicensed" MW	**bill and move toward another provider**
Transmission to device is strong within the structure	**Many times WiSP must fund and install backhaul**
Many "networks" available	**Signal diminishes when outside**
Multiple Networks can be co-located on a structure	**Many networks "interfere" with one another**

3. Satellite Wireless Networks

Satellite service has come a long way since its early beginnings over 25 years ago. While satellite has typically been able to receive or "downlink" a greater amount of data, the limiting factor has been the "uplink" or "upload." Many times this is accomplished via telephone lines. Today the systems provide an excellent service of both uplink and downlink and have become a viable player not only in the rural but also urban and suburban markets.

There are limitations such as weather and obstructions such as trees and other structures. However, if these issues are resolved then satellite service is very good and is competitive in price.

The satellite providers in Clarke County are:

1. ViaSat Communications
2. NOVECNET
3. SkyCasters
4. HughesNet
5. StarBand

Example of Satellite Service: Satellite Dish pointed to a terrestrial satellite

Strengths	Weakness
Location can be anywhere	Must have "Line of Sight" to the satellite
Integrates TV, Internet, voice and data	One System "Common point of failure"
Signal strength is excellent	Weather Dependent
Many types of channels	Too many channels…..
Can operate several devices	Not all devices are interoperable
Requires Technical Installation	Service response times may be slow
Excellent "in-building" service	Not much service outside
Must "size" system for peak operation	Channel congestion if not sized properly

4. Broadband….Where is Clarke County charting?

Public Input

The **Center for Innovative Technology** "CIT" located in Reston, VA performed a study in 2016 in which many residents of Clarke County participated. This study was a basic community input survey to identify what the resident experience currently is concerning internet service. This survey was titled "***RUOnline.***" Clarke County had over 690 responses. This represented a 95% +/- 3.52 Based on # of total households (ACS) and responses. **(See Tabulated Data: Exhibit 1.)**

Interesting Responses:

Take Away: 92% of respondents don't have the service they want.

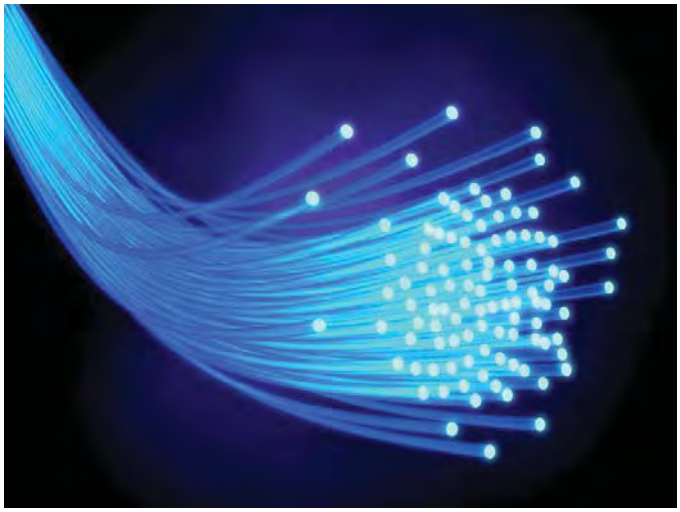
Take Away: 24% of respondents have home based business.

Take Away: 46% of respondents rely on cellular or satellite internet service.

Take Away: 92% of Residential subscribers do not have the service they want.

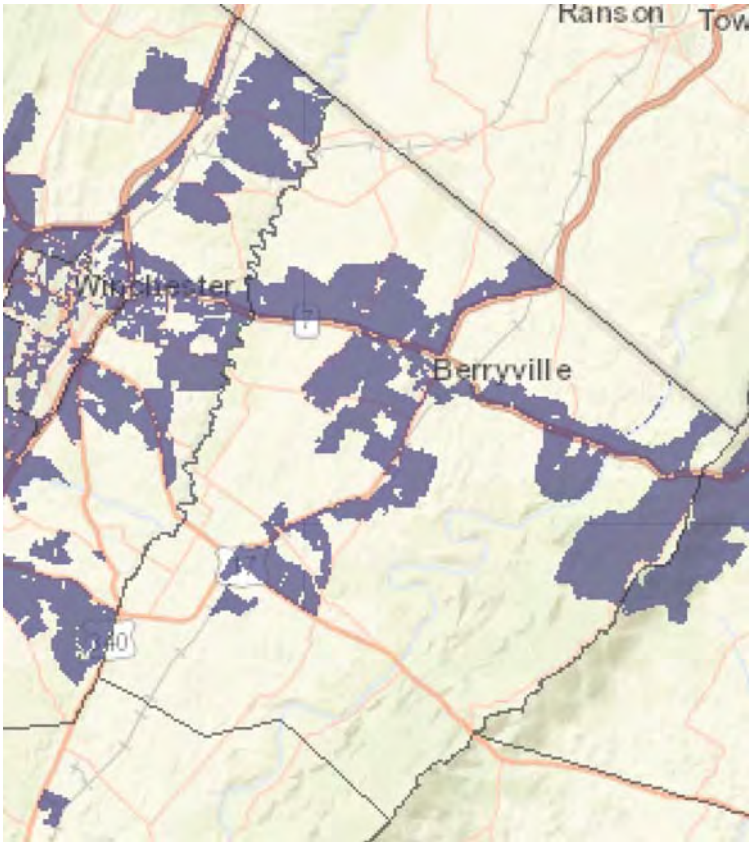
Take Away: 94% of Business Subscribers do not have the service they want.

In summary, the Residents of Clarke County are looking for more choices and better/faster Broadband services. (See responses Tab 11.)



5. Broadband….What is available in Clarke County now?

a. Comcast Cable: Fiber Optic & Copper Coax Broadband Services

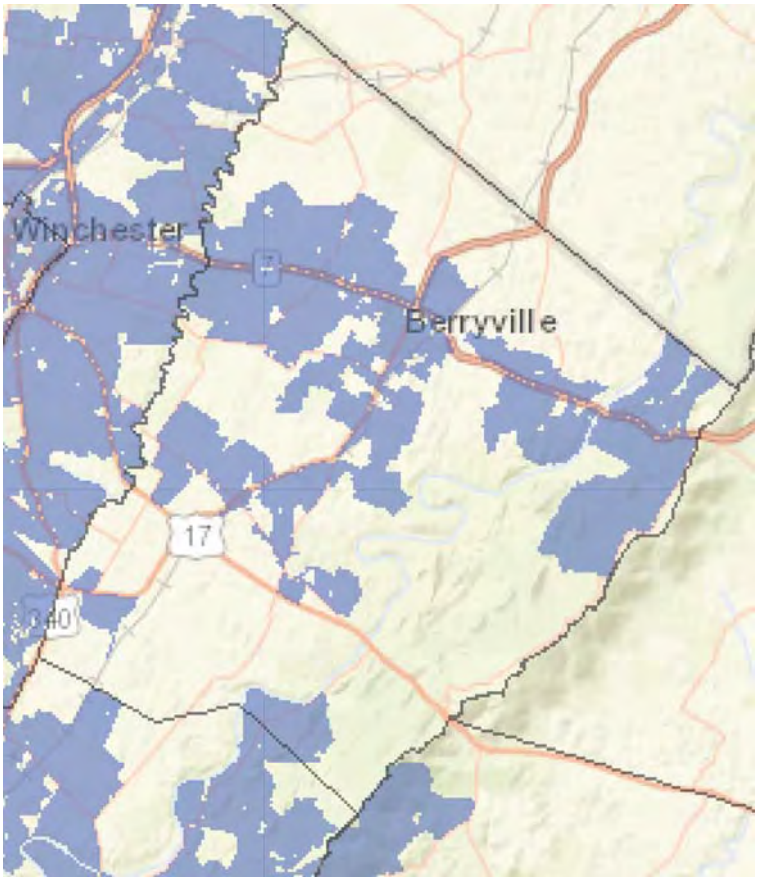


(Source: CIT Data for Clarke County, Virginia)

Comcast provides basic coverage along the major arteries such as Rt. 7 and Rt. 340. Their network is set up as a switched network known as a "hybrid" network. The hybrid is the mixture of fiber optic cable and coaxial cable. Typically a "community" is "fed" by a fiber optic cable, but "distribution" is over a coaxial cable. The Comcast system is reliable if the commercial power is backed up with standby power. The system is driven in a "Node" system. This means a "Node" of equipment is deployed in a geographic area, connected with fiber optic cable, then distribution within the community is typically copper coax cable. Comcast owns a great deal of fiber optic cable that it leases "strands" to other fiber users such as Verizon or any data user. Comcast uses Verizon fiber optic cables for their network also. It is common practice to lease fiber optic service strands.

In many cases, one internet service provider is a customer of the other's fiber optic network.

b. Verizon Fiber Optic Service

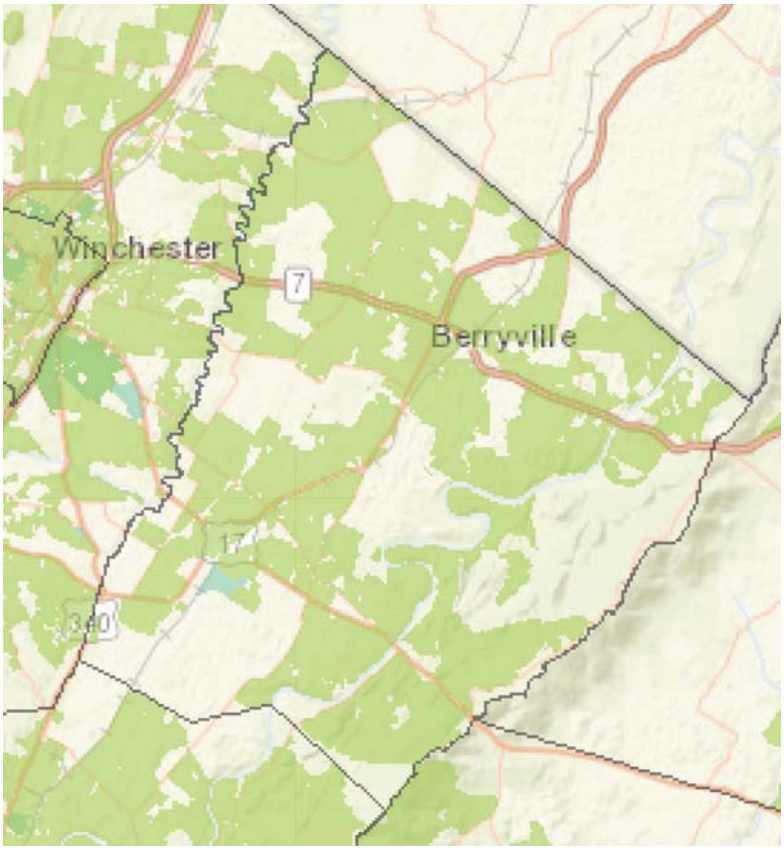


(Source: CIT Data for Clarke County, Virginia)

Verizon has been the LEC for over 100 years in this region. The major "Hub" Tandem Central Office is in Winchester. The Berryville, Boyce, and White Post Central offices are the outlying offices that are fed from the Winchester office. Verizon has major fiber optic "Feeder" cables that run along Rt. 7, Rt. 50 and 340. As you can see above, the "foot print" of Comcast and Verizon are very similar. As competitors they go after the same customers for voice and data, but also each company provides the other with fiber optic "backhaul" to either of their central Offices or Cable Nodes.

Verizon has a limited foot print of broadband service in Clarke County due to the lack of fiber optic "distribution" within its own network. It serves Comcast and communications towers well, however the communities are not within the "Distribution" network.

Verizon has marketed what is known as ***Digital Subscriber Loop*** or "DSL" over a copper network for Residential subscribers. This has <u>at best</u> a 5 Mbps download and a 3 Mbps upload. (See map below of Verizon DSL footprint.)



(Source: CIT Data for Clarke County, Virginia)

VERIZON DSL SERVICE

Limitations to the Verizon copper network is that of geographic location of the Central Offices to the subscriber. The typical "copper" network that can sustain DSL service is approximately 7 miles or less in distance from the Central Office. The transmission levels decrease as you travel away from the Central Office. Amplifiers and line conditioning can be done to assist the signal transmission, but 7 miles is about the most one can expect.

While this type of service is better than modem service, home based business and distance learning is impossible to accomplish effectively.

c. Wireless "Land Mobile Radio" providers

A. FCC License Holders in Clarke County

The FCC is charged with regulating interstate and international communications by radio, television, wire, satellite and cable. Among its responsibilities, the FCC grants licenses to license holders to operate at certain frequencies or within certain frequency ranges.

The FCC also ensures that wireless telecommunication service providers comply with the Communications Act and Commission rules, orders, and policies. The Wireless Telecommunications Bureau is a branch of the FCC and is responsible for all domestic wireless telecommunication programs, except those involving satellites.

Listed below are the current wireless communication providers licensed by the FCC to operate in Clarke County:

1. AT&T Wireless

2. Verizon Wireless

3. T-Mobile

4. Sprint

B. Un-Licensed FCC Service Providers in Clarke County

Point to Multipoint -PMP

The term point-to-multipoint wireless communications relates to fixed wireless data communications for Internet or voice over IP via radio or microwave frequencies in the gigahertz range.

Point to Multipoint is the most popular approach for wireless communications that have a large number of nodes, end destinations or end users. Point to Multipoint generally assumes there is a central Base Station to which a remote Subscriber Unit or Customer Premises Equipment (CPE--a term that was originally used in the wired telephone industry) is connected over the wireless medium. Connections between the Base Station and Subscriber Units can be either Line of Sight or for lower-frequency radio systems Non-Line-of-Sight where link budgets permit. Generally, lower frequencies can offer non-Line-of Sight connections. Various software planning tools can be used to determine feasibility of potential connections using topographic data as well as link budget simulation. Often the point to multipoint link is installed to reduce the cost of infrastructure and increase the number of CPE's and connectivity.

Point to Multipoint wireless networks employing directional antennas is affected by the hidden node problem (also called hidden terminal) in case they employ a CSMA/CA medium access control protocol. The negative impact of the hidden node problem can be mitigated using a TDMA based protocol or a polling protocol rather than the CSMA/CA protocol.

The telecommunications signal in a Point to Multipoint system is typically bi-directional, either time division multiple access (TDMA) or channelized. Systems using Frequency Division Duplexing (FDD) offer full duplex connections between base station and remote sites, and Time Division Duplex (TDD) systems offer half duplex connections. Point to Multipoint systems can be implemented in Licensed, Semi-licensed or Unlicensed frequency bands depending on the specific application. Point-to-point and point-to-multipoint links are very popular in the wireless industry and when paired with other high-capacity wireless links or technologies such as Free Space Optics (FSO) can be referred to as backhaul.

Description of WiSP Service Providers in Clarke County

1. All Points Broadband

Service: Residential Primarily

Network: Hybrid = Fiber and Fixed Wireless

Service: Broadband Internet, Streaming, Gaming and Messaging

Service Area: Central/Western Clarke County (Small footprint)

2. Visual Link Internet

Service: Residential and Commercial

Network: Hybrid = Fiber and Fixed Wireless

Service: Broadband Internet Various Plans:

Residential = Basic, Pro & Pro+

(2 to 12 Mbps Download)

Commercial = Dedicated Circuit

Service Area: Central/Western Clarke County (Small Footprint)

3. Wave 2 Net

Service: Residential and Commercial

Network: Hybrid = Fiber and Fixed Wireless

Service: Broadband Internet

Several Plans:

Level 1, Level 2, Enterprise and Hot Zone.

Service Area: <u>Southern Clarke County (Small Footprint)</u>

4. Winchester Wireless

Service: Residential and Commercial

Network: Hybrid = Fiber and Fixed Wireless

Service: Broadband Internet (Various Residential Plans with Equipment Leasing)

Plans from 1.5 to 50 Mbps download.

Has Plans for: "Rural" = Non-wired Backhaul areas

"Cable" = Areas with Cable or Fiber optic.

Service Area: <u>Central/Western Clarke County(Medium Footprint)</u>

d. Satellite in Clarke County

Satellite

Marketed as the center of the new broadband, satellite networks are a new generation of high-powered GEO satellites positioned 35,786 kilometers (22,236 mi) above the equator, operating in Ka-band (18.3–30 GHz) mode. These new purpose-built satellites are designed and optimized for broadband applications, employing many narrow spot beams, which target a much smaller area than the broad beams used by earlier communication satellites. This spot beam technology allows satellites to reuse assigned bandwidth multiple times which can enable them to achieve much higher overall capacity than conventional broad beam satellites. The spot beams can also increase performance and consequential capacity by focusing more power and increased receiver sensitivity into defined concentrated areas. Spot beams are designated as one of two types: subscriber spot beams, which transmit to and from the subscriber-side terminal, and gateway spot beams, which transmit to/from a service provider ground station. Note that moving off the tight footprint of a spot beam can degrade performance significantly. Also, spot beams can make impossible the use of other significant new technologies including 'Carrier in Carrier' modulation.

In conjunction with the satellite's spot-beam technology, bent-pipe architecture has traditionally been employed in the network in which the satellite functions as a bridge in space, connecting two communication points on the ground. The term "bent-pipe" is used to describe the shape of the data path between sending and receiving antennas, with the satellite positioned at the point of the bend. Simply put, the satellite's role in this network arrangement is to relay signals from the end user's terminal to the ISP's gateways, and back again without processing the signal at the satellite. The satellite receives, amplifies, and redirects a carrier on a specific radio frequency through a signal path called a transponder.

The satellite has its own set of antennas to receive communication signals from Earth and to transmit signals to their target location. These antennas and transponders are part of the satellite's "payload," which is designed to receive and transmit signals to and from various places on Earth. What enables this transmission and reception in the payload transponders is a repeater subsystem (RF (radio frequency) equipment) used to change frequencies, filter, separate, amplify and group signals before routing them to their destination address on Earth. The satellite's high-gain receiving antenna passes the transmitted data to the transponder which filters, translates and amplifies, then redirects the data to the transmitting antenna on board. The signal is then routed to a specific ground location through a channel known as a carrier. Beside the

payload, the other main component of a communications satellite is called the bus, which comprises all equipment required to move the satellite into position, supply power, regulate equipment temperatures, provide health and tracking information, and perform numerous other operational tasks.

Satellite Providers in Clarke County:

6. What infrastructure is in place now in Clarke County?

Vertical – Towers and Water Tanks

Today in the Clarke County area there are approximately sixteen (16) communications towers that range from a radio tower 444' AGL to what is referred to as a Stealth mini cell site of 87' AGL. The towers are mostly outside of the geographic border of the County or just slightly inside the borders with 2 major towers in the center of the County. This is what is known as "Hub and Spoke" coverage. This type of geographic deployment was adequate for voice communications of the past, however with the need for digital data, the devices require that transmit and receive data antennas are much closer to the device.

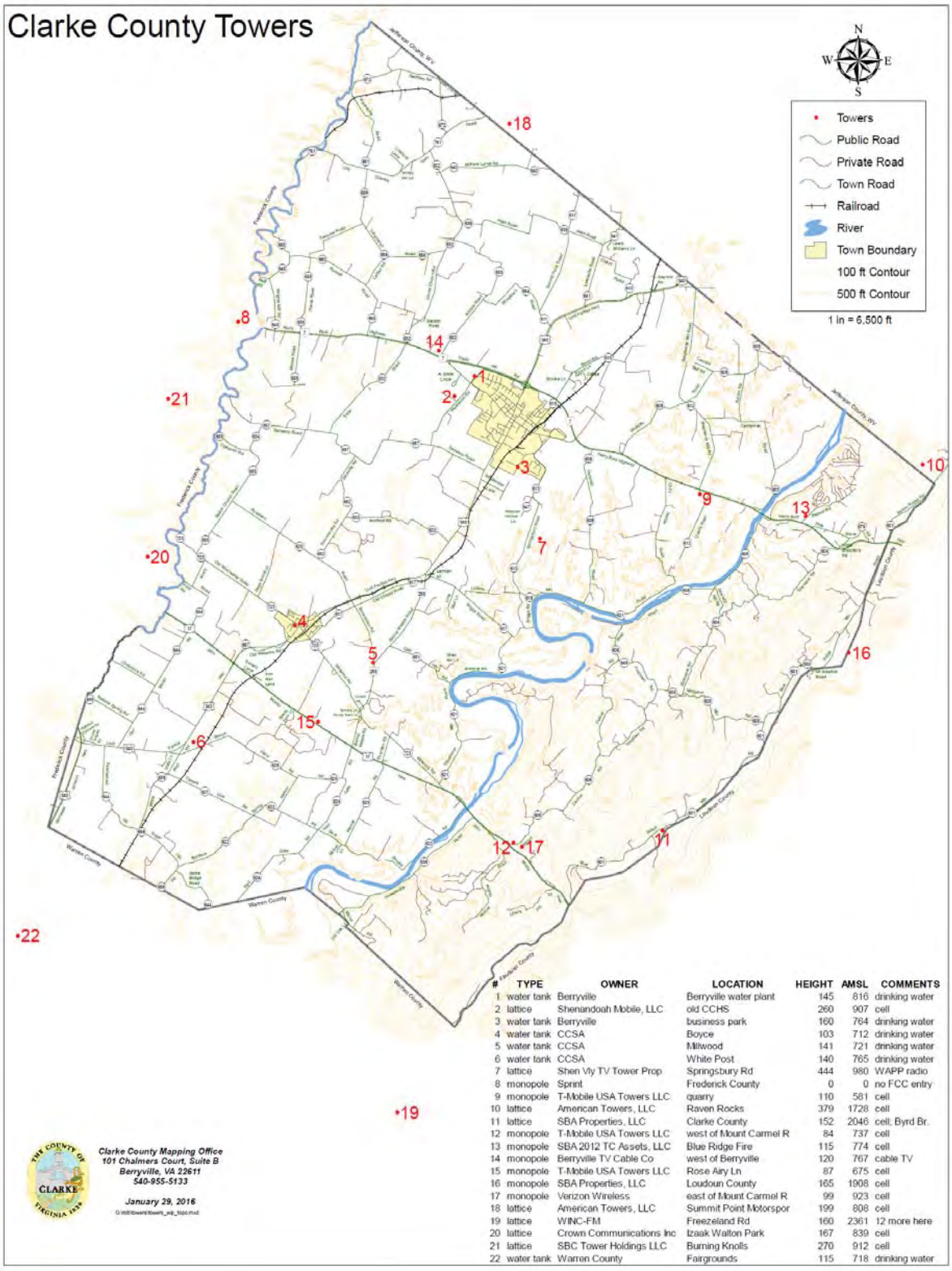
In addition, there are six (6) water tanks that are utilized for antenna placement. These water tanks vary from approximately 103' AGL to 160' AGL. This makes for a total of twenty-two (22) vertical structures that may accommodate wireless antennas. ***With a County of this geographic size, the County lacks infrastructure for effective wireless broadband deployment.***

The County has set into practice from the existing Ordinance with the Planning and Zoning Guidelines that it prefers shorter towers of the monopole design. Planned results for communication towers prefer shorter structures and possibly use of "Stealth" design to blend the wireless communications facility into the existing topography of the County. A stated objective is also to stay off of ridgelines and seek to place within densely forested areas. Through discussion and debate, communications towers seem to have a positive response if they are less than 120' AGL. There are many historic and environmentally sensitive areas of the County with many scenic by-ways. To meet the requirements for the Planning and Zoning Ordinance, it became important to look at the topography of the County and what locations should be avoided with the placement of new wireless communications facilities.

Another consideration for tower design and placement is that of not just the existing technology but also the future technologies that may be on the horizon. In looking at the current and future technologies, it became apparent that the infrastructure of the Wireless Communications Facilities must be located closer to the locations where people live, work, recreate, and travel.

In summary, to meet current and future wireless Broadband requirements, more towers are required; however heights and locations should be limited.

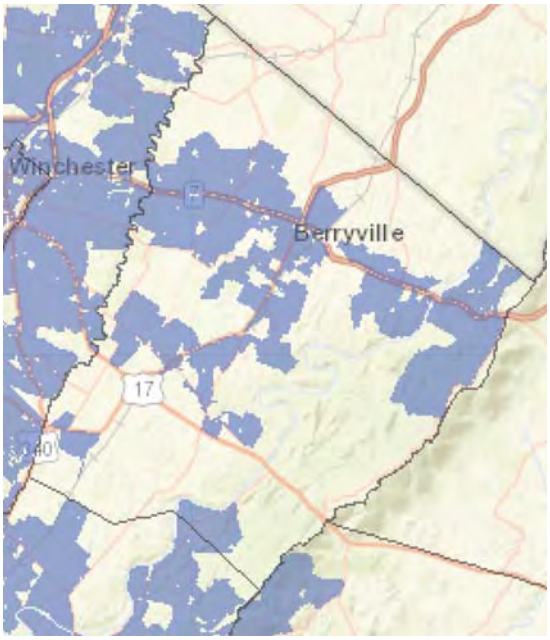
Existing Towers and Water Tanks in Clarke County (Vertical Assets)



#	TYPE	OWNER	LOCATION	HEIGHT	AMSL	COMMENTS
1	water tank	Berryville	Berryville water plant	145	816	drinking water
2	lattice	Shenandoah Mobile, LLC	old CCHS	260	907	cell
3	water tank	Berryville	business park	160	764	drinking water
4	water tank	CCSA	Boyce	103	712	drinking water
5	water tank	CCSA	Millwood	141	721	drinking water
6	water tank	CCSA	White Post	140	765	drinking water
7	lattice	Shen Vly TV Tower Prop	Springsbury Rd	444	980	WAPP radio
8	monopole	Sprint	Frederick County	0	0	no FCC entry
9	monopole	T-Mobile USA Towers LLC	quarry	110	581	cell
10	lattice	American Towers, LLC	Raven Rocks	379	1728	cell
11	lattice	SBA Properties, LLC	Clarke County	152	2046	cell; Byrd Br.
12	monopole	T-Mobile USA Towers LLC	west of Mount Carmel R	84	737	cell
13	monopole	SBA 2012 TC Assets, LLC	Blue Ridge Fire	115	774	cell
14	monopole	Berryville TV Cable Co	west of Berryville	120	767	cable TV
15	monopole	T-Mobile USA Towers LLC	Rose Airy Ln	87	675	cell
16	monopole	SBA Properties, LLC	Loudoun County	165	1908	cell
17	monopole	Verizon Wireless	east of Mount Carmel R	99	923	cell
18	lattice	American Towers, LLC	Summit Point Motorspor	199	808	cell
19	lattice	WINC-FM	Freezeland Rd	160	2361	12 more here
20	lattice	Crown Communications Inc	Izaak Walton Park	167	839	cell
21	lattice	SBC Tower Holdings LLC	Burning Knolls	270	912	cell
22	water tank	Warren County	Fairgrounds	115	718	drinking water

Horizontal – Fiber Optic

Verizon is the incumbent Loop Exchange Carrier or "LEC." The County is part of the overall Verizon Land Line network. The "Host" Central Office known as a "Tandem" Office is located in Winchester with Central Offices in Berryville, Boyce, White Post, Paris and Bluemont. These Central Offices are connected via fiber-optic cables known as "trunking" cables. The Central Offices "Feed" a geographic community via fiber-optic cable to an Optical Remote Site or "ORS" where the switching equipment is typically in a green cabinet. From this location most of the "Distribution" cable is copper/twisted pair for the most part.



All of the schools, municipal buildings, banks, and larger business entities have fiber optic infrastructure, which provides various broadband speeds.

All communications towers that are in Clarke County have fiber optic cable pulled to the site, thus giving the wireless communications facility the "backhaul" capability as a fixed broadband subscriber.

The fiber optic cables run in two parallel directions (Rt. 7 and Rt. 17) and one horizontal direction (Rt. 340). There are no other known fiber "distribution" cables.

In summary, if more communications towers are to be built, more fiber optic cables or point to point microwave systems will be required.

7. Broadband… Services that could be available in Clarke County by 2020

There will be three (3) major new technologies deployed by 2020:

1. **5G Mobile Systems**
2. **"White Space" Internet**
3. **Broadband over the Power Line (BPL)**

- ***Note: While these technologies may be deployed in the Clarke County area, these technologies will not eliminate the need for communications towers. The "Last Mile" link is a communication tower with a Transmitter and Receiver for the Subscriber.***

1. 5G Mobile Systems status

The current status of the 5G technology for cellular systems is very much in the early development stages. Many companies are looking into the technologies that could be used to become part of the system. In addition to this, a number of universities have set up 5G research units focused on developing the technologies for 5G.

Many of the technologies to be used for 5G will start to appear in the systems used for 4G and then as the new 5G cellular system starts to formulate in a more concrete manner, the technologies will be incorporated into the new 5G cellular system. This is what defines what is known as "LTE – Long Term Evolution."

The major issue with 5G technology is that there is such an enormously wide variation in the requirements: superfast downloads to small data requirements for IoT that any one system will not be able to meet these needs. Accordingly a layer approach is likely to be adopted. 5G is not just a mobile technology; it is ubiquitous access to high & low data rate services.

5G concepts

There are many new concepts that are being investigated and developed for the new 5th generation mobile system. Some of these include:

Pervasive networks: This technology being considered for 5G cellular systems is where a user can concurrently be connected to several wireless access technologies and seamlessly move between them.

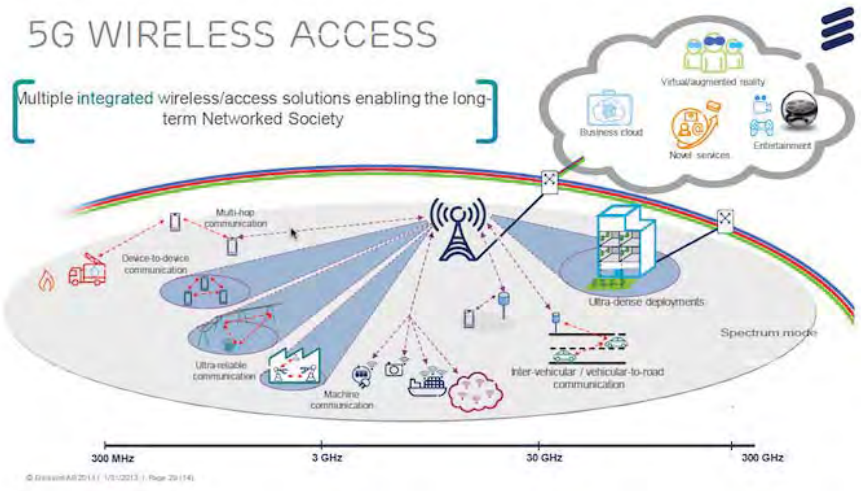
Group cooperative relay: This is a technique that is being considered to make the high data rates available over a wider area of the cell. Currently data rates fall towards the cell edge where interference levels are higher and signal levels lower.

Cognitive radio technology: If cognitive radio technology was used for 5th generation, 5G cellular systems, then it would enable the user equipment / handset to look at the radio landscape in which it is located and choose the optimum radio access network, modulation scheme and other parameters to configure it to gain the best connection and optimum performance.

Wireless mesh networking and dynamic ad-hoc networking: With the variety of different access schemes it will be possible to link to others nearby to provide ad-hoc wireless networks for much speedier data flows.

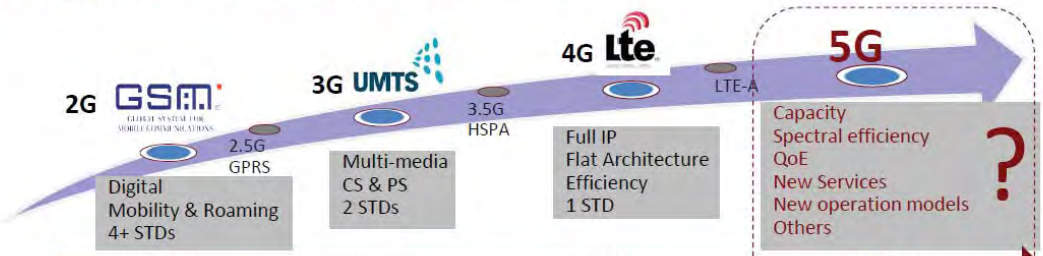
Smart antennas: Another major element of any 5G cellular system will be that of smart antennas. Using these it will be possible to alter the beam direction to enable more direct communications and limit interference and increase overall cell capacity.

There are many new techniques and technologies that will be used in the new 5G cellular or mobile telecommunications system. These new 5G technologies are still being developed and the overall standards have not yet been defined. However, as the required technologies develop, they will be incorporated into the new system which will be defined by the standards bodies over the coming years.



"5-G" Fifth Generation Land Mobile Service Evolution

Technology & Standards Evolution



	1990's	2000's	2010's	2020's
Multiple access **Carrier bandwidth** **RT Delay**	TDMA 124 KHz 150 ms	WCDMA 5 MHz 50 ms	OFDMA&CS-OFDM 20 ->100 MHz 10 ms	Small Cell / High frequency 100 Mhz -> higher **SDR** 0.1-1 ms
Data rate	9.6 - 100 kb/s -> GPRS	2 - 42 / 100 Mb/s -> HSPA+ & MC	300 Mb/s - 1 Gb/s -> LTE-A	10 – 100 Gb/s Asymmetric & balanced UL/DL
Transport	TDM Copper & MW	TDM/ATM Copper & MW	IP/MPLS Fiber & MW	IP/MPLS - Self Backhauling Fiber, MW & mmW
Core NW	CS Core	CS and PS core	All PS (Flat IP)	Flatter, **NFV,** **SDN**
Services	Voice /SMS	Voice & Data /Multimedia	IP Voice & Data Mobile Internet	IP Voice & Data (HD, 3D, ...) TV (Broadcast & Multicast), D2D
Service Pricing	Voice and SMS Usage based	Usage based -> Unlimited/Capped	Unlimited/Capped	OTT, Cloud Free voice(?), Unlimited/Capped
Spectrum	L band Licenced operation	L band Licenced operation	L & S band Licenced operation	Millimetre band (C, K, E, ...) Licensed & unlicensed operation Spectrum sharing

Dr Shahram G Niri, July 2014

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Publishing Credit to Dr. Shahram Niri July 2014 for Webinar titled:

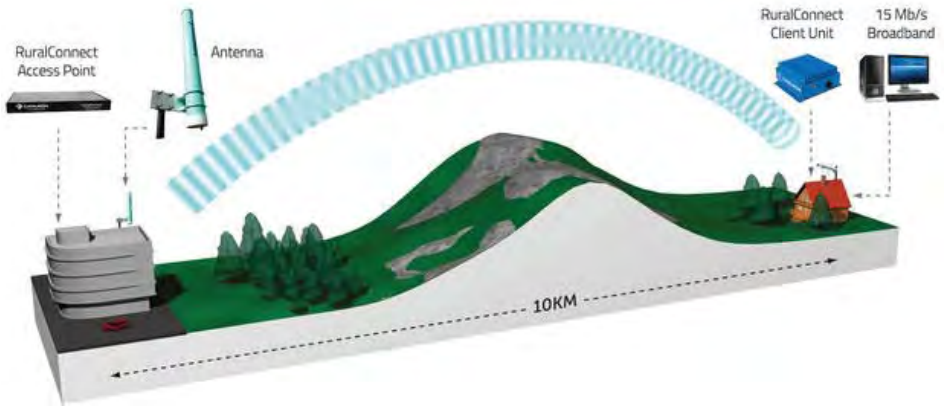
"Exploring 5G: Performance Targets, Technologies & Timelines"

2. White Space Internet

In telecommunications, white spaces refer to frequencies allocated to a broadcasting service but not used locally. Typically these are analog TV frequencies.

National and international bodies assign different frequencies for specific uses, and in most cases license the rights to broadcast over these frequencies. This frequency allocation process creates a band plan, which for technical reasons assigns white space between used radio bands or channels to avoid interference. In this case, while the frequencies are unused, they have been specifically assigned for a purpose, such as a guard band. Most commonly however, these white spaces exist naturally between used channels, since assigning nearby transmissions to immediately adjacent channels will cause destructive interference to both. In addition to white space assigned for technical reasons, there is also unused radio spectrum which has either never been used, or is becoming available as a result of technical changes. In particular, the switchover to digital television frees up large areas between about 50 MHz and 700 MHz. This is because digital transmissions can be packed into adjacent channels, while analog ones cannot. This means that the band can be "compressed" into fewer channels, while still allowing for more transmissions.

In the United States, the abandoned television frequencies are primarily in the upper UHF "700-megahertz" band, covering TV channels 52 to 69 (698 to 806 MHz). U.S. television and its white spaces will continue to exist in UHF frequencies, as well as VHF frequencies for which mobile users and white-space devices require larger antennas. In the rest of the world, the abandoned television channels are VHF, and the resulting large VHF white spaces are being reallocated for the worldwide (except the U.S.) digital radio standard DAB and DAB+, and DMB.

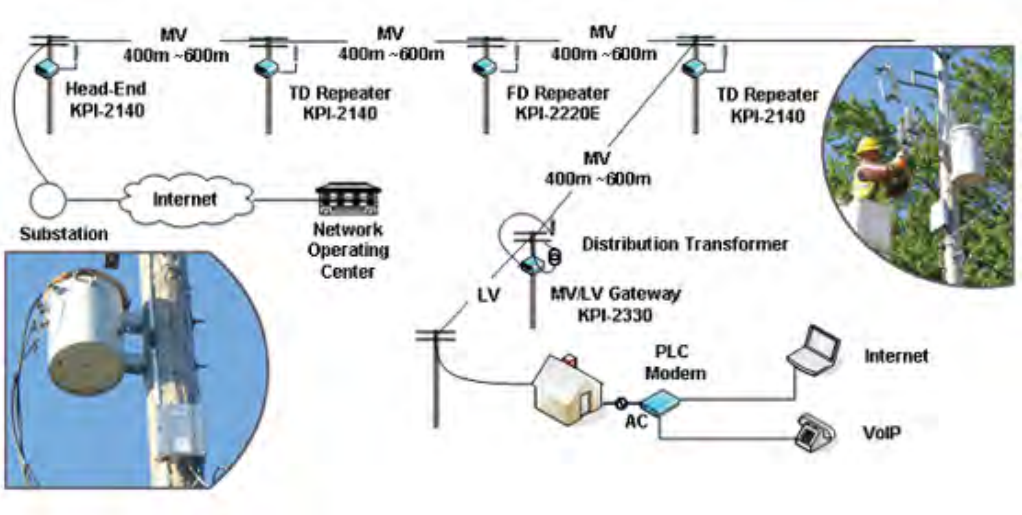


3. Broadband over the Power Line (BPL)

Broadband over power line (BPL) is a technology that allows data to be transmitted over utility power lines. BPL is also sometimes called Internet over power line (IPL), power line communication (PLC) or power line telecommunication (PLT). The technology uses medium wave, short wave and low-band VHF frequencies and operates at speeds similar to those of digital subscriber line (DSL). BPL has existed for many years, but so far, hasn't been implemented in the United States on a broad scale because of technical difficulties involving interference. For instance, amateur radio operators have voiced concerns that BPL will interfere with ham radio, an important communication technology in times of disaster.

Initially it was hoped that BPL would allow electric companies to provide high-speed access to the Internet across what providers call "the last mile." In this scenario, the service provider would deliver phone, television and Internet services over fiber or copper-based long haul networks all the way to the neighborhood or curb and then power lines would bring the signals into the subscriber's home. The BPL subscriber would install a modem that plugs into an ordinary wall outlet and pay a subscription fee similar to those paid for other types of Internet service. No phone, cable service or satellite connection would be required.

Proponents of the technology speculate that even if BPL is not accepted as a viable way to deliver high-speed Internet access, it may find a place in helping consumers to manage their energy consumption. High-speed data transmission between electrical plugs in a building would allow devices such as thermostats, appliances and smart meters to communicate with each other.



8. Infrastructure Planning for Clarke County

County governments plan for community growth in what is known as the "County Comprehensive Plan." Typically this Plan is updated every 5 to 10 years and addresses Land Use, Zoning and other issues that a County would use to help guide the logical growth patterns of a population. In many Counties, issues such as roads, water, sewer, gas and utilities are part of the Comprehensive Plan. Many Counties now are also planning for telecommunications as it relates to Broadband and the Wireless component.

Many counties target planned growth areas and seek to address communications issues and in particular the infrastructure element to include the "tower" component of the Broadband delivery system along with fiber optic cable easements and right-of-ways.

The question that faces all counties is that of the where, what, and how many towers or Wireless Communication Facilities are required for an area.

Many Counties limit the size, height and appearance as to the Zoning of a property. In addition, Historic and Environmental requirements must be met due to the fact that a communications tower is a "Federal Undertaking" because the US Government (in this case the FCC) actually owns and manages the radio frequency spectrum of the United States and, therefore, the Federal Code of Regulations prevails.

In the review of a communications tower, there are really three levels of requirements:

1. Local Government – Clarke County

   (Local Planning and Zoning requirements)

2. State Government- COVA Departments of VDCR & VDHR

   Virginia Antiquities Act (§ 10.1-2300 Code of Virginia)

   Virginia Environmental Impacts Report Act (§ 10.1-1188 Code of Virginia)

3. Federal Government- USDC/FCC & USDEPA

   (United States Code: CFR 47 & CFR 10)

The Planning and Review of these Facilities begins with local government being the "Gatekeeper" of the process.

Local Governments Role as "Gatekeeper"

Local government by virtue of its position and responsibility for local Land Use for the political subdivision has become the "gate keeper" for the introduction, review and approval for communications facilities and the various requirements for the three levels of government in the United States.

All communications facilities that either transmits, receives, or reflects radio waves are considered to be a "Federal Undertaking." Property that is private or public ownership (without Sovereign Immunity Status) under the Code of Virginia (or any state) is regulated by local government. Local Government (in this case Clarke County) is required to receive, review and act upon an Application in a timely manner.

There are exceptions such as federally owned lands and lands that have been excluded by a specific Act of Congress. (Such as Rail Road property under the National Rail Road Act, Indian Reservations by Treaty, etc.)

Local government must proceed with Land Use Ordinances and Zoning and Planning requirements in the review of these Applications and should not unreasonably delay any actions for these Applications.

One challenge for Clarke County is to require all information that the Applicant must acquire for the three levels of government and have the information available for review, analysis and public viewing.

These documents are:

1. The National Environmental Protection Act Study
2. Historic Antiquities Section 106 Reviews
3. FAA Air Space Study
4. FCC License Review
5. Interference and Intermodulation Study
6. Tower Structural Analysis
7. Propagation Study for this Application
8. Site Plan
9. Electrical Plan for Service and Grounding

Communications Infrastructure Plan

There are two major components that should be included into a successful Communications Infrastructure Plan:

a. Wireless Communications Facilities (Towers)

b. Fiber Optic Cable Networks.

A. Wireless Communications Facilities (Towers)

A typical Wireless Communications Facility possesses several elements:

1. Communications Tower
2. Communications Equipment Shelter of Cabinets
3. Stand-by Power Source
4. Commercial Power Source
5. Telco Fiber Optic Switched Network for Backhaul
6. Fenced compound for Security
7. FCC/FAA approved signage for Registration, Ownership and Contact Information.
8. Gravel Access Road and Parking.

The telecommunications tower comes in three varieties:

1. Self-Supportive Lattice
2. Guyed Lattice
3. Monopole

The Consultant recommends the "low profile" or "short" monopole tower style structures. Shorter towers strategically placed to work with the existing topography and tree heights to screen as much as possible.

Classes of Towers

With the existing towers and the geographic areas that they cover for voice and data, new towers will be required to "fill–in" gaps in existing and future service. The "fill-In" of these communications "dead areas" for data requirements will be more aggressive due to higher levels of signal strength in order for the devices inside a structure to be able to "uplink" with a wireless communication's facility in the general area.

Essentially it takes approximately 40% more signal power for the wireless data devices to operate effectively.

In order to provide vertical support for voice and data services within Clarke County, it is recommended to look at towers "classified" by height.

They are:

Class 1……..Tower height of 50' or less

Class 2……..Tower height of 80' or less

Class 3……..Tower height of 120' or less

Class 4……..Tower height of 199' or less

Class 5……..Amateur Radio as per Federal Law

(See Page 67: Examples of Classes of Towers Schematics)

By placing towers in "classes" based on height, it gives both the residents and legislators of the County as well as the Carriers or Providers the ability to serve a specific geographic area and have the tower height and appearance to "harmonize" with the immediate surrounding area.

If only one height of tower is considered such as a 199' AGL structure, then the community, legislators, and Applicant may not be able to meet a viable solution.

The wireless industry has demonstrated many times that it can plan, engineer, and build "low profile" wireless communications sites that blend and harmonize with the surrounding area when required. Many counties and historic places in Virginia have adopted these principles in tower setting with great success. **(See Page 78 – Examples of Low Profile WCFs)**

B. Fiber Optic Cable Networks

Currently there are two (2) switched fiber optic networks within Clarke County; the first belonging to Verizon and the second to Comcast. While both are designed and well managed, they are currently located in a "trunking" mode along Rt. 7 and Rt. 50 in an east to west direction and Rt. 340 carries one of the North/South trunks.

The new PCTDA towers will require a fiber optic cable "back haul." The towers were positioned so that fiber optic cable could be efficiently engineered and placed to minimize long runs and transmission loss.

PCTDA "Fiber Optic" Backhaul

The most efficient route will connect PCTDAs 1, 2, 3, 4 and 5. These are the towers located on the east end of the county along the Rt. 604-605 corridor. At both ends of Rt. 604 and 605, there is a fiber optic Remote Module owned by Verizon that can provide switching to this fiber optic route.

The length of the run would be approximately seven (7) miles. The unit cost for rural Fiber Optic Placement is approximately $70k per mile to include engineering, right of way acquisition, permits, fiber optic cable, ductwork and placement.

Estimated Total is $490k.

PCTDAs 6, 7, 8, 9, 10 & 11 each are located within ½ mile of a fiber optic Remote Module. Six PCTDAs at .5 mile @$70k per mile.

Estimated Total is $210k.

Total Fiber Optic Backhaul Project …….$700,000

Planning and Engineering

When planning a wireless communications network, tower ***spacing*** is important. The goals are to have contiguous service for areas that are high traffic and high personal utilization such as homes, schools, work and recreational areas. In seeking to do this, the signal strength is the key aspect to a successful network.

A. The "Evolution" of Technology: How has "spacing" changed?

In 2002, LMR carriers had technology that was designed for Mobile Cellular service. Meaning, traveling in your car, the system was set up as a true "mobile" system. The goals were to cover as much "to the curb" cellular service as possible in the "Commercial" areas. This was 2G or second generation service seeking to become 3G service using a Long Term Evolution of "LTE" strategy.

Today, LMR carriers with the 4G LTE service are providing not just "mobile" service but wireless Broadband. With the advent of the internet and Applications called "APPs," Verizon is seeking a wider geographic area to cover. This area is the Residential Market. Hence, the location of the tower is in the "Residential" area.

The 2G/3G service requirements were rather low in scale. A system could effectively work up to -104 dBm Signal Strength. This could typically complete the "Uplink and Downlink" of a voice signal or a Text Message or Internet link for a small PDA like a "tablet."

A tower facility will be used for:

1. Voice Communications
2. Light Data such as Text and PDA activity (APPs)
3. Broadband (Full motion video, deep and wide "pipe" for down loading and uploading data, etc.) Tele-commuters will benefit
4. Frequency Bands with 3 sets of antennas:
    a. 700 MHz : Voice
    b. 800 MHz : Light Data
    c. 1700 – 2100 MHz: Broadband

Signal Strength Required for 4G:

-74 dBm: Excellent

-74 dBm to -82 dBm: Very good

-82 dBm to -92 dBm: Good

> -92 dBm: Poor and pixilation failure.

Signal Strength required for 2/3G:

-104 dBm = -12 dBm

10% Addition in Signal Strength

Interpretative Analysis:

For 4G to work, the Signal strength must be approximately 10% higher in value

B. Tower Spacing -2016 Clarke County

Tower spacing is an engineered effort. It is the balance of approximately twenty-three (23) factors which include: physical location, antenna height, gain and direction, cable loss, effective Radiated Power from the transmission of radio frequencies, curvature of the earth, sound attenuation, etc.

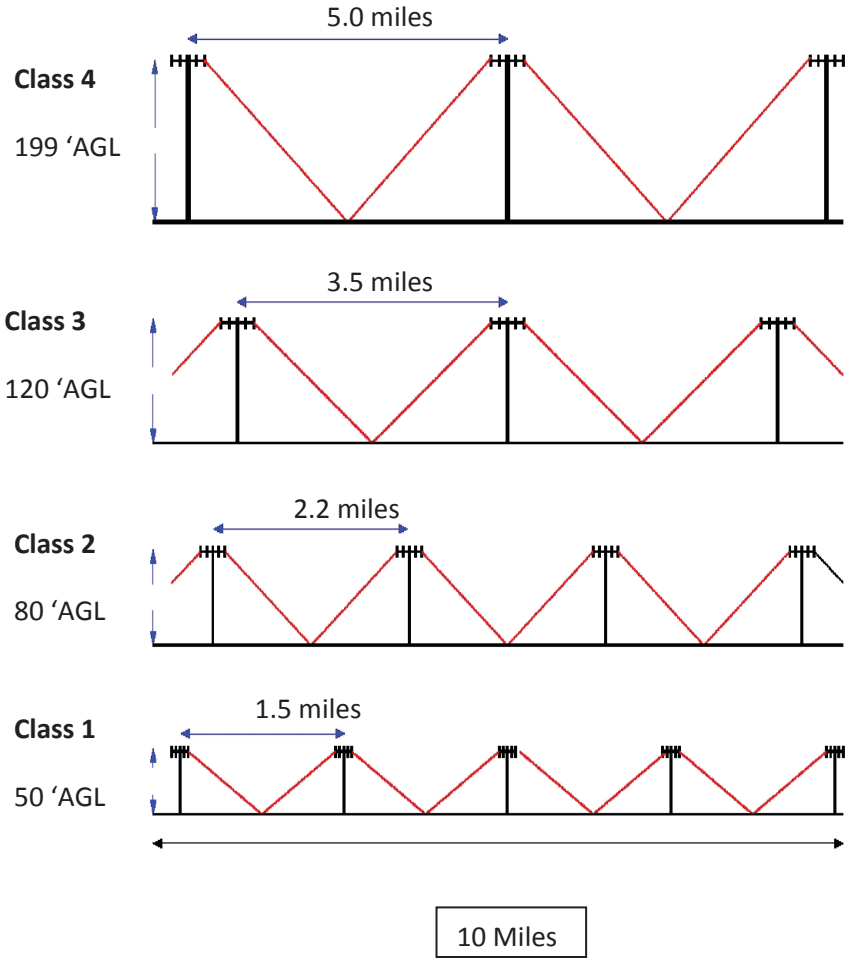
Considering all of these characteristics, the site will produce what is known as radio frequency propagation as to a pattern or "coverage area" that radio signal can interface with a transceiver device and successfully transmit and receive radio signals. When this occurs, there is a successful "uplink and downlink" for communications.

Clarke County Existing Towers

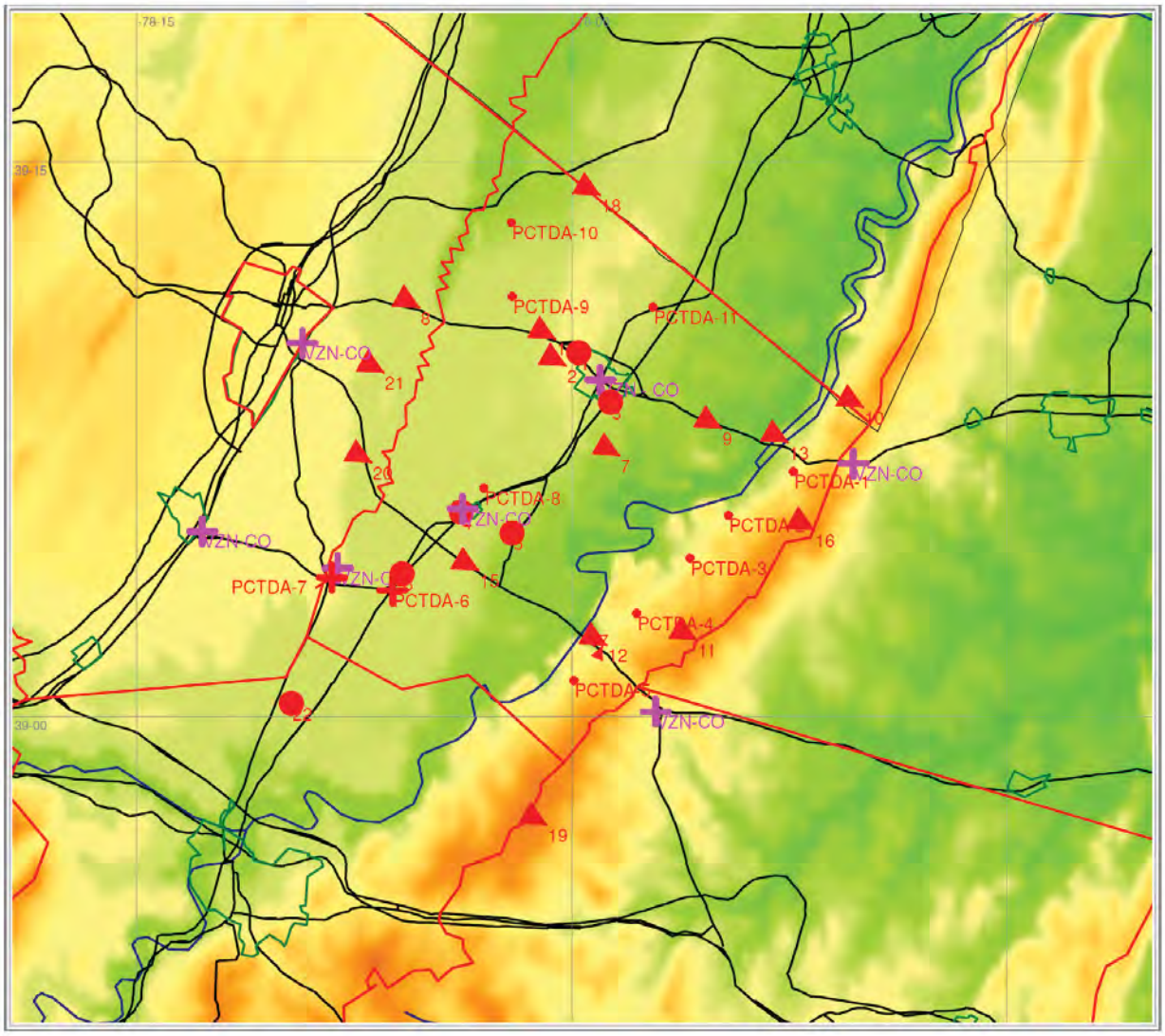
For the most part, Clarke County has several tall towers that are located on the perimeter of the County or slightly outside the County as well as several tall towers in the center of the County that provide a "hub" with "spokes" type of coverage. Any additional towers will be "fill-in" of unserved or underserved areas that have little voice and extremely low levels of data transmissions.

When planning where towers should be placed, here is some generic information on the placement distances for LMR Carrier towers.

“LMR Tower Spacing Rule of Thumb Chart”



Clarke County Telecommunications Sites



Terrain View

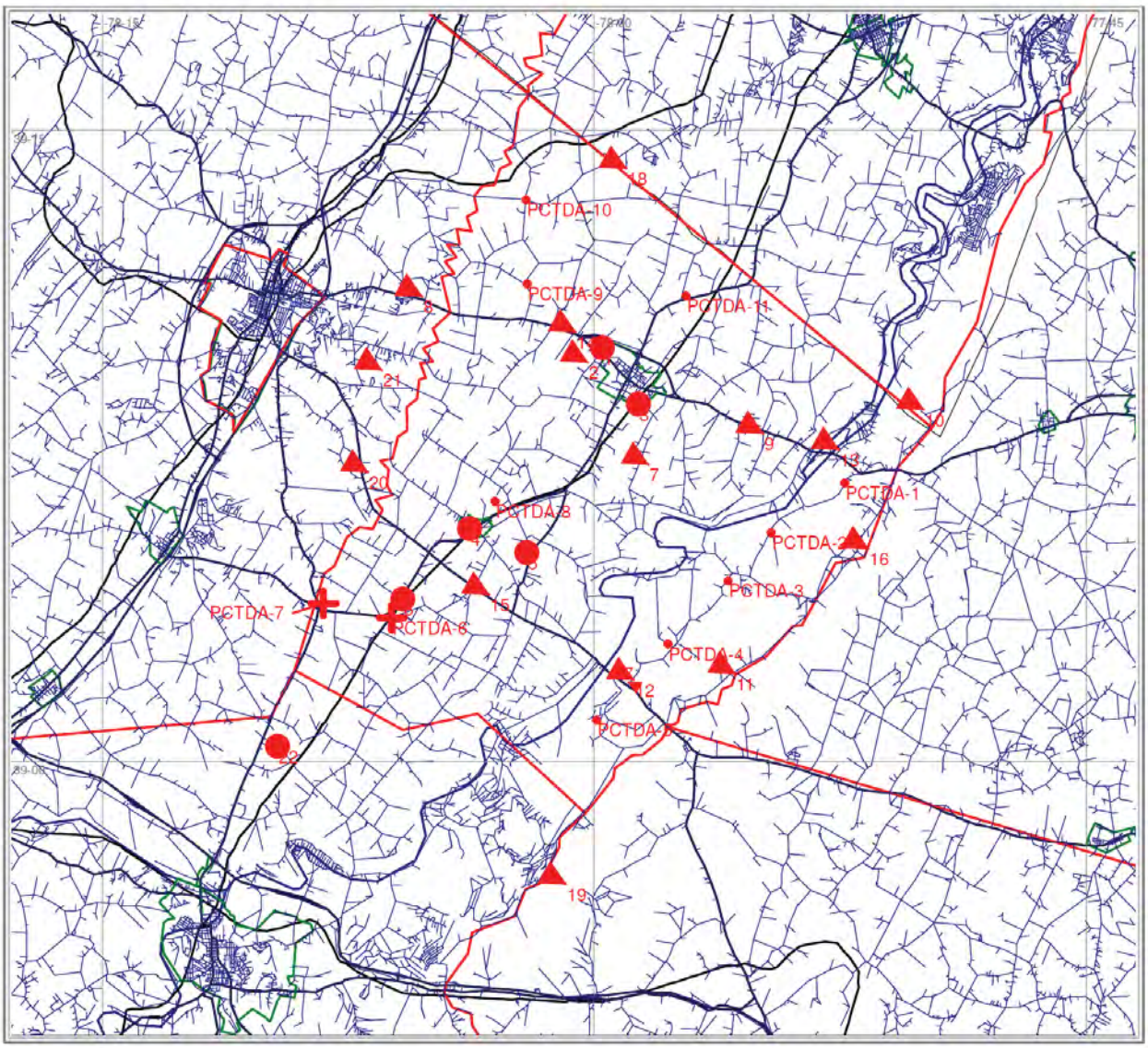
The Terrain analysis for the County is signified by the higher elevations in brown to the east and a gentle slope to the west. The PCTDA's fit on a **"Shelf"** along Rt. 604 and Rt.605. Due to this topographic feature the tower heights for the PCTDAs along this corridor do not require a height above 120' AGL. The other PCTDAs in the County "Fill in" the other Gaps in coverage therefore making a uniform height for all of 120' AGL.

= Existing Tower

= Water Tank

= PCTDA

Clarke County Telecommunications Sites



Existing Tower-Water Tank and Positioned PCTDA sites

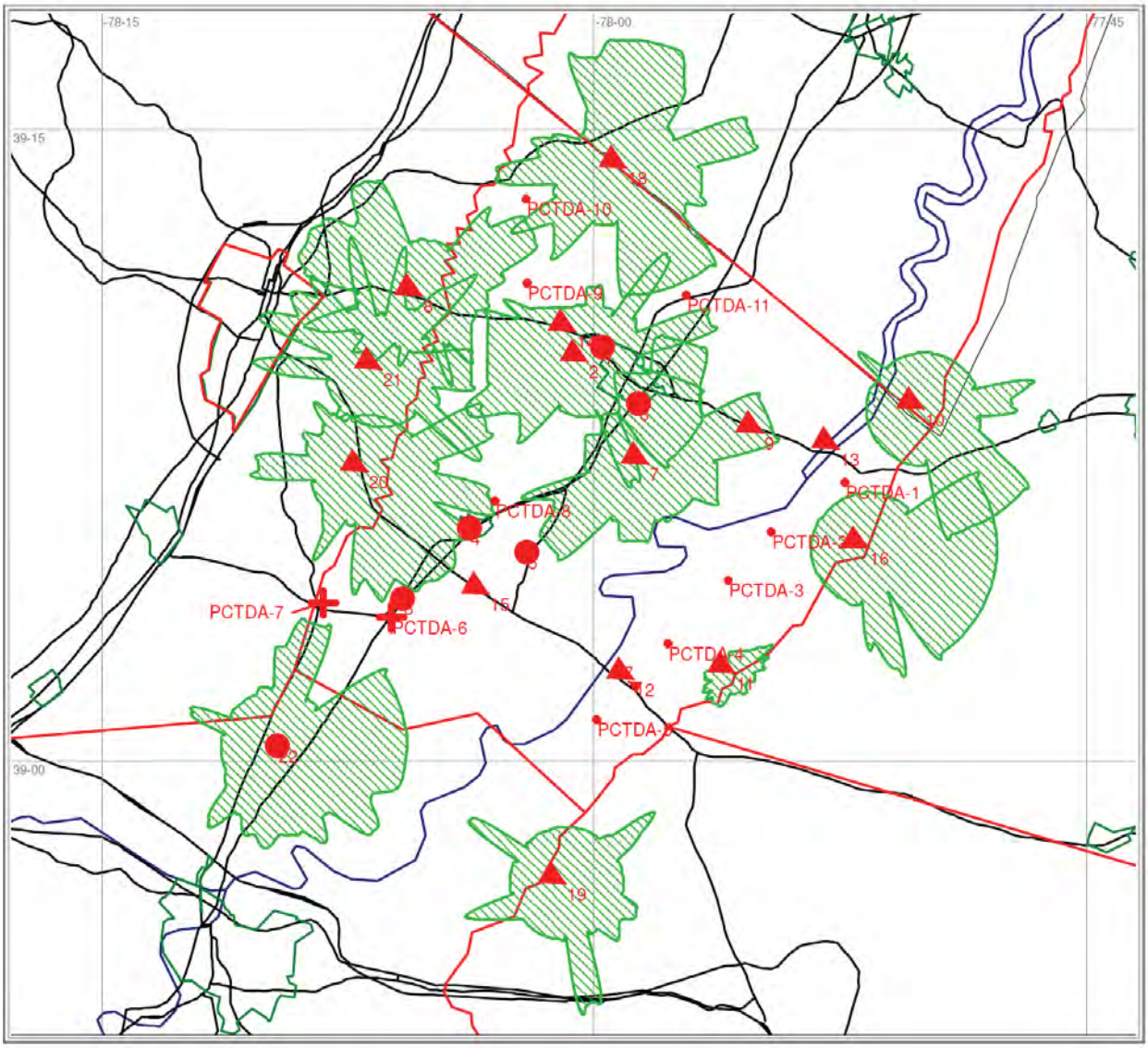
Existing towers and water tanks throughout the county are dispersed in a "Hub and Spoke" formation. The Hub is Site #2 and Site #7 with the rest of the facilities around the perimeter.

= Existing Tower

= Water Tank

= PCTDA

Clarke County Telecommunications Sites



Existing Data Coverage with Major Sites

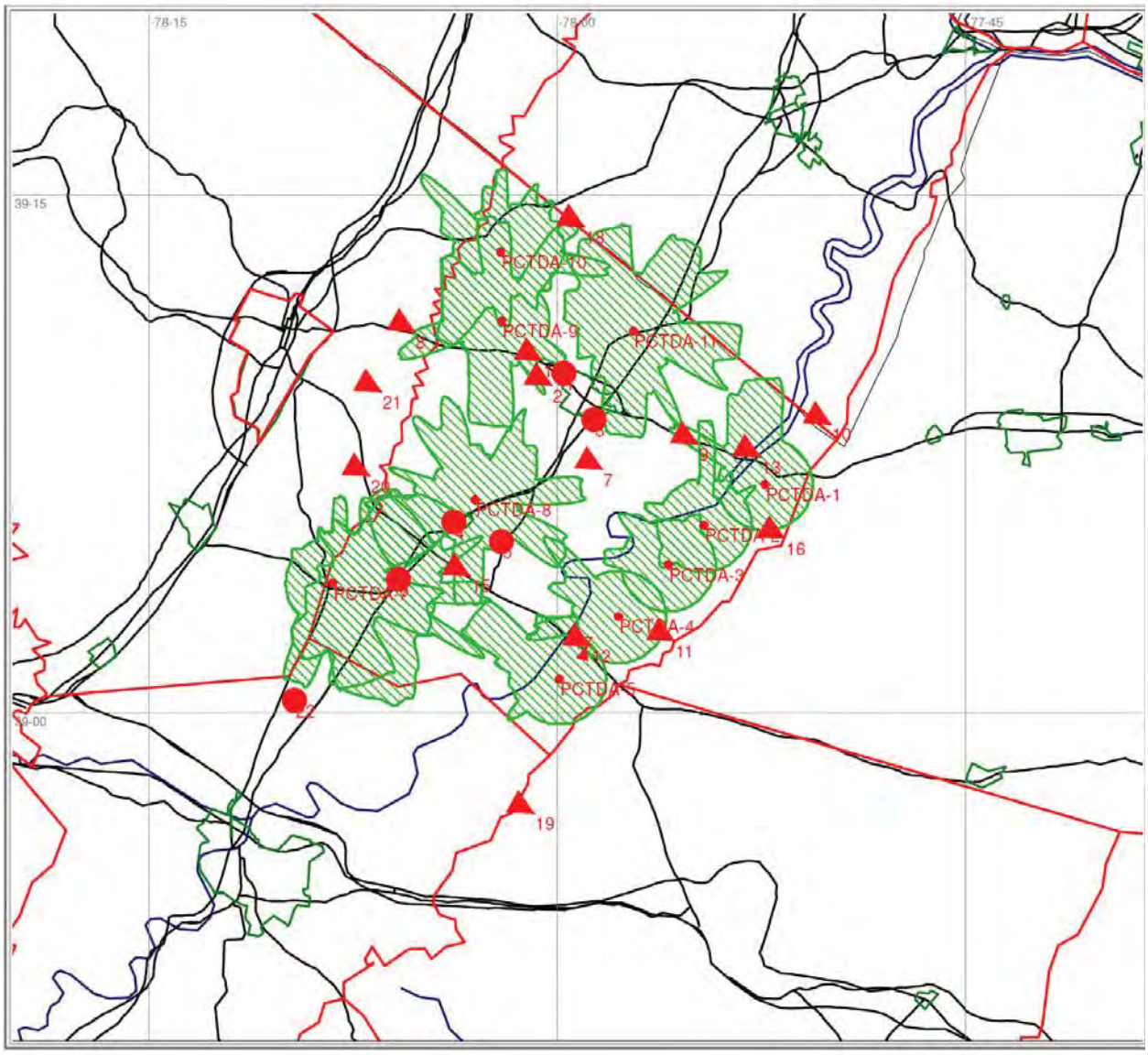
This is the existing prediction model of wireless data 800 MHz service from the LMR providers. There is approximately 60% of the County that lacks reliable wireless broadband.

= Existing Tower

= Water Tank

= PCTDA

Clarke County Telecommunications Sites



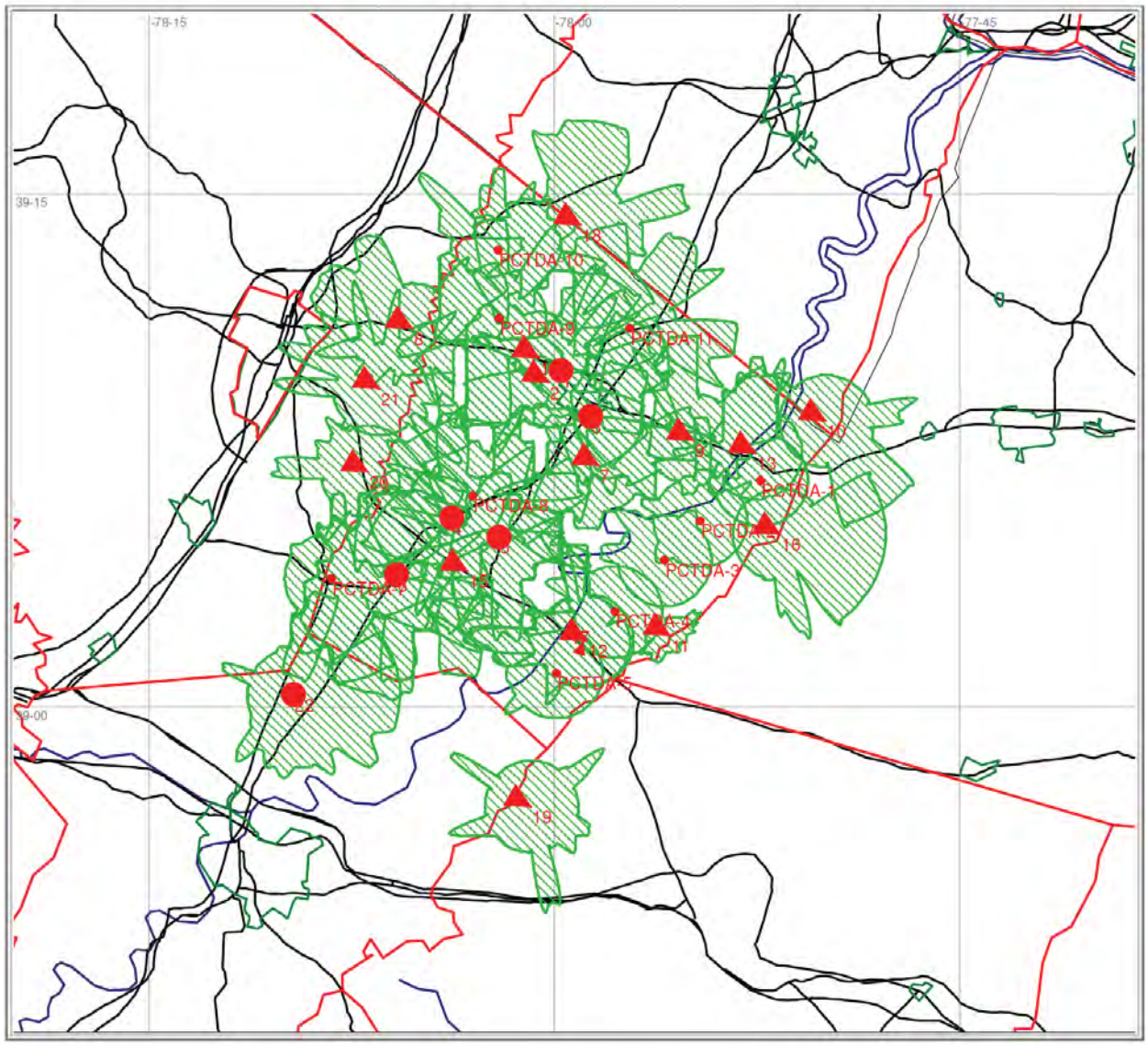
Coverage for 11 PCTDAs

This is coverage of what the 11 PCTDAs would cover if deployed for 800 MHZ LMR service. The PCTDA towers would be 120' AGL. The 11 PCTDAs boost service by approximately 45 to 50% of geographic area of the County.

= Existing Tower

= Water Tank

= PCTDA



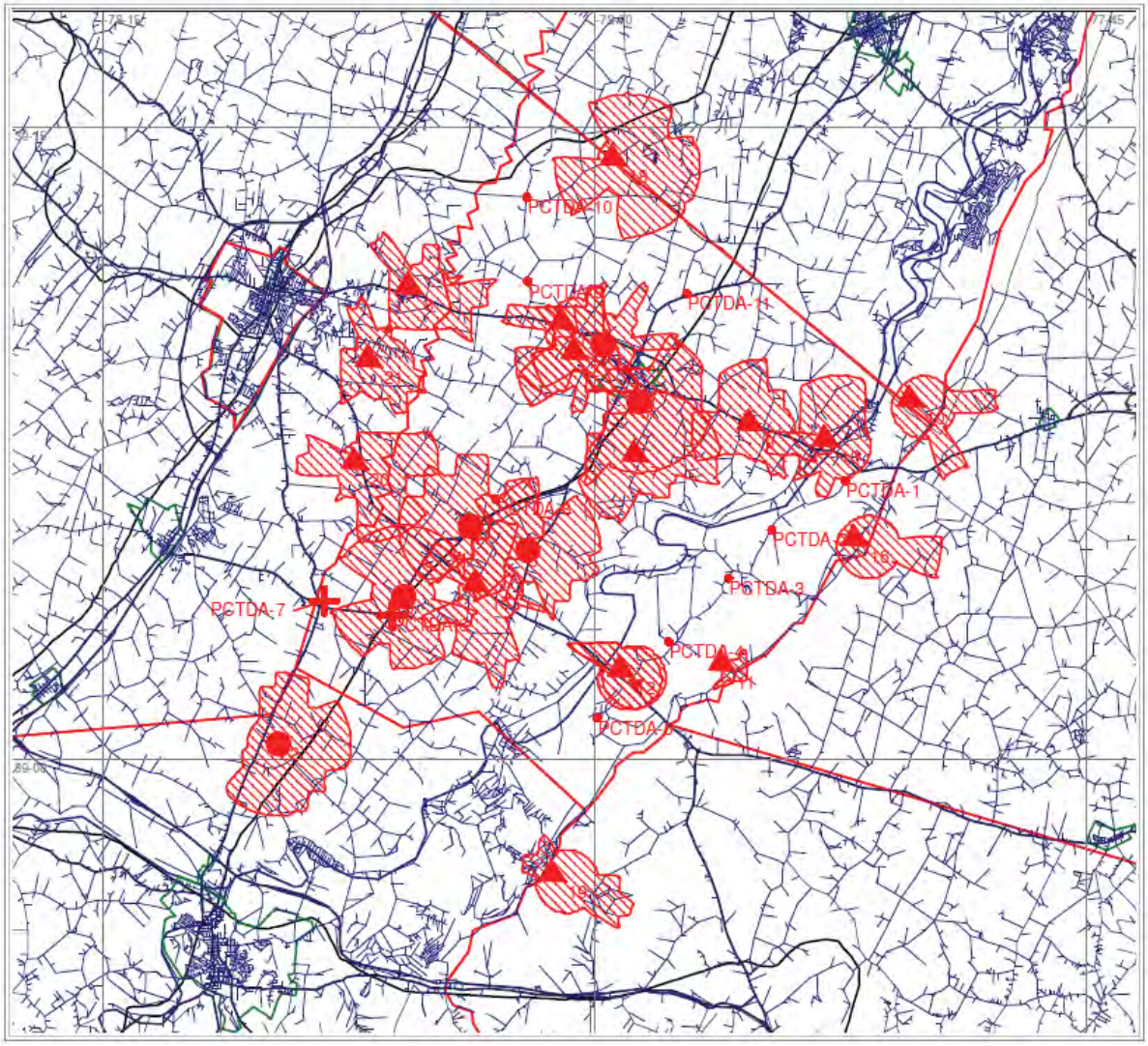
Coverage for Existing & 11 PCTDAs

This is the Composite of all existing towers with the 11 PCTDAs coverage. This would cover approximately 90%+ of the County. The other locations in "White" would need to be supplemented with Class 1 or 2 towers.

= Existing Tower

= Water Tank

= PCTDA



2.1 GHz Service-Licensed on Existing Tower-Water Tanks and PCTDA Sites

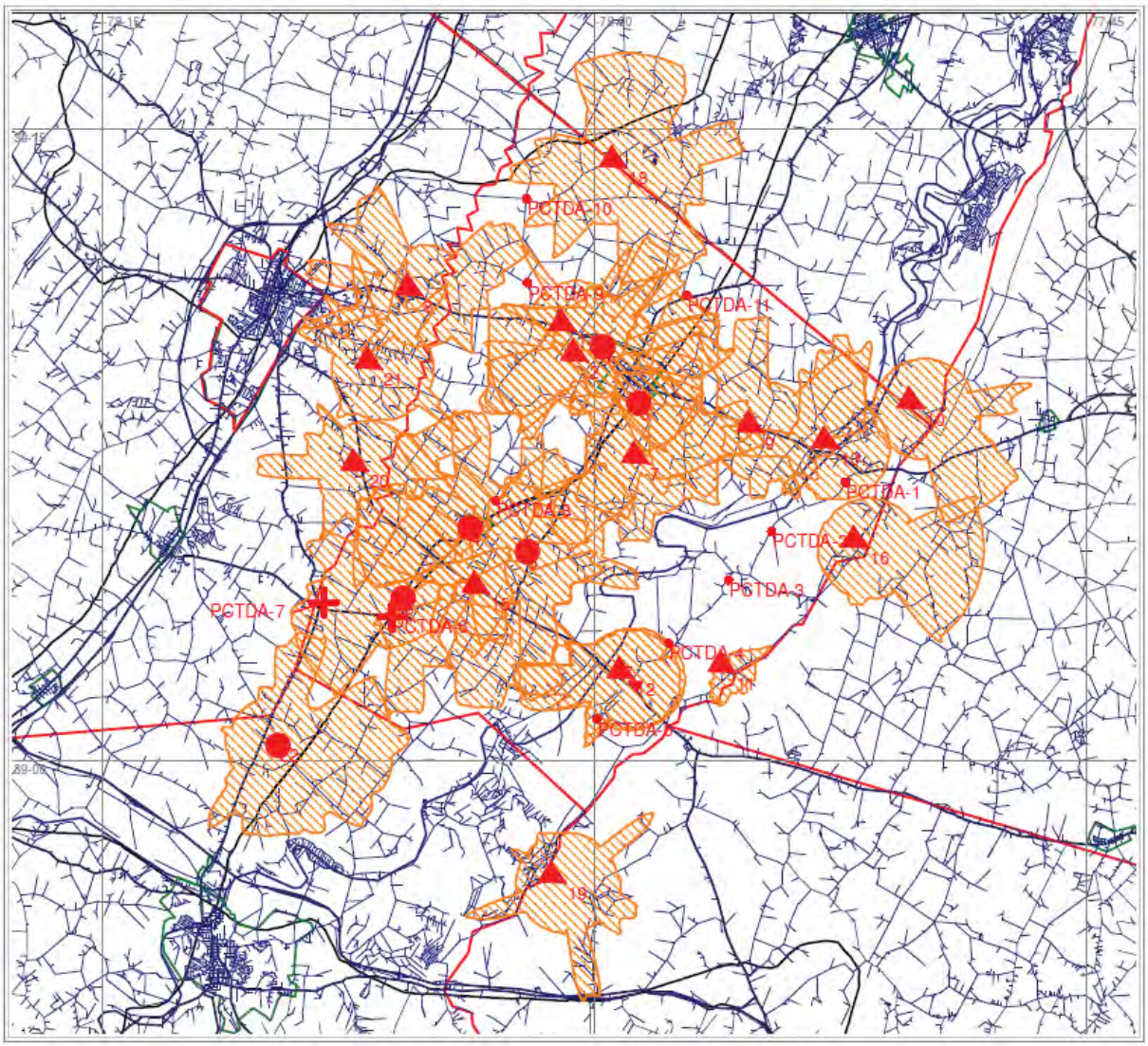
= Existing Tower

= Water Tank

= PCTDA

Un-Licensed Broadband Prediction Coverage

Clarke County Telecommunications Sites



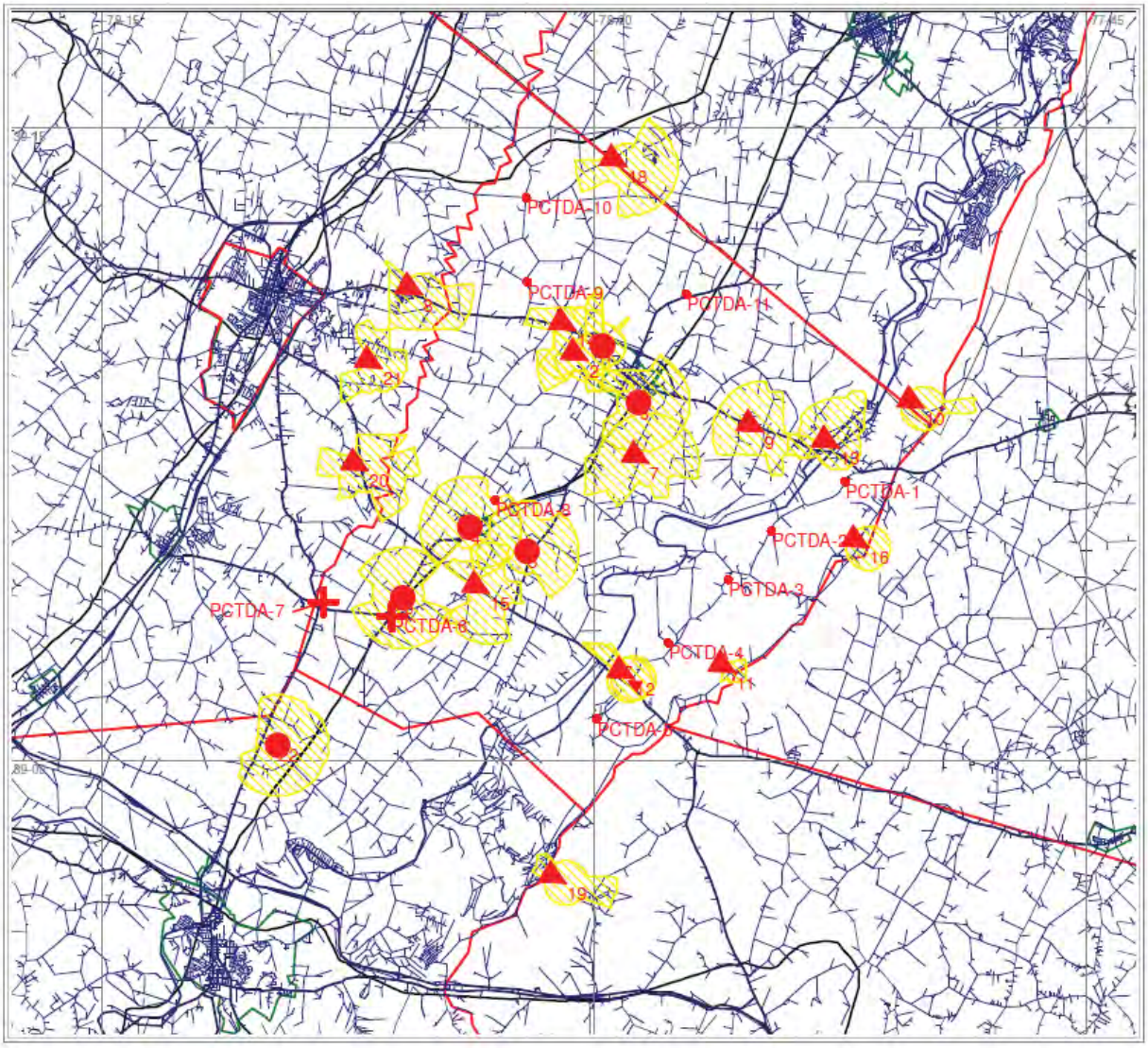
900 MHz Service-Unlicensed on Existing Tower-Water Tank and Positioned PCTDA Sites

Unlicensed 900 MHz data coverage from towers and Water Tanks located within the County. This represents approximately 60% of the County.

= Existing Tower

= Water Tank

= PCTDA



2.4 GHz Services –Unlicensed on Existing Tower-Water Tank and PCTDA sites

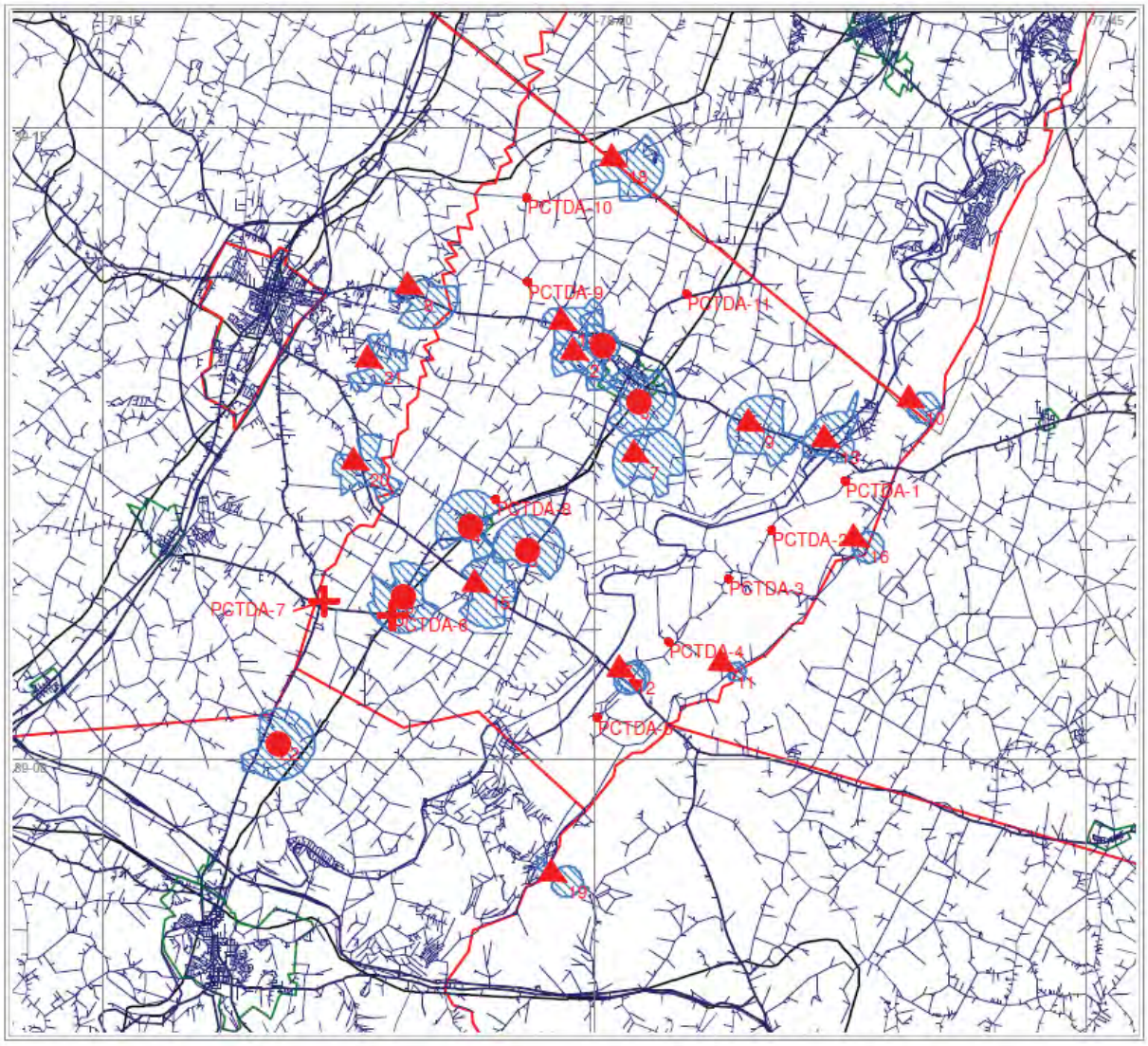
Unlicensed 2.4 GHz service if located on all towers and water tanks. This represents about 40% of the County.

= Existing Tower

= Water Tank

= PCTDA

Clarke County Telecommunications Sites



5.8 GHz Service-Unlicensed on Existing Tower-water Tank and Positioned PCTDA Sites

Unlicensed 5.8 GHz service. This represents approximately 20% of the County.

= Existing Tower

= Water Tank

= PCTDA

9. Permitted Commercial Tower Development Areas (PCTDA)

The "Fill-In" Solution

Permitted Commercial Tower Development Areas or **PCTDA**s are predetermined locations where wireless communication facilities are planned for future growth. Communities plan for residential growth, and utilities such as water, sewer and gas. Today, cable, communications towers and telephony must be considered. The "wireless" medium of service delivery must be planned if a community desires to regulate and control the deployment of such facilities.

A Wireless Communications Facilities (WCF) is a combination of horizontal and vertical components of equipment that facilitates the housing of antennas and electronic equipment.

Components of a PCTDA

The vertical component for a WCF is typically a "tower." This tower component is recommended to be a "monopole" tower or a single cylindrical structure which antennas may be mechanically attached to the vertical structure. The monopole tower which is placed in a predetermined area should seek to accommodate as many antennas physically possible within the structural limitations of the material.

The "horizontal" component of a WCF would be equipment cabinets, power cabinets and telephone interface cabinets that attach the wireless signal to that of a land line network.

Both the monopole tower and the equipment cabinets make up the WCF.

Radio Frequency Analysis

A radio frequency propagation study for the various frequency bands that carry wireless data signals of the existing WCF facilities was completed. The analysis of this study revealed approximately 40% of the geographic area of the County had sufficient data coverage with these existing tower sites. This means that 60% of the County is unserved or underserved with wireless data coverage. The question is: How to fill in these Gaps in Coverage?

Taking into consideration the topography, sound attenuation, heights of existing trees, signal strength and many other technical considerations, the careful location of WCFs would be required. These WCF's would define what is to become a **Permitted Commercial Tower Development Area or PCTDA.**

Results

After reviewing the existing coverage and filling in the "dead zones," it is estimated that Clarke County will require **eleven (11) PCTDAs**. The PCTDAs are positioned in the County to "fill in" existing unserved or underserved areas and this could be accomplished at **a targeted height of 120' Above Ground Level (AGL).** These proposed WCFs supplement the existing and future technology for licensed and un-licensed frequency bands managed by the Federal Communications Commission or FCC. **(See Page 55 – Map of PCTDAs for Clarke County)**

The locations and heights are as follows:

PCTDA	Latitude	Longitude	Height (AGL)
1	39-06-37.3 N	77-52-21.5 W	120'
2	39-05-26.7 N	77-54-36.3 W	120'
3	39-04-17.8 N	77-55-55.1 W	120'
4	39-02-47.8 N	77-57-45.0 W	120'
5	39-00-59.2 N	77-59-55.6 W	120'
6	39-03-25.0 N	78-06-10.7 W	120'
7	39-03-45.4 N	78-08-15.3 W	120'
8	39-06-10.9 N	78-03-01.5 W	120'
9	39-11-21.4 N	78-02-02.9 W	120'
10	39-13-21.3 N	78-02-04.8 W	120'
11	39-11-04.1 N	77-57-12.0 W	120'

Clarke County plans to integrate these proposed locations (if approved) as part of its Wireless Infrastructure Plan for Community Development. The deployment of PCTDAs will encourage the "planned" deployment of wireless communications technologies for the citizens of Clarke County. Each PCTDA location is considered the "center" of a circle with a ½ mile radius that this WCF can be constructed if all of the Planning and Zoning Ordinances are met.

Design Standards

Design standards have been established that are reflective in the Ordinance concerning communication towers. The Atlantic Group recommends having PCTDA areas that have towers at a targeted height of 120' AGL with a monopole design. The monopole design should be of a non-reflective surface. The compound surrounding the tower should be no greater than 75' x 75' and surrounded by a chain link fence with the mesh being a dark green or black color. The WCF should be positioned within a 200' grove of trees measured from the base and the physical approach of the access road should not be constructed as such to reveal the compound from a public access road.

Potential Solution if the PCTDA towers need to be taller if criteria are met.

*There is a strategy in tower development known at **"Reverse Stacking."** Simply put, the monopole tower is designed and constructed to be 199' AGL. The Applicant places the foundation pier and erects the first 120'. Co-location of antennas is then allowed. If later, a taller tower is required at that location, then the Tower Owner must Apply for a Special Use Permit or Conditional Use Permit and request that the additional height be allowed up to but not exceeding 199'. This gives the tower developer "flexibility" and the community the ability to receive wireless data, but allow for more carriers to be co-located.* ***If the Planning Commission and Board of Supervisors determine in either direction, the public can see what impact a 120' AGL tower has to the area and then determine the impact on the community.***

Summary:

Clarke County should allow the strategic location of 11 towers that are 120' AGL structures to fill in the "Gaps" that exist in 2016 at the prescribed areas known as Permitted Commercial Tower Development Areas.

Cost for Total Project

1. **Towers**

   Each tower is estimated for construction cost of $250,000 per tower.

   Total Cost of 11 towers @ $250k/tower = $2,750,000

2. **Fiber Optic Backhaul**

   Total Cost for Fiber Optic Project

   Approx. 10 miles @ $70k/mile = $700,000

Total Projected Cost…….$3,450,000

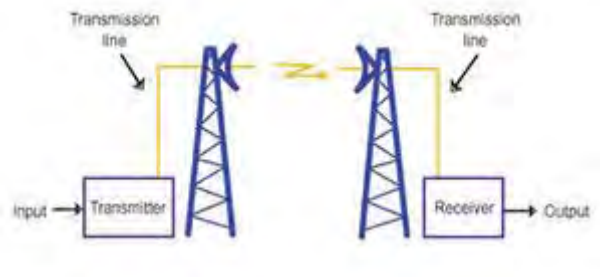
Criteria for Towers greater than 120' AGL.

Even with the eleven (11) PCTDA location areas, it may be necessary for an Applicant to request a tower that may have an overall height of 199' AGL. This doesn't mean that the original calculations for the "horizontal" coverage for the wireless networks was inaccurate, but the tower may require a "Vertical" solution for a non-cable backhaul such as microwave to be required to provide the back haul capability to reach the switched telephony system as described earlier. (Satellite and Laser Technology may also be required.)

Microwave or "MW" technology is a "point to point" narrow beam of radio waves used to connect one site to another in what is referred to as "trunked radio." Microwave "replaces" the need for a copper or fiber optic cable. Most communications towers are connected to the switched telephone networks with cable. Typically the "cable" connection is approximately 90%. Only about 10% of communications towers are connected with microwave. The deployment of microwave is typically in remote terrain and locations of great distance from a telephony switch or access to a fiber optic cable.

This could be required in Clarke County if fiber optic cable is not placed for the backhaul.

For microwave to acquire an adequate "point to point" a path study is performed vertically and horizontally to "connect" these two locations together. The two locations must have a clear and defined Line of Site between the two dishes. For the correct elevation of the round microwave dish, it may require the tower be of a specific height greater than the "targeted" 120' AGL.



In addition to the microwave horizontal and vertical alignment issues, the communications tower may be located in a topographic "depression." A topographic "depression" is a ground elevation that is less than the surrounding topographic elevation. This is referred to as a "hole."

When PCTDAs are calculated using the ground elevation at the intersection of two streets, a ½ mile radius is to be considered in the exact plotting of the proposed communications tower. Within the ½ mile there may be only limited locations which property owners would allow the tower to be placed that meets setback requirements as well as environmental and historical

considerations. Some consideration must be given to ground elevation issues that may force the tower to be sighted on low lying properties.

In summary, there are two major considerations for increasing the height of a tower above 120' AGL:

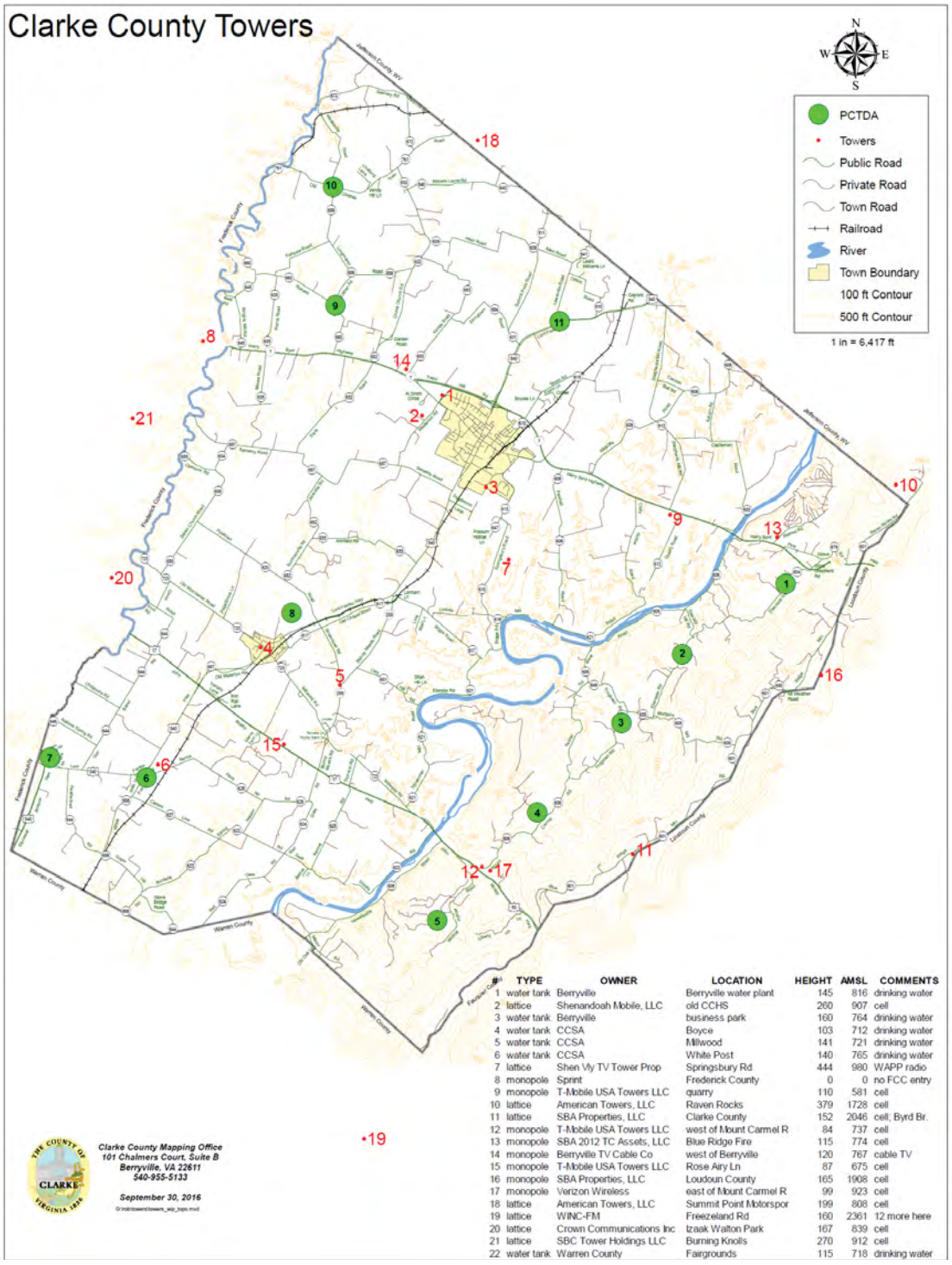
1. **To ensure proper connectivity for microwave "point to point" systems.**

   -Documentation required: Path Study and rejection from fiber optic providers.

2. **Proposed tower is located within a topographic depression.**

   -Documentation required: Setback Calculations with Ground Elevation Profile Diagrams and Property Owner requirements in writing.

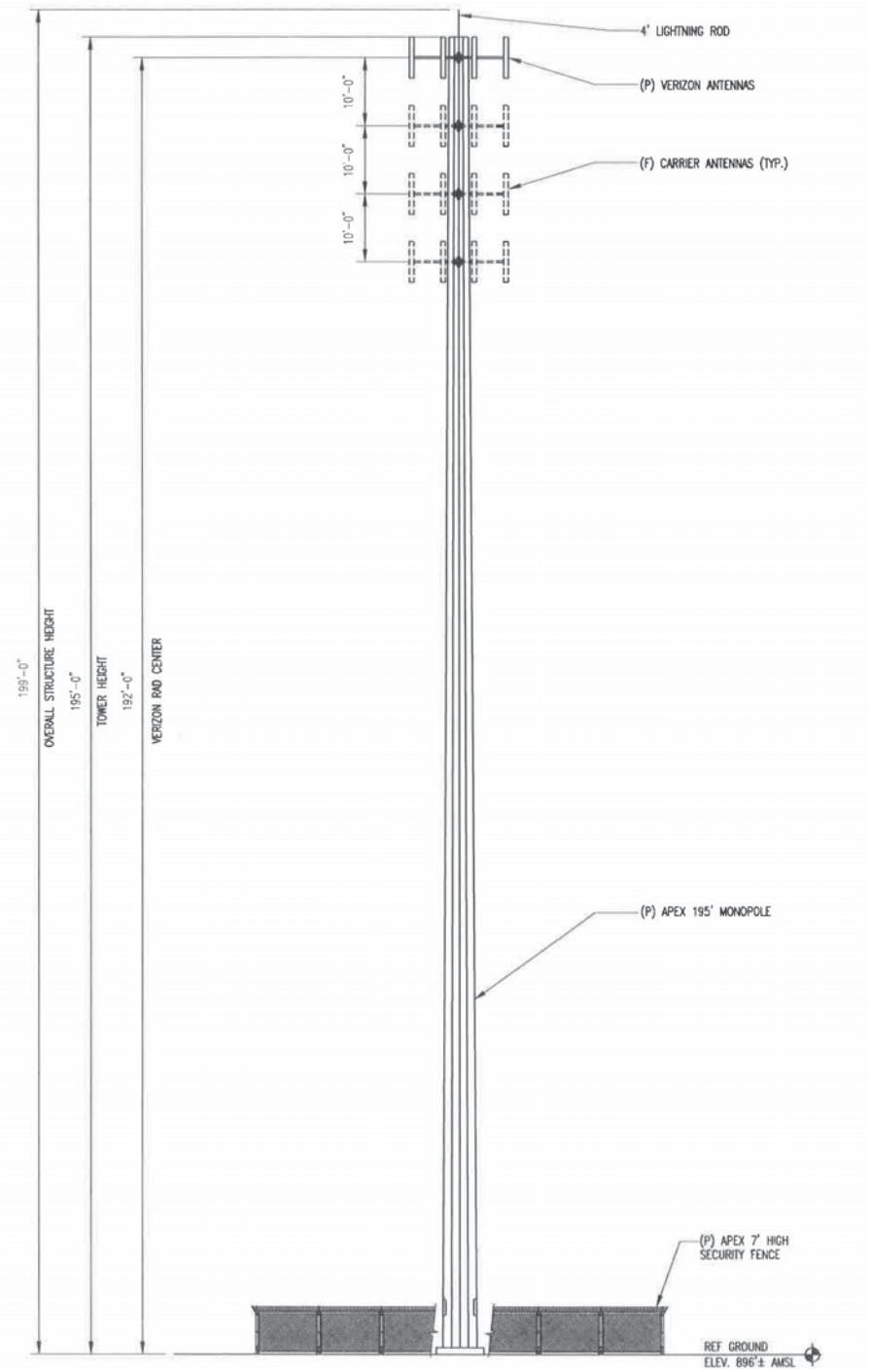
Map of PCTDAs for Clarke County



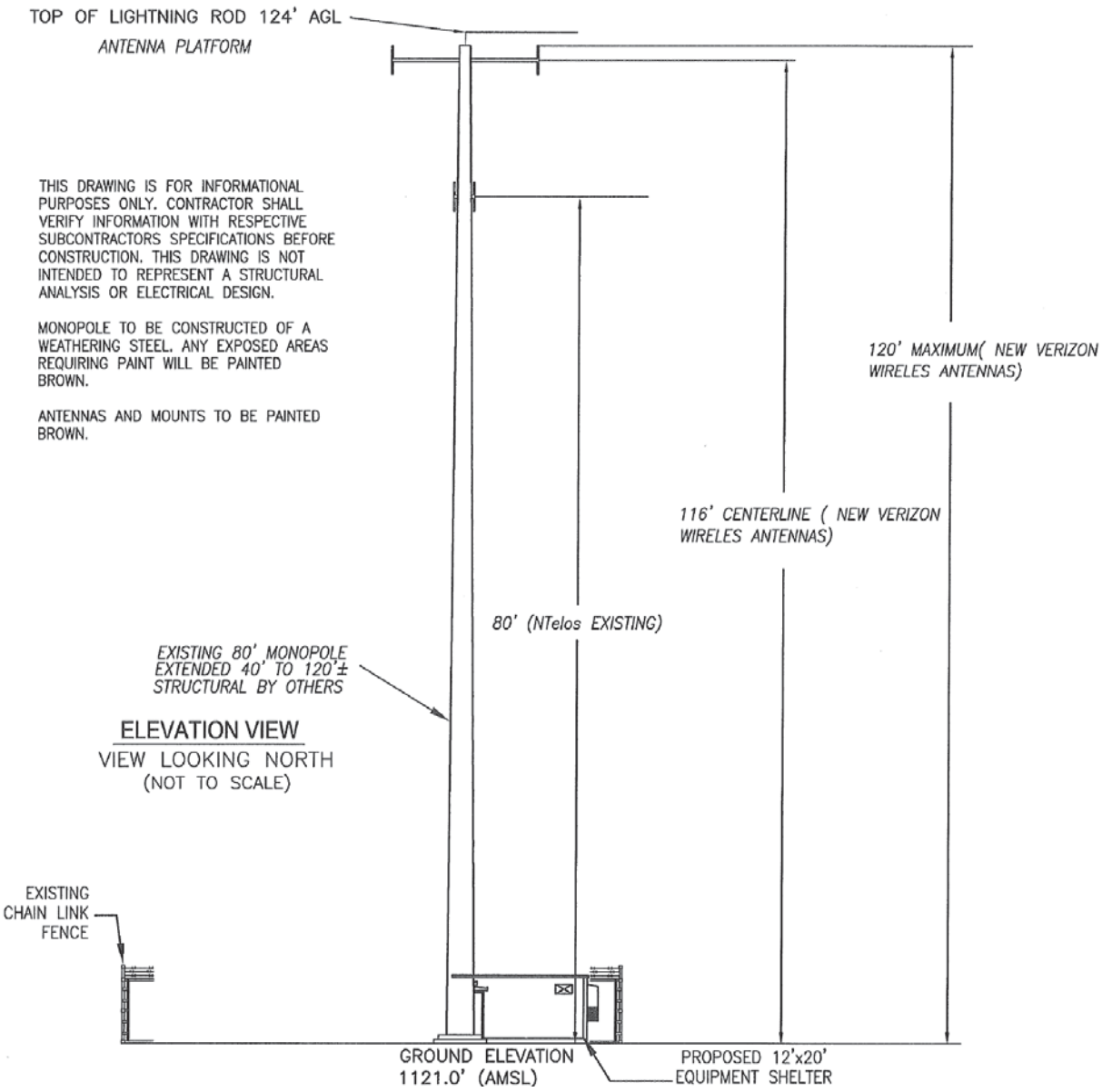
#	TYPE	OWNER	LOCATION	HEIGHT	AMSL	COMMENTS
1	water tank	Berryville	Berryville water plant	145	816	drinking water
2	lattice	Shenandoah Mobile, LLC	old CCHS	260	907	cell
3	water tank	Berryville	business park	160	764	drinking water
4	water tank	CCSA	Boyce	103	712	drinking water
5	water tank	CCSA	Millwood	141	721	drinking water
6	water tank	CCSA	White Post	140	765	drinking water
7	lattice	Shen Vly TV Tower Prop	Springsbury Rd	444	980	WAPP radio
8	monopole	Sprint	Frederick County	0	0	no FCC entry
9	monopole	T-Mobile USA Towers LLC	quarry	110	581	cell
10	lattice	American Towers, LLC	Raven Rocks	379	1728	cell
11	lattice	SBA Properties, LLC	Clarke County	152	2046	cell; Byrd Br.
12	monopole	T-Mobile USA Towers LLC	west of Mount Carmel R	84	737	cell
13	monopole	SBA 2012 TC Assets, LLC	Blue Ridge Fire	115	774	cell
14	monopole	Berryville TV Cable Co	west of Berryville	120	767	cable TV
15	monopole	T-Mobile USA Towers LLC	Rose Airy Ln	87	675	cell
16	monopole	SBA Properties, LLC	Loudoun County	165	1908	cell
17	monopole	Verizon Wireless	east of Mount Carmel R	99	923	cell
18	lattice	American Towers, LLC	Summit Point Motorspor	199	808	cell
19	lattice	WINC-FM	Freezeland Rd	160	2361	12 more here
20	lattice	Crown Communications Inc	Izaak Walton Park	167	839	cell
21	lattice	SBC Tower Holdings LLC	Burning Knolls	270	912	cell
22	water tank	Warren County	Fairgrounds	115	718	drinking water

Schematics of Classes of Towers

a. Example of 195’ Monopole Tower……Class 4



b. Example of 120' Monopole Tower …..Class 3 - PCTDA



c. Example of 80’ Monopole Tower….. Class 2

d. Example of 50’ Monopole tower……Class 1

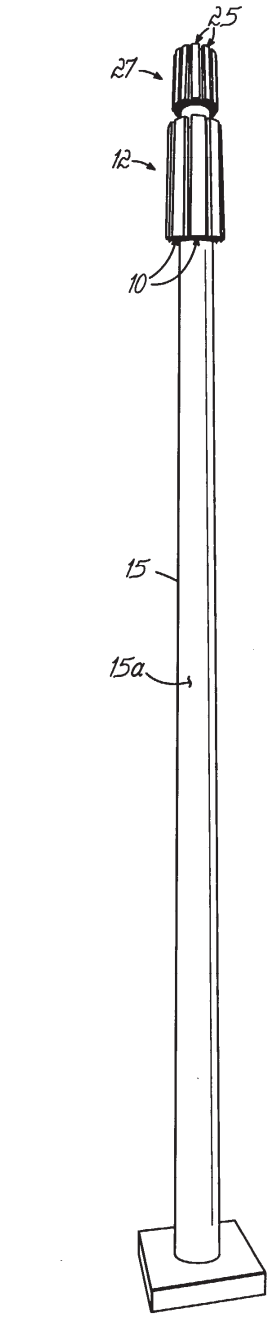


FIG. 1

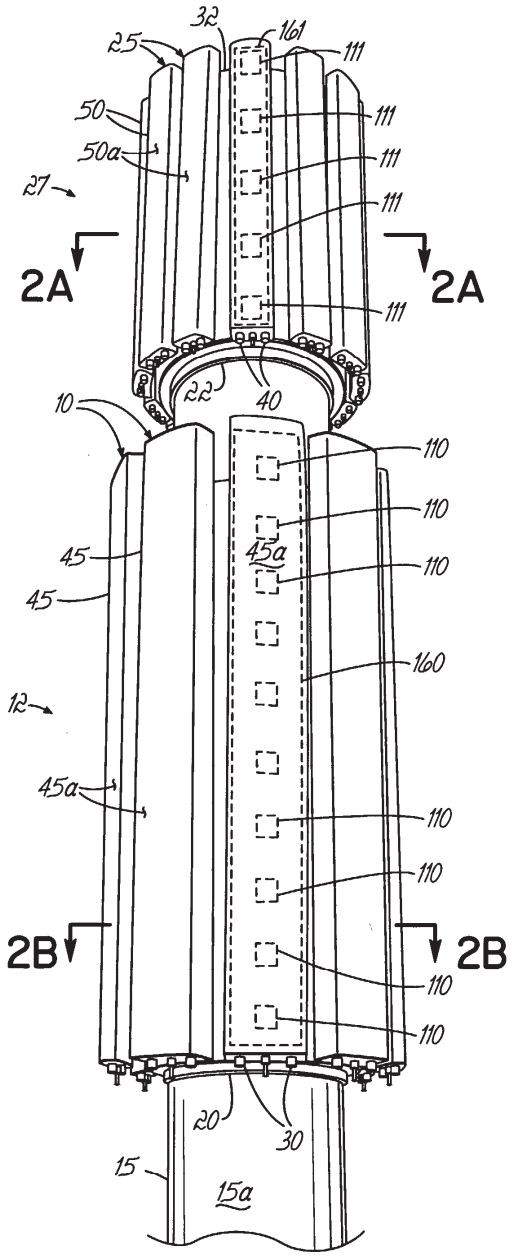


FIG. 1A

10. Recommendations:

The Atlantic Group's assessment is that Clarke County has progressed well in all areas of Broadband. By including broadband providers space on the County web site that facilitates information about who is providing such services and in what general technology platform, Clarke County has "partnered" with the community and the providers. With careful Planning and Zoning Ordinances, Clarke County can balance the "future with the historic past."

Our recommendations are:

1. Implement the preplanned tower locations (plan known as **Permitted Commercial Tower Development Area-PCTDA)** to 120' Above Ground Level heights.

2. Seek to place these **Permitted Commercial Tower Development Areas** near or on County, State or Federal properties if available.

3. Seek to "streamline" tower Application Process by approving a **"By Right"** system for the wireless industry to meet market growth demands by approving the tower "Class" system.

4. Continue to encourage co-location on existing towers and structures such as water tanks and rooftops. Seek to streamline the review process for these Applications.

5. "Collaborate" with private fiber optic facility owners, Broadband providers and tower development companies to facilitate the deployment of fiber optic cables and towers to areas that are unserved or underserved.

6. Have all co-location and new tower build applications reviewed by an independent Third Party to ensure all technical information is reviewed, and that the Planning and Zoning guidelines are adhered to.

11. Exhibit 1. CIT RUOnline Survey Results for Clarke County

RUOnline
Clarke County

Prepared by

CIT
CENTER FOR INNOVATIVE TECHNOLOGY

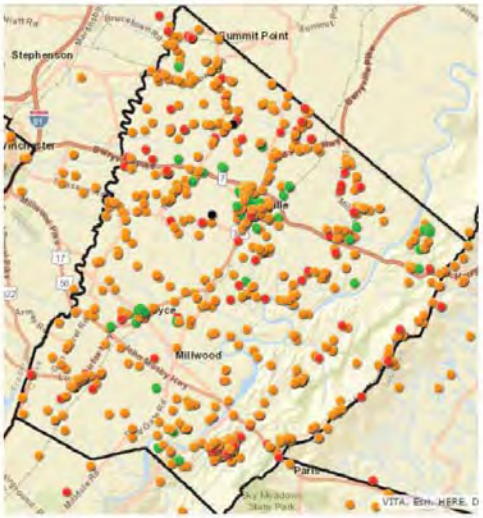
Clarke County RUOnline Response

Does this address currently subscribe to Internet service?

- Yes, but would like improved services or other options
- No, but I would subscribe if there was a service available
- Yes, I am happy with my service
- No, I am not interested in subscribing to an Internet service

690 responses

95% +/- 3.52
Based on # of total households (ACS) and responses



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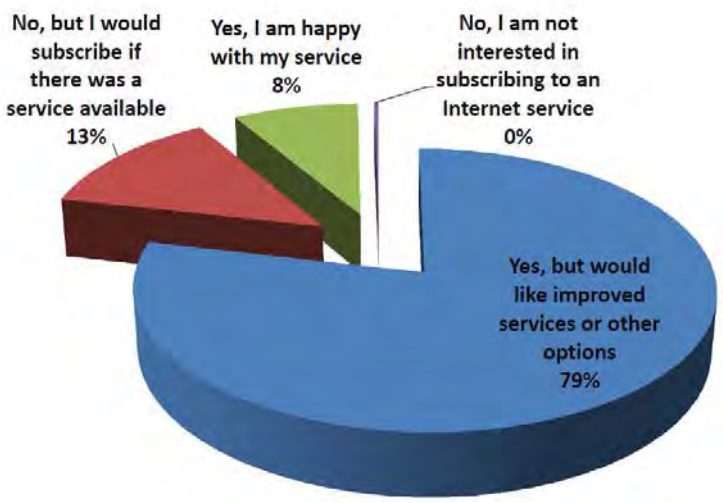
RUOnline Responses

Total Responses: 690



Take away – 92% of respondents don't have the service they want

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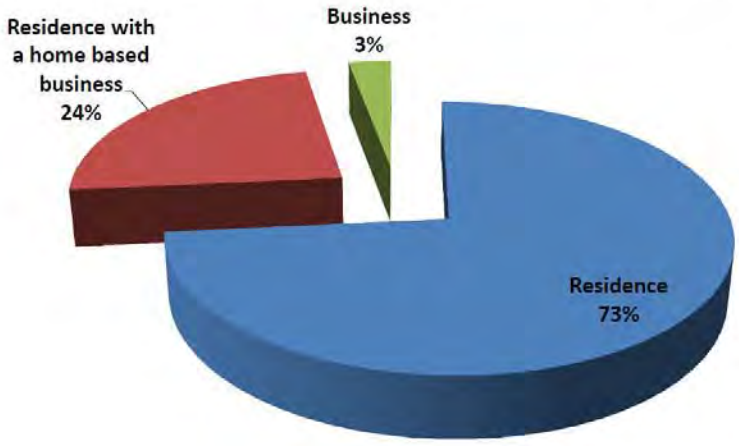
RUOnline Responses cont'd



Take away: 24% of respondents have home based businesses

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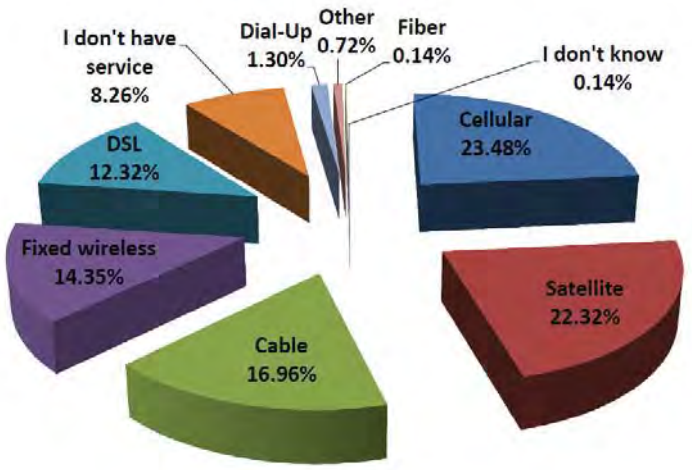
RUOnline Responses cont'd

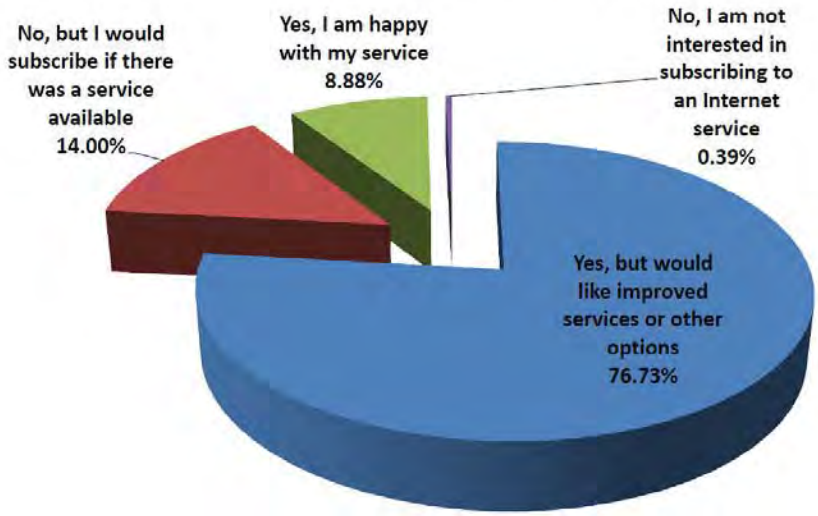


Take away: 46 % of respondents rely on cellular or satellite Internet service.

9/15/2016 Prepared by CIT

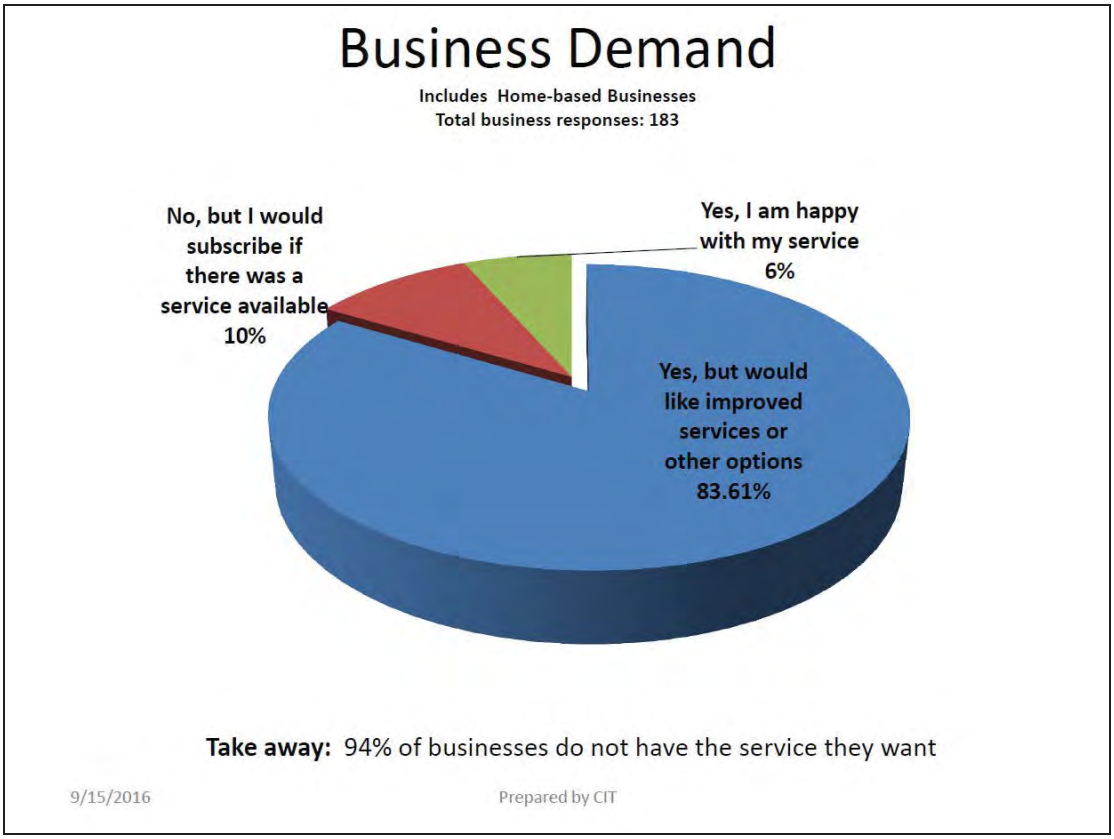
Residential Demand

Total residential responses: 507



Take away: 92% of residents do not have the service they want.

9/15/2016 Prepared by CIT


Business Demand
Includes Home-based Businesses
Total business responses: 183
No, but I would subscribe if there was a service available 10%
Yes, I am happy with my service 6%
Yes, but would like improved services or other options 83.61%
Take away: 94% of businesses do not have the service they want
9/15/2016
Prepared by CIT

12. Exhibit 2…….Stealth Technology

Aesthetics and the need to provide "Stealth Technology"

The purpose of the Plan for Wireless Communications Facilities provides for the camouflage and concealment/stealth of proposed telecommunication towers. The following are general guidelines designed to preserve the aesthetic value for tower facilities. The towers constructed in the County shall not be located along ridge lines, but downslope from the top of ridge lines to preserve views of the local mountain ranges. Visual impact can be further minimized, particularly in the instance of an 80' monopole by screening the structure in preserved woodland having a minimum radius depth of 100'.

In the instance of a rural/agricultural setting, an option for the concealment of towers can be found in the employment of new and/or existing silos where deemed compatible. While unsightly in areas out of context with this type of application, silos provide the opportunity to blend the best of rural landscape tradition with modern technology without sacrificing the option for aesthetic continuity. This is accomplished by introducing form and material types familiar to the setting while accommodating tower design criteria and County goals. Additionally, this type of structure lends itself to being an advantageous solution because of its capacity to house both tower and related equipment simultaneously, thereby eliminating the need for an additional equipment hut which is typically constructed adjacent to most tower installations. It is recommended that newly constructed silos maintain a 2:1 through 3:1 ratio with its surrounding structures in order to maintain a balanced sense of proportion and scale with the existing environment.

All applications that involve locations designated as scenic byways, wildlife management areas, and/or historic places are to be reviewed by members of the Architectural Review Board as part of the overall process. Every attempt should be made to avoid historical, scenic and wildlife managed areas.

While every wireless communications facility should seek to be "low profile," not every facility should be required to have "stealth technology."

Recommendations for Low Profile and Stealth Technology Applications:

1. Require the usage if the NEPA or Section 106 reports are reporting: **Affected Preservation Environment** "APE" status.

2. Require that a Landscape Architect be engaged by the Applicant to provide renderings and plans as to this requirement.

3. Review on a periodic schedule the progress of the design.

4. Require a Community meeting to show the public.

5. If required, have the Landscape Architect make a scale model of the WCF.

6. Provide renderings from the four (4) different views of the facility.

7. Require that this technology be used if the WCF is within 1,000' of a Scenic Byway or Conservation Easement.

8. Require that all WCFs have a forest buffer at the site that is equal to or more than the height of the WCF.

9. Require that the WCF have a dark green or black wire mesh fence rather than galvanized steel around the compound for security.

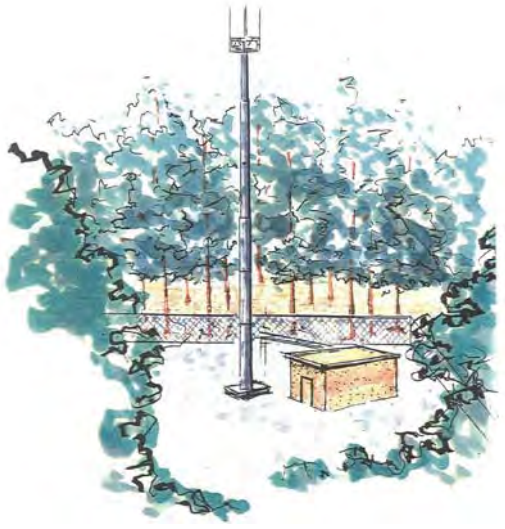
10. Require the entrance and access road to the WCF be curved as not to be able to see the WCF from the State Road.

11. Any WTF built within a one half (1/2) mile distance from a Scenic Byway must be a Class 1 or 2 Structure.

Examples of Low Profile WCFs:

Example of a <u>Class 1 or Class 2</u> Facility

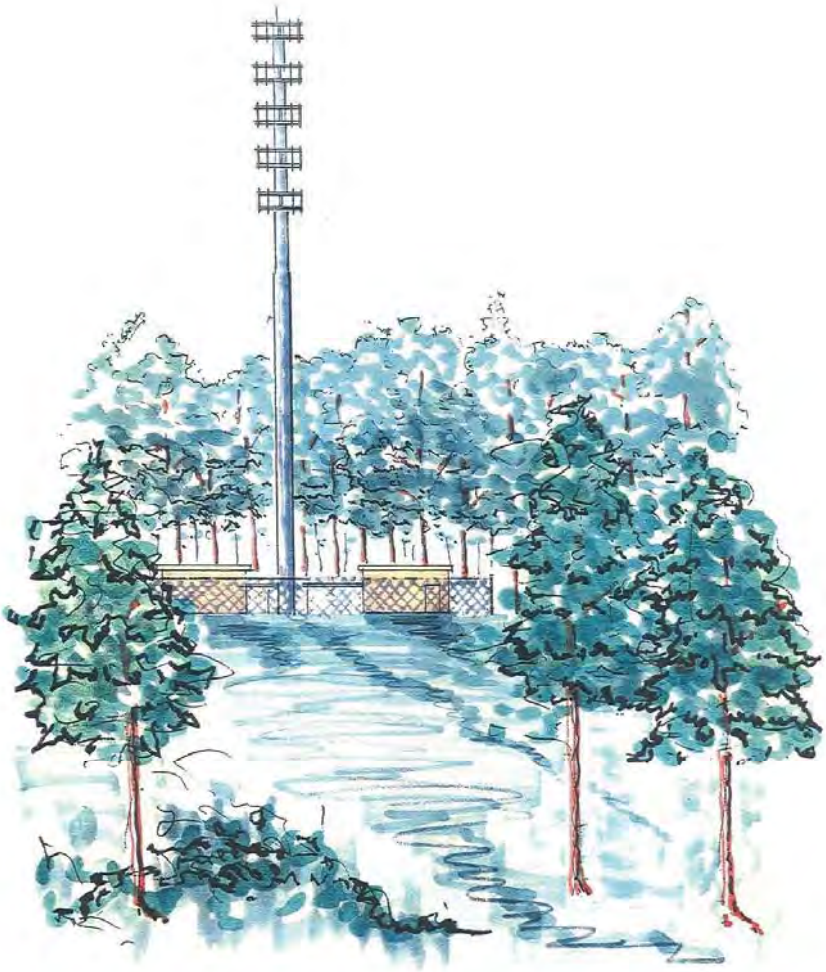
(50’ & 80’ AGL)



TYPICAL 80' MONOPOLE TOWER WITHIN WOODED AREA TO MINIMIZE VISUAL IMPACT

Single Provider usage
Low Profile
Nestled in trees and does not draw attention
Aesthetically pleasing
Could be deployed in a community
Fills in a Gap of about 1 mile radius

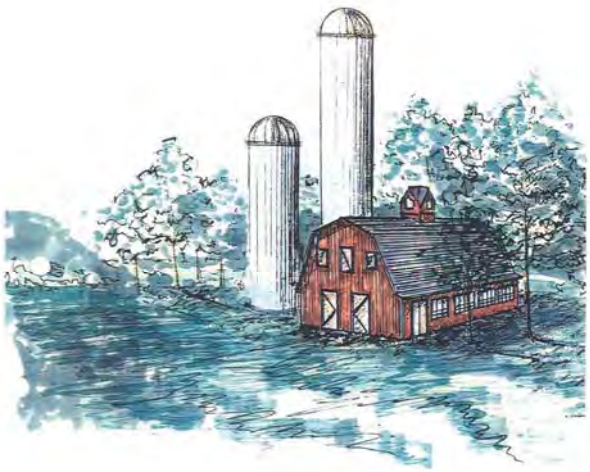
Example of Class 3 Facility



120' MONOPOLE CO-LOCATION COMMUNICATION FACILITY IN THE PERMITTED COMMERCIAL TOWER DEVELOPMENTAL AREA (PCTDA)

Stealth Technology Examples

Works best with structures 100’ AGL or Less



CAMOFLOUGE SCREENING USING EXISTING OR NEW STRUCTURES EMPLOYING A 2:1 AND 3:1 RATION

100’ Stealth Tree Located at Mount Vernon

Example of Church Steeple Retrofit

Example of a low profile flagpole

13. Exhibit 3……..Background Reading

"Benefits of Licensed and Unlicensed Spectrum"

By Chris Szymanski

In the U.S., the Federal Communications Committee (FCC) makes decisions about how to allocate the two flavors of wireless spectrum — licensed and unlicensed.

Licensed spectrum, used for services like TV broadcasting, commercial radio and cellular voice and data, is auctioned off by the FCC. The auctions give companies and organizations exclusive use of a particular frequency band of spectrum over a set period of time. By allotting certain frequencies for voice and data transmission, cellular carriers have been able to guarantee a quality of service and expand their customer base, as well as their product offerings. Unlicensed spectrum, on the other hand, consists of frequency bands that anyone is free to use to operate wireless devices. They are essentially open sandboxes where users can operate without the high barriers to entry that accompany licensed spectrum.

This is a platform for innovation, a "greenfield" space for technology startups, entrepreneurs and established companies alike. Unlicensed spectrum levels the playing field. That alone has tremendous value. Unlicensed spectrum generates $62 billion a year for the U.S. economy, according to a new report from the Consumer Electronics Association, an Arlington, Va.-based trade group. Gary Shapiro, President of the CEA, has referred to unlicensed spectrum as "the oxygen for innovation," and says its usefulness can't be predicted.

"We didn't know we needed garage door openers, cordless phones, or TV remote controls until someone came along and invented them," Shapiro said.

Companies such as Broadcom continue to advocate for additional unlicensed spectrum for next-generation Wi-Fi. For most of the new gadgets on the horizon, Wi-Fi will be the preferred technology for Internet connectivity. On the speed front, Wi-Fi has made huge gains since its 1997 debut, growing 350 times faster and pushing gigabit speeds under the right conditions. Those advancements have been enabled through the continued allocation of unlicensed spectrum by the FCC. Opening up more unlicensed spectrum is critical to making Internet access ubiquitous, as more and more consumers connect to the Internet using Wi-Fi. Otherwise, these consumers will find that their quality of service, range of operations, and overall user experience will become severely diminished. And it is not just consumers that benefit. Policy makers must recognize the economic gains and high-paying jobs that will be created through mainstream adoption of the Internet of Things (IoT), which is projected to generate a whopping 14 trillion dollars in economic activity. The IoT cannot take off unless there is sufficient spectrum at all frequency ranges to support all of the required connections.

Over the past few years, it appears clear that the FCC understands the importance of innovation and the evolution of technologies such as Wi-Fi. Recent decisions include making more unlicensed spectrum available in the 5 GHz, 3.5 GHz, and 600 MHz bands. Because of the large bandwidths available in 5 GHz, it is the workhorse for Wi-Fi, allowing gigabit throughput for bandwidth-hungry tasks, such streaming video and data offload. The Wi-Fi standard 802.11ac provides for downloads using 20, 40, 80, and 160 MHz channels. The larger the channel the faster the download speeds. Even though a considerable portion of the 5 GHz spectrum is available, more is needed to ensure there are a sufficient number of 80 and 160 MHz channels. The FCC has moved to address this need through its March 31st order to make another 100 MHz of spectrum in the 5.150 to 5.250 GHz band more usable for unlicensed technologies, doubling the amount available in the 5 GHz band and enabling gigabit speeds through the 802.11ac Wi-Fi standard. But policy makers cannot stop there. Even more spectrum is needed to support the widespread deployments of superfast 802.11ac Wi-Fi. Last month, Sens. Marco Rubio and Cory Booker introduced the Wi-Fi Innovation Act. If enacted, this would make additional 5 GHz spectrum available for 802.11ac and would go a long way in solving the mobile spectrum crunch in crowded stadiums and homes with multiple users. Beyond 802.11ac, the growth of small cell technologies will be enabled through the FCC's allocation of 100 MHz of spectrum in the 3.5 GHz band. Small cells enable Internet connectivity for applications using both cellular and Wi-Fi networks in crowded areas, and other spots that cannot be easily served through massive telecom base stations.

Moving past small cells and connecting the masses, the 600 MHz band is seen as prime real estate for long-range applications using 802.11af, since such signals can travel farther and even penetrate deeper into office buildings and into your basement. IoT changes the dynamics of connectivity so that you no longer only require center-of-the-room access. New applications being developed on Broadcom technology require connectivity in your backyard, so that when your calendar shows a BBQ on Saturday, your swimming pool heats up. Or when you leave your home the temperature setting on the thermostat increases and the lights turn off. Or, your doorbell rings and a video of the person at your front door is sent to your smartphone. That's the promise of unlicensed spectrum.

RELATED

Greg Fischer in ECN Magazine: "The Answer to the Internet of Things Spectrum Crunch"

Once again, the FCC has taken action on this front. In May, the agency announced the allocation of new spectrum in the 600 MHz band through a reverse auction in 2015. It is expected that a total of between 14 to 28 MHz of guard band will be made available, which will enable long-range Wi-Fi connectivity. However, the devil is in the details. It is important that the technical rules are written in such a way to fully maximize this spectrum.

Consumer Experience Matters

If mainstream consumers are expected to adopt a connected lifestyle, ease-of-use is critical.

Consumers don't really care which frequencies their devices tap into as long as the experience is seamless. Broadcom is innovating in this area. We have developed software that acts as a referee to ensure that devices are operating on the most appropriate frequencies. Our technology will ensure that the bandwidth-hungry video streaming in the living room is prioritized through 5 GHz, and the tablet computer operating in the basement or backyard uses 600 MHz. Basically, devices will operate in the bands necessary to maximize the consumer experience without requiring an engineering degree.

Chris Szymanski

Christopher Szymanski is Director of Global Regulatory, Trade Compliance, and International Government Relations for Broadcom, responsible for assisting in the development of Broadcom's spectrum policy priorities and advocacy efforts. Prior to Broadcom, he served a compliance and government relations role for Semiconductor Manufacturing International Corporation (SMIC) in Shanghai. Prior to SMIC, he worked for several years on Capitol Hill for Congressman Don Manzullo, the House Committee on Small Business, and the U.S.-China Interparliamentary Exchange. He holds a Master's in Business Administration (MBA) degree from the Washington University Olin School of Business, with a focus on leadership in China. He also received a certificate for Leadership and Management from the Fudan University School of Business in Shanghai.

County Organizational Structures and Funding Strategies

For

Telecommunications Infrastructure

And

Broadband Study

2020

November 22, 2016

Performed by

THE ATLANTIC GROUP OF COMPANIES, INC.

"Navigating the Seas of Technology"

6260 Pine Slash Road
Mechanicsville, Virginia 23116
(804) 559-6004
www.atlanticgroup.us.com

INDEX

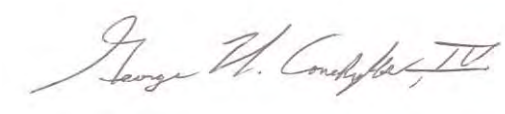
1. Executive Summary

After studying the existing Infrastructure, service providers, Advisory Committee and community input, I would like to recommend the following steps to be taken to advance the Broadband services in Clarke County.

They are:

1. Continue with the Broadband Advisory Committee organizational structure.
2. Continue to provide County web space for providers.
3. Continue to provide GIS Map layer for towers and structures.
4. Continue open dialog with service providers.
5. Approve the Recommendations as per "Telecommunications Infrastructure and Broadband Study 2020" dated November 22, 2016.
6. Produce and publish two (2) RFP/RFIs for industry response for infrastructure and Broadband services.
    1. Eleven (11) PCTDA Towers
    2. Fiber Optic Cable (approx. 10 miles)
7. Seek Grant Funds or "self-fund" for one (1) tower and one (1) fiber optic backhaul location to property owned and controlled by the County. (The one area of greatest need for school aged children with least likelihood of commercial service as the criteria.)

    Total Grant or Self-Funded project would be approximately $300,000.



George N. Condyles, IV
President & COO
The Atlantic Group

2. Goals and Objectives

A political subdivision or county seeks to ensure a quality of life for its residents, businesses and institutions. There is always a "balance" between resident needs, business interests and historic institutions. Local government must provide and conform to county, state, and federal codes that provide for the wellbeing of its residents and businesses. Education, public safety, transportation, commerce, environmental concerns, etc. all must be considered by the elected officials and residents of what is known as Clarke County, Virginia.

To achieve these and many other concerns that must be taken into consideration, goals and objectives are developed to plan and advance a concern toward completion. The subject area of Broadband crosses over many areas of concern. In an attempt to plan and participate in the subject of Broadband, goals and objectives should be qualified and stated. Following are a few "generic" goals that the consultant believes would be the basic elements.

Goals for Broadband in Clarke County

1. **Clarke County will seek to advance the deployment of Broadband by providing clear and consistent Ordinances and Plans to broadband providers and residents alike in a logical growth pattern consistent with market demands, technology deployment and Clarke County, Commonwealth of Virginia, and United States Code.**

2. **Clarke County will provide open and clear communications with all residents and Applicants providing Broadband services and infrastructure.**

3. **Clarke County will seek technical consulting, if required, in the planning, review or administration of Broadband issues.**

4. **Clarke County's goal is that all residents and businesses have a "selection" of several broadband sources to stimulate competition and quality of services.**

5. **Clarke County will be receptive for County, State or Federal properties to be considered for placement of broadband infrastructure.**

6. **Clarke County will appoint a body of residents to form a Committee to address Broadband in a comprehensive manner and report to the Board of Supervisors periodically on these activities.**

Objectives for Broadband in Clarke County

1. **Seek to provide communications between the Broadband Service providers and the Broadband Committee by meeting annually to discuss challenges and project status.**

2. **Assist residents by placing on the County web site a "Listing and Hyperlink" to the Broadband providers web site.**

3. **Streamline Tower Review Applications by providing a "By-Right" Status for certain heights of towers. Seek to have a 30 day Staff and Consultant Review.**

4. **Clearly define requirements in Ordinances and Plans of what will be required for Applications. Have new Ordinances completed by 2nd quarter of 2017.**

5. **Consider "Stealth" technology to be used in areas and locations that may be within "Protected" areas if all aesthetic designs are fulfilled. Seek 100% Stealth in "Protected" areas.**

6. **Seek to have every school age child to have access to Broadband services to the home by 2018.**

7. **Seek to have adequate Broadband for all home based and small business by 2018.**

8. **Seek to "support/enhance/partner etc." with Broadband Service, Infrastructure and/or Industry providers with open dialog and quick response times for inquiries and questions.**

Many of these Goals and Objectives have been established and are currently ongoing. The lists above are "generic" in nature, and the current Broadband committee may have more targeted Goals and Objectives. These are for discussion in relationship to "Organizational Structures" further down in this document.

The consultant believes that there are several of the Objectives that should be established by Clarke County to "advance" the subject that, frankly, cannot wait. The Objective concerning Students to have Broadband at the home is vital and must be actively pursued.

3. Organizational Structures

Local governments have addressed the Broadband issue in many ways and organizational structures. The following are several organizational structures that many counties in the Commonwealth of Virginia have sought to address with the issue of Broadband. The consultant will provide three (3) of the many potential ways that a County can address Broadband.

A. Single Point of Contact

This method typically is for "Rural/Low Commercial Business" County. A single person such as the County Administrator, IT Director or Planning Director is the "Single Point of Contact" or "SPC" for any issues that arise in this area. This approach is typically "Reactive" in nature. The Single Point of Contact maybe attends seminars or webinars and has a contact with the local cable franchisee and incumbent telephone company. The infrequent meetings typically deal with issues such as right-of-way, placement of fiber optic cables, services and location of services by community. The typical "atmosphere" is that "commercial industry will respond if there is enough market demand." The SPC reports quarterly to the Board of Supervisors and Planning Commission with any activities. Typically "voice" cell service has coverage over the majority of the County. The County has limited cell towers. There are occasional Applications for cell towers. Very few "data" services from Land Mobile Radio providers and no WiSP service outside of the County Courthouse area. Schools are "hard wired" fiber optic cable and the Cable provider has less than 50% of the population and geographic coverage of the County covered. Home based businesses suffer, small businesses suffer. Very little Distance Learning, very few Telemedicine patients and few options for economic growth.

Strengths	Weakness
Single point/familiar face	Person may not have a Broadband background
Acquire local institutional knowledge	Person leaves, knowledge leaves
Able to develop "Goals and Objectives"	May not be "in touch" with all issues
Reactive vs. Proactive	Time element of one's primary job

Speaks with BOS delegated authority to the service providers and infrastructure owners	Telephone, Cable and Broadband companies seem never to have the same schedule or interest at the same time
Efficient communications between County and SPC and providers	A committee may be able to have a greater "reach" to a service provider

In summary, the consultant has experienced about 30% of the rural counties in Virginia have a similar response for Broadband.

Results

1. Goals are difficult to achieve.
2. Becomes the "last" item on a person's Work List vs. the "first" item.
3. Not a lot to do because not much going on in the planning or deployment of infrastructure or services.
4. Only hears about grants and programs typically after the Applications are due.
5. Does not seem to address issues up front but only as a consequence of last resort.
6. No real "investment" into planning or identifying areas of need or areas of broadband market growth.
7. Not "plugged into" non-traditional services like WiSP and Point to Multipoint providers.
8. Wireless E-911 is marginal.

B. County Broadband Advisory Committee = "BAC"

This organizational structure is typical for over 50% of most counties in Virginia. Most Counties seek to address the issue by having the Board of Supervisors appoint members from their respective Districts and "at Large" members of various demographic groups. Demographic groups include education, commerce, community development, small business, WiSP, Telephone Company, Cable franchise, real estate developers, etc.

The "Broadband Advisory Committee" is charged with developing a Plan that will identify existing infrastructure such at towers and digital services. The BAC identifies new technology and determines how unserved and underserved areas can be serviced.

In addition, this committee interfaces with the Staff, Planning Commission and Board of Supervisors to "craft" Ordinances to help balance technology with resident, business and environmental requirements.

While Committees sometime become "laborious" they can provide a greater sense of community input and have a greater reach into the community. The Chairman should not be a County Employee, but a knowledgeable professional that has experience in this area.

The "BAC" should look at how communications are performed with the infrastructure providers, service providers and network providers. Economic Development representation along with service provider information and web site hyperlink should also be provided.

Strengths	Weakness
Greater Knowledge Base	Many Opinions that may be directed toward least cost-effective and least likely solutions
Ability to seek "Comprehensive" Solution	Plan may have too many elements for implementation
Greater Community Involvement	

Non-County Employee Chairman	May not be schedule driven
Committee Members circulate on and off the PAC	Knowledge Base may suffer
No Infrastructure "Investment" Budget	Theory vs. Infrastructure
Review Tower/Infrastructure SUP/CUP Applications for Broadband	Can add addition layers and time on Review Time Line
Advises BOS, PC, Service Providers and the Community on services and technology	Has no real "Approval" authority. May have "Recommendations" that are not "Approved" by the BOS, potentially sending mixed signals

In summary, this is what Clarke County has currently, and it seems to work well. The Consultant believes Clarke County should continue with this organizational structure.

C. Broadband Authority

This organizational structure is defined by various Codes of Virginia. This form of organizational structure is used by roughly 20% of counties in Virginia. While there are some urbanized counties such as Roanoke using this structure, many rural counties such as Nelson, Page, King and Queen, Bedford, and Rockbridge have formed these "Authorities."

The Authority can own or lease infrastructure, provide or contract/partner for broadband services, or manage and maintain a Broadband network as per State and Federal codes.

Many of these counties use this Authority because there was the lack of fiber optic and tower infrastructure in the county and the lack of interest of the telephone company or the cable company to address these issues. Many small businesses as well as residents did not have any internet or meaningful broadband services. The telephone companies and cable companies used the "Subscriber per mile" argument and few of the areas of the county met the criteria. As a result, many rural counties explored this solution and many have chosen this organization as their response.

In looking at this response, the consultant believes that discussions with each of the rural counties that have established "Authorities" would be a must. The "shifting" of a broadband "commercial" business venture to a "Government Agency" may bring greater responsibility than originally perceived. ***Infrastructure ownership by the Authority with WiSP paying Rents or Fees (and providing Broadband services) are lucrative for the Authority.***

The positive aspect of this organization is that the residents have a service provider that they can meet, discuss, and solve service problems.

The monetary investment in an Authority could be staggering. In the document known as ***"Telecommunications Infrastructure And Broadband Study 2020"*** dated November 22, 2016, for Clarke County to enter the Broadband investment for just fiber optic cable and eleven (11) 120 communications towers was approximately $3,450,000. These are just the "hard" or capital costs. There are Administrative and "Soft" costs that could range to over $1,000,000. These soft costs are employee wages, office rents, insurance, office supplies etc.

Estimated marginal cost for Broadband electronics and service equipment is $1,000,000.

Total Estimated Turnkey for 1st year funding would be approximately $ 6,500,000 for a full countywide system.

The Consultant recommends if the County desires to go in this direction to remain in the Infrastructure investment and begin with one (1) project that is targeted to a community that has the greatest need that will support children and their education. ("Don't try to be all things to all people".)

There are several methods of revenue for these costs: Grants, Municipal Bonds, debt financing/loans, etc.

There are many considerations in moving in this direction. They are defined in Strength and Weakness below.

Strengths	Weakness
Placing Broadband where Commercial providers would not go	Will the next provider "Steal" your subscriber because they offer cheaper service?
Own and Control the network	You "Own and Control" the network Maintenance of Fiber and infrastructure
Must act as "Owner"	Disconnect for non-payment? Am I getting the Service Levels I am paying for?
If Competitor wants to purchase network, can or would you sell?	What is required by COVA to sell your network in a timely schedule?
Must Staff for business	Wages, insurance, healthcare, retirement, office rents, training etc. Operating Costs quickly add up
Capital Funding as per Business Plan	Revenues cover debt payments and operational cost?
Subscribers pay for services	Will they sign up and retain to your service?
"Partner" with various providers for infrastructure	Lose control of infrastructure

As you can see, there are many factors that may prove that the ownership of the network has responsibilities and requirements that a local county government may not be ready to address. The consultant recommends that Clarke County does not move in this organizational structure without thorough research and funding.

4. Funding

Government Funding for Broadband has diminished over the years. While there are several sources for funding for Broadband Projects, the dollar amounts have lessened. The Consultant has seen “Large Project Funds” be broken into “Small Project Funds” to give more Counties the ability to receive funds that will provide for Broadband Studies and maybe solve an immediate need in a small geographic area of the County.

Many Rural counties have taken a position that instead of owning an entire network, the county would provide one (1) mile of fiber optic cable to be used by the Broadband provider. Another investment is communications towers. The county would place a communications tower on property owned by the county, build the tower and lease tower space to the LMR and WiSP service providers.

Currently, LMR and WiSP providers lease space if the Public Safety communications towers/water tanks can structurally hold the commercial antennas and cables. The LMR and WiSP providers also will lease land from the county and build their own tower structures.

There are several major funding sources for grant money:

1. VHDA- Virginia Department of Housing Authority
2. The Federal Recovery and Reinvestment Act of 2009
3. US Department of Housing and Urban Development: Rural Broadband Program
4. Universal Service Administrative Company, or USAC. Support for Broadband Services in Schools and Libraries
5. USDA :

    - Rural Development Broadband Program

    -The Distance Learning and Telemedicine (DLT) Program

    -The Community-Oriented Connectivity Broadband Grant Program

These are several funding sources if infrastructure ownership is considered. These plans and grant requests can be downloaded.

5. Recommended Actions

After studying the existing Infrastructure, service providers, Advisory Committee, and community input, The Atlantic Group would like to recommend the following steps to be taken to advance the Broadband services in Clarke County:

1. Stay with the Broadband Advisory Committee organizational structure.
2. Continue to provide County web space for providers.
3. Continue to provide GIS Map layer for towers and structures.
4. Continue open dialog with service providers.
5. Approve the Recommendations as per ***"Telecommunications Infrastructure And Broadband Study 2020" dated November 22, 2016.***
6. Produce and publish two (2) RFP/RFIs to measure industry interest in infrastructure and service.
    1. Eleven (11) PCTDA Towers
    2. Fiber Optic Cable (approx.. 10 miles)
7. Seek Grant money for one tower and one fiber optic backhaul location to property owned and controlled by the County. (The one area of greatest need for school aged children with least likelihood of commercial service as the criteria.)

    Total Grant or Self-Funded project would be approximately $300,000.

Telecommunications Infrastructure And Broadband Study 2020

November 22, 2016

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- Ordinance Review
- SUP/CUP Tower 3rd Party Reviews
- Technology Seminars
- Stealth Technology Applications
- Leasing/Facility Audits
- Broadband Plans
- Agency “Facility Plans”

Broadband

There are several “truths” that must be reinforced when discussing Broadband and its future in a community environment. They are:

1. There will not be a “one technology wins all subscribers” that will make other technologies obsolete in the digital age.

2. Networks will continue to be “hybrid” in nature with various delivery systems, transport technologies, transmit frequencies, device access and infrastructure requirements.

3. Service equipment will migrate toward “generic” technologies with speeds that will provide faster “uplink and downlink” to the subscriber.

4. The consumer/subscriber will “shop” for services that they can afford but have multiple service providers that they contract. There will be less “one stop shop” service single providers. “My device will subscribe to the services I want, when and where I need them. The technology is irrelevant to me.”

Broadband….What does it mean?

"Broadband" has evolved as the generic term for "internet access" for most localities in the United States.

The "user" or "subscriber" seeks to have a fast and broad ability to upload or download data for use. (Voice Communications are not a part of this.)

"Broadband" has come to symbolize a term that has two dimensions:
volume and speed.

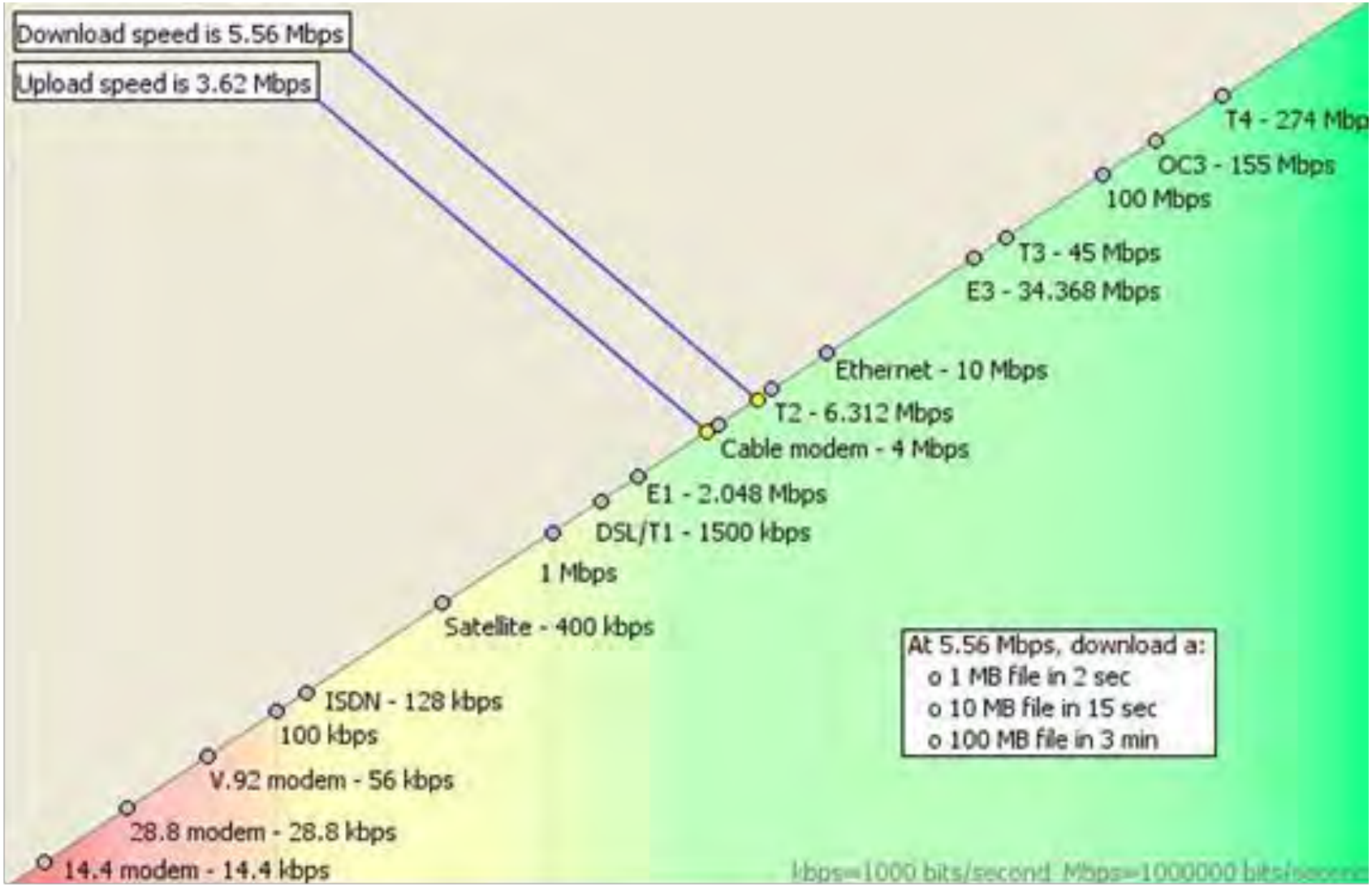
In 2016, volume and speed are measured in Megabits per Second of service for a subscriber.

On Jan 29, 2015, the FCC raised the standard speeds for broadband:

Download to **25 megabits per second from 4 Mbps**

Upload **speed to 3 Mbps from 1 Mbps**

Speed vs. Data Usage Chart



Federal Communications Commission

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Household Broadband Guide

Use the chart below to compare minimum download speed (Mbps) needs for light, moderate and high household use with one, two, three or four devices at a time (such as a laptop, tablet or game console).

You can also compare typical online activities with the minimum Mbps needed for adequate performance for each application by using our Broadband Speed Guide (/guides/broadband-speed-guide).

For more information on broadband speeds, see our Measuring Broadband America report (/measuring-broadband-america).

	Light Use (Basic functions only: email, web surfing, basic streaming video)	**Moderate Use** (Basic functions plus *one* high-demand application: streaming HD, video conferencing, OR online gaming)	**High Use** (Basic functions plus *more than one* high demand application running at the same time)
1 user on 1 device (e.g., laptop, tablet, or game console)	Basic	Basic	Medium
2 users or devices at a time	Basic	Basic	Medium/Advanced
3 users or devices at a time	Basic	Basic/Medium	Advanced
4 users or devices at a time	Basic/Medium	Medium	Advanced

Basic Service = 1 to 2 Mbps*

Medium Service = 6 to 15 Mbps

Advanced Service = More than 15 Mbps

*Mbps (Megabits per second) is the standard measure of broadband speed. It refers to the speed with which information packets are downloaded from, or uploaded to, the internet.

Federal Communications Commission

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Broadband Speed Guide

Compare typical online activities with the minimum download speed (Megabits per second, or Mbps) needed for adequate performance for each application. Additional speed may enhance performance. Speeds are based on running one activity at a time.

For household broadband needs, use our Household Broadband Guide (/guides/household-broadband-guide) to compare minimum Mbps needs for light, moderate and high household use with one, two, three or four devices at a time (such as a laptop, tablet or game console).

For more information on broadband speeds, see our Measuring Broadband America report (/measuring-broadband-america).

Activity	Minimum Download Speed (Mbps)
Email	0.5
Web browsing	
Job searching, navigating government websites	0.5
Interactive pages and short educational videos	1
Streaming radio	Less than 0.5
Phone calls (VoIP)	Less than 0.5
Watching video	
Standard streaming videos	0.7
Streaming feature movies	1.5
HD-quality streaming movie or university lecture	4
Video conferencing	
Basic video conferencing	1
HD video conference and telelearning	4
Game console connecting to the Internet	1
Two-way online gaming in HD	4

Example: 4 people in a home:
2 parents + 2 children = 4 users

-All have their devices on and checking e-mails
…….. 4 x .5 Mbps = 2.0 Mbps

-All Surfing the Web/Facebook
……. ……..4 x 1 Mbps= 4.0 Mbps

-Son Gaming with person in Germany
……..1 x 4 Mbps = 4.0 Mbps

Daughter video Streaming a Movie
……..1x1.5 Mbps= 1.5 Mbps

-Mom Video Lecture/Distance Learning
……..1x4 Mbps = 4.0 Mbps

-Dad working on Office Report
……..1 x 2 Mbps = 2.0 Mbps

Total Mbps required
……**17.5 Mbps**

Wireless "Last Mile"

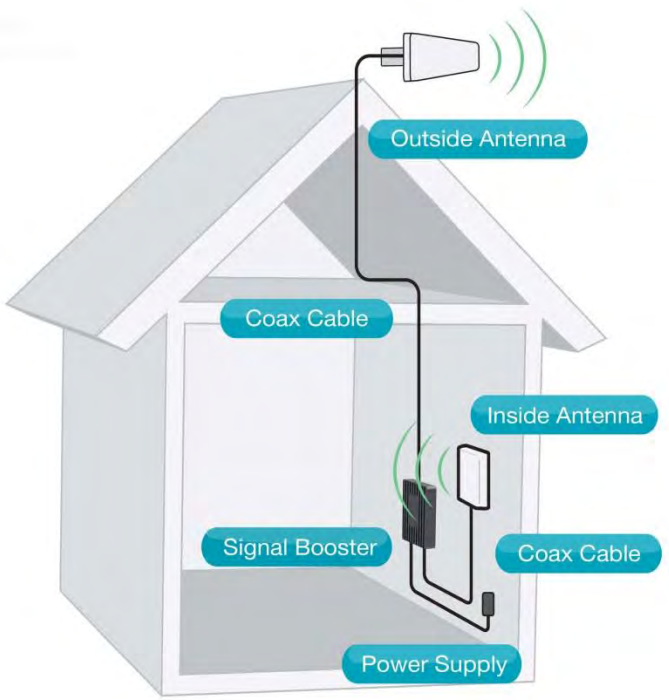
Wireless communications have evolved over the last fifteen years. The networks have developed into three (3) distinct types:

1.) **Licensed**
2.) **Unlicensed**
3.) **Satellite Wireless Networks**

1. Licensed Wireless Networks

The FCC has opened radio frequency for both licensed and unlicensed networks. Typically the "Licensed" networks are what are known as "LMR," "Cellular," or "Mobile" networks. These are typically owned and operated by the large cell companies such as:

1. AT&T
2. Verizon
3. Sprint
4. T-Mobile



2. Unlicensed Wireless Networks

Unlicensed "carriers or providers" have strategically directed their frequency base to the FCC provided frequency bands that are able to be used by providers without having to buy or lease a license for a fee.

These frequencies were released by the FCC to help stimulate Broadband growth in areas that are unserved or underserved by the LMR service providers.

Clarke County is an excellent example.

These service providers must adhere also to USC CFR 47 that pertains to their networks.

The FCC requirements limit these providers with the type and power of their equipment, however gives greater latitude in the deployment of their networks with fewer Federal requirements such as NEPA and Section 106 requirements.

The frequency bands are typically the 900 MHz, 2.4 GHz, and the 5.8 GHz bands.

These service providers are known in the industry as **"WiSP"** defined by their technology platform

"Wireless Internet Service Provider."

Clarke County has approximately 4 major players currently.

They are:

1. All Points Broadband
2. Winchester Wireless
3. Visual Link Internet
4. Wave 2Net

3. Satellite Wireless Networks

Satellite service has come a long way since its early beginnings over 25 years ago. While satellite has typically been able to receive or “downlink” a greater amount of data, the limiting factor has been the “uplink” or “upload.”

Today the systems provide an excellent service of both uplink and downlink and have become a viable player not only in the rural but also urban and suburban markets.

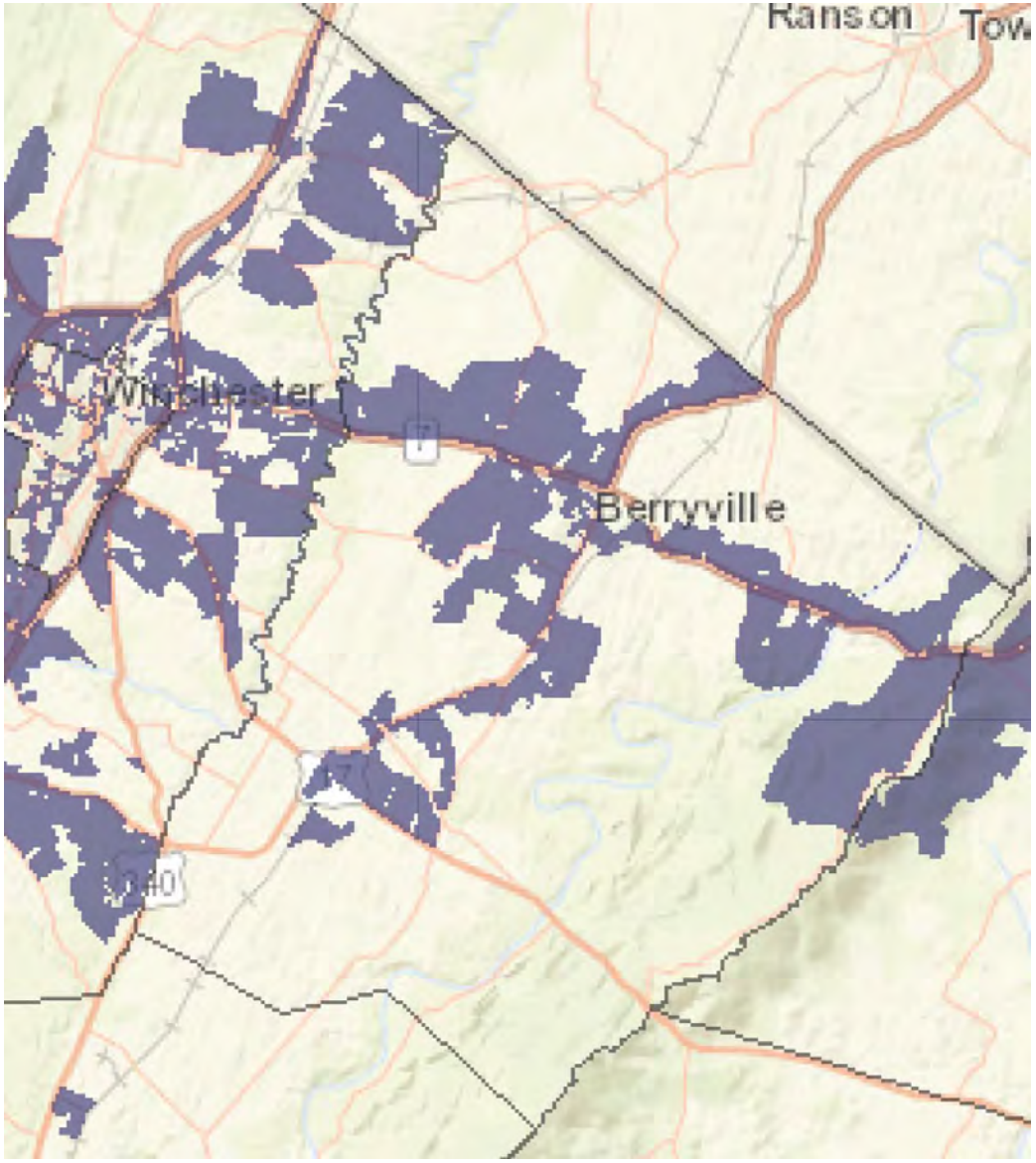
There are limitations such as weather and obstructions such as trees and other structures. However, if these issues are resolved then satellite service is very good and is competitive in price.

The satellite providers in Clarke County:

1. **ViaSat Communications**
2. **NOVECNET**
3. **SkyCasters**
4. **HughesNet**
5. **StarBand**

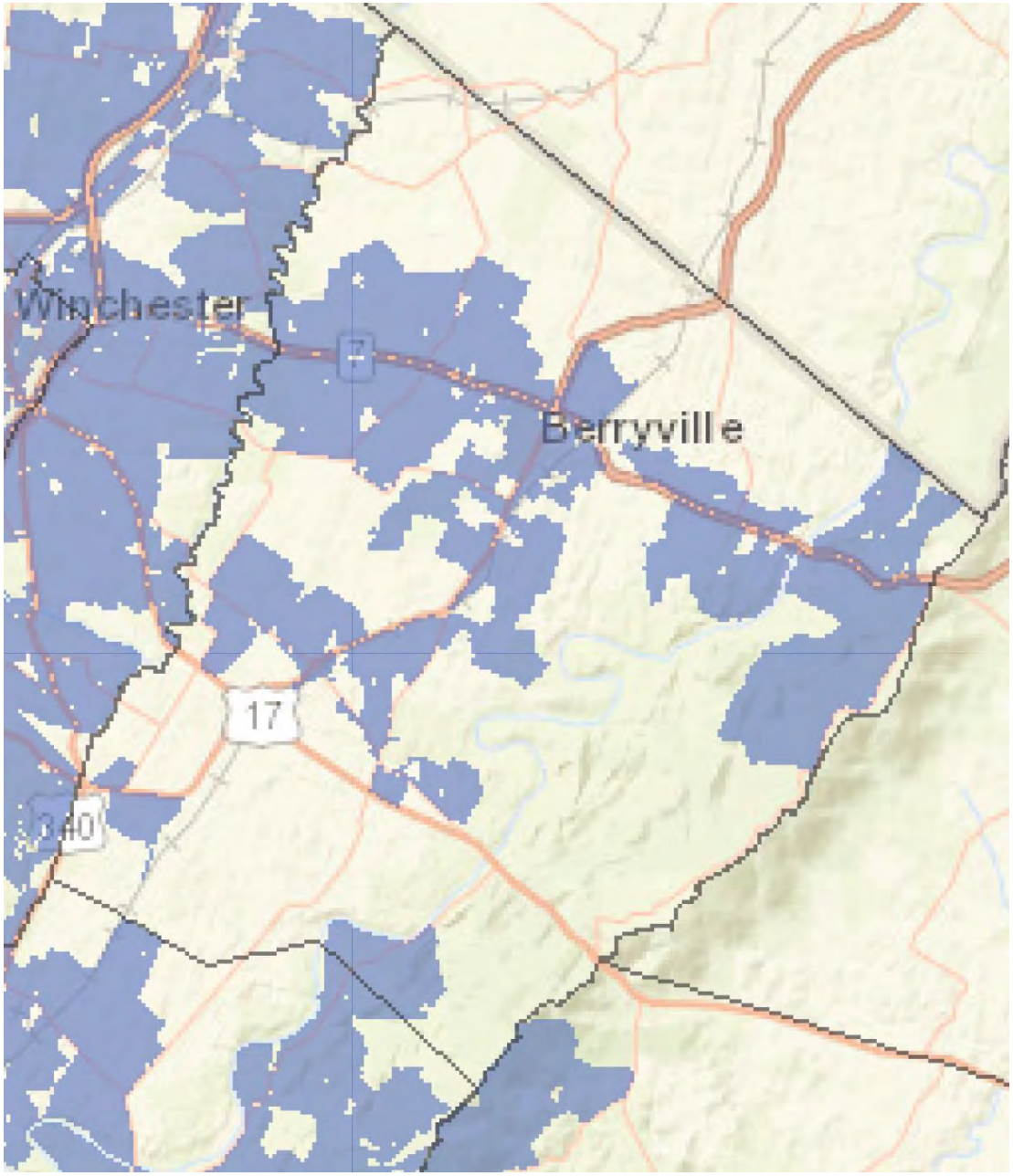
•Broadband….What is available in Clarke County now?

•Comcast Cable: Fiber Optic & Copper Coax Broadband Services



(Source: CIT Data for Clarke County, Virginia)

•Verizon Fiber Optic Service



(Source: CIT Data for Clarke County, Virginia)

VERIZON DSL SERVICE

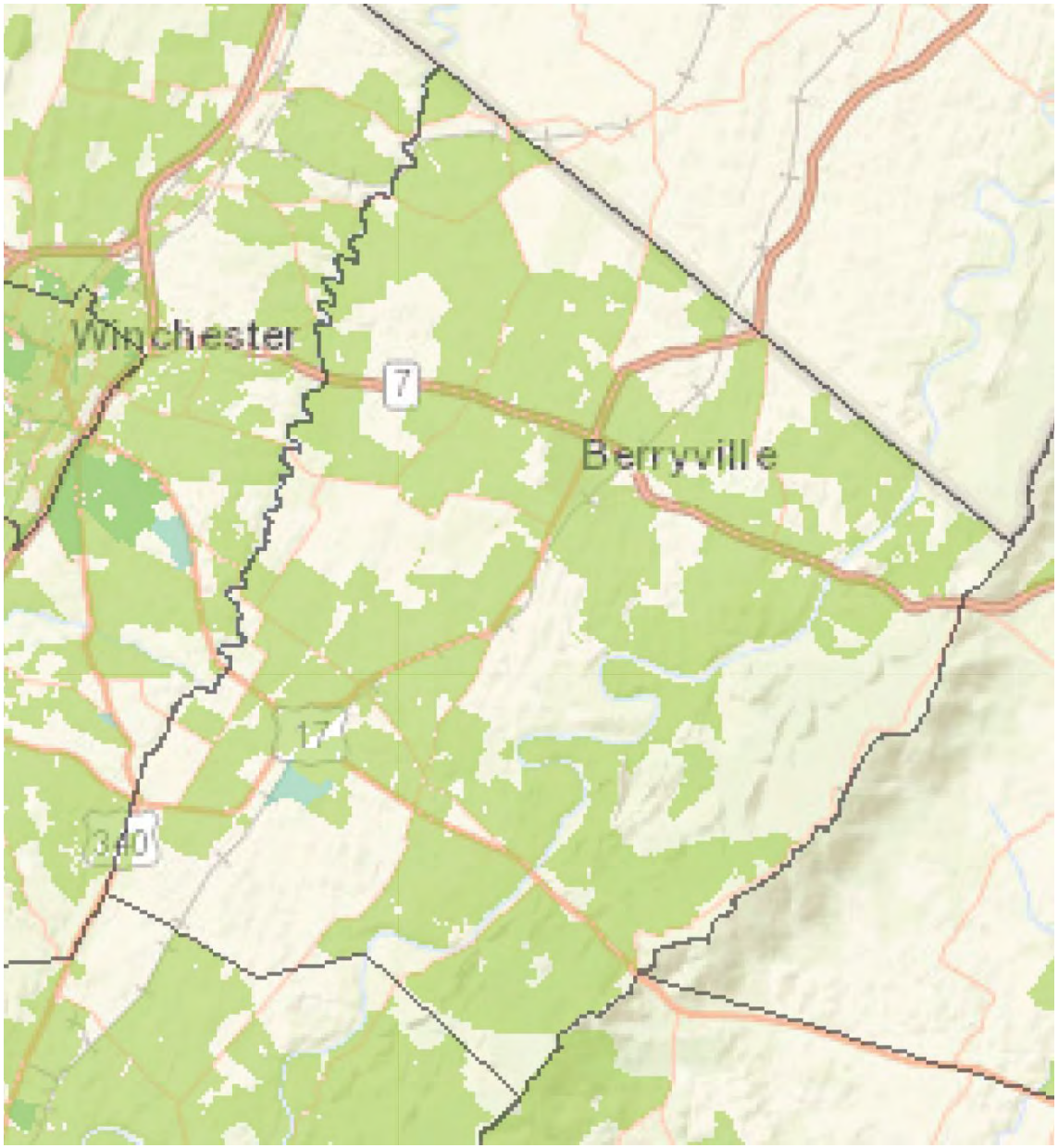
Digital Facilities

Fiber Optic Cable Facilities

Trunking Routes ……Rt. 7 e/w
……Rt. 50 e/w
……Rt. 340 n/s
Distribution: Parallel/Loop & Spur
to Optical Remote Mod

Central Offices :
Verizon-Berryville
- Boyce
- White Post
- Paris
- Bluemont
- Winchester
Comcast Nodes:
Where service exist

Basic Network :
Copper/Coax/Twisted pair



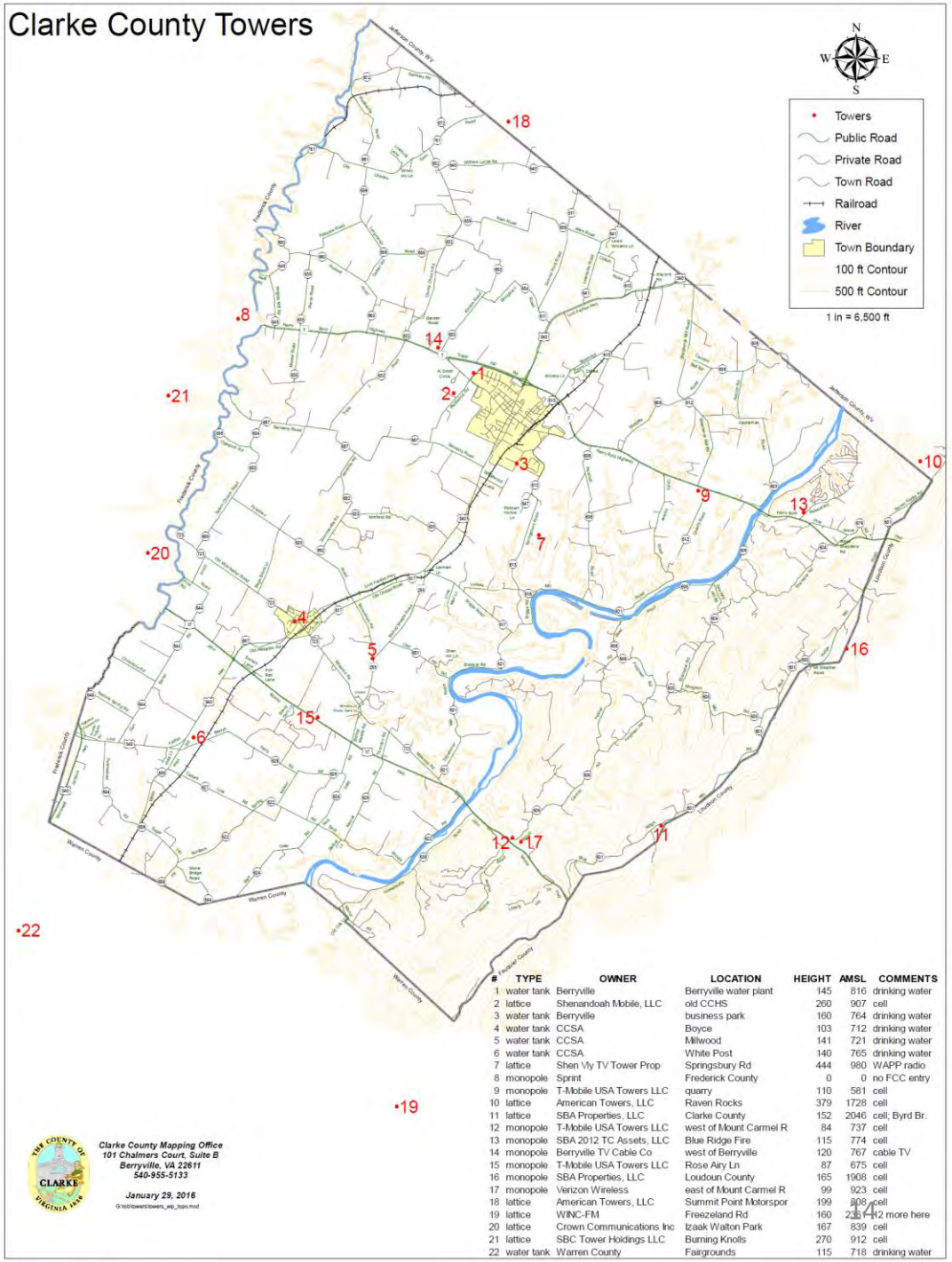
(Source: CIT Data for Clarke County, Virginia)

Tower/Structure Infrastructure Assets

	Inside	Outside
Towers	10 (7u)	7
Water Tanks	4	1

Assessment:

Lacking "Vertical" Assets for Data Distribution



#	TYPE	OWNER	LOCATION	HEIGHT	AMSL	COMMENTS
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2	lattice	Shenandoah Mobile, LLC	old CCHS	260	907	cell
3	water tank	Berryville	business park	160	764	drinking water
4	water tank	CCSA	Boyce	103	712	drinking water
5	water tank	CCSA	Millwood	141	721	drinking water
6	water tank	CCSA	White Post	140	765	drinking water
7	lattice	Shen Vly TV Tower Prop	Springsbury Rd	444	980	WAPP radio
8	monopole	Sprint	Frederick County	0	0	no FCC entry
9	monopole	T-Mobile USA Towers LLC	quarry	110	581	cell
10	lattice	American Towers, LLC	Raven Rocks	379	1728	cell
11	lattice	SBA Properties, LLC	Clarke County	152	2046	cell; Byrd Br.
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13	monopole	SBA 2012 TC Assets, LLC	Blue Ridge Fire	115	774	cell
14	monopole	Berryville TV Cable Co	west of Berryville	120	767	cable TV
15	monopole	T-Mobile USA Towers LLC	Rose Airy Ln	87	675	cell
16	monopole	SBA Properties, LLC	Loudoun County	165	1908	cell
17	monopole	Verizon Wireless	east of Mount Carmel R	99	923	cell
18	lattice	American Towers, LLC	Summit Point Motorspor	199	808	cell
19	lattice	WINC-FM	Freezeland Rd	160	2317	2 more here
20	lattice	Crown Communications Inc	Izaak Walton Park	167	839	cell
21	lattice	SBC Tower Holdings LLC	Burning Knolls	270	912	cell
22	water tank	Warren County	Fairgrounds	115	718	drinking water

Broadband… Services that <u>could be available</u> in Clarke County by 2020

There will be three (3) major new technologies deployed by 2020:

1. 5G Mobile Systems
2. “White Space” Internet
3. Broadband over the Power Line (BPL)

- Note: While these technologies may be deployed in the Clarke County area, these technologies will not eliminate the need for communications towers. The “Last Mile” link is a communication tower with a Transmitter and Receiver for the Subscriber.

5G concepts

There are many new concepts that are being investigated and developed for the new 5th generation mobile system. Some of these include:

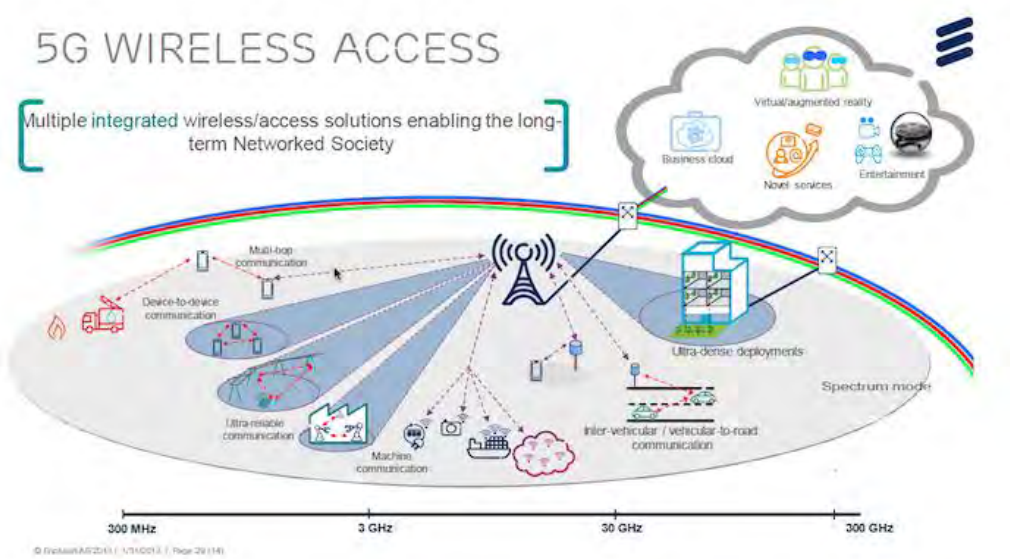
1. **Pervasive networks:** This technology being considered for 5G cellular systems is where a user can concurrently be connected to several wireless access technologies and seamlessly move between them.

2. **Group cooperative relay:** This is a technique that is being considered to make the high data rates available over a wider area of the cell. Currently data rates fall towards the cell edge where interference levels are higher and signal levels lower.

3. **Cognitive radio technology:** If cognitive radio technology was used for 5th generation, 5G cellular systems, then it would enable the user equipment / handset to look at the radio landscape in which it is located and choose the optimum radio access network, modulation scheme and other parameters to configure it to gain the best connection and optimum performance.

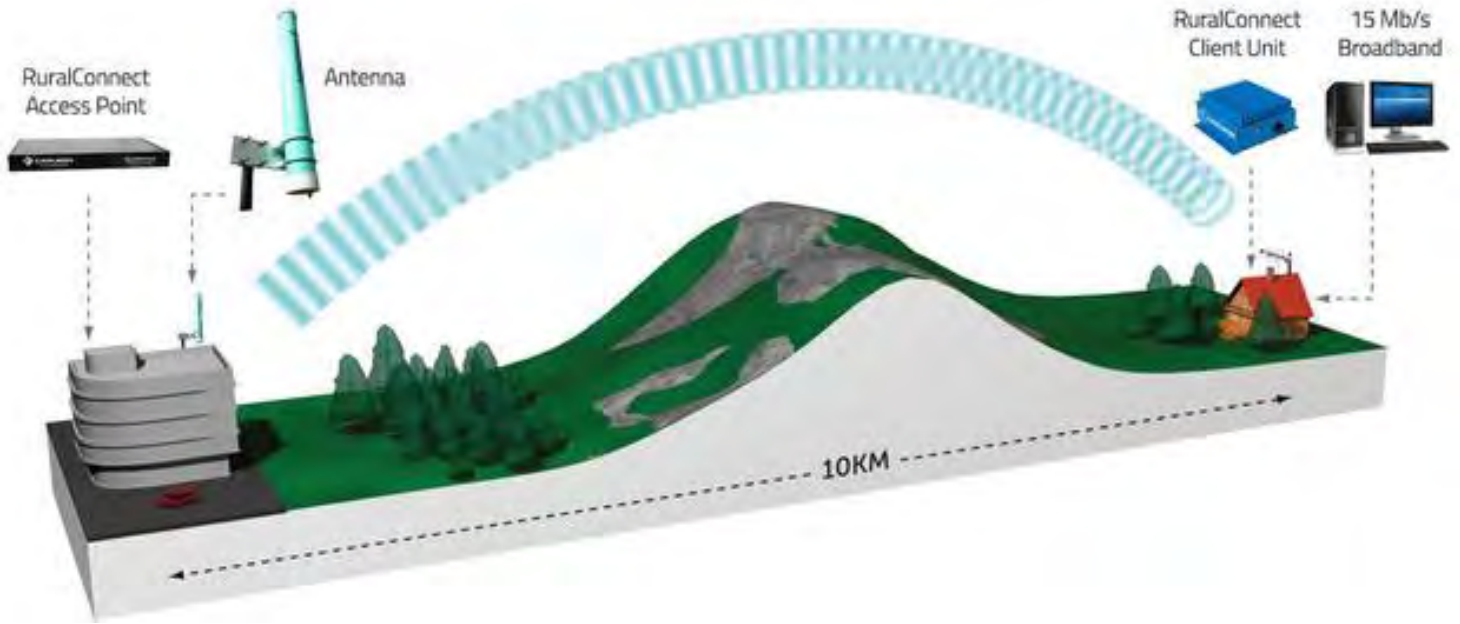
4. **Wireless mesh networking and dynamic ad-hoc networking:** With the variety of different access schemes it will be possible to link to others nearby to provide ad-hoc wireless networks for much speedier data flows.

5. **Smart antennas:** Another major element of any 5G cellular system will be that of smart antennas. Using these it will be possible to alter the beam direction to enable more direct communications and limit interference and increase overall cell capacity.



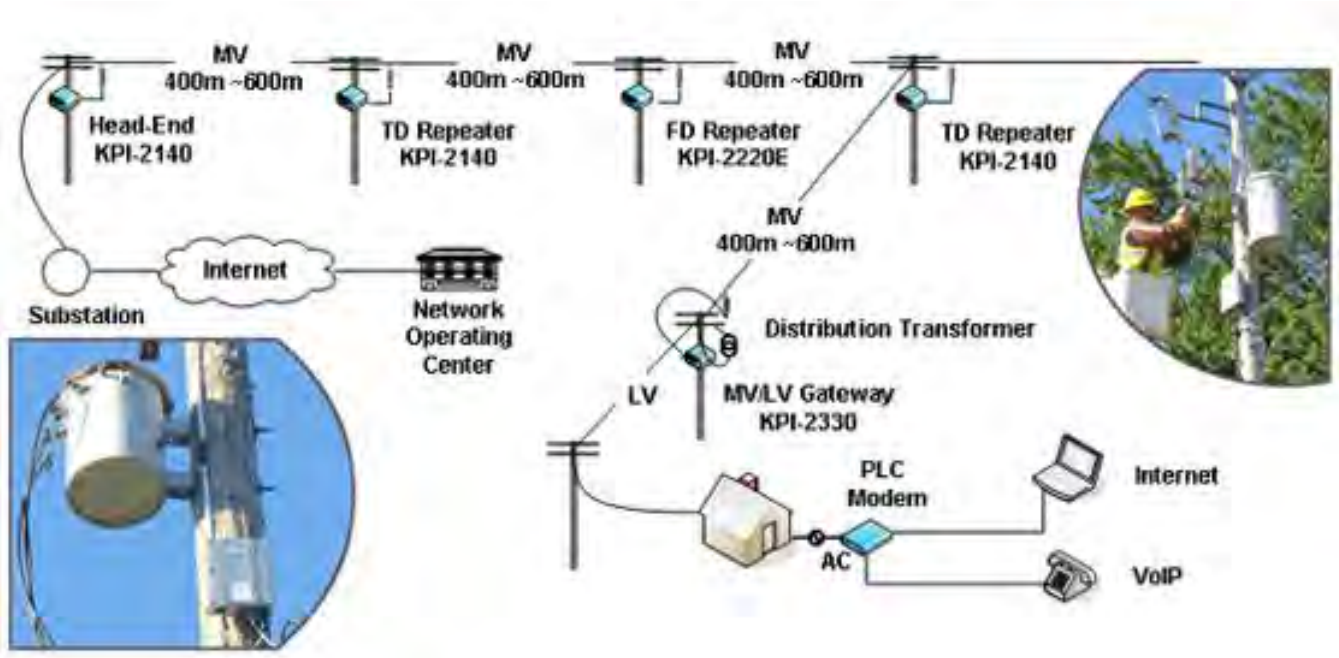
White Space Internet

In telecommunications, white spaces refer to frequencies allocated to a broadcasting service but not used locally. Typically these are analog TV frequencies. In the United States, the abandoned television frequencies are primarily in the upper UHF "700-megahertz" band, covering TV channels 52 to 69 (698 to 806 MHz). U.S. television and its white spaces will continue to exist in UHF frequencies, as well as VHF frequencies for which mobile users and white-space devices require larger antennas. In the rest of the world, the abandoned television channels are VHF, and the resulting large VHF white spaces are being reallocated for the worldwide (except the U.S.) digital radio standard DAB and DAB+, and DMB.



Broadband over the Power Line (BPL)

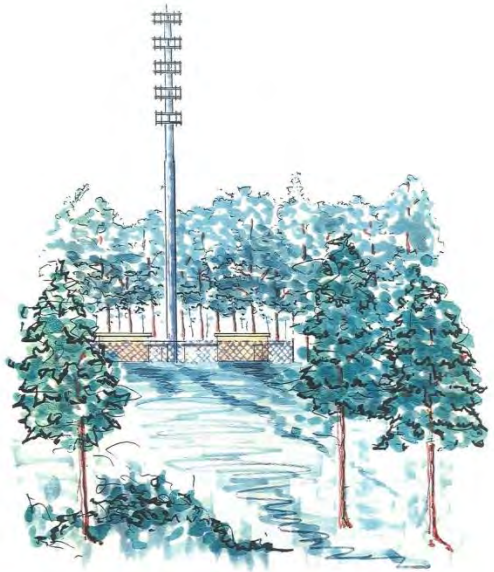
Broadband over power line (BPL) is a technology that allows data to be transmitted over utility power lines. BPL is also sometimes called Internet over power line (IPL), power line communication (PLC) or power line telecommunication (PLT). The technology uses medium wave, short wave and low-band VHF frequencies and operates at speeds similar to those of digital subscriber line (DSL). BPL has existed for many years, but so far, hasn't been implemented in the United States on a broad scale because of technical difficulties involving interference. For instance, amateur radio operators have voiced concerns that BPL will interfere with ham radio, an important communication technology in times of disaster.



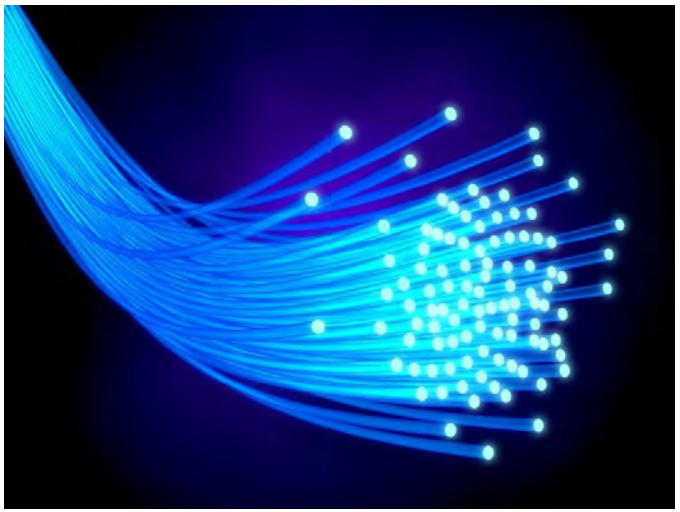
Communications Infrastructure Plan

There are two major components that should be included into a successful Communications Infrastructure Plan:

1. Wireless Communications Facilities (Towers)
2. Fiber Optic Cable Networks.



) E' MONOPOLE CO-LOCATION COMMUNICATION FACILITY IN THE PERMITTED COMMERCIAL TOWER DEVELOPMENTAL AREA (PCTDA)



1. Classes of Towers

With the existing towers and the geographic areas that they cover for voice and data, new towers will be required to "fill–in" gaps in existing and future service.

The "fill-In" of these communications "dead areas" for data requirements will be more aggressive due to higher levels of signal strength in order for the devices inside a structure to be able to "uplink" with a wireless communication's facility in the general area.

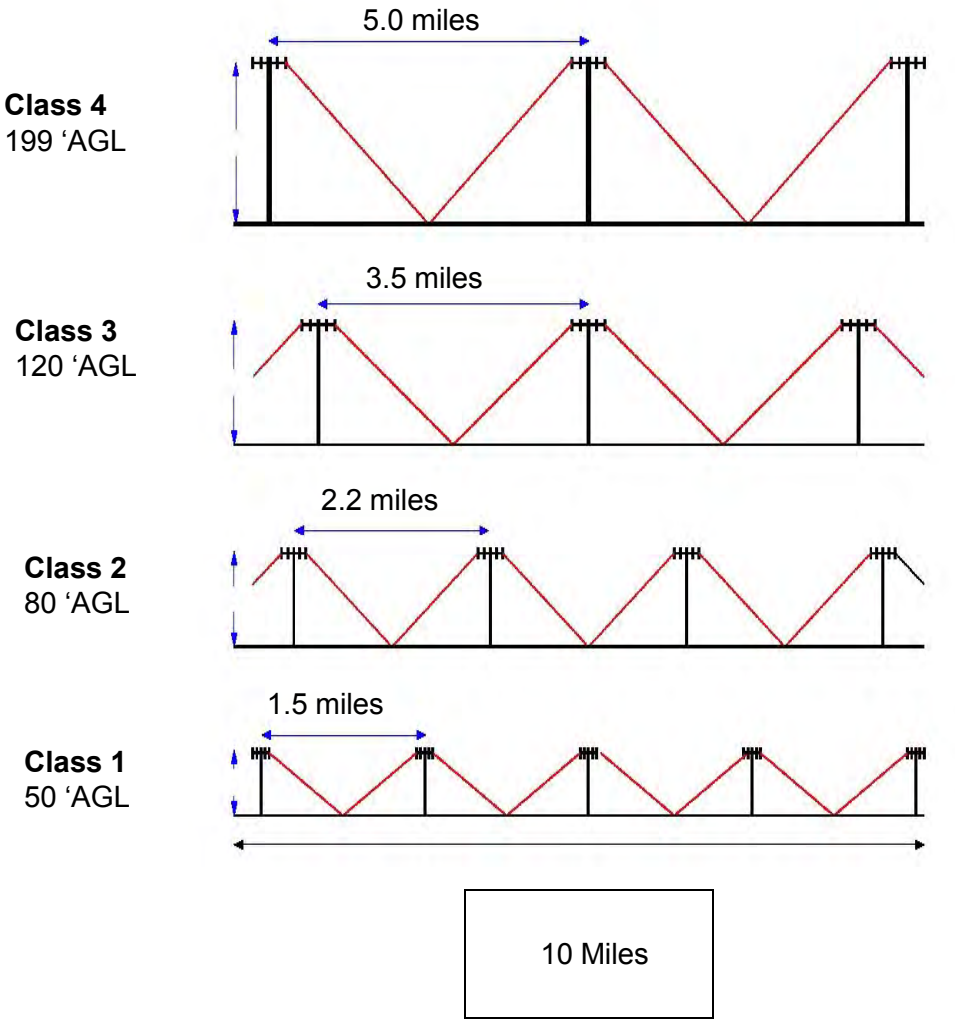
Essentially it takes approximately 40% more signal power for the wireless data devices to operate effectively.

In order to provide vertical support for voice and data services within Clarke County, it is recommended to look at towers "classified" by height.

They are:

Class 1……..Tower height of 50' or less
Class 2……..Tower height of 80' or less
Class 3……..Tower height of 120' or less
Class 4……..Tower height of 199' or less
Class 5……..Amateur Radio as per Federal Law

“LMR Tower Spacing Rule of Thumb Chart”



2. Fiber Optic Cable Networks

Two switched fiber optic networks within Clarke County;

1. *Verizon*
2. *Comcast.*

- While both are designed and well managed
- Located in a **"trunking"** mode along Rt. 7 and Rt. 50 in an **East/West** direction
- Rt. 340 carries one of the **North/South** trunks.

- Design: New PCTDA Towers will require a fiber optic cable "back haul."

The towers were positioned so that fiber optic cable could be efficiently engineered and placed to minimize long runs and transmission loss thus forming a "RING or LOOP"

PCTDA "Fiber Optic" Backhaul

Connect PCTDAs 1, 2, 3, 4 and 5 at the east end of the county along the Rt. 604-605 corridor.
At both ends of Rt. 604 and 605, there is a fiber Optic Remote Modules owned by Verizon that can provide switching to this fiber optic route.

Cost:
Length: approximately seven (7) miles. The unit cost for Rural Fiber Optic Placement approximately $70k per mile to include engineering, right of way acquisition, permits, fiber optic cable, ductwork and placement.

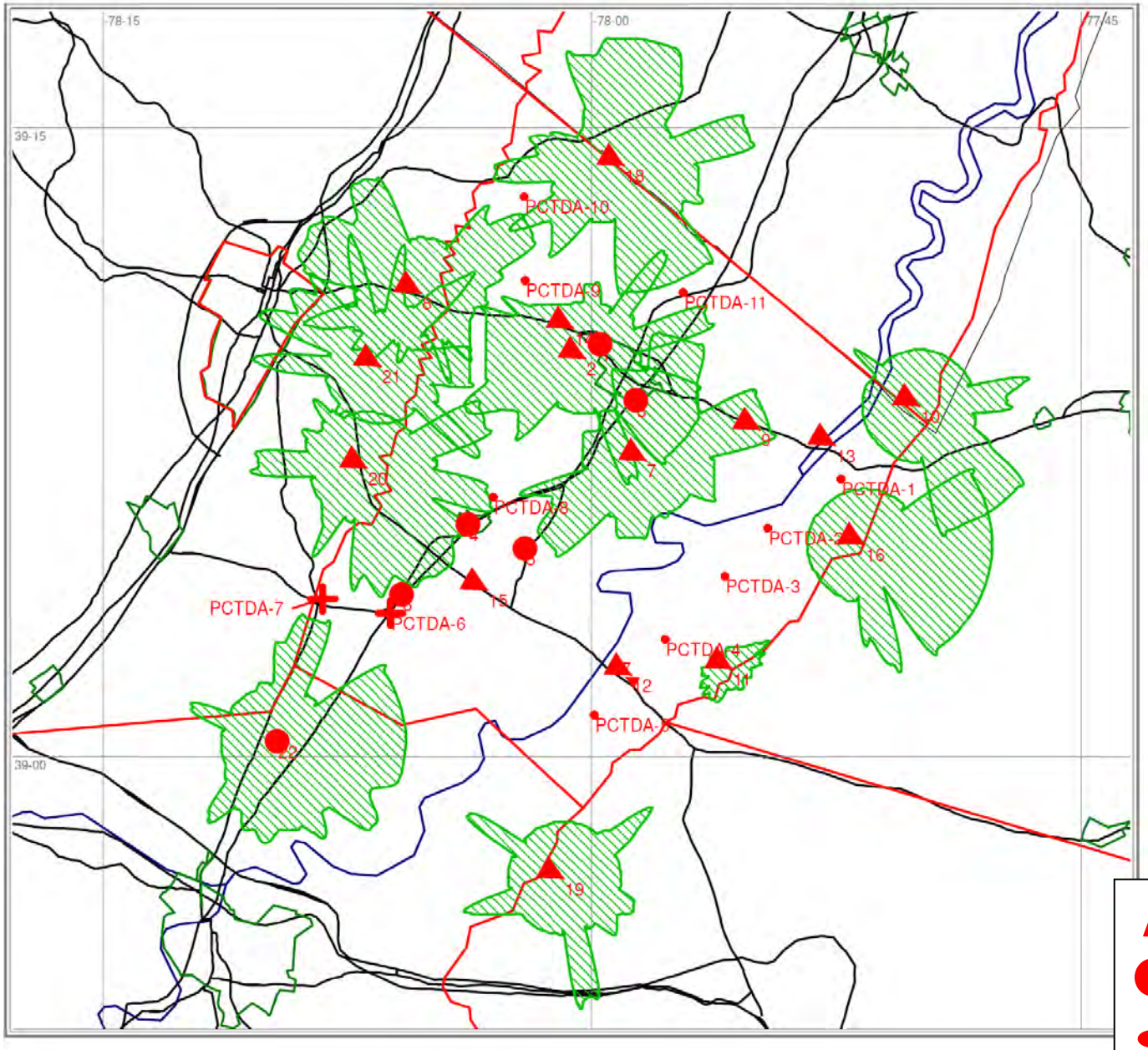
Estimated Total is $490k.

PCTDAs 6, 7, 8, 9, 10 & 11 each are located within ½ mile of a fiber optic Remote Module. Six PCTDAs at .5 mile @$70k per mile.

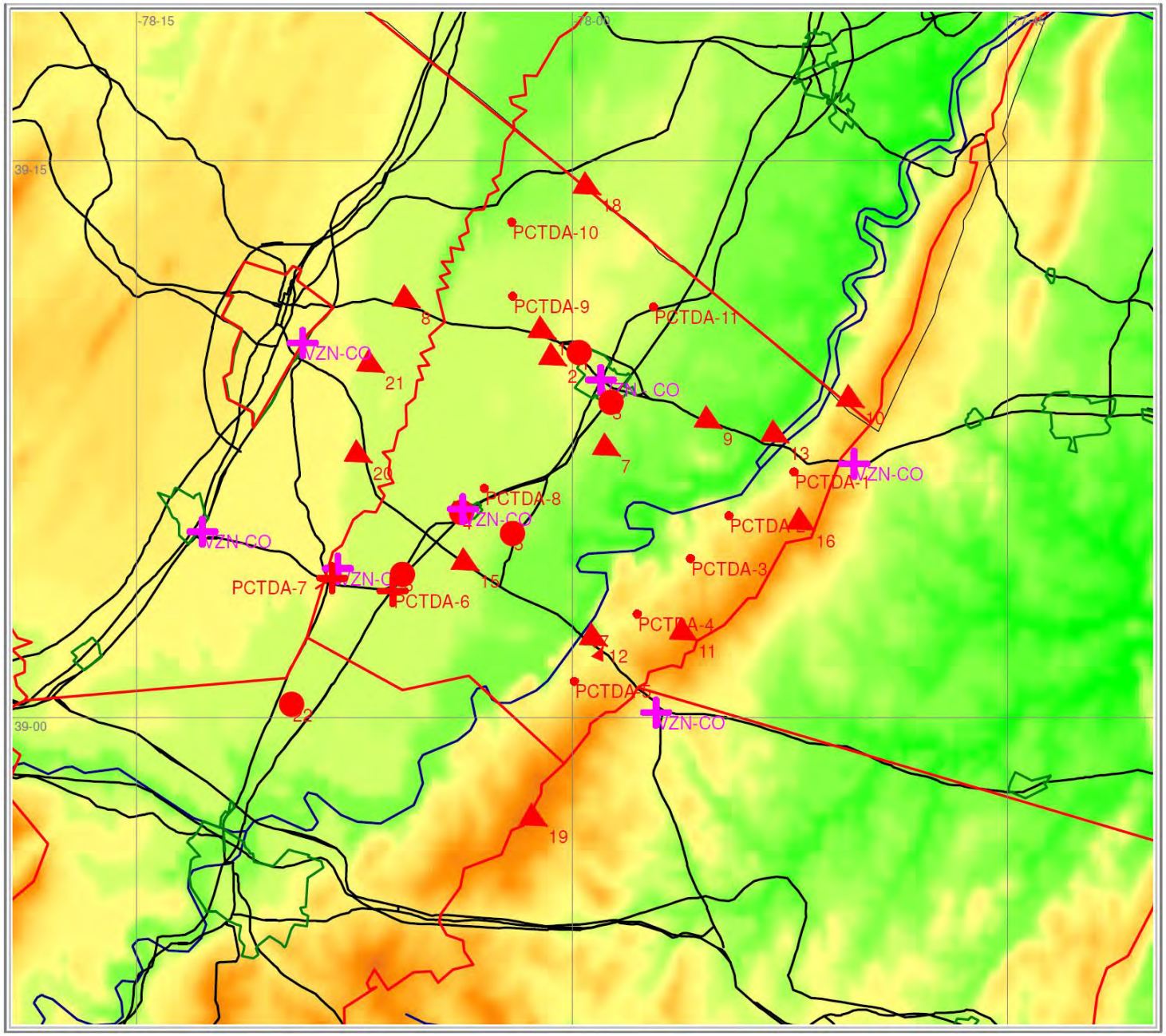
Estimated Total is $210k.

Total Fiber Optic Backhaul Project …….$700,000

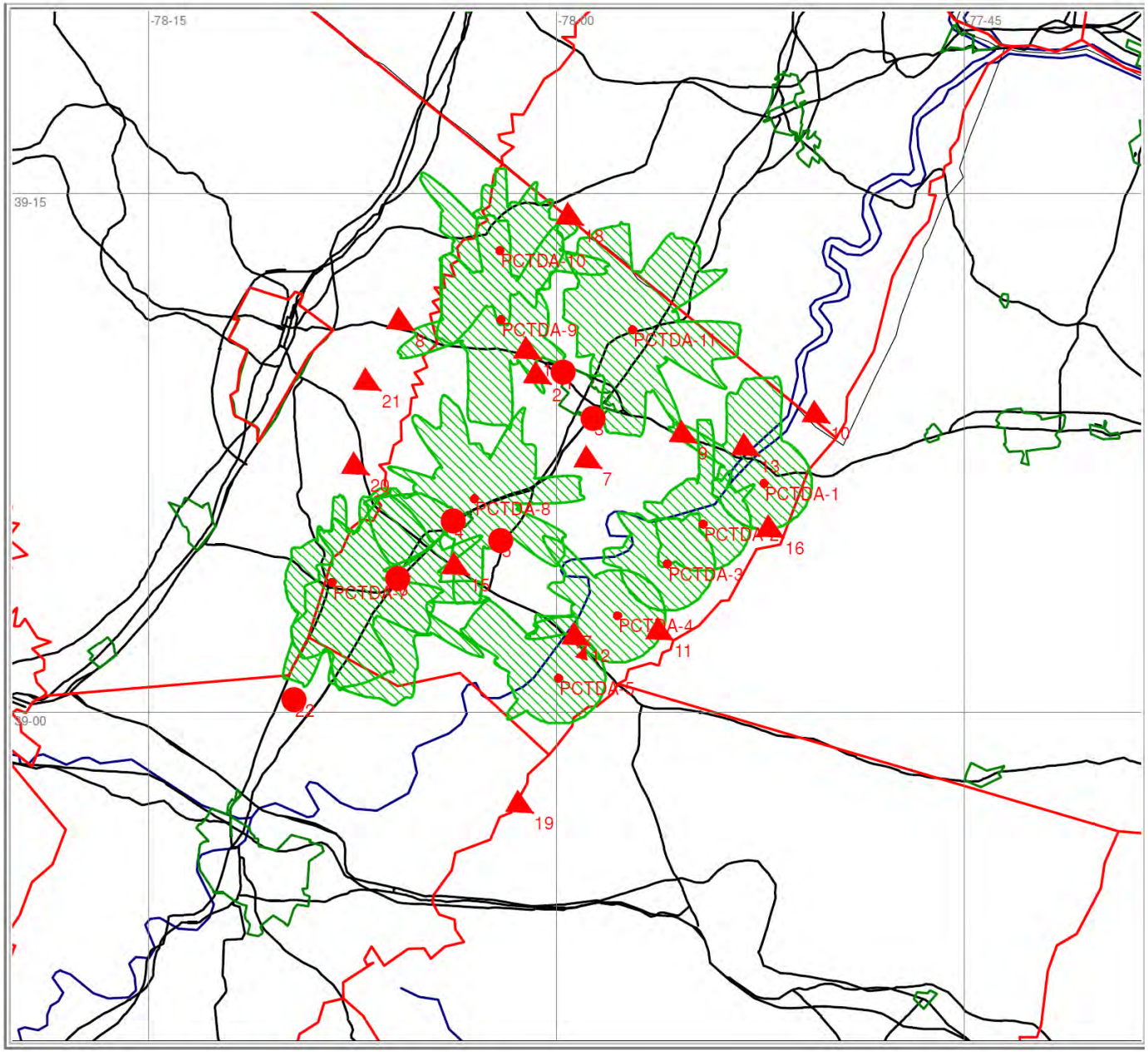
Clarke County Telecommunications Sites



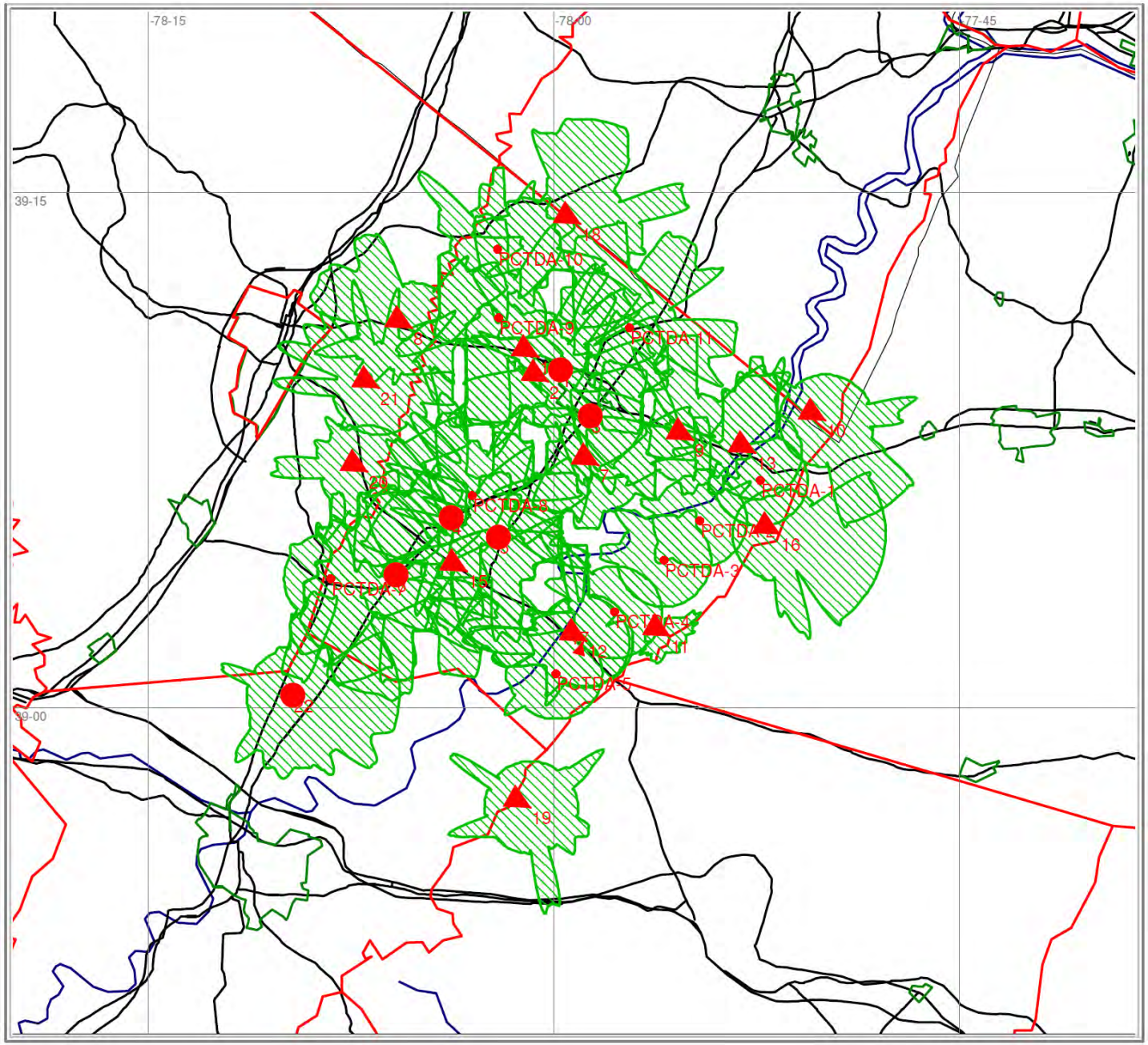
Existing Data Coverage with Major Sites



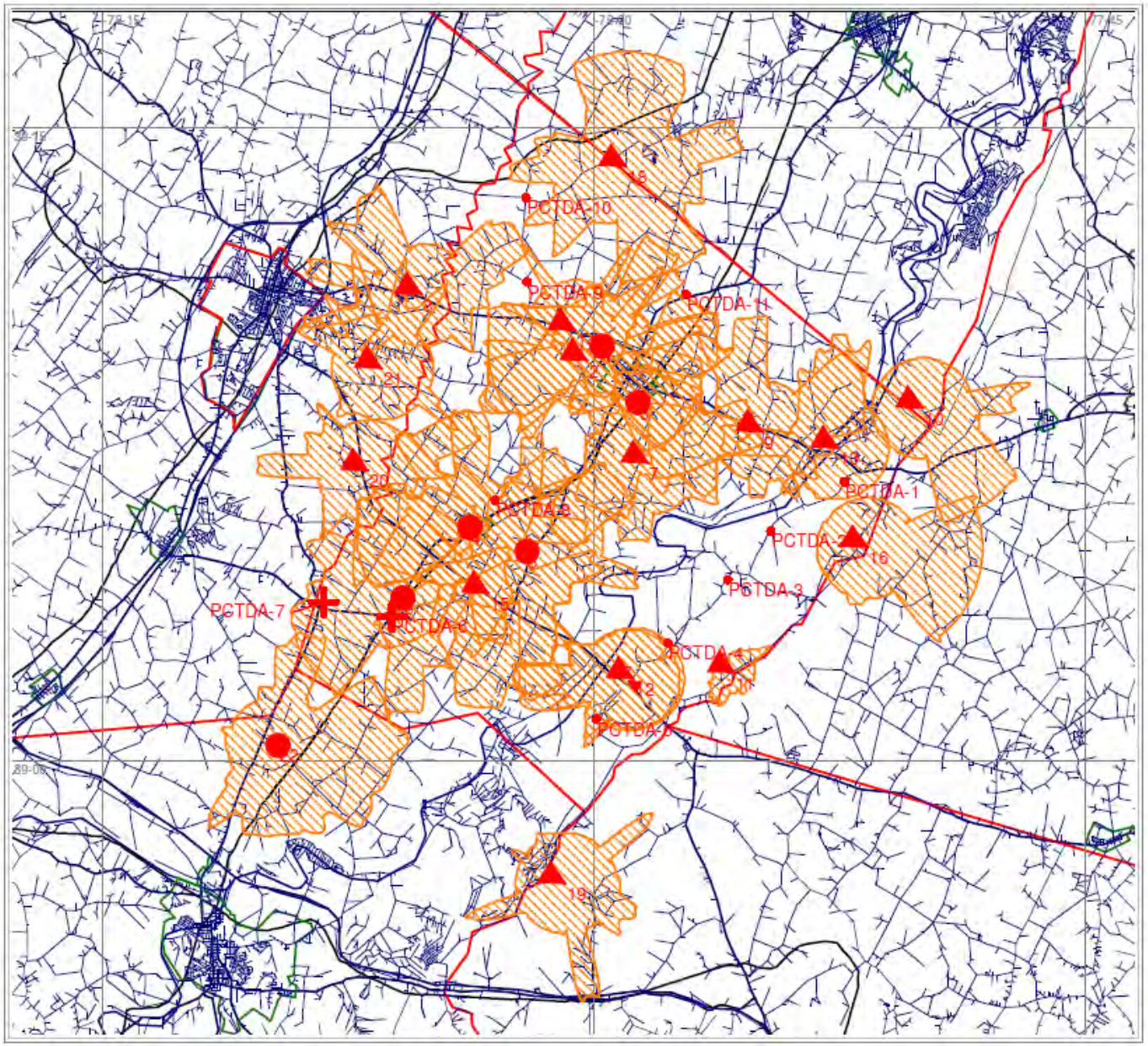
Terrain View



Coverage for 11 PCTDAs



Coverage for Existing & 11 PCTDAs



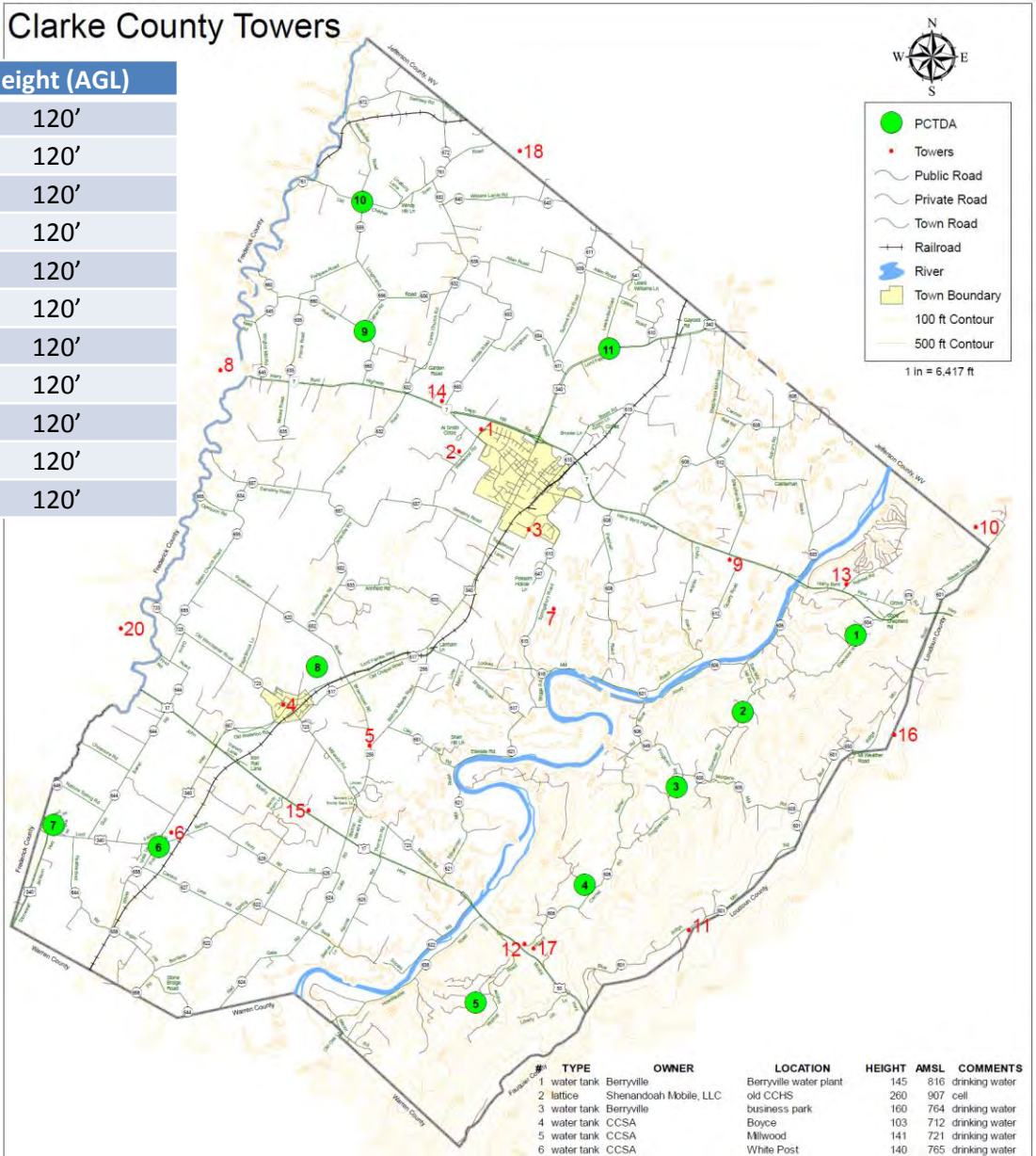
900 MHz Service-Unlicensed on Existing Tower-Water Tank and Positioned PCTDA Sites

PCTDA	Latitude	Longitude	Height (AGL)
1	39-06-37.3 N	77-52-21.5 W	120’
2	39-05-26.7 N	77-54-36.3 W	120’
3	39-04-17.8 N	77-55-55.1 W	120’
4	39-02-47.8 N	77-57-45.0 W	120’
5	39-00-59.2 N	77-59-55.6 W	120’
6	39-03-25.0 N	78-06-10.7 W	120’
7	39-03-45.4 N	78-08-15.3 W	120’
8	39-06-10.9 N	78-03-01.5 W	120’
9	39-11-21.4 N	78-02-02.9 W	120’
10	39-13-21.3 N	78-02-04.8 W	120’
11	39-11-04.1 N	77-57-12.0 W	120’

1. Towers Cost

Each tower is estimated for construction cost of $250,000 per tower.

Total Cost of 11 towers @ $250k/tower = $2,750,000



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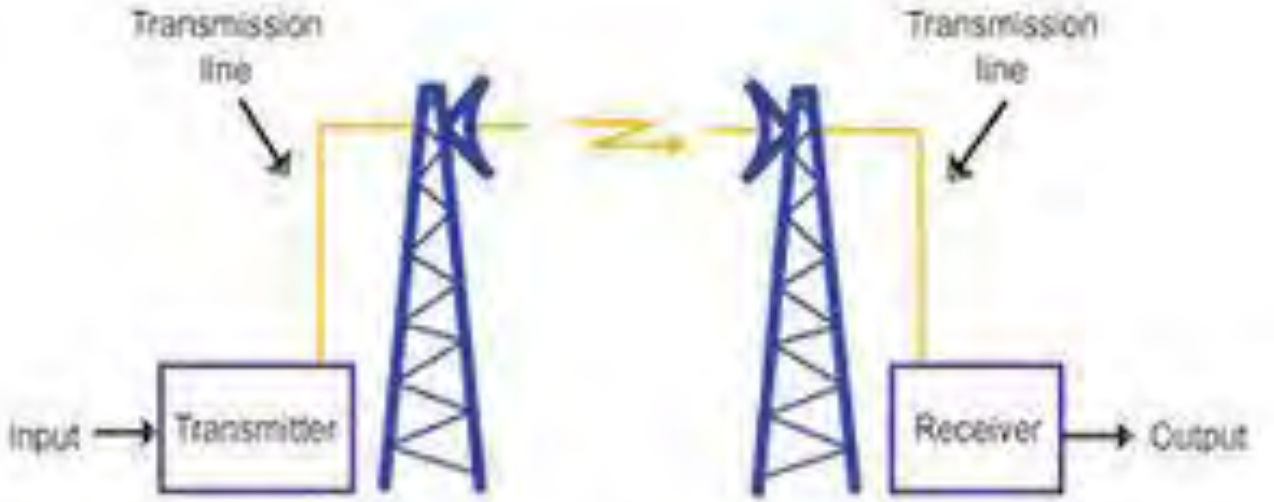
20	lattice	Crown Communications Inc	Izaak Walton Park	167	839	cell
21	lattice	SBC Tower Holdings LLC	Burning Knolls	270	912	cell

Criteria for Towers greater than 120’ AGL.

There are two major considerations for increasing the height of a tower above 120’ AGL:

1. **To ensure proper connectivity for microwave “point to point” systems.**
   -Documentation required: Path Study and rejection from fiber optic providers.
2. **Proposed tower is located within a topographic depression.**
   -Documentation required: Setback Calculations with Ground Elevation Profile Diagrams and Property Owner requirements in writing.



The Atlantic Group would like to make the following recommendations:

1. Implement preplanned tower locations (plan known as Permitted Commercial Tower Development Area-PCTDA) to 120' Above Ground Level heights.

2. Seek to place these Permitted Commercial Tower Development Areas near or on County, State, or Federal properties if available.

3. Seek to "stream line" tower Application Process by approving a "By Right" system for the wireless industry to meet market growth demands by approving the tower "Class" system.

4. Continue to encourage co-location on existing towers and structures such as water tanks and rooftops. Seek to streamline the review process for these Applications.

5. "Collaborate" with private fiber optic facility owners, Broadband providers and tower development companies to facilitate the deployment of fiber optic cable and towers to areas that are unserved or underserved.

6. Have all co-location and new tower build applications reviewed by an independent Third Party to ensure all technical information is reviewed, and that the Planning and Zoning guidelines are adhered to.

Organizational Structures

Local governments have addressed the Broadband issue in many ways and organizational structures. The following are several organizational structures that many counties in the Commonwealth of Virginia have sought to address with the issue of Broadband.

The consultant will provide three (3) of the many potential ways that a County can address Broadband.

1. Single Point of Contact

-Too big/complicated of a subject for one person.

2. County Broadband Advisory Committee = "BAC"

-Strength in numbers, experience and need.

3. Broadband Authority

-Major financial and management commitment.

In summary, this is what Clarke County has currently, and it seems to work well. The Consultant believes Clarke County should continue with this organizational structure.

Administrative Strategy Recommendations

After studying the existing Infrastructure, service providers, Advisory Committee and community input, I would like to recommend the following "Strategy" steps to be taken to advance the Broadband services in Clarke County.

They are:

1. Continue with the Broadband Advisory Committee organizational structure.
2. Continue to provide County web space for providers.
3. Continue to provide GIS Map layer for towers and structures.
4. Continue open dialog with service providers.
5. Approve the Recommendations as per "Telecommunications Infrastructure and Broadband Study 2020" dated November 22, 2016.
6. Produce and publish two (2) RFP/RFIs for industry response for infrastructure and Broadband services.
    1. Eleven (11) PCTDA Towers
    2. Fiber Optic Cable (approx. 10 miles)
7. Seek Grant Funds or "self-fund" for one (1) tower and one (1) fiber optic backhaul location to property owned and controlled by the County. (The one area of greatest need for school aged children with least likelihood of commercial service as the criteria.)

Total Grant or Self-Funded project would be approximately $300,000.