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Town of Erie, Colorado

Broadband Assessment and Feasibility Study Report

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1. Executive Summary

Vantage Point Solutions was awarded a competitively bid contract to conduct a Broadband Assessment and Feasibility Study for the Town of Erie, Colorado. The purpose of this Report is to explore municipal broadband networks and detail options for the Town of Erie to consider in order to improve broadband connectivity in the community.

This Report provides a detailed overview of the data gathered and provides recommendations. Any of the network options considered here would require the Town to overturn the SB 152 restriction with a referendum ballot vote.

Based on the findings of the Study, this Report presents multiple options for Erie to consider, but does not recommend that Erie move forward with considering an option to build a full Fiber-to-to-Home Network serving all residents.

To conduct the feasibility assessment, VPS gathered data and information by:

- Engaging with Town staff;
- Meeting with incumbent providers of Century Link and Comcast;
- Meeting with other ISP providers;
- Holding outreach meetings with citizens;
- Conducting a residential and business survey;
- Analyzing Information provided by the Town; and
- Researching information obtained through publicly available sources.

Based on all the information and data obtained through the residential and business survey, there are multiple key findings to highlight:

- Internet and cellular data are the most important telecommunications services purchased by residents in Erie.
- Overall satisfaction level with current services provider is high. While respondents are quite concerned with the price of their current service, speed and reliability outrank price in important attributes.
- Price is a big concern for residents and it would be a risk for a new provider to offer more than $70 a month for gigabit and charge more than $100 for a one-time connection fee.
- Traditional television is waning in popularity as more people turn to internet streaming for television. Bundling of services is no longer as important. However, television is not obsolete and may still be needed as a service to help drive subscription rates. This is something that should be discussed with any provider-partners.
- The business options for small businesses in Erie are lacking in price sensitivity and bandwidth availability.
- Residents are strongly supportive of the Town having a role in solving the broadband challenges in Erie.

Overall, however, it is clear that Erie does not lack for internet access. In other words, residents in Erie can access the internet from their homes no matter where they live within the town boundary.

In fact, one incumbent provider – Comcast, states that they have ubiquitous coverage throughout the Town with the ability of every homeowner to purchase gigabit service. However, Erie is not equally served by all the providers. For example, there are neighborhoods such as Erie Highlands where residents are receiving high-speed internet gigabit service. There are also four neighborhoods (Kenosha Farm, Northridge, Historic Erie and Erie Village), where residents are underserved by one of the incumbent providers (Century Link).

2. Technology Overview

Before jumping directly into the overview of municipal broadband network models and trends, it's important to understand the definition of broadband as well as the different types of technologies that are being deployed across the country. Broadband technologies can be broken down into two main categories – wireline and wireless. This section provides an overview of each and helps define some the terms that will be utilized in this report. A full glossary of terms can be found as Appendix A.

2.1 Broadband Defined

The Federal Communications Commission (FCC) currently defines broadband as speeds that reach a minimum of 25mbps downstream and 3mbps upstream (25/3). Other FCC programs for high cost rural areas through the Connect America Fund, require minimum speed of 10mbps downstream and 1mbps upstream (10/1). Practically speaking, even the current FCC definition of broadband is far behind what most customers perceive to be adequate for residential use. The discussion of wireline and wireless technologies will explore the benefits and limitations on bandwidth associated with each technology.

2.2 Wireline Technologies

Wireline technologies rely on a physical cable for transmission of the communication signal. These cables usually transport an electrical signal on a copper cable or an optical signal on a fiber optic cable. There are three common wireline technologies used by wireline companies today. These are:

- Digital Subscriber Line (DSL) – This wireline technology overlays a broadband signal on existing twisted pair copper cables. Broadband speeds on DSL networks are dependent on the customer's distance from electronics in remote terminals or central offices. Modern DSL technologies can typically provide 1 Mbps to 2 Mbps download speeds, depending upon the quality and size of the copper cable. However, for customers served by copper cable that exceeds 18,000 feet in length, the distortion caused by the capacitance of the cable renders the cable unsuitable for quality voice. Telephone companies have historically provided voice service over twisted pair copper cable. Consequently, millions of miles of twisted pair copper cable have been deployed throughout the country. However, most service providers have concluded that DSL is near the end of its useful life and will not be a long-term solution for broadband delivery. Therefore, they have been looking to fiber technology to meet the increasing customer demand.

- Coaxial Cable (DOCSIS) – Coaxial cable can also be used to provide wireline broadband services with typical speeds of 160 Mbps downstream and 120 Mbps upstream that can be shared by a large number of subscribers. Most Cable Television (CATV) providers rely on COAX cables. The CATV industry has implemented standards called Data Over Cable Service Interface Specifications (DOCSIS), which defines how the COAX network can be used to deliver broadband services to their customers. It is important to note that the CATV coax networks are shared – meaning a single cable leaving the CATV headend is split many times to serve many customers. Often, a single cable will provide broadband and/or video to hundreds of customers. This architecture worked well for broadcast video services, since it was a "one-to-many" service, but has limitations when delivering services such as broadband, where each customer requires their own unique connection.

- Fiber to the Premises (FTTP) – This wireline technology serves all customers by a fiber optic cable. Most FTTP equipment allows between 70 Mbps and 1 Gbps of broadband to each customer and is capable of serving customers that are more than twelve miles from the central office or electronic field terminal locations.

2.3 Wireless Technologies

Wireless technologies transmit the communication signal "over the air" on a radio frequency (RF) carrier. There are four common wireless technologies used by providers today. These are:

- Fifth Generation (5G) – The Third Generation Partnership Program (3GPP) organization is in process of defining the 5G standards, expected circa 2019. Per the GSM Association, 5G will be targeting user throughputs of 10 Gbps peak, a hundred times that of 4G networks. Although inherently a mobile technology, the first wave of 5G will be utilized for the fixed delivery of wireless broadband services. 5G is anticipated to incorporate higher-order spatial diversity (MIMO schemes, beam forming, cell splitting, etc.), self-organizing networks to minimize self-interference and new user interfaces to support the Internet of Things (IoT).

- Fourth Generation (4G) – Utilizes Long Term Evolution (LTE) licensed spectra to provide wireless broadband services, as defined by the 3GPP organization, with duplexing methodology of both time (TD-LTE) and frequency Divisions. Although inherently a mobile technology, today, nearly all terrestrial wireless providers have standardized on Long Term Evolution (LTE) with fixed Customer Premises Equipment (CPE), as the Wireless Metropolitan Area Network (WMAN) broadband technology of choice. All major cellular providers in the U.S. have deployed LTE and continue to expand their LTE footprints.

- Unlicensed Operations – Unlicensed operations on unlicensed spectra can also be used to provide wireless broadband services. Systems operating on unlicensed spectra typically utilize vendor proprietary air interfaces, Institute of Electrical and Electronics Engineers (IEEE) 802.11, or another variant of the IEEE standards. Operations in the unlicensed spectra inherently are utilized for the fixed delivery of wireless broadband services, as the utilization of fixed devices allow for additional deployment efforts to overcome interference inherent within the unlicensed bands.

- Satellite - Satellite-based broadband is not considered a viable broadband alternative due to the high latency which makes it unsuitable for many applications and unable to provide reliable, high-quality voice connectivity.

Some believe that wireless can be a substitute for terrestrial wireline connections that may be too costly to construct. While wireless can be part of the solution and should be considered for deployment in very rural areas – there are considerations that should be taken into consideration.

- Wireless technologies must be replaced every 5-7 years and they can be very costly to maintain.
- Wireless is not suited for growth. For example –it may be suited for a point-to-point connection to one location but would not allow for adding additional locations off that one connection. Since bandwidth is shared among subscribers, available bandwidth per subscriber decreases as density of subscribers increases.
- Available bandwidth decreases as distance of subscriber from access point increases.
- Broadband speeds are more limited. 4G technologies might allow customers to burst up to 10 or 20 Mbps for short periods of time.

- Not well suited for large bandwidth needs and often discouraged by carriers by only allowing a limited amount of data per month.
- Geography and atmospheric conditions can and will impact service delivery for technologies that need to be in sight of each other in order to transmit a signal. Mountains, hills, valleys, buildings, and trees interfere with the propagation of the wireless signal. Some technologies such as LTE can provide non-line-of-site service (NLOS) to some extent, but at significantly reduced throughput compared to direct LOS. These terrain issues and obstacles can mean that some customers cannot receive the broadband signal or that additional towers (and investment) are required.

2.4 Wireline vs. Wireless Technology

Both wireless and wireline broadband service providers have benefited from technology advances, but *wireline* technologies have historically been capable of speeds many times faster than the best *wireless* technologies. Fiber optic cable has been used by service providers for more than forty years to build high-speed broadband networks, primarily for long haul transport routes. Over the last ten to fifteen years, fiber has also been used to increase broadband speeds to the customer because no other technology can deliver as much broadband speed. With FTTP,[1] the broadband speed provided is not dependent upon cable length, but electronics, and each new generation of FTTP electronics allows service providers the ability to offer significantly higher broadband speeds over greater distances without having to make significant changes to their outside plant architecture. There is no foreseeable end to the amount of bandwidth that can be provided over fiber cables.

There are many reasons why fiber is the best technology to construct modern network or upgrade existing networks. Fiber is immune to electromagnetic interference, provides the most reliable services, and minimizes operational expenses. Therefore, it delivers the best voice and broadband services available for today and the foreseeable future. Over the last several years, increases in copper prices, advances in technology, and growth in broadband demand have all worked together to make FTTP a more economical wireline technology for providing broadband. Not only is a fiber network less expensive to deploy, maintain, and upgrade than other wireline technologies, but it has superior broadband capabilities, such as being able to offer telecommuting, telemedicine services, and telepresence. All of these factors make it clear that copper is a dying technology in the telecommunications industry. It would be unwise for companies to utilize copper in their network deployments going forward, except in certain very limited situations.

Once fiber infrastructure is in place, service providers are able to increase the broadband by simply upgrading the electronics on the fiber cable, which represents a relatively small portion of the overall fiber network investment. Fiber technology will allow higher speeds to be delivered to customers over time with minimal incremental investment, making it the best technology for meeting future broadband service needs.

The amount of bandwidth per customer is significantly greater for a FTTP network when compared to a wireless network. Using the technologies available today, the bandwidth delivered to a customer can be more than 100 times greater than what is possible over a wireless network under similar conditions. The bandwidth advantage for FTTP will increase significantly in the coming years due to technology advances with the electronics.

Fiber optic cable is the most-costly to construct. However, it is also an enabling technology that allows for growth. A lion's share of the FTTP investment is the cable facilities, which typically has a 30-year life, compared to the wireless infrastructure, which has a greater portion of the investment associated with faster-depreciating infrastructure. When

[1] Fiber-to-the-Premises is sometimes referred to as Fiber-to-the-Home (FTTH).

placement costs are included over a 30-year life, the cost savings for a wireless network are significantly reduced or eliminated.

3 Municipal Broadband Trends and Models

For communities looking at options for deploying municipal broadband networks across the country, there is much talk about models. What is the best model for a local government to follow to deploy a broadband network in the community? What are the emerging models?

It is important to note that while there are quite a few different model variations in development, there are actually very few municipal networks that are completed and in operation. This section explores the different types of municipal networks and provides examples of those currently in operation around the country and in Colorado. It should be noted that there is no one-size fits all model. The reality is that the right solution is solely dependent on factors within the community. Simply because a model is not yet in operation does not mean that it will not work. The model that fits best for the Town of Erie is one that must be customized based on local financial, legal, political, and practical considerations.

3.1 Network Model Types

There are two main types of municipal networks that serve end-users (other than networks built exclusively for internal government use) and they are most commonly referred to as last-mile and middle–mile. Both types of networks are defined and explored below. For purposes of this discussion, the term network is inclusive of all technologies.

3.1.1 Last-Mile Networks

A last-mile network (also known as Fiber-to-the-Premise or FTTP) is one that provides services directly to homes and businesses in the community. Last-mile networks can also serve government buildings and other community anchor institutions.

Last-mile networks are the most expensive to deploy but can provide the biggest benefit to the community. However, municipal FTTP networks are also more rare due to the cost it takes to deploy the infrastructure and the need to have an operator/provider who can run and manage the network. For this reason, most of the municipal last-mile networks in existence are in communities that also have a municipal electric utility. This is because the local government (through it's municipal utility) already owns utility pole infrastructure that can be leveraged to offset deployment costs. Municipal electric utilities also have operating and billing systems already in place to serve customers. Therefore, they have experience in serving customers and can more easily shift gears to offer a broadband service as a new offering rather than having to create an operational system greenfield.

The other key factor is that last-mile networks usually require a take-rate that is between 40-60%. This means that the network operator needs to obtain 40-60% of the residential subscriptions available in the community in order to recoup the capital investment, make a profit and be sustainable. Examples of FTTP networks – both those that have a municipal electric utility and those that do not - are provided below.

3.1.1.1 Muni Electric FTTH Network Examples

There are several muni-electric FTTH networks in existence across the country. They are all similar in nature – wherein the city leverages their utility assets to build a fiber network. Examples include Chattanooga, TN, Lafayette, LN and Longmont, Colorado.

Longmont, Colorado

Starting its build out in 2014, Erie's neighbor to the north now has a completed, fully-functioning and in service fiber network. Longmont's "NextLight" is a gigabit fiber network owned and operated by the city and its power utility, Longmont Power & Communications (LPC).

In 2013 Longmont supported the network build at a 70% level, approving a $40.3 million bond issuance to cover the startup costs of the Internet service. Even the $40 million price tag would have been significantly higher if not for the existing asset of an 18-mile fiber loop within the City's limits.

Longmont has 38,000 premises and 92,000 residents within its approximately 30 square miles. NextLight offers symmetrical gigabit service at $50/month for those who signed up early. This $50 rate is for both the lifetime of the home as well as the owner should he/she move within city limits.

Late in 2016 the City voted to increase LPC's budget by $7 million, sourced from the Electric and Broadband Utility Fund balance to hire staff needed to support take rates twice as high as initially predicted (feasibility study in 2013 predicted 27 percent while take rates average of 56 percent). Take rates will allow a swift payback of both the bonds and the additional appropriation.

3.1.1.2 Non-Muni Electric FTTH Network Examples

Of greater interest to Erie, are those communities that are building fiber networks without the benefit of a municipal electric utility. These examples are below.

Ammon, Idaho

The City of Ammon Idaho has a very unique model. Ammon has built an open access network that lets multiple private ISPs offer service to customers over city-owned fiber. The City self-funded a portion of the network. However, Ammon is using a model similar to Google Fiber's "Fiberhoods," in which construction happens first in neighborhoods where a majority of residents commit to buying service. Those who opt-in have the option to pay either an upfront fee of $3000 or pay the amount gradually over a 20 year period, excluding an additional utility fee of $16.50 a month. Should a home-owner sell their house prior to the $3,000 fee being paid off – it would be the responsibility of the new home-owner to continues those payments. Conversely, should a homeowner move after paying the upfront free – the new homeowner would have the benefit of the network connection without needing to pay the connection fee.

This model has been touted as the "model of the future" but it is far from being complete. Success is yet to be determined and the fee structure may not be appropriate for many communities.

Hudson Oaks, Texas

The Town of Hudson Oaks, Texas is in the process of building a FTTP network. The rural town (located outside of Dallas) has a population of less than 2,000. The town is self-financing the infrastructure build and will own the network assets. The town found a wireless ISP that is going to become the FTTP service provider and network operator. The provider will be leasing the assets back from the town.

Rio Blanco, Colorado

Rio Blanco County utilized county funds and Colorado DOLA grant funds to construct an FTTP network serving its rural community. The technologies deployed are a mix of fiber and wireless. The goal is ubiquitous coverage by 2018. This is one of the few municipal last-mile project that does not involve a municipal electric utility.

Rio Blanco County is building a fiber to the premises network in its main two population centers (Meeker and Rangley) and a shared fixed wireless solution designed to reach all other addresses. Additionally, Rio Blanco is building middle-mile fiber available for carriers to lease in the county.

3.1.2 Middle Mile Networks

A middle-mile network is typically defined as a network that serves community anchor institutions (i.e. schools, libraries, government buildings, public safety agencies, hospitals, etc.) but does not directly serve homes and businesses. A middle-mile network could either be operated directly by the municipality or outsourced to a network operator.

The purpose of middle-mile networks is generally to build a high fiber count (fiber cables with strand counts of 144 and above) backbone[2] that provides direct lateral connections to key institutions and enables infrastructure assets to be leveraged by others to service homes and businesses. Third-parties may have an interest in leasing these assets because it helps with reducing their costs of deployment. A provider, then, would only need to invest in the lateral connections to homes and businesses and would not have to build the backbone.

3.1.2.1 Middle-Mile Examples

Howard County, MD

Howard County, Maryland has a network of over 175 miles that was funded by a combination of County general funds, bonds and federal grants. The County owns and operates the middle-mile network with the help of outside vendors for maintenance and other technical needs. The County has now become an ISP and is the internet provider and E-Rate provider for the entire County School system. The network also leases dark fiber and provides internet service to some commercial businesses. This is one of the most unique and successful municipal middle-mile models in the country.

Centennial, CO

The City of Centennial (107,000 residents) is in the process of building a fiber backbone. The City is self-funding the middle-mile portion of the network build and will own the assets. Centennial has selected Ting to be the FTTP service provider, who is currently taking signups for residential service for $89/month range for symmetrical gigabit speeds.

While the network is the property of the City and eventually an “open network,” Ting partnerships typically feature an “exclusive right to operate network” term of multiple years. While the build is the responsibility of the respective cities, Ting will lease and light the fiber and provide all equipment and Internet access. City’s partnering with Ting are mitigating risk and staying out of the challenging ISP business.

[2] A backbone is literally the spine of the network. Backbone’s are usually built along main corridors and provide transport to and from the hub site where the electronics are located to the connected entity.

Funding the build is a $5.7 million allocation from the general fund. The city council led by the fiber subcommittee looked at this funding as an infrastructure investment removing the expectation that this funding would be directly paid back.

Northwest Colorado Broadband (NWCB); Steamboat Springs, CO

The City has teamed with Routt County and 4 other entities to form a nonprofit. The partners supplied some of the capital along with DOLA grant funds to build a middle-mile network through Steamboat Springs. The nonprofit has teamed with a network operator who oversees the network operations and technical support. The nonprofit hopes to lease dark fiber to attract last-mile providers to build out to homes and business.

3.2 Ownership Models

There are multiple kinds of ownership and operating models. The below chart details four basic types:

Type of Operating Structure	Description
Publicly-Owned and Operated	This is a municipal network that is 100% self-provisioned. In other words, the municipality solely owns, and internally manages and operates the network. There are very few of these around the country.
Publicly-Owned and Privately Operated	In this model, the municipality owns the assets, and provides oversight, but outsources the management and operations to a third-party entity that could be a private provider or a nonprofit.
Privately-Owned and Operated	This is a network entirely owned and operated by a third-party but one where the municipality provides some resources (not financial) and resources and benefits from the service.
Hybrid	Another option is to create a hybrid model that combines one or more of the above options. An example of a hybrid option is a Public-Private Partnership (discussed below) wherein both the public and private entity bring resources and may share in the ownership of the assets.

3.2.1 Public Private Partnerships (PPPs)

Public-private partnerships (PPPs) are a relatively new phenomenon in broadband. A PPP is a legal partnership wherein the partners balance and apportion risk, benefit and control. Recently, more and more municipalities are exploring establishing a PPP for deploying and operating last-mile networks. But what does that mean?

There are many different types of PPPs. They include but are not limited to the following:

- An investment entity that steps forward to provide funding for the network in exchange for a long-term payback on their investment. This is a traditional PPP. The investment entity usually requires an ownership stake in the assets and sets other conditions such as requiring the municipality to provide a credit backstop to guarantee investments. The municipality generally does not need to provide cash contributions. An investment entity is only likely to be drawn to projects that cost a minimum of $15 million dollars.
- A partnership wherein both the municipality and provider contribute funding and resources to the project. Both may share in ownership of the assets.
- A partnership wherein the municipality provides all funding, owns the network but does not operate or manage the network.

The type of PPP depends on a number of factors, including:

- Whether the provider can make a profit with take rates that justify an investment;
- The sum total amount of financial resources the municipality can provide;
- Whether the municipality is willing to be flexible on asset ownership;
- Whether there is a private-entity that is interested and viable;
- Whether the municipality and private partner can come to agreement on terms and requirements.

A recent trend by communities interested in exploring PPPs, is for the municipality to issue a Request for Information (RFI) to invite potential interested partners to submit proposals. To date, this has not yet proven to be an effective strategy in the establishment of a PPP. This is due to a few key reasons. First, there are instances where the RFI itself has created confusion and significant delay in network planning – particularly where the RFI is issued prematurely, is open ended, vague, or includes too many difficult to meet requirements.[3] In some cases, this has resulted in situations where a community has had to re-issue the RFI with new requirements and/or hold multiple rounds of interviews.

Despite the fact that PPPs are widely pursued as options for last-mile municipal broadband networks, a PPP is difficult to establish. This is particularly true in rural areas where the cost of the build is high and the number of potential customers makes it difficult to justify the investment. This is also true in areas where there are existing incumbent providers that have a market share of subscribers.

Communities thinking of utilizing this RFI approach to finding partners should do so cautiously and should identify potential local partners first. It is a much more effective strategy to identify and meet with providers in order to explore the viability of a PPP prior to expending the time and money to enter into a lengthy procurement process that does not guarantee the desired result.

3.3 Network Revenue Opportunities

3.3.1 Conduit Leasing

The most expensive part of deploying a broadband network is the construction. The cost of the actual assets (fiber and conduit) are nominal. Therefore, if engaging in a network build, it is cost-effective to install extra conduit banks and install high-count fiber during the initial construction phase to cover all current and future needs. You only want to have to dig once.

In most cases, excess[4] conduit and fiber deployed can be leased through an agreement called an Indefeasible Right of Use (IRU). IRUs are commonly used in the industry to provide long-term access to assets. The term of an IRU typically runs between 10-20 years. Conduit pricing is usually based on a per-foot basis. Pricing varies based on demand in the region and amount of conduit available.

Below is a chart that provides examples of three different pricing structures for conduit:

[3] PPP proposals are time consuming and expensive to develop. Vendors can be hesitant to respond to RFIs where they are unclear on what is expected or they are unsure if it is likely to result in a contract for any vendor.

[4] Conduit and fiber strands that will not be used by the municipality.

Location	Price	IRU Term	Total Cost
Boulder, Co	$5.50 per foot	20 years	$722,271 in a one-time payment
Lincoln, NE	$65,000 per year	20 years	$1.3 million paid monthly over 20 years with an escalation clause not exceed CPI.
Baltimore, MD	$3.00 per foot (appx)	Negotiable	Depends on how much leased. City requires any new conduit built by provider to be owned by City

3.3.2 Dark Fiber Leasing

Dark fiber refers to fiber optic cable that has been installed and is available to use but is not connected to any electronic devices and not transmitting any data. Dark fiber is also referred to as excess capacity. Fiber optic cable comes in strand counts ranging from 12 strands to 1400+ strands. Any strands not in use by the owner (or other entity) are considered dark fiber strands that can leased.

Similar to conduit, dark fiber pricing is subjective and includes but is not limited to the following criteria:

- Availability of dark fiber in the area;
- Market rate of other dark fiber in the area (sometimes very difficult to ascertain);
- Number of strands to be leased (minimum of two);
- Amount of footage to be leased (per mile);
- Term of years requested;
- Payment up-front versus over time;
- Amount of strands remaining that may not be marketable (i.e. if an entity only leases a portion of a route, the corresponding strands on the remainder of the route may not be usable. Often you will see a provider require the entire route to be leased for this reason.)

Unlike conduit, dark fiber is not based on price per foot but rather based on a per-strand, per mile, per month basis. Prices can range from $5-$750 per pair of strands with a typical IRU term of 10-20 years. Similar to conduit, payments can be made on monthly, annually or on a one-time payment. One-time payments require less administrative work and book keeping. It also provides a large infusion of cash. However, smaller entities may not be able to provide one-time payment and it is difficult to estimate market value over the course of twenty years. Ultimately, all of these considerations are discussed in the negotiating process.

Below is a chart that shows some dark fiber pricing in rural communities across the country.

Rural Community	Rates Per Pair and Per Month	Maintenance	Up-Front Fee per pair	Term
California	$9	$250	$1,000	20
Illinois	$7	$150	$750	20
North Carolina	$7	$250	$750	20-25
Maryland	$90	0	0	20

Maintenance can be included in the cost of the IRU or added as an additional fee. Maintenance fees range from about $200-700 per mile, per year.

The below chart shows what a rate schedule would look like for a price per pair of strands ranging from $10 - $100 exclusive of any up-front or maintenance fees.

Rate Schedule Based on Flat Fee Per Pair of Strands										
Per Pair	**Per Mile**	**Per month**	**Per Year**	**10 Yrs**	**20 Yrs**	**Per Mile**	**Per month**	**Per Year**	**10 Yrs**	**20 Yrs**
$10	1	$10	$120	$1,200	$2,400	10	$100	$1,200	$12,000	$24,000
$20	1	$20	$240	$2,400	$4,800	10	$200	$2,400	$24,000	$48,000
$30	1	$30	$360	$3,600	$7,200	10	$300	$3,600	$36,000	$72,000
$40	1	$40	$480	$4,800	$9,600	10	$400	$4,800	$48,000	$96,000
$50	1	$50	$600	$6,000	$12,000	10	$500	$6,000	$60,000	$120,000
$60	1	$60	$720	$7,200	$14,400	10	$600	$7,200	$72,000	$144,000
$70	1	$70	$840	$8,400	$16,800	10	$700	$8,400	$84,000	$168,000
$80	1	$80	$960	$9,600	$19,200	10	$800	$9,600	$96,000	$192,000
$90	1	$90	$1,080	$10,800	$21,600	10	$900	$10,800	$108,000	$216,000
$100	1	$100	$1,200	$12,000	$24,000	10	$1,000	$12,000	$120,000	$240,000

In Colorado, we have received data regarding a recent dark fiber leasing agreement. We cannot disclose the parties, however, this took place in a rural community similar to Weld County.

The agreement resulted in an up-front payment of $300,000 for 2 strands of dark fiber priced at $156 per pair of strands. The term of the agreement was for 10 years and the entity received a discount in exchange for an up-front payment.

Finally, when leasing conduit and dark fiber, the owner of the network must take into account the following considerations:

- A map and inventory of all assets leased and available to be leased must be kept current and active;
- Maintenance of the conduit and the fiber generally falls to the network owner and so the owner must have policies and procedures in place to meet any service level agreements (SLAs) that the lessee's have in place. In other words – the network owner must be able to repair fiber cut within an emergency window to prevent downtime outages to the network customers;
- The network owner must have a plan in place for third-party network access;
- The network owner must have a process in place for interested third-party applications as well as templates for legal agreements and other documents.

Enabling third-party access of the network must be part of the implementation plan. Municipalities sometimes have difficulty executing this process internally and need to outsource these activities to a vendor.

3.4 Open Access

An open access network is one where the infrastructure assets (conduit and fiber) are made available under certain policies and procedures to multiple non-network owners. Usually this occurs in the form of dark fiber leases as described above. Publicly funded grant programs offered by the federal and state government often require networks to be open access.

On paper, open access seems like a great idea. Middle-mile networks that lease dark fiber and conduit are by definition open access – otherwise, networks would be limited to one customer. Middle-mile networks need multiple users to be sustainable. Further, allowing multiple providers to access a network should mean increased competition and lower prices. A municipality should benefit from more users on the network.

However, open access is a hotly debated topic particularly as it relates to last-mile networks because the greater the number of providers, the harder it is for a new-entrant provider to meet its take-rate goals and make a profit. This will be of particular concern for providers that are also making a financial investment. Will a provider be able to meet take rates of 40-60% while other providers are invited to compete for the same customers? Ultimately, the open access question will be determined by all the investors and stakeholders.

4 Competitive Landscape in Erie

Overall, Erie does not lack for internet access. In other words, residents in Erie can access the internet from their homes no matter where they live within the town boundary. In fact, one incumbent provider – Comcast, states that they have ubiquitous coverage throughout the town with the ability of every homeowner to purchase gigabit service. However, Erie is not equally served by all the providers.

For example, there are neighborhoods such as Erie Highlands where residents are receiving high-speed internet gigabit service. There are also four neighborhoods (Kenosha Farm, Northridge, Historic Erie and Erie Village), where residents are underserved by one of the incumbent providers (Century Link)– meaning – they are not currently able to access internet speeds that meet the FCC definition of broadband (25/3) or even the high-cost definition of 10/3. While residents in these neighborhoods have the option of subscribing to Comcast for adequate service, there is not the same level of competition as in other parts of Erie. This situation presents opportunities for Century Link (should they choose to upgrade their facilities) or other ISPs.

To undertake an analysis of the competitive landscape, the existing infrastructure and current provider services in Erie - VPS gathered data and information by the following methods:

- Meetings with the providers;
- Outreach meetings with citizens;
- The residential and business survey;
- Information provided by the Town; and
- Additional information obtained through publicly available sources.

4.1 Existing Infrastructure

As a part of this analysis, VPS took a look at the existing provider infrastructure. As expected, Comcast and Century Link declined to provide exact information on the location of their infrastructure. Informally, the providers did share some information on service levels and offerings in Erie. Independently, VPS gathered the below information to show the range of service offerings and prices by Providers in Erie. It should be noted that some rates are promotional based on one or two-year commitments.

Recently Comcast announced that residents in Colorado can purchase gigabit service from Comcast. Comcast says that any subscriber potentially has the ability to obtain gigabit service. Century Link, on the other hand – varies in the service level offerings that are available to customers. Speed availability is limited by whether the lines serving the residence are copper or fiber lines. Copper lines generally limit speeds to 10Mbps.

The below chart provides an overview of some of the offerings in Erie that residents can purchase from the incumbent providers.

Internet																		
Companies	4 Mbps	6 Mbps	10 Mbps	20 Mbps	25 Mbps	30 Mbps	50 Mbps	55 Mbps	60 Mbps	75 Mbps	80 Mbps	100 Mbps	120 Mbps	150 Mpbs	200 Mbps	250 Mbps	1 Gbps	2 Gbps
CenturyLink	-			$ 45.00					$ 55.00		$ 55.00		$ 65.00		-	-		-
Xfinity	-	-	$ 29.99					$ 39.99				$ 49.99			$ 59.99	$ 69.99	$ 109.99	$ 299.95
Comcast Business					$ 69.95		$ 109.95			$ 149.95		$ 199.95		$ 249.95				
Exede			-															
Hilltop Broadband	$ 44.95	$ 59.95	$ 69.95			$ 99.95												

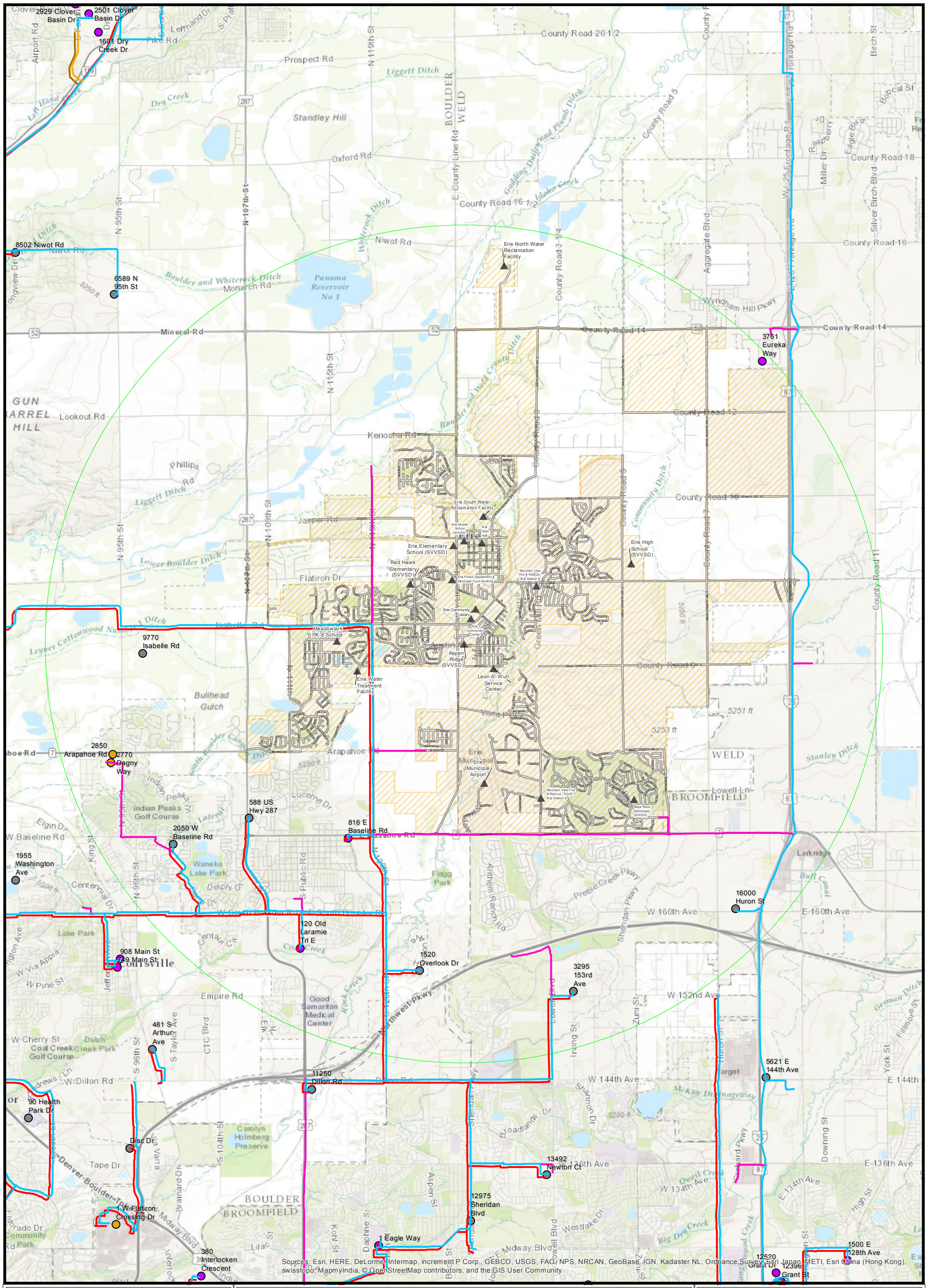
TV & Internet Bundle																		
Companies	4 Mbps	6 Mbps	10 Mbps	20 Mbps	25 Mbps	30 Mbps	50 Mbps	55 Mbps	60 Mbps	75 Mbps	80 Mbps	100 Mbps	120 Mbps	130 Mbps	200 Mbps	250 Mbps	1 Gbps	2 Gbps
CenturyLink	-	-		$ 84.99					$ 94.99		$ 94.99		$ 104.99					
Xfinity	-	-	-					$ 69.99				$ 89.99			$ 59.99			

Triple Play Bundles (TV, Internet, and Phone Service)																		
Companies	4 Mbps	6 Mbps	10 Mbps	20 Mbps	25 Mbps	30 Mbps	50 Mbps	55 Mbps	60 Mbps	75 Mbps	80 Mbps	100 Mbps	120 Mbps	150 Mpbs	200 Mbps	250 Mbps	1 Gbps	2 Gbps
CenturyLink				$ 124.99					$ 134.99		$ 134.99		$ 144.99					
Comcast Business					$ 109.85		$ 139.85			$ 179.85								
Xfinity	-	-	-					$ 89.99				$ 109.99			$ 129.99			

Internet and Phone Bundle																		
Companies	4 Mbps	6 Mbps	10 Mbps	20 Mbps	25 Mbps	30 Mbps	50 Mbps	55 Mbps	60 Mbps	75 Mbps	80 Mbps	100 Mbps	120 Mbps	150 Mpbs	200 Mbps	250 Mbps	1 Gbps	2 Gbps
CenturyLink				$ 85.00					$ 95.00		$ 95.00		$ 105.00					
Comcast Business					$ 89.90		$ 129.90			$ 169.90								
Xfinity	-							$ 49.99										
Hilltop Broadband	$ 64.95	$ 79.99	$ 89.99			$ 119.95												

In addition to the residential service providers, VPS looked at other carrier infrastructure such as Zayo. Zayo is a national wholesale service provider has assets located in and around Erie.

Unlike Comcast and Century Link, Zayo does not claim that their infrastructure is confidential and proprietary. In fact, Zayo's website contains an interactive map where you can download the exact location of Zayo assets. A map of Zayo's infrastructure is provided below.



Town of Erie
Colorado
ZAYO Global
Network Fiber
5 MILE EXTENT

Legend

- Planned Network
- Metro Network
- Longhaul Network
- Metro Dark Network
- Longhaul Dark Network
- Enteprise Building
- Network Building
- Cell Site
- Facilities
- 5 Mile Buffer
- Street
- Town Boundary

N

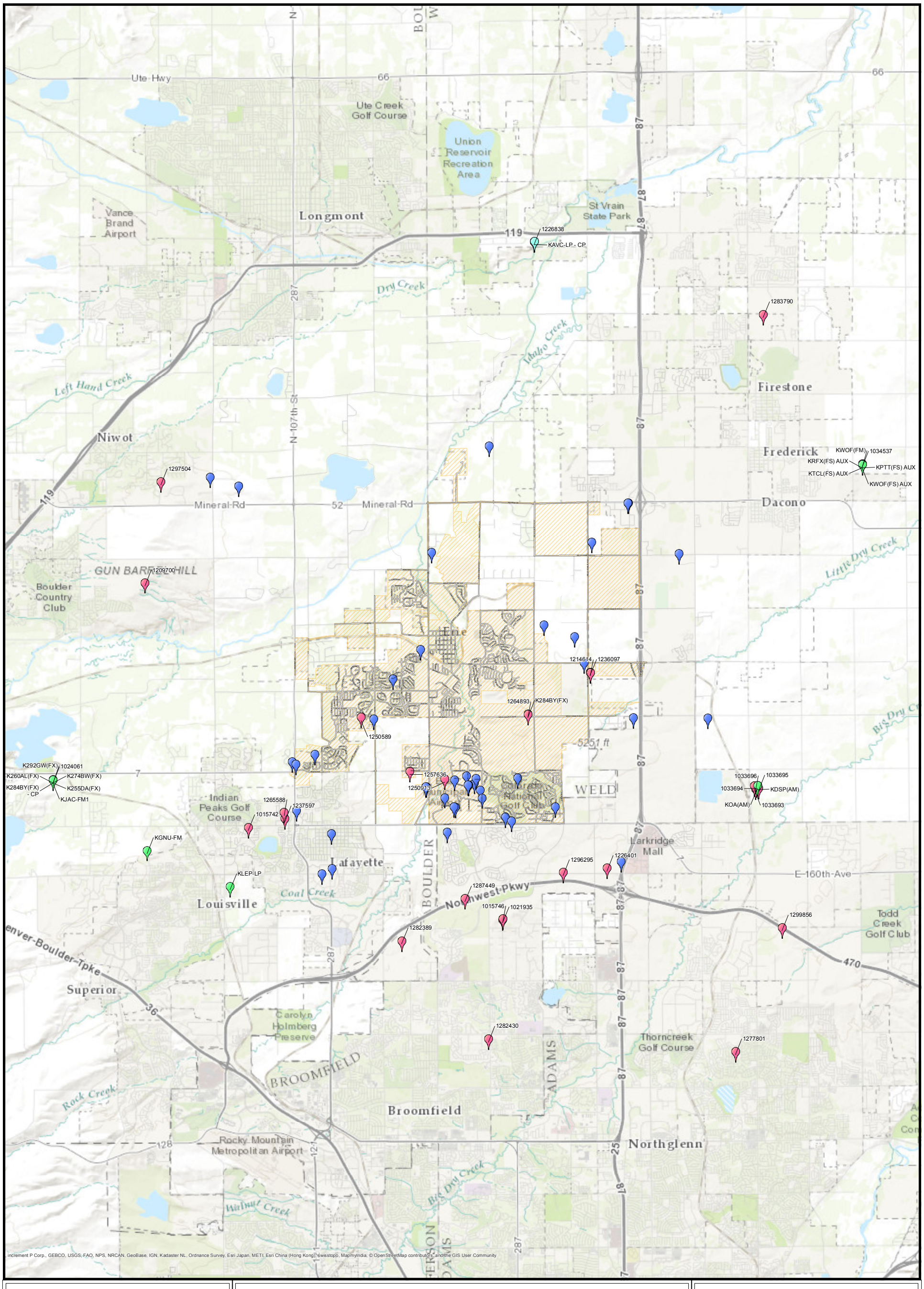
0 0.25 0.5 1 1.5 2 Miles

Date: 10/27/2017

Coordinate System: NAD 1983 HARN StatePlane Colorado North FIPS 0501 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983 HARN
False Easting: 3,000,000.0003
False Northing: 1,000,000.0000
Central Meridian: -105.5000
Standard Parallel 1: 39.7167
Standard Parallel 2: 40.7833
Latitude Of Origin: 39.3333
Units: Foot US

VantagePoint

Finally, VPS looked at tower infrastructure in Erie. The last map shows locations of existing tower sites in Erie.



Town of Erie
Colorado
FAA and FCC
Tower Sites

Legend

- FAA Database Tower Application
- FCC Database Tower (Construction Permit)
- FCC Database Tower (Tower)
- FCC Database Tower (Radio Station Tower)
- Street
- Town Boundary

N

0 0.250.5 1 1.5 2
Miles

Date: 10/31/2017

Coordinate System: NAD 1983 HARN StatePlane Colorado North FIPS 0501 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983 HARN
False Easting: 3,000,000.0003
False Northing: 1,000,000.0000
Central Meridian: -105.5000
Standard Parallel 1: 39.7167
Standard Parallel 2: 40.7833
Latitude Of Origin: 39.3333
Units: Foot US

VantagePoint EMPLOYEE OWNED

4.2 Infrastructure Gap Analysis

All of this data shows that Erie does have a fair amount of existing infrastructure. However, this infrastructure is private sector owned and not necessarily available to be leveraged. Comcast and Century Link do not provide access to their infrastructure other than to offer leased services. Zayo, on the other hand, is in the business of leasing access and Zayo has fiber in Erie. This means that Erie or a provider -partner or network operator working with Erie could potentially lease internet capacity from Zayo in a network build.

Overall, however - without a municipal electric utility, there are not many options for Erie to leverage existing network architecture.

5 Erie Survey Results

In order to assess the current and future citizen needs for broadband, VPS conducted surveys targeting residential households and businesses in Erie. The following represents a summary of the data obtained in the surveys as well as key findings from each.

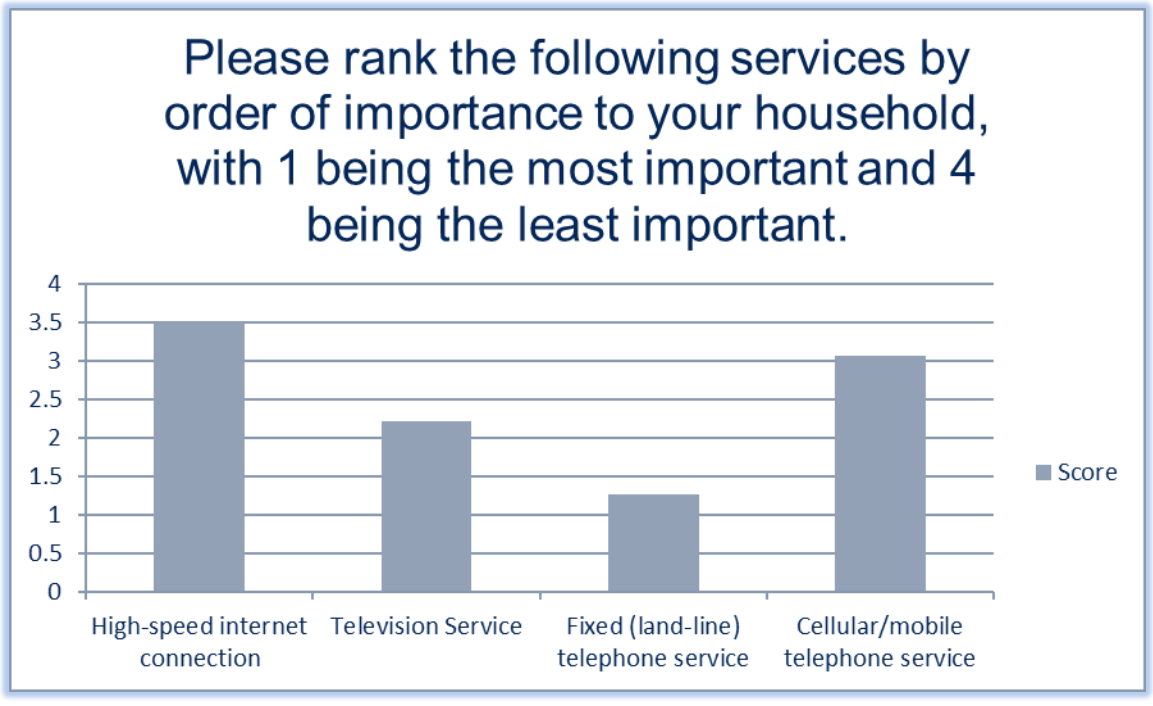
5.1 Residential

The residential survey consisted of 24 questions excluding demographic information. To solicit respondents, VPS working with National Research Center in Boulder, mailed postcards to a random sample of 3,000 households. Residents were encouraged to visit a website to complete the online survey. The same residents received a total of 3 mailings to encourage a higher completion rate. In addition, the Town publicized the survey through email lists and social media. As a result, 1,373 submitted responses to the survey.

5.1.1 Current Household Services

The first set of questions explored the type of telecommunications services purchased by residents. Almost 99% of respondents currently purchase internet service. The next most popular service is cellular telephone. Just over 70% reported purchasing television services while less than 35% still purchase traditional copper telephone landline service.

Not surprisingly, high-speed internet connection was ranked as the most important on a weighted scale with 1 being ranked as the most-important and 4 as the least important.



For television service, the most respondents purchase cable television at almost 45% with almost 42% purchasing television service through their internet connection. Just over 25% purchase satellite services with a surprising 23% receiving over-the air antenna television services. Note that a household can purchase television through multiple sources.

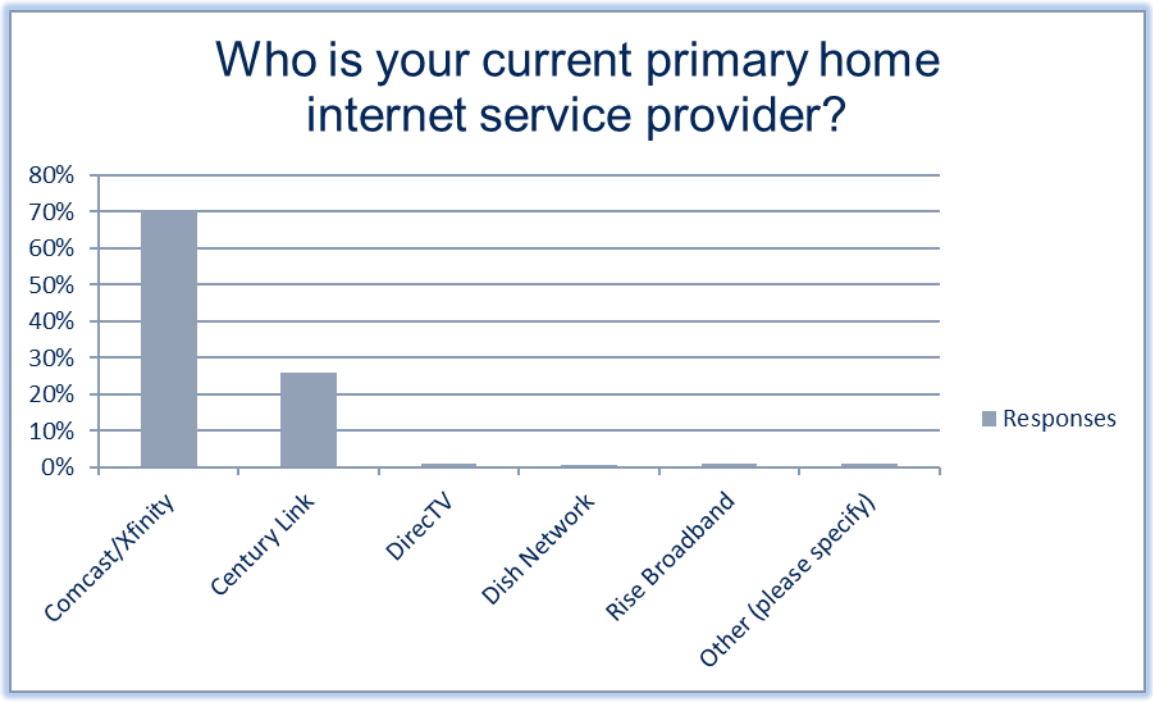
- **Key takeaway: Internet and cellular data are the most important telecommunications services purchased by residents in Erie.**

5.1.2 Current Internet Service

Survey respondents were asked several questions about their current internet service. Only 5 people out of the 1,373 respondents said that they do not purchase internet service. As a result, we will only focus on those that do.

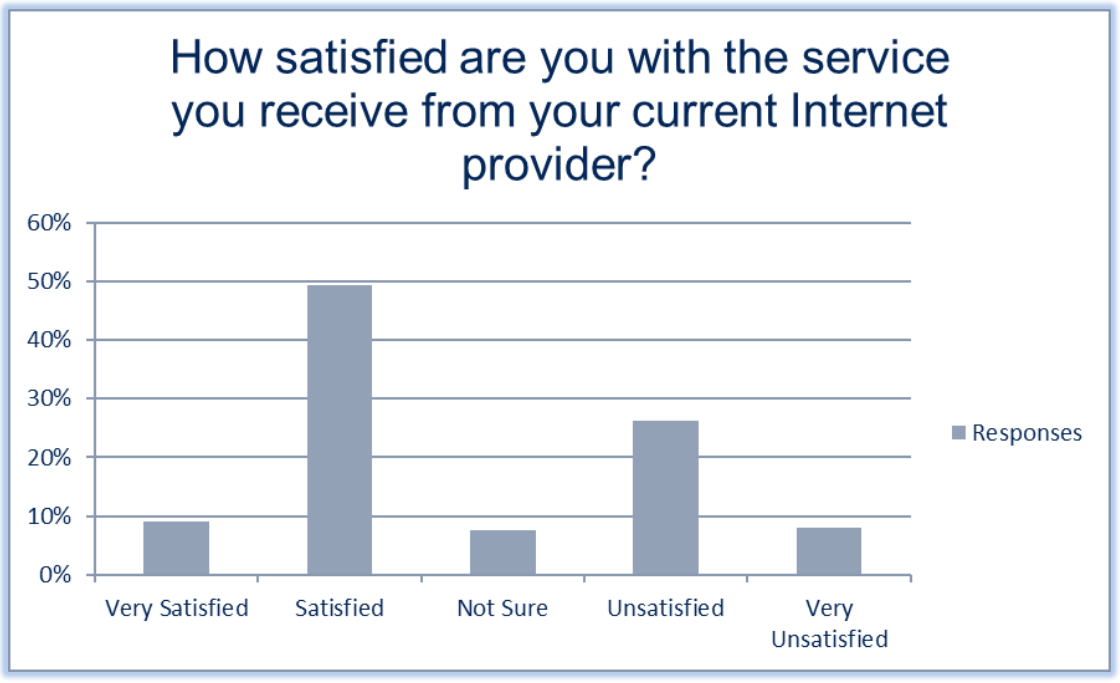
Over two-thirds of respondents currently purchase internet service through a cable modem. Almost 20% purchase internet through a DSL line while less than 10% purchase internet either through fixed wireless signal or a fiber-optic connection.

Comcast/Xfinity hold the largest market share serving over 70% of respondents. Century Link currently provides services to just over 1/4 of respondents.



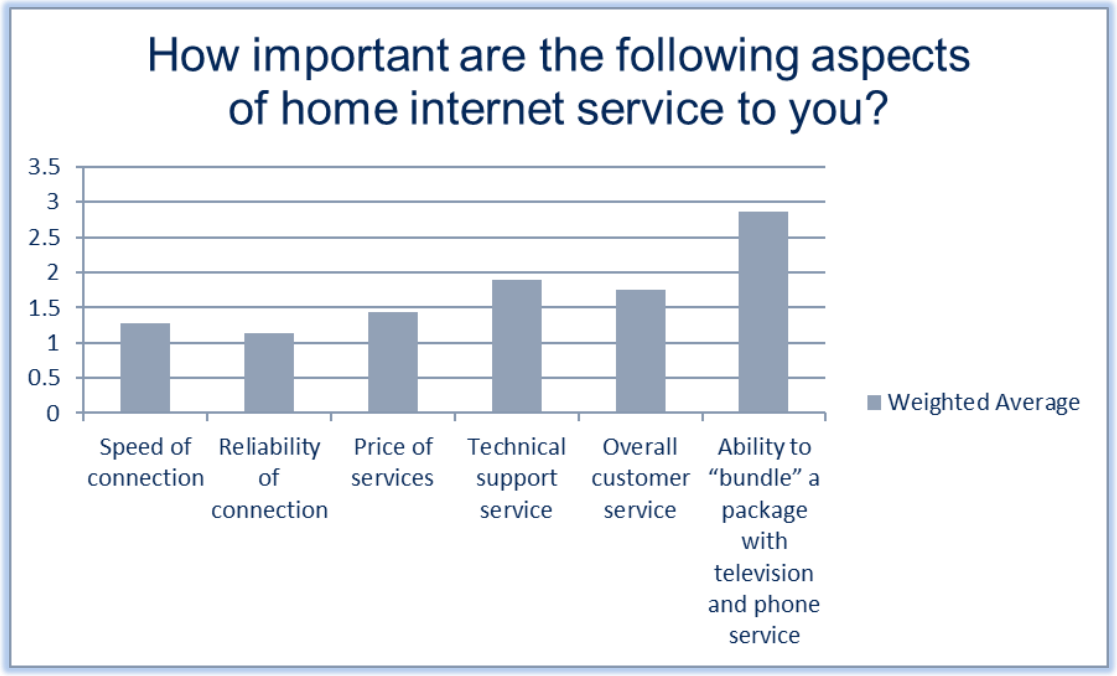
Regarding the cost of current internet service, respondents reported paying a range from less than $20 a month to over $100 a month with most paying between $40 and $80. However, over 25% reported that because they bundle services, they do not currently know how much their internet costs on a monthly basis.

The most interesting find is that almost 60% of respondents are either very satisfied or satisfied with their current internet service. Only 34% are unsatisfied or very unsatisfied. This is a particularly high-percentage of those who are satisfied, and this will directly impact the number of subscribers who would consider buying services from a new provider.



To further drill down, we asked several more questions regarding respondent's satisfaction with their current provider. On a weighted average scale, satisfaction levels were fairly constant and satisfactory regarding speed, reliability and overall customer service. However, pricing continues to be the biggest problem with almost 65% indicating that they were unsatisfied or very unsatisfied with current price of services.

Finally, we asked respondents what attributes were most important to them. On a 5 point scale from very important to very unimportant, you can see that speed and reliability are the most important aspects of home internet service. The ability to bundle services is by far the least important of all the attributes.

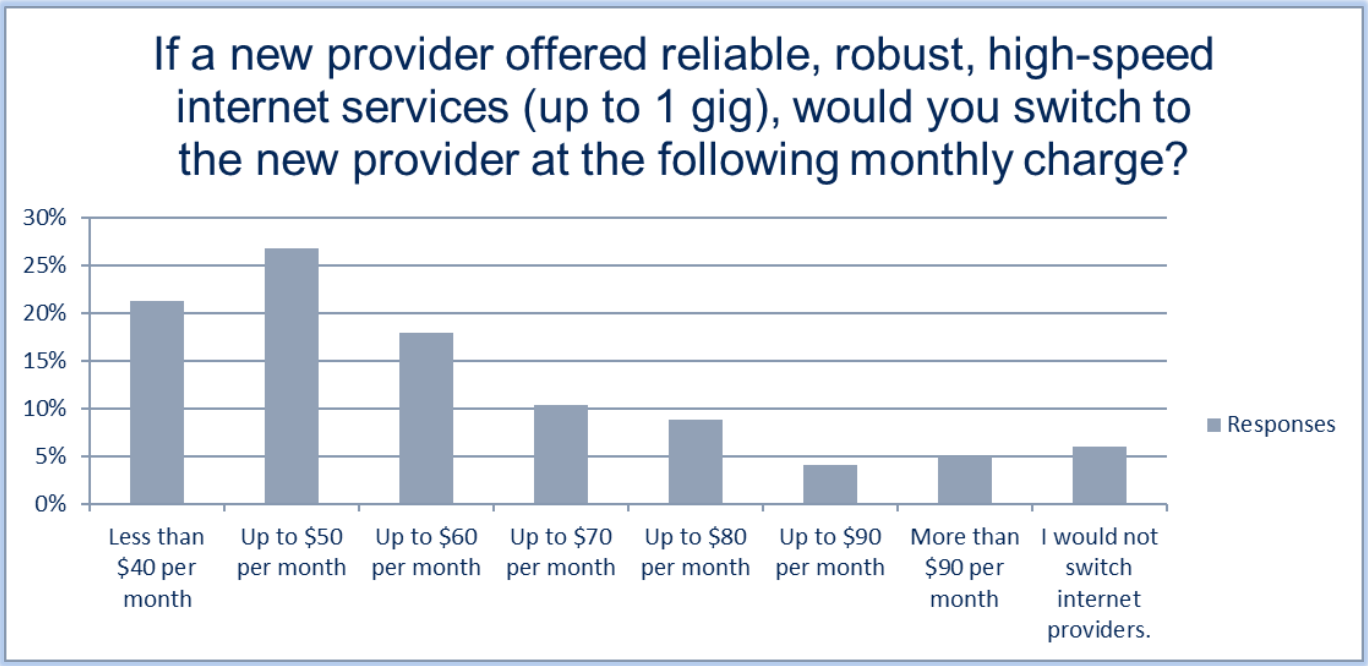


- **Key finding: Overall satisfaction level with current services provider is high. While respondents are quite concerned with the price of their current service, speed and reliability outrank price in important attributes.**

5.1.3 Reasonable Price for Internet Service

The next section of the survey asked questions focused on pricing. If a new provider came to town and could offer robust, high-speed internet service - what do respondents think is reasonable pricing? What would it take for respondents to switch internet providers?

Keeping in mind that the majority of respondents currently pay between $40-$80 a month for service, it is not surprising that two-thirds said they would consider switching for $60 or less.



In a follow-up question, over 50% stated that they consider up to $50 a month to be reasonable. Only 26% thought that over $70 a month was affordable.

Since many network providers need to charge some sort of one-time hook-up fee to help offset connection costs, respondents were asked how much they would be willing to pay if such a fee were required. Almost 20% said they would not pay a fee while 70% felt that up to $100 would be considered reasonable.

- **Key Finding: Price is a big concern for residents and it would be a risk for a new provider to offer more than $70 a month for gigabit and charge more than $100 for a one-time connection fee.**

5.1.4 Television Service

Due to the fact that broadcast retransmission rates are so high, television service is not a money-maker for a provider. However, over the last few years it has been viewed as a service necessary in order to retain subscribers. With cord-cutting gaining in popularity – it is important to understand how important television is as a service offering.

The good news is only just over 12% of respondents said that they would not be likely to switch providers if they could not also get television services. And while approximately 25% of Erie respondents still bundle their television, phone and internet – almost 70% said bundling is not important.

As a side note, Longmont originally offered only internet services. In 2017, they begin offering internet television service through a partner. It is unclear whether television service was needed to help retain subscribers or if they just wanted to add an additional service.

- **Key Finding: Traditional television is waning in popularity as more people turn to internet streaming for television. Bundling of services is no longer as important. However, television is not obsolete and may still be**

needed as a service to help drive subscription rates. This is something that should be discussed with any provider-partners.

5.1.5 Municipal role in broadband

The last question provided respondents with 5 options regarding what they thought the role of the Town should be in ensuring better broadband in Erie. The raw data is as follows:

To what extent do you agree/disagree with the following?					
	Strongly Agree	**Agree**	**Not Sure**	**Disagree**	**Strongly Disagree**
The Town should finance and build a municipal-owned broadband network to either directly or indirectly provide broadband services for schools, government agencies and other institutions only.	14.98%	17.26%	25.16%	25.81%	16.78%
The Town should finance and build a municipal-owned broadband network to either directly or indirectly provide broadband services for institutions, homes and businesses.	37.23%	25.14%	21.17%	9.65%	6.81%
The Town should not finance or build a network but should try to work with providers to improve broadband in Erie.	16.08%	20.73%	27.76%	19.10%	16.33%
The Town has a role in improving broadband services but you aren't sure what the Town should do.	8.70%	31.34%	26.58%	20.92%	12.47%
Current providers are meeting the need for broadband in Erie and there isn't a need for the Town to do anything.	3.17%	8.94%	21.54%	30.65%	35.69%

On average, just over a quarter of respondents are not sure about any of the options. However, over 65% do not believe that current providers are meeting the needs in Erie. In addition, just over 60% are supportive of a town-financed municipal network that serves homes and businesses. A caveat here to keep in mind is that residents were not presented with any cost information.

- **Key Finding: Residents are strongly supportive of the Town having a role in solving the broadband challenges in Erie.**

5.2 Business

Working with the Chamber of Commerce, VPS conducted an informal business survey. The Chamber sent the survey link to their members and 16 business completed the survey.

The bulk of the companies that responded are small businesses in the professional services field with less than 4 employees. Over half of the companies are home-based businesses. Teleworking is a big part of the culture of these companies.

Over 60% are operating their business utilizing a cable modem with 25% purchasing a DSL service. Similar to the residential service, the breakdown is that almost 70% subscribe to Comcast with 25% purchasing services from Century Link. It could be inferred that the Century Link subscribers are the ones purchasing a DSL service – which utilizes a copper line and not a coaxial cable or fiber-optic.

Almost half pay between $100-$400 a month, with 25% paying between $75-99 dollars. The bandwidth packages range from 10mpbs to 100mpbs with over 12% unsure of what speed they are getting.

Not surprisingly, over half of the business customers are very unsatisfied or unsatisfied. They are paying much more than residential customers for less bandwidth. Almost three-quarters of respondents are likely or extremely likely to switch providers.

Unlike the residential customers, the business customers would be willing to pay much more for better service. Almost half would pay up to $100/month while over 37% would be willing to pay between $200-$500 a month.

In addition, business customers would also be more willing to pay a higher one-time hookup fee. Even 6% said they would be willing to pay $1,000.

- **Key Finding: The business options for small businesses in Erie are lacking in price sensitivity and bandwidth availability.**

6 Potential Erie Models

VPS developed multiple network models (including last-mile and middle-mile networks) providing a variety of options for broadband deployment in Erie. Each of these options is detailed below. It should be noted that the estimates provide a high-level capital cost estimates only for the design and construction of a fiber-optic network.[5] In addition, these models do not consider the operational structure (network operator to run and manage the network) that would be needed to support each network option. Operational structures will be discussed in Section 8.

As a side note, any network options considered here would require the Town to overturn the SB 152 restriction with a referendum ballot vote.

For each model detailed in this section, we provided estimates for a build that is 100% underground. VPS made the following basic assumptions for each model:

- RF or IP video expenses, switching costs, data network equipment, or transport to exchange fees are not included;
- Assumes serving all locations from an existing building in Erie;
- Assumes a 100% fiber-optic infrastructure[6];
- Estimates include engineering fees or taxes;
- Electronics & fiber management costs assume GPON (type of equipment);
- Does not include any costs for right-of-way acquisitions;
- Outside Plant (OSP) costs do not include any additional fees for construction in rocky soil conditions (this is TBD determined).

We have also provided a Key to understanding the terminology and reading the models.

Terminology		Description
	CO Electronics	This includes the electronics, spares, miscellaneous materials needed for network operations, installation, and Optical Network Terminals (ONTs) that are attached to each premise. Installation 10% means that it costs roughly 10% of the cost of equipment.
	ONTs	
	ONT Installation	
OSP		OSP stands for Outside Plant
	Cable	This includes the cost of the fiber, conduit, miscellaneous materials needed for the construction of the network. Drops refers to the cost of fiber drops to each premise. These cost estimates also include the cost of construction (labor) and engineering.
	Drops	
	Fiber Management	
Number of Households		Number of housing and premises included in the network design

[5] Note: VPS was not tasked to develop a full business plan around one or all of the models at this phase of the project. We do not recommend conducting a business plan until a network design and operating model are selected. This may or may not include the selection of a provider to manage the network.

[6] Wireless technology such as microwave (point to point or fixed wireless) was not considered in the development of these models. For residential networks in more dense and suburban areas, wireless is more limited and does not provide for growth. The engineering phase would determine if and where it would be appropriate to consider wireless.

Mainline miles	This refers to miles of backbone built
Mainline miles	This refers to miles of drops direct from the backbone to the customer premise

6.1 Middle-Mile Option

The middle-mile option for Erie is the most cost effective of all the self-funded network options. While a middle-mile network would not directly connect or provide residential or commercial services, the proposed middle-mile network in Erie could span a maximum total of 24.5 miles, and directly connect a maximum of 18 facilities.

This list includes the following facilities and schools:

- Erie Town Hall
- Erie South Water Reclamation Facility
- Erie Community Center
- Leon A. Wurl Service Center
- Erie Water Treatment Facility
- Erie North Water Reclamation Facility
- Erie Municipal Airport
- Erie Police Department & Municipal Court Building
- Mountain View Fire & Rescue – Erie Station 6
- Mountain View Fire & Rescue – South Erie Station 8
- Black Rock Elementary (SVVSD)
- Erie Elementary (SVVSD)
- Erie Middle (SVVSD)
- Erie High School (SVVSD)
- Aspen Ridge (SVVSD)
- Red Hawk Elementary (SVVSD)
- Meadowlark PK-8 School
- Erie Community Library

As an alternative, the middle-mile network could connect only the 8 town facilities or even none at all. In evaluating these options, the Town would need to conduct a cost-benefit analysis. For example, would it be more cost effective for the Town to build and operate a network (with the assistance of a network operator) rather than pay Comcast an annual lease rate of approximately $54,000 a year? In cities or communities with more anchor institutions, the benefits of removing the lease costs are much more substantial.

In addition, as a part of this analysis, the Town would need to engage in detailed discussions with the School Districts and the Fire Districts to determine interest level of those facilities being part of the network. Often, school districts pool resources and utilize E-Rate[7] subsidies from the federal government to offset costs.

The below detail provides an overview of the breakdown of the costs to build a middle-mile network serving 18 facilities. The cost would drop slightly depending on the actual number of facilities that would be connected.

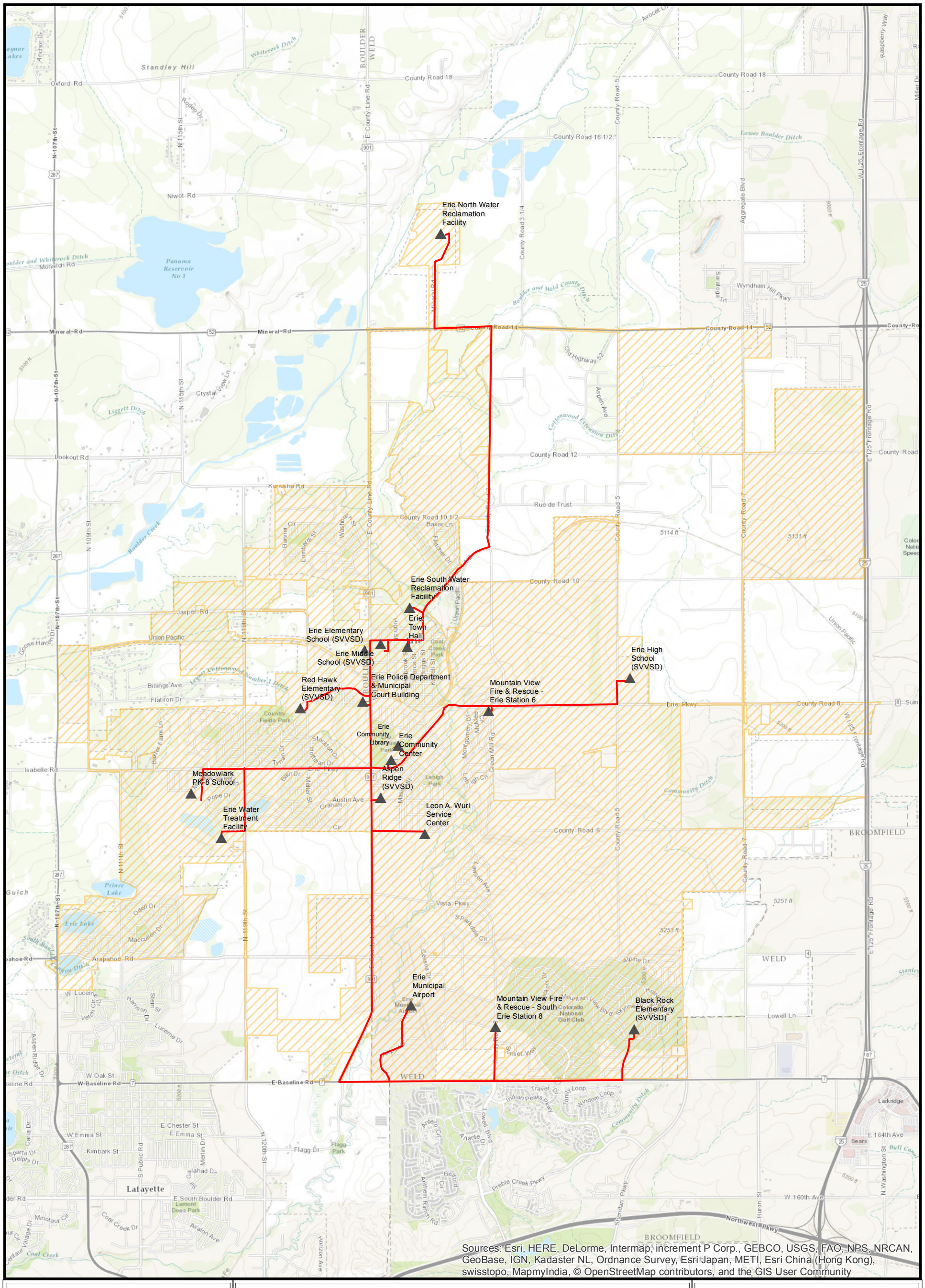
[7] A federal program that provides subsidies to schools and libraries based on the percentage of students in the district that receive free and reduce meals. In some districts, this savings is substantial.

Item	Cost
Electronics	$31,000
OSP	$3,125,000
Total Cost	$3,156,000
Total Miles	24.5

A middle-mile network retains some benefits even if it does not connect to any sites. Of course, the more users – the more beneficial the network would be to the Town. The real benefit of a middle-mile network is that the excess fiber and conduit capacity can be leased for revenue and to enable providers to more cost-effectively invest in last-mile infrastructure to reach homes and businesses. Under this option, there could potentially be over 20 route miles of cable and conduit that could be leased – excluding the fiber drops to connect Town facilities or anchor institutions from the backbone.

In addition, the middle-mile network would provide the backbone connectivity needed for any of the last-mile network options. As such, each of the last-mile models below include the costs of building out the middle-mile network model as described above.

Please note, as depicted on the map, the Town owns and maintains the fiber run from the South Water Reclamation Facility to the North Water Reclamation Facility. The below map shows what this middle-mile network would potentially look like.



Town of Erie Colorado Facilities and Routing

Legend

- Facilities
- Middle Mile Route
- Town Boundary

N

0 0.125 0.25 0.5 0.75 1 Miles

Date: 10/4/2017

Coordinate System: NAD 1983 HARN StatePlane Colorado North FIPS 0501 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983 HARN
False Easting: 3,000,000.0003
False Northing: 1,000,000.0000
Central Meridian: -105.5000
Standard Parallel 1: 39.7167
Standard Parallel 2: 40.7833
Latitude Of Origin: 39.3333
Units: Foot US

VantagePoint

6.2 Last Mile; FTTP across Erie

The first thing to note is that unlike Erie's neighbor to the North – Longmont – Erie does not have a municipal electric utility. This means that Erie does not own an existing network of utility pole assets that could be leveraged to significantly offset and lower construction deployment costs. In addition, most of Erie's utilities are underground except for a small area in Historic Erie. As such, deployment costs are going to be the most expensive for a FTTP network in Erie because it must be built greenfield and it must be built underground.

The first set of last-mile network models developed detail the costs for a full FTTP network across Erie with 3 different penetration rates. Penetration rates refer to the percentage of households connected or passed by the network. Penetration does not equal subscriber percentages – only the percentage of households that could potentially subscribe to the network.

These options include:

- A FTTP network deployed to 100% the premises;
- A FTTP network deployed to 60% of the premises;
- A FTTP network deployed to 30% of the premises.

The following chart summarizes the total estimated costs of the three FTTP options.

	100% Penetration	60% Penetration	30% Penetration
OSP and Electronics Cost	$43,426,000	$36,896,000	$31,156,000
# of Households passed	8986	5392	2696

As you can see, there is a $12,270,000 difference between the network that reaches 30% of the premises and one that reaches all premises constructed 100% underground.

To analyze the difference between what 100% and 30% penetration means you have to consider take rates. Although take rates – or subscriber penetration varies greatly from project to project, it is common to achieve between 30% to 60% in areas where existing broadband speeds are lacking. As discussed in Section 5.1.2, current satisfaction rates with existing provider service is high at almost 60% - thus take rates for Erie generally, are estimated to be between 30-35%. Of course, by reducing the number of homes passed (building to 30% or 60% penetration), you are also greatly reducing the number of potential subscribers to the network. The fewer subscribers, the less revenue that is generated to offset the deployment costs. It is also very difficult to determine which 30% or 60% may be the most interested in subscribing to the network ahead of time.

For this reason, many networks utilize a technique called Demand Aggregation. Demand aggregation refers to a deployment strategy wherein residents are encouraged to commit to sign up for service and many even be required to pay a small fee ($10-$20). When the percentage of residential sign-ups in an area reaches 60% or greater, construction commences in that neighborhood. This enables a network to find the most interested subscribers and bring in revenue in high-subscription areas before building out the entire system. Google utilized this technique very effectively in their buildout strategy by establishing Google "Fiber-hoods". In essence, this technique enables a phased-in construction plan with the goal of achieving 100% penetration in steps.

The full details and assumptions for each of these three network options are provided on the following pages.

Town of Erie	
PROPOSED FTTP HIGH LEVEL ESTIMATE - 100% PENETRATION	
CO Electronics	**Buried**
CO Electronics	**$1,213,000**
Installation (10%)	**$122,000**
ONTs	**$3,624,000**
ONT Installation	**$2,013,000**
OSP	
Cable	**$26,802,000**
Drops	**$8,627,000**
Fiber Management	**$1,025,000**
Total	**$43,426,000**
Mainline Miles	211.5
Drops Miles	306.3
Total Miles	**517.8**
Total Subscribers	**8,986**

Assumptions:

- **Subscriber counts based on "Residential Development Conditions" Complete and Near Complete data.**
- **Assumes residential subscribers and "Erie Facilities".**
- **Last Mile costs include costs to serve Middle Mile.**
- **Does not include RF or IP video expenses, switching costs, data network equipment, or transport to exchange.**
- **Installation estimated at 10% of equipment.**
- **Assumes serving all locations from 5 existing CO buildings. Therefore, no building or land costs are included.**
- **Assumes 100% penetration.**
- **Estimates include engineering and overhead.**
- **Electronics & fiber management costs assume GPON.**
- **Does not include any costs for right-of-way acquisitions.**
- **OSP costs do not include any costs for rocky soil conditions.**
- **OSP costs assume all buried construction.**
- **Drop costs assume 180' buried drop.**

Notes:

We make every attempt to have our estimates be within +/- 10% of the actual project cost, which is normally the case. However, it is still an estimate, there are many factors outside of our control that could result in the actual cost differing by more than 10%, such as material or labor charges, design changes since estimate, inflation, construction delays, etc. Please keep this in mind when budgeting for this project.

These are estimates of the total project costs and do not consider any limitations due to the FCC's Capital Investment Allowance (CIA). Please contact Vantage Point if you would like assistance determining your CIA limits.

Town of Erie	
PROPOSED FTTP HIGH LEVEL ESTIMATE - 60% PENETRATION	
CO Electronics	**Buried**
CO Electronics	**$735,000**
Installation (10%)	**$74,000**
ONTs	**$2,175,000**
ONT Installation	**$1,208,000**
OSP	
Cable	**$26,802,000**
Drops	**$5,177,000**
Fiber Management	**$725,000**
Total	**$36,896,000**
Mainline Miles	211.5
Drops Miles	183.8
Total Miles	**395.3**
Total Subscribers	**5,392**

Assumptions:

- **Subscriber counts based on "Residential Development Conditions" Complete and Near Complete data.**
- **Assumes residential subscribers and "Erie Facilities".**
- **Last Mile costs include costs to serve Middle Mile.**
- **Does not include RF or IP video expenses, switching costs, data network equipment, or transport to exchange.**
- **Installation estimated at 10% of equipment.**
- **Assumes serving all locations from 5 existing CO buildings. Therefore, no building or land costs are included.**
- **Assumes 60% penetration.**
- **Estimates include engineering and overhead.**
- **Electronics & fiber management costs assume GPON.**
- **Does not include any costs for right-of-way acquisitions.**
- **OSP costs do not include any costs for rocky soil conditions.**
- **OSP costs assume all buried construction.**
- **Drop costs assume 180' buried drop.**

Notes:

We make every attempt to have our estimates be within +/- 10% of the actual project cost, which is normally the case. However, it is still an estimate, there are many factors outside of our control that could result in the actual cost differing by more than 10%, such as material or labor charges, design changes since estimate, inflation, construction delays, etc. Please keep this in mind when budgeting for this project.

These are estimates of the total project costs and do not consider any limitations due to the FCC's Capital Investment Allowance (CIA). Please contact Vantage Point if you would like assistance determining your CIA limits.

Town of Erie	
PROPOSED FTTP HIGH LEVEL ESTIMATE - 30% PENETRATION	
CO Electronics	**Buried**
CO Electronics	**$375,000**
Installation (10%)	**$38,000**
ONTs	**$1,088,000**
ONT Installation	**$604,000**
OSP	
Cable	**$26,802,000**
Drops	**$2,589,000**
Fiber Management	**$499,000**
Total	**$31,995,000**
Mainline Miles	211.5
Drops Miles	91.9
Total Miles	**303.4**
Total Subscribers	**2,696**

Assumptions:

- **Subscriber counts based on "Residential Development Conditions" Complete and Near Complete data.**
- **Assumes residential subscribers and "Erie Facilities".**
- **Last Mile costs include costs to serve Middle Mile.**
- **Does not include RF or IP video expenses, switching costs, data network equipment, or transport to exchange.**
- **Installation estimated at 10% of equipment.**
- **Assumes serving all locations from 5 existing CO buildings. Therefore, no building or land costs are included.**
- **Assumes 30% penetration.**
- **Estimates include engineering and overhead.**
- **Electronics & fiber management costs assume GPON.**
- **Does not include any costs for right-of-way acquisitions.**
- **OSP costs do not include any costs for rocky soil conditions.**
- **OSP costs assume all buried construction.**
- **Drop costs assume 180' buried drop.**

Notes:

We make every attempt to have our estimates be within +/- 10% of the actual project cost, which is normally the case. However, it is still an estimate, there are many factors outside of our control that could result in the actual cost differing by more than 10%, such as material or labor charges, design changes since estimate, inflation, construction delays, etc. Please keep this in mind when budgeting for this project.

These are estimates of the total project costs and do not consider any limitations due to the FCC's Capital Investment Allowance (CIA). Please contact Vantage Point if you would like assistance determining your CIA limits.

6.3 Last-Mile; FTTP to Under-served Neighborhoods

The next set of last-mile network models explore the costs for deploying a middle-mile network plus an FTTP network to select neighborhoods in Erie. The benefit of this approach would be to maximize monetary resources by building to only those areas that are more in need of high-speed broadband access.

As discussed previously, there are 4 neighborhoods that are currently under-served. These neighborhoods are:

- Kenosha Farms
- Northridge
- Historic Erie
- Erie Village

Similar to the FTTP models for all of Erie, below we have broken out the costs by 100%, 60% and 30% penetration for each neighborhood. The first table provides a summary of the FTTP deployment to 100% of the households in each neighborhood. The full detail for each of the neighborhoods can be found in Appendix B

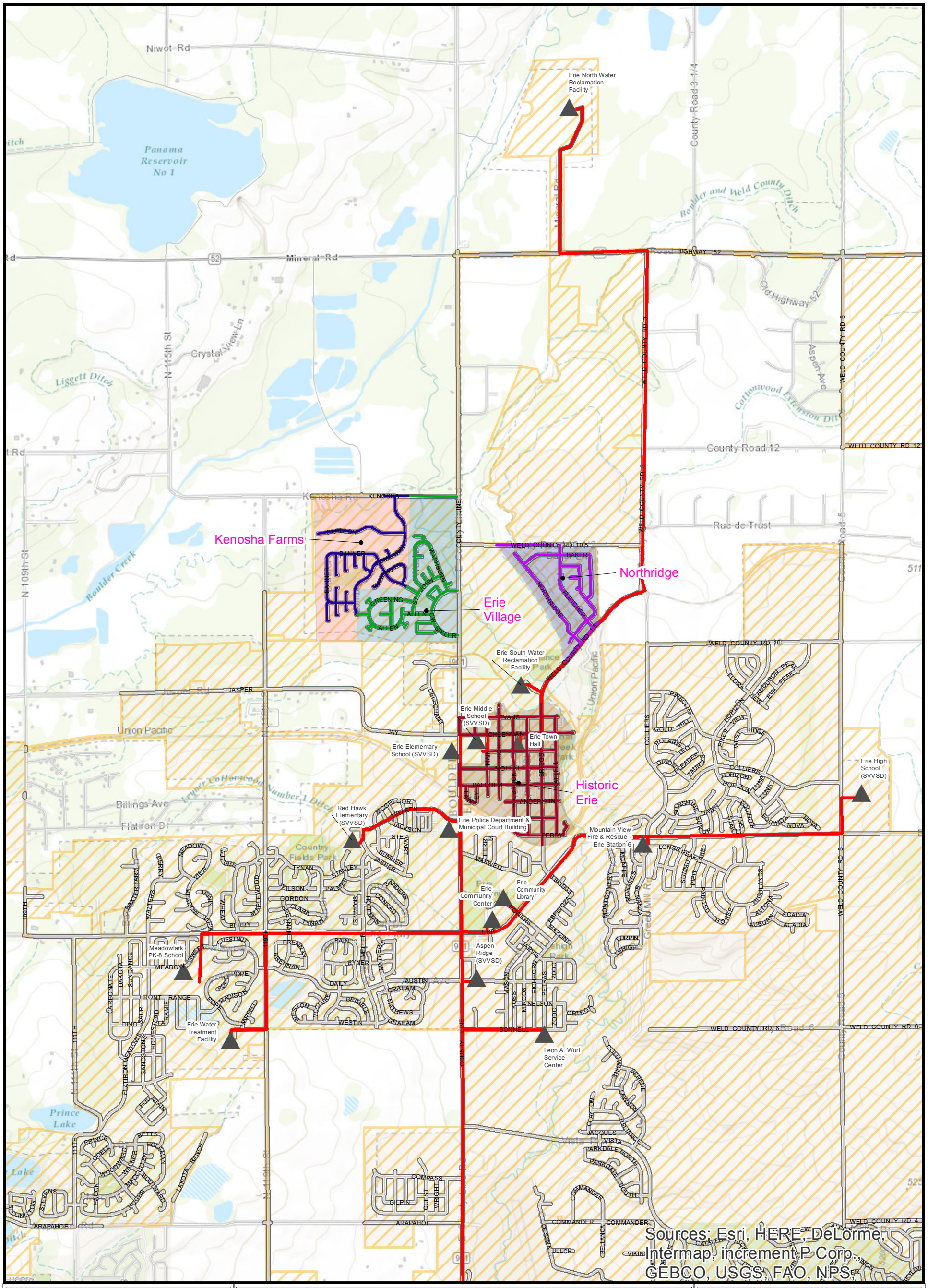
100% Penetration

Neighborhood	Households	OSP/Electronics Cost	MM Cost	Total Cost
Kenosha Farms	280	$1,077,000	$3,156,000	$4,233000
Northridge	181	$812,000	$3,156,000	$3,968000
Historic Erie	628	$2335,000	$3,156,000	$5,491000
Erie Village	420	$1,335,000	$3,156,000	$4,491000
All 4 neighborhoods	**1509**	**$5,559,000**	**$3,156,000**	**$8,715,000**

As you can see, the cost for building out to all 4 under-served neighborhoods is $8,715,000. The individual neighborhood costs each include the cost of the middle-mile as if it were a stand-alone project. Of course, the middle mile costs are only attributed once so the more neighborhoods built, the more cost-effective those builds are.

While the take rates will average between an estimated 30-35% for all of Erie, the take rates in these four locations are estimated to be higher due to the lack of service options that currently exist.

The below map shows what a potential network would look like.



Town of Erie
Colorado
Split Area
Mileage and
Location Counts

Legend

- Erie Village Roads - 3.36 Miles
- Historic Erie Roads - 7.22 Miles
- Kenosha Farms Roads - 3.36 Miles
- Northridge Roads - 2.86 Miles
- Erie Village - 420 Loc.
- Historic Erie - 628 Loc
- Kenosha Farms - 280 Loc
- Northridge - 181 Loc
- Facilities
- Middle Mile Routes
- Streets
- Town Boundary

N

0 0.125 0.25 0.5 0.75 1 Miles

Date: 11/28/2017

Coordinate System: NAD 1983 HARN StatePlane Colorado North FIPS 0501 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983 HARN
False Easting: 3,000,000.0003
False Northing: 1,000,000.0000
Central Meridian: -105.5000
Standard Parallel 1: 39.7167
Standard Parallel 2: 40.7833
Latitude Of Origin: 39.3333
Units: Foot US

VantagePoint

The next 2 tables provide a summary of the FTTP deployment to 60% and 30% of the households in each neighborhood.

60% Penetration

Neighborhood	Households	OSP/Electronics Cost	MM Cost	Total Cost
Kenosha Farms	168	$873,000	$3,156,000	$4,029,000
Northridge	109	$690,000	$3,156,000	$3,846,000
Historic Erie	377	$1,878,000	$3,156,000	$5,034,000
Erie Village	252	$1,032,000	$3,156,000	$4,188,000
All 4 neighborhoods	**906**	**$4,473,000**	**$3,156,000**	**$7,629,000**

30% Penetration

Neighborhood	Households	OSP/Electronics Cost	MM Cost	Total Cost
Kenosha Farms	84	$714,000	$3,156,000	$3,870,000
Northridge	55	$584,000	$3,156,000	$3,740,000
Historic Erie	189	$1,528,000	$3,156,000	$4,684,000
Erie Village	126	$801,000	$3,156,000	$3,957,000
All 4 neighborhoods	**454**	**$3,627,000**	**$3,156,000**	**$6,783,000**

Below is a summary of what it cost to build to all 4 neighborhoods by penetration including the middle-mile for each.

Summary by Penetration for all Neighborhoods

Penetration	Households	OSP/Electronics Cost	Total Cost
100%	1509	$5,559,000	$8,715,000
60%	906	$4,473,000	$7,629,000
30%	454	$3,627,000	$6,783,000

As you can see, the costs are not significantly less to build out to 30% of the households vs. 100%. However, the number of potential subscribers decreases substantially. As a result, it does not make much sense to build out to less than 100% of the households per neighborhood for this model. As previously discussed, demand aggregation techniques could be utilized in this model as well to encourage sign-ups per street and/or per neighborhood for a more phased-in approach.

A few other things to consider with this model are as follows:

- This is a significant investment for a maximum of 1509 households. If you conservatively assume a take rate of 40% - the question becomes whether this model could support a return on investment. This question would be answered during the business plan phase.
- This model could be used to jump start expanding services into other neighbors.

6.4 Last-Mile Operational Costs

The prior data provided high-level capital costs for the deployment of different FTTP network options. This was developed to provide a high-level estimate of the capital cost of network design, engineering, electronics, materials and construction for each model. If and when a model is selected, the next phase would be to develop a full business and financial that would include operating costs. Since this has not been done yet, we wanted to provide a rough overview of what operating costs look like for a FTTP Network.

Operating costs for a FTTP network include the following items:

- Personnel expenses – network, customer service, corporate;
- Operational vehicles;
- Electronics and equipment warranty and support
- Insurance;
- Electricity/utilities;
- Transport/bandwidth cost;
- Marketing/billing systems;
- Professional services - legal/consulting/accounting;
- Depreciation;
- Maintenance.

Based on VPS experience in developing business plans for providers across the country, below are some examples of what we have seen in terms of operating costs.

Example 1: Operating costs range from $1,000 - $6,000 Per Mile/Per Month. For Erie this could mean:

- Middle Mile network of 24 miles: Operating Costs of $24,000 - $144,000.
- FTTP Network of 118 miles: Operating costs of $118,000 - $708,000

Example 2: Operating costs range from $95 - $155 per location/per month. For Erie this could mean:

- Middle Mile Network connecting 18 facilities. Operating costs of $1,710 - $2,790
- FTTP Network of 8,900 subscribers. Operating costs of $845,000 - $1,3795,000

Of course, a full Business and Financial Plan would pinpoint the exact costs and include:

- **10 Year Forecast**
    - Estimated market penetration, service offering rates and information
    - Capital expenditure costs and depreciation
    - Balance sheet, income statement (operating revenues, expenses) and cash flows

- **Forecasted financial Schedule**:
    - Projected Balance Sheet
    - Projected Income Statement
    - Projected Cash Flow

    - Projected Rate of Return (ROR) on Investment

- **Projected Capital Expenditures -** Detail the cost of the property plant, equipment and real estate as needed, to provide service over the years of the plan for the customers anticipated.

- **Projected Depreciation Schedule –** Detail the depreciation expense on investments. Rates would be based upon regular business practices and industry standards.

- **Projected Personnel Expense -** Determine positions, salaries and total personnel expense needed.

- **Projected Operating Expenses** – Detail necessary operational expenses including but not limited to: network operations, contracted inside wiring, leased facilities, billing, maintenance, and various other corporate, legal, accounting, marketing and customer operating expenses, will be detailed in the business plan.

The full business plan will also determine the pricing for offerings such as video, phone, and broadband services. Pricing of services should not be developed without a business plan.

6.5 Public-Private Partnership (PPP)

All of the network models discussed in Section 6, could potentially serve as the basis for a PPP. While a PPP is difficult to establish, Erie may have some potential options. Based on preliminary discussions, there is at least one ISP that would be interested in investing in **a Partial FTTP network model** that would include a public WiFi option. The public WiFi option discussed would be for the specific purpose of enhancing broadband capabilities in the Historic Downtown Business District inclusive of Coal Creek Park.

Some ISPs would prefer to own their own infrastructure -including the middle-mile backbone in order to control the infrastructure. On the other hand, other ISPs need the municipality to build the middle-mile to offset deployment costs.

Before considering issuing an RFI, the Town should first meet with ISPs individually. Based on the meetings, the Town can determine whether to issue an RFP that could include:

- Level of financial investment;
- Speed to market;
- Public-WiFi offering;
- Middle-Mile network requirement;
- Ownership/Operating model;
- Other services.

6.6 Wireless Infrastructure Deployment

From the results of this study, it is clear that Erie has some considerable wireless (LTE) challenges as well. While not part of the scope of this project, it is important to provide a brief discussion.

Driving around Erie it is obvious that there are significant gaps in LTE coverage. Notably – areas where a cell phone cannot get any service. Not only is this a challenge for residents, it is a public safety concern and impacts the quality of life of residents and visitors. This issue also came up repeatedly in the survey and during the outreach meetings. One resident in

the outreach meetings said that to make a phone call, she has to stand in the middle of her living room and not move. But other times, that doesn't work, and she must walk outside and keep walking until she picks up a signal.

This indicates that there may be a need for more cell towers and more wireless technology to be deployed by the carriers. It is unlikely that wireless carriers will address these issues on their own, or through encouragement only by the Town. However, there are some things that the Town can do to begin to address this problem.

- Conduct a RF engineering wireless feasibility study; this will help identify the exact locations where a tower or monopole would be needed to help improve wireless coverage. The list of tower locations that were pulled as a part of this project shows some gaps, however until an RF engineering analysis is conducted – it will not possible to pinpoint the exact locations of where facilities should be placed.
- Consider investing in building the towers needed as identified by the RF engineering study.
- Meet with the wireless carriers (AT&T, T-Mobile, Sprint and Verizon) to determine if the town were to invest in towers, if they would place equipment on them.
- Plan to deploy fiber to the towers as a part of the network design. Wireless technology/towers need to be connected to a fiber network. This can be done as part of a Middle-Mile network as previously discussed or a stand-alone piece that is part of this wireless infrastructure strategy.

While the wireless carriers are unlikely to invest in their own towers, they may very well be willing to collocate on towers constructed by the Town. An added benefit of course is that the Town would be able to generate revenue from space leased by the carriers.

A very rough estimate of costs for these items are as follows:

Item	Cost
RF Engineering Study	$75,000
Tower Deployment (engineering and construction)	$100-250,000 per tower depending on type of tower
Fiber connecting the towers	TBD – It would depend on the network design and if this would be part of larger middle-mile network.
Potential Revenue Generated	A rough estimated would be $1500 -$2500 per month per carrier per tower depending on how much space is leased on the tower and ground.

Improving the wireless infrastructure in Erie can be done as a stand-alone project if the Town determines not to move forward with any of the broadband network models previously discussed.

6.7 Policy Incentives

The question with incentives is whether the Town can improve broadband without making any infrastructure investments. In other words, is there anything the Town can do to encourage the providers to improve service. As stated previously, the majority of the Town of Erie is well served in terms of internet deployment. This is especially true of the newer neighborhoods. Only a few of the older neighborhoods are under-served. That said, while encouragement alone is very unlikely to result in any significant improvements, there may be some best-practices enhancements that the Town can consider.

For example, Is the Town engaged in best-practices that could assist in broadband deployment? Examples include:

- Clear and transparent permitting requirements and process overviews that are easily accessible online for providers.
- Inter-departmental coordination to ensure that departments are working together on public or private land-development projects, permit applications, and other projects.
- Work with land developers to encourage a plan for telecommunications facilities when they are looking to develop a new residential community and ensuring that providers are meeting with the developer before any construction commences.
- Ensuring that telecommunications infrastructure is a part of any short and long/term planning by the Town.

7. Funding and Financing

Once a network model and operating structure have been determined, it is recommended to complete a sound business plan that includes costs, revenue projections and a financing plan. It is also recommended that the full plan be completed in coordination with any financial contributors or provider- partners.

A key component in developing that business plan is to identify all funding sources and identifying funding gaps. This last section briefly discusses possible funding options for municipalities separate from any private-sector partners.

7.1 Self-Funding

Aside from allocating capital project funds as part of the budget process, bond funding is something municipalities can utilize to assist with funding network construction, and to support startup and maintenance costs. There are two main types of bonds utilized for capital projects – Revenue Bonds and General Obligation bonds. General Obligation bonds are typically the kind of bond utilized for this kind of funding. Another option would be to pursue revenue bonds secured with sales tax or other revenues.

7.2 Federal Funding Opportunities

Federal funding opportunities change year to year. Currently, options are very limited for more suburban communities such as Erie. There are more opportunities for very rural areas. For example - one of these programs will be in play for providers in 2018.

The FCC created the Connect America Fund (CAF) to help expand access to voice and broadband services to areas where services are currently unavailable. In 2015, through a competitive auction, the FCC awarded carriers nearly $1.7 billion annually for six years to bring broadband to unserved parts of their local service territories. Carriers accepted or declined funding on a state-by-state basis and were required to build out to 95% of the funded areas. Century Link accepted funding for areas in Colorado under this program.

In 2018 there will be a second round called the CAF Phase II (CAF II) auction. The FCC has tentatively determined that census block groups or tracts will be the minimum geographic unit for bidding. Unfortunately, based on the FCC list of eligible census blocks to be up for auction, there does not appear to be anything in the Town boundaries of Erie.

7.3 State Grants

Over the last few years, the Colorado Department of Local Affairs (DOLA) has awarded broadband grant funding to some local governments in Colorado. However, those funds have been expended. The State does have another fund set up to assist providers in serving more rural areas. Those funds were expended in 2017 but could be replenished in 2018 and beyond.

7.4 Other

Occasionally there are some other grant funding or loan programs that may provide some broadband funding options for communities. For example, recently, the company Cisco announced a partnership with third-party investors to make available over a billion dollars of financing to municipalities that want to develop smart city applications. However, the financing is in the form of loans and it is a little unclear what the cities would use the funding for.

8 Feasibility Analysis and Recommendations for Consideration

Based on all the information detailed in this Report, this Section provides an analysis and recommendations for the Town to consider in order to improve broadband in the Erie community. Any of the network options considered here would require the Town to overturn the SB 152 restriction with a referendum ballot vote.

8.1 Full FTTP Network

Unlike other Colorado communities in rural areas, Erie is currently served by multiple providers with most residents having multiple options for competitive service offerings. Every resident has access to internet service. Overall, more than 60% of survey respondents were satisfied or very satisfied with their current service. On the other hand – survey respondents were also concerned with the current price they are paying for their services.

Generally, this means that unless the cost of a new service could be significantly lower than what residents are currently paying for broadband service, it is unclear whether a new FTTP network could obtain enough subscribers (take rates) to financially support the network. Unfortunately, you cannot say that the price should be $59 or less for a gigabit because that is what another provider is charging in their community. Price is dictated by what the network needs to sustain itself as determined by the completion of the business plan. It could be $59 a gigabit or it could end up being $89 a gigabit which is what Ting just announced they will be offering residents in Centennial. Based on the survey results, $89 a gigabit would not be a successful offering in Erie.

Speed to market and other factors also impact take rates. For example, it would most likely be a minimum of 24-36 months before a FTTP network could be built and ready to provide service. In that time, current providers could offer better packages and pricing which has happened in other communities planning network builds.

In addition, without a municipal electric utility that the Town could leverage to offset deployment costs, a greenfield FTTP network would be extremely costly to build and operate. A municipal electric utility not only provides valuable assets to be utilized, but it also has back-office operational billing and technical support. A municipal electric utility has trucks and staff to assist with the operations of broadband network and a track record of being a local utility service provider. Rather than building an operational structure from scratch - a municipal electric has a base and expertise with which to build from. While operations can of course be outsourced – it would easier, and most cost effective to do this through an existing municipal electric utility.

A full FTTP network places too much financial risk on Erie. For these same reasons, and given that multiple providers are in Erie, this option is also unlikely to attract potential PPP providers who could invest in a FTTP network.

- **Recommendation: VPS <u>does not</u> recommend that Erie move forward with consideration of a FTTP network model to build to all homes and business in Erie.**

8.2 Partial FTTP Network to Select Neighborhoods

While Erie residents do have access to the internet – the level of internet service is not equal in all neighborhoods. Residents in areas such as Erie Highlands have access to gigabit level broadband already. However, from our outreach meetings, we know that there are 4 neighborhoods that are relatively under-served. One current provider (Century Link) in these areas is not able to offer high-speed broadband service due to a variety of reasons including aging infrastructure

(e.g., copper lines) and as of now, there are no current plans for that to be upgraded. Though Comcast says they offer gigabit services in these neighborhoods – residents are asking for more-choice, and better service.

The cost to deploy to these areas is just under $9million. While that cost is less than the over $43 million for a full FTTP network build, it still represents a significant allocation of resources that could be more effectively utilized for other purposes covering a broader area of the community. If this option is considered, utilizing demand aggregation strategies, a partial FTTP build could be effectively deployed. As mentioned, at least one ISP has expressed an interest in exploring this model by making their own financial investment in the network build - potentially developing a public-private partnership with Erie.

- **Recommendation: VPS recommends that Erie consider continuing conversations with potential ISP partners in an effort to move forward with a partial provider-funded FTTP network model to serve all 4 under-served neighborhoods at no or substantially reduced costs to the Town. This would include discussions with the potential ISP partners opportunities to provide enhanced WiFi for the Historic Busineses District inclusive of Coal Creek Park.**

8.3 Middle-Mile Network

Middle-mile networks cost less to deploy because they are only designed to reach anchor institutions or provide critical backbone infrastructure for the primary purposing of bringing in lease revenue and helping to incent private sector development. It is also important to remember that middle-mile networks would also need a network operator and have operating costs.

As mentioned in Section 7.1 – there are 8 Town of Erie facilities and there are 18 total potential anchor institutions to connect to with a middle-mile network. Of the 18 - 8 are schools that receive their telecommunications facilities from the school system. At this time, it is unclear whether the schools in Erie would purchase their broadband services outside of the school system. Prior to moving forward with the network design for this option, Erie would need to have detailed conversations with the school and fire districts to ascertain the level of interest in participating as end-users of a middle-mile network.

The more users there are, the more cost-effective the network is to build. However, a middle-mile network could be deployed without end users for the sole purpose of providing infrastructure to be leased by providers as detailed in Section 4.3.

Similar to an FTTP network, a middle-mile Network could also:

- Bring gigabit speeds to Erie by being leveraged by providers;
- Increase economic development opportunities;
- Increase value in real estate value (particularly for those areas that are currently unserved by fiber);
- Deploy critical infrastructure that will serve the community for the next 30+ years (including WiFi);
- Enable Erie to better compete with neighboring communities.

In addition, there are these added benefits:

- The investment cost is much smaller and the risk is much less significant;
- The Town would own the network and this could be a valuable long term asset;
- This would need to be an open access network to maximize the amount of users and the towns could lease excess capacity (fiber and/or conduit) to providers and others. The return on the capital investment could be realized much more quickly;

- This could by leveraged by other providers and significantly increase competition.

➢ **Recommendation: VPS recommends that Erie consider either building a middle-mile network to deploy critical infrastructure that could serve Town facilities (Option A) or all anchor institutions (Option B) or none at all with the intent that the network could be leveraged by providers to build out to under-served areas of Erie. Enhanced WiFi for the Historic Busineses District inclusive of Coal Creek Park should be included these conversations.**

8.4 Ownership Model and Operating Structure

If Erie determines that it would like to further explore developing a middle-mile network with a partial FTTP build, several key questions must be answered. Specifically – how will this be funded; who will own the network; and who will operate the network? The below analysis assists with answering these questions.

Ownership Questions:

- Public Funds: If any public funds are utilized, the Town must own the assets purchased with those funds. This is obvious – however, this needs to be made clear to any potential partners.

- Middle Mile: If the Town funds the middle-mile infrastructure, then it will be able to retain rights to any revenue generated from dark fiber or conduit leases. This could be a significant long-term asset for the Town that could be used for the future. A privately-funded middle-mile network would most likely not be made available to anyone else to leverage. In other words, a publicly funded middle-mile network would be open-access whereas a privately funded one would not be open access.

- Private Funds: A private provider will want to own any infrastructure built with private funds. However, the Town could work out other resource sharing arrangements with a PPP.

Even if the Town determines that it would self-fund a middle-mile or partial FTTP network, who would operate the network? The Town is not equipped to self-provision a network and become a service provider. **For these reasons, operations should be outsourced.**

There are many different models to work with depending on the type of network:

- Middle-Mile Network: For a self-funded and owned middle-mile network, the Town could contract with a network operator that could serve as a dark fiber/conduit leasing agent and service provider.

- Partial FTTP Build: For a self-funded and owned partial FTTP network, the Town could either find one network operator to provide all needed services or the Town could separate the middle-mile and last mile functions.

- PPP: With a PPP, the partners collectively determine the best ownership/operating models. If the Provider is supplying the investment capital – typically they will be the ISP.

- **Recommendation: VPS recommends that the Town explore establishing a PPP with a private provider for a Partial FTTP Network that includes the middle-mile before determining whether to self-fund any portion or in full.**

8.5 Wireless Infrastructure

Whether or not the Town decides to move forward with the above network recommendations, the Town should consider the wireless infrastructure model. Cellular service was repeatedly mentioned as a significant problem throughout the outreach meetings and in the survey.

For a relatively low cost – compared to what it costs to build any fiber-optic network, the Town could potentially improve cellular service in Erie. This would significantly impact the quality of life of residents and visitors in those areas that are currently lacking in LTE.

Fiber needed to power the towers could be built into a middle-mile model or considered as part of this as a stand-alone project.

- **Recommendation: VPS recommends that the Town commission an RF Feasibility Study to determine if the Town should invest in towers or wireless infrastructure that would be utilized by the cellular carriers to improve cellular service in Erie.**

8.6 Incentives

The policy incentives discussed will probably not encourage additional investment by existing providers. However, they do provide some ideas for implementing best-practices that will help Erie continue to manage telecommunications needs and services.

8.7 Summary of Recommendations

To summarize – the below options are recommended for consideration by the Town – based on Town priorities.

1. Erie **should not** move forward with a FTTP network model to build to all homes and business in Erie.

2. Erie should consider building a middle-mile network to deploy critical infrastructure that could serve Town facilities and/or anchor institutions and/or be leveraged by providers to build out to under-served areas of Erie.

3. Erie should consider moving forward with a partial FTTP network model to serve under-served neighborhoods in Erie. However, Erie should explore establishing a PPP with a private provider for a Partial FTTP Network that includes the middle-mile and Enhanced WiFi for the Historic Business District inclusive of Coal Creek Park before determining whether to commit Town funds for any portion of the above network options.

4. Erie should consider commissioning an RF Feasibility Study to determine if the Town should invest in towers or wireless infrastructure that would be utilized by the cellular carriers to improve cellular service in Erie.

Appendix A – Glossary

Backbone: A high-fiber count fiber optic mainline that provides connectivity to the internet. Connections to buildings from the backbone are called lateral connections.

Conduit: A means by which something is transmitted. The conduit houses the fiber.

Dark Fiber: Refers to fiber optic cable that has been installed and is available to use but is not connected to any electronic devices and not transmitting any data. *Also referred to as excess capacity.*

E-Rate: A federal program that provides reimbursement funding for telecommunications services to schools and libraries based on free and reduced lunch program percentages within an applying jurisdiction.

Demand Aggregation: Strategies utilized to identify interested subscribers in an area before engaging in network deployment.

Fiber-optic: A high-speed data transmission medium that contains tiny glass or plastic filaments that carry light beams. Digital data is transmitted through the cable via rapid pulses of light.

Fiber-to-the-Premise (FTTP) or Fiber-to-the-Home (FTTH): A last-mile network that connects all buildings in a community.

Gigabit Passive Optical Networks (GPON): This is equipment based at the premise that supports triple-play services, high-bandwidth, long reach, etc.

Indefeasible Right of Use (IRU): Commonly used in the industry to provide long-term access to assets. Conduit and fiber deployed is leased through an agreement called an IRU.

Internet Service Provider (ISP): A company that is in the business of providing internet connectivity services to end-users and customers.

Last-Mile Network: Network that provides services directly to homes and businesses in the community.

Middle-Mile Network: Typically defined as a network that serves community anchor institutions (i.e. Schools, libraries, government buildings, public safety agencies, hospitals, etc.) but does not directly serve homes and businesses.

Network Operator: A third-party contractor hired to manage a network and oversee network operations.

Open-Access Network: Network where the infrastructure assets (conduit and fiber) are made available under certain policies and procedures to multiple non-network owners.

Outside Plant (OSP): Commonly used to refer to the engineering and construction of fiber infrastructure assets.

Penetration Rate: Number of households “passed” by a network that could potentially subscribe to a network.

Public-Private Partnerships (PPPs): A relatively new phenomenon in broadband where partners establish a legal partnership that balances and apportions risk, benefit and control of a last-mile network.

Appendix B – Partial Neighborhood FTTP Model

Town of Erie				
PROPOSED HIGH LEVEL ESTIMATE SUMMARY - 30% / 60% / 100% PENETRATION - KENOSHA FARMS				
	Last Mile - 30%	**Last Mile - 60%**	**Last Mile - 100%**	**Middle Mile**
Number of Subscribers	84	168	280	18
Total Miles of Construction	7.1	9.9	13.7	24.5
OSP Estimate	$640,000	$729,000	$844,000	$3,125,000
Electronics Estimate	$74,000	$144,000	$233,000	$31,000
Total Estimate	**$714,000**	**$873,000**	**$1,077,000**	**$3,156,000**

Assumptions:

- **Estimates only for Kenosha Farms area.**
- **Subscriber counts based on "Residential Development Conditions".**
- **Routes for Middle Mile to only the "Erie Facilities".**
- **Last Mile costs DO NOT include costs to serve Middle Mile.**
- **Costs only include Town boundary routes.**
- **Does not include RF or IP video expenses, switching costs, data network equipment, or transport to exchange.**
- **Assumes serving all locations from existing CO buildings. Therefore, no building or land costs are included.**
- **Estimates include engineering and overhead.**
- **Electronics & fiber management costs assume GPON.**
- **Does not include any costs for right-of-way acquisitions.**
- **OSP costs assume all buried construction.**
- **OSP costs do not include any costs for rocky soil conditions.**

Notes:

We make every attempt to have our estimates be within +/- 10% of the actual project cost, which is normally the case. However, it is still an estimate, there are many factors outside of our control that could result in the actual cost differing by more than 10%, such as material or labor charges, design changes since estimate, inflation, construction delays, etc. Please keep this in mind when budgeting for this project.

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Town of Erie			
PROPOSED FTTP HIGH LEVEL ESTIMATE - KENOSHA FARMS			
	30% Penetration	60% Penetration	100% Penetration
CO Electronics			
CO Electronics	**$19,000**	**$34,000**	**$51,000**
Installation (10%)	**$2,000**	**$4,000**	**$6,000**
ONTs	**$34,000**	**$68,000**	**$113,000**
ONT Installation	**$19,000**	**$38,000**	**$63,000**
OSP			
Cable	**$533,000**	**$533,000**	**$533,000**
Drops	**$81,000**	**$162,000**	**$269,000**
Fiber Management	**$26,000**	**$34,000**	**$42,000**
Total	**$714,000**	**$873,000**	**$1,077,000**
Mainline Miles	4.2	4.2	4.2
Drops Miles	2.9	5.7	9.5
Total Miles	**7.1**	**9.9**	**13.7**
Total Subscribers	**84**	**168**	**280**

Assumptions:

- **Estimates only for Kenosha Farms area.**
- **Subscriber counts based on "Residential Development Conditions".**
- **Assumes residential subscribers only.**
- **Last Mile costs DO NOT include costs to serve Middle Mile.**
- **Does not include RF or IP video expenses, switching costs, data network equipment, or transport to exchange.**
- **Installation estimated at 10% of equipment.**
- **Assumes serving all locations from existing CO buildings. Therefore, no building or land costs are included.**
- **Estimates include engineering and overhead.**
- **Electronics & fiber management costs assume GPON.**
- **Does not include any costs for right-of-way acquisitions.**
- **OSP costs do not include any costs for rocky soil conditions.**
- **OSP costs assume all buried construction.**
- **Drop costs assume 180' buried drop.**

Notes:

We make every attempt to have our estimates be within +/- 10% of the actual project cost, which is normally the case. However, it is still an estimate, there are many factors outside of our control that could result in the actual cost differing by more than 10%, such as material or labor charges, design changes since estimate, inflation, construction delays, etc. Please keep this in mind when budgeting for this project.

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Town of Erie

PROPOSED HIGH LEVEL ESTIMATE SUMMARY - 30% / 60% / 100% PENETRATION - NORTHRIDGE

	Last Mile - 30%	Last Mile - 60%	Last Mile - 100%	Middle Mile
Number of Subscribers	55	109	181	18
Total Miles of Construction	5.4	7.3	9.7	24.5
OSP Estimate	$528,000	$586,000	$660,000	$3,125,000
Electronics Estimate	$56,000	$104,000	$152,000	$31,000
Total Estimate	**$584,000**	**$690,000**	**$812,000**	**$3,156,000**

Assumptions:

- **Estimates only for Northridge area.**
- **Subscriber counts based on "Residential Development Conditions".**
- **Routes for Middle Mile to only the "Erie Facilities".**
- **Last Mile costs DO NOT include costs to serve Middle Mile.**
- **Costs only include Town boundary routes.**
- **Does not include RF or IP video expenses, switching costs, data network equipment, or transport to exchange.**
- **Assumes serving all locations from existing CO buildings. Therefore, no building or land costs are included.**
- **Estimates include engineering and overhead.**
- **Electronics & fiber management costs assume GPON.**
- **Does not include any costs for right-of-way acquisitions.**
- **OSP costs assume all buried construction.**
- **OSP costs do not include any costs for rocky soil conditions.**

Notes:

We make every attempt to have our estimates be within +/- 10% of the actual project cost, which is normally the case. However, it is still an estimate, there are many factors outside of our control that could result in the actual cost differing by more than 10%, such as material or labor charges, design changes since estimate, inflation, construction delays, etc. Please keep this in mind when budgeting for this project.

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Town of Erie			
PROPOSED FTTP HIGH LEVEL ESTIMATE - NORTHRIDGE			
	30% Penetration	60% Penetration	100% Penetration
CO Electronics			
CO Electronics	**$18,000**	**$31,000**	**$34,000**
Installation (10%)	**$2,000**	**$4,000**	**$4,000**
ONTs	**$23,000**	**$44,000**	**$73,000**
ONT Installation	**$13,000**	**$25,000**	**$41,000**
OSP			
Cable	**$452,000**	**$452,000**	**$452,000**
Drops	**$53,000**	**$105,000**	**$174,000**
Fiber Management	**$23,000**	**$29,000**	**$34,000**
Total	**$584,000**	**$690,000**	**$812,000**
Mainline Miles	3.6	3.6	3.6
Drops Miles	1.9	3.7	6.2
Total Miles	**5.4**	**7.3**	**9.7**
Total Subscribers	**55**	**109**	**181**

Assumptions:

- **Estimates only for Northridge area.**
- **Subscriber counts based on "Residential Development Conditions".**
- **Assumes residential subscribers only.**
- **Last Mile costs DO NOT include costs to serve Middle Mile.**
- **Does not include RF or IP video expenses, switching costs, data network equipment, or transport to exchange.**
- **Installation estimated at 10% of equipment.**
- **Assumes serving all locations from existing CO buildings. Therefore, no building or land costs are included.**
- **Estimates include engineering and overhead.**
- **Electronics & fiber management costs assume GPON.**
- **Does not include any costs for right-of-way acquisitions.**
- **OSP costs do not include any costs for rocky soil conditions.**
- **OSP costs assume all buried construction.**
- **Drop costs assume 180' buried drop.**

Notes:

We make every attempt to have our estimates be within +/- 10% of the actual project cost, which is normally the case. However, it is still an estimate, there are many factors outside of our control that could result in the actual cost differing by more than 10%, such as material or labor charges, design changes since estimate, inflation, construction delays, etc. Please keep this in mind when budgeting for this project.

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Town of Erie

PROPOSED HIGH LEVEL ESTIMATE SUMMARY - 30% / 60% / 100% PENETRATION - HISTORIC ERIE

	Last Mile - 30%	Last Mile - 60%	Last Mile - 100%	Middle Mile
Number of Subscribers	189	377	628	18
Total Miles of Construction	15.5	21.9	30.4	24.5
OSP Estimate	$1,370,000	$1,568,000	$1,830,000	$3,125,000
Electronics Estimate	$158,000	$310,000	$505,000	$31,000
Total Estimate	**$1,528,000**	**$1,878,000**	**$2,335,000**	**$3,156,000**

Assumptions:

- **Estimates only for Historic Erie area.**
- **Subscriber counts based on "Residential Development Conditions".**
- **Routes for Middle Mile to only the "Erie Facilities".**
- **Last Mile costs DO NOT include costs to serve Middle Mile.**
- **Costs only include Town boundary routes.**
- **Does not include RF or IP video expenses, switching costs, data network equipment, or transport to exchange.**
- **Assumes serving all locations from existing CO buildings. Therefore, no building or land costs are included.**
- **Estimates include engineering and overhead.**
- **Electronics & fiber management costs assume GPON.**
- **Does not include any costs for right-of-way acquisitions.**
- **OSP costs assume all buried construction.**
- **OSP costs do not include any costs for rocky soil conditions.**

Notes:

We make every attempt to have our estimates be within +/- 10% of the actual project cost, which is normally the case. However, it is still an estimate, there are many factors outside of our control that could result in the actual cost differing by more than 10%, such as material or labor charges, design changes since estimate, inflation, construction delays, etc. Please keep this in mind when budgeting for this project.

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Town of Erie			
PROPOSED FTTP HIGH LEVEL ESTIMATE - HISTORIC ERIE			
	30% Penetration	60% Penetration	100% Penetration
CO Electronics			
CO Electronics	**$34,000**	**$65,000**	**$100,000**
Installation (10%)	**$4,000**	**$7,000**	**$10,000**
ONTs	**$77,000**	**$153,000**	**$254,000**
ONT Installation	**$43,000**	**$85,000**	**$141,000**
OSP			
Cable	**$1,144,000**	**$1,144,000**	**$1,144,000**
Drops	**$182,000**	**$362,000**	**$603,000**
Fiber Management	**$44,000**	**$62,000**	**$83,000**
Total	**$1,528,000**	**$1,878,000**	**$2,335,000**
Mainline Miles	9.0	9.0	9.0
Drops Miles	6.4	12.9	21.4
Total Miles	**15.5**	**21.9**	**30.4**
Total Subscribers	**189**	**377**	**628**

Assumptions:

- **Estimates only for Historic Erie area.**
- **Subscriber counts based on "Residential Development Conditions".**
- **Assumes residential subscribers only.**
- **Last Mile costs DO NOT include costs to serve Middle Mile.**
- **Does not include RF or IP video expenses, switching costs, data network equipment, or transport to exchange.**
- **Installation estimated at 10% of equipment.**
- **Assumes serving all locations from existing CO buildings. Therefore, no building or land costs are included.**
- **Estimates include engineering and overhead.**
- **Electronics & fiber management costs assume GPON.**
- **Does not include any costs for right-of-way acquisitions.**
- **OSP costs do not include any costs for rocky soil conditions.**
- **OSP costs assume all buried construction.**
- **Drop costs assume 180' buried drop.**

Notes:

We make every attempt to have our estimates be within +/- 10% of the actual project cost, which is normally the case. However, it is still an estimate, there are many factors outside of our control that could result in the actual cost differing by more than 10%, such as material or labor charges, design changes since estimate, inflation, construction delays, etc. Please keep this in mind when budgeting for this project.

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Town of Erie				
PROPOSED HIGH LEVEL ESTIMATE SUMMARY - 30% / 60% / 100% PENETRATION - ERIE VILLAGE				
	Last Mile - 30%	**Last Mile - 60%**	**Last Mile - 100%**	**Middle Mile**
Number of Subscribers	126	252	420	18
Total Miles of Construction	8.5	12.8	18.5	24.5
OSP Estimate	$686,000	$818,000	$995,000	$3,125,000
Electronics Estimate	$115,000	$214,000	$340,000	$31,000
Total Estimate	**$801,000**	**$1,032,000**	**$1,335,000**	**$3,156,000**

Assumptions:

- **Estimates only for Erie Village area.**
- **Subscriber counts based on "Residential Development Conditions".**
- **Routes for Middle Mile to only the "Erie Facilities".**
- **Last Mile costs DO NOT include costs to serve Middle Mile.**
- **Costs only include Town boundary routes.**
- **Does not include RF or IP video expenses, switching costs, data network equipment, or transport to exchange.**
- **Assumes serving all locations from existing CO buildings. Therefore, no building or land costs are included.**
- **Estimates include engineering and overhead.**
- **Electronics & fiber management costs assume GPON.**
- **Does not include any costs for right-of-way acquisitions.**
- **OSP costs assume all buried construction.**
- **OSP costs do not include any costs for rocky soil conditions.**

Notes:

We make every attempt to have our estimates be within +/- 10% of the actual project cost, which is normally the case. However, it is still an estimate, there are many factors outside of our control that could result in the actual cost differing by more than 10%, such as material or labor charges, design changes since estimate, inflation, construction delays, etc. Please keep this in mind when budgeting for this project.

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Town of Erie			
PROPOSED FTTP HIGH LEVEL ESTIMATE - ERIE VILLAGE			
	30% Penetration	60% Penetration	100% Penetration
CO Electronics			
CO Electronics	**$31,000**	**$50,000**	**$68,000**
Installation (10%)	**$4,000**	**$5,000**	**$7,000**
ONTs	**$51,000**	**$102,000**	**$170,000**
ONT Installation	**$29,000**	**$57,000**	**$95,000**
OSP			
Cable	**$533,000**	**$533,000**	**$533,000**
Drops	**$121,000**	**$242,000**	**$404,000**
Fiber Management	**$32,000**	**$43,000**	**$58,000**
Total	**$801,000**	**$1,032,000**	**$1,335,000**
Mainline Miles	4.2	4.2	4.2
Drops Miles	4.3	8.6	14.3
Total Miles	**8.5**	**12.8**	**18.5**
Total Subscribers	**126**	**252**	**420**

Assumptions:

- **Estimates only for Erie Village area.**
- **Subscriber counts based on "Residential Development Conditions".**
- **Assumes residential subscribers only.**
- **Last Mile costs DO NOT include costs to serve Middle Mile.**
- **Does not include RF or IP video expenses, switching costs, data network equipment, or transport to exchange.**
- **Installation estimated at 10% of equipment.**
- **Assumes serving all locations from existing CO buildings. Therefore, no building or land costs are included.**
- **Estimates include engineering and overhead.**
- **Electronics & fiber management costs assume GPON.**
- **Does not include any costs for right-of-way acquisitions.**
- **OSP costs do not include any costs for rocky soil conditions.**
- **OSP costs assume all buried construction.**
- **Drop costs assume 180' buried drop.**

Notes:

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