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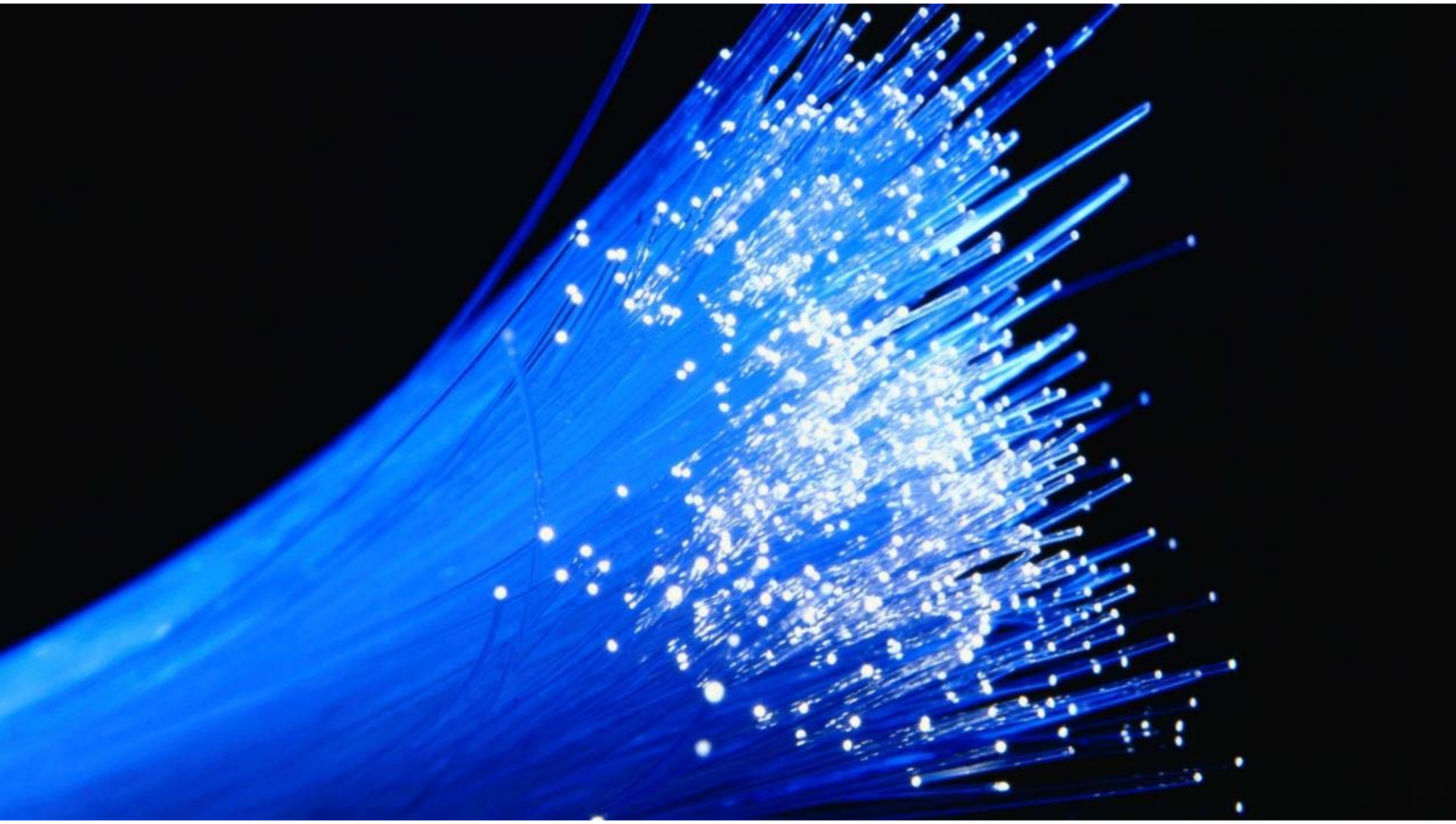

Strategic Analysis of Broadband Opportunities in Fayette County

Prepared for LFUCG

May 2017

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1 Executive Summary

This report represents a pragmatic analysis of broadband infrastructure and buildout opportunities in the rural areas of Fayette County outside of Lexington. The study was commissioned by the Lexington-Fayette Urban County Government (LFUCG) to understand the scale of the challenge of fully meeting broadband needs in Fayette County, and to develop cost estimates and potential strategies for meeting those needs.

In the sections below, we first describe our analysis of the current state of infrastructure demand and supply (Section 2), then describe potential approaches to filling those gaps—through public–private partnership (Section 3), middle mile fiber construction (Section 4) or a fiber-to-the-premises (FTTP) network buildout (Section 5). The final section (Section 6) presents a detailed financial analysis of the middle mile and FTTP solutions.

This report was prepared by CTC Technology & Energy (CTC) during the winter of 2016 – 2017.

1.1 Project Tasks

During the course of this engagement, CTC performed the following tasks:

1. Facilitated stakeholder discussions and evaluated current state of infrastructure, services, and user needs (gap analysis)
2. Analyzed potential federal funding sources for broadband in Fayette County
3. Explored candidate public–private partnerships with the LFUCG's incumbent and competitive service providers
4. Prepared high-level designs and cost estimates for candidate middle mile and FTTP networks
5. Developed a financial analysis of middle mile and FTTP networks
6. Developed strategic recommendations based on analysis of potential partnerships, joint-build opportunities, and construction costs
7. In collaboration with the Fayette Alliance, conducted an online survey of key businesses in Fayette County to determine the level of interest in new connectivity[1]

[1] CTC extends its thanks to Ms. Susan Speckert, Executive Director of the Fayette Alliance, for her extraordinary efforts in connecting CTC with stakeholders and in helping to prepare the survey and recipient list.

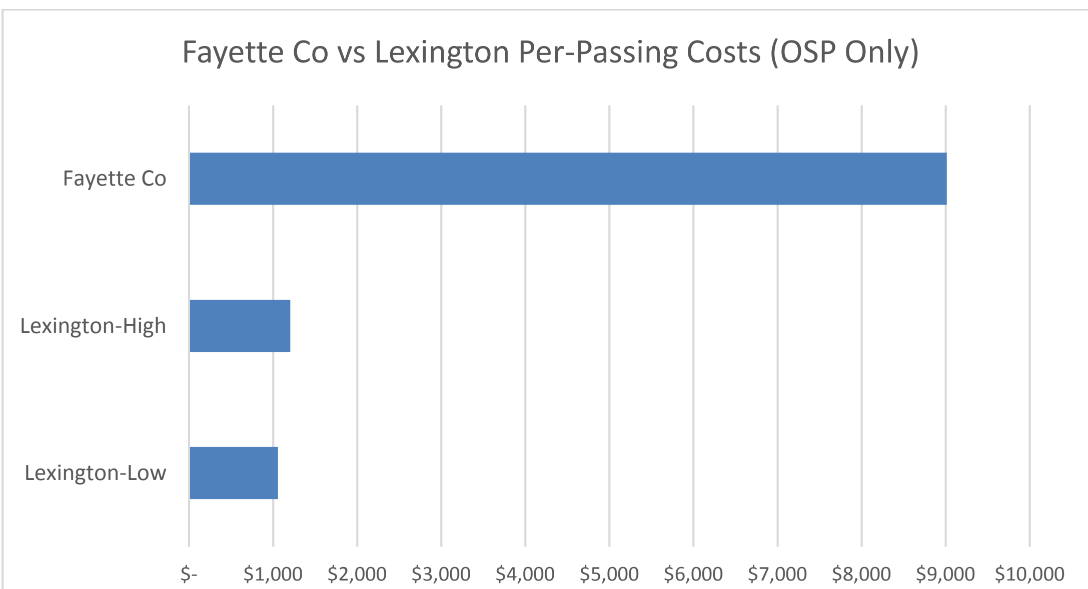
1.2 The Current Broadband Environment

The challenging economics of deploying broadband are difficult to overcome in rural communities nationwide. This is true even in prosperous communities with willing customers, as in the rural areas of Fayette County.

The primary challenge is population density. Fiber optic construction becomes cost-effective when each mile of fiber can pass a large number of potential customers; where population density is low—as is the case in Fayette County, where large farms stretch for miles—the return on investment is almost always too low to incentivize broadband service providers to invest. Indeed, this challenge is true for almost all rural infrastructure; for example, absent substantial public subsidy, the phone networks would not have been built in rural parts of the United States.

The issue of low population density for broadband investment is illustrated by the challenge facing Fayette County. Based on our engineering analysis, the cost of building outside plant (OSP) fiber optics in the Fayette County areas of the LFUCG is nine times higher than the cost to build fiber in Lexington. (Figure 1 illustrates the cost comparison.) As a result, the cost to pass each of the Fayette County area's farms and other potential customers is significantly higher than it would be to reach customers in the city and in other metropolitan areas of the United States.

Figure 1: Fayette County vs Lexington Per-Passing Costs



Given that privately funded fiber to every home and business has not emerged even in a high-density area like Lexington, where the per passing construction costs are much lower, there does not exist a scenario where such a deployment happens purely through private investment in the County areas.

It is therefore not surprising that there exists limited broadband infrastructure in Fayette County—and as a result, there is an unmet need for high-capacity broadband services among the LFUCG's farms and residential communities.

Windstream, the LFUCG's incumbent local exchange carrier (ILEC), offers dialup internet access and some Digital Subscriber Line (DSL) service in the County. Charter, the incumbent cable company, delivers limited cable modem service. Both companies operate aging infrastructure.

While some of the largest farms pay for leased lines, many farms and other businesses in the rural parts of the County are using dial-up Internet connections. This is all the more remarkable and concerning given that these farms represent an enormous economic driver for the LFUCG and the region. From an economic development standpoint, this unmet need represents a significant concern.

1.3 Summary of Engineering Analysis and Cost Estimates

CTC's engineers undertook two system-level design and cost estimation efforts. First, they developed a candidate design and cost estimates for construction of a "middle mile" network that would serve government facilities and pass some of the farms and other businesses located in the County area that were identified as priority economic development sites by the LFUCG and the Fayette Alliance. This middle mile infrastructure could then serve as the core platform for deployment of wireless or fiber connections directly to homes, businesses, and farms. Middle mile fiber is analogous to state highways or major county roads; it connects communities to each other and ties neighborhoods together—and ideally makes it more cost-effective and efficient to build the "last mile" infrastructure to the home and business that is analogous to neighborhood streets.

The capital expense to build this core **middle mile infrastructure would be more than $11 million**.

Second, CTC's engineers developed a system-level design and cost estimate for constructing both the middle and last miles with fiber optics, with the goal of bringing fiber to all homes and businesses in the County. The capital cost for this **fiber-to-the-premises (FTTP) network would be approximately $43 million**, in addition to the cost for constructing "lateral" or "drop" fiber from the street to the buildings being served at each location.

These are capital costs only and do not include financing and operations costs (those costs are addressed in the financial model described below).

1.3.1 Summary of Middle Mile Network Design and Cost Estimate

CTC developed a system-level network design as the basis for estimating costs. Design priorities targeted by this conceptual design include a list of sites provided by the LFUCG:

- Providing fiber connectivity to all County facilities for which leased service fees can be avoided (see "School and Fire Station Sites" in Figure 2)
- Providing fiber connectivity to 54 priority farms to spur economic development (see "Priority" sites in Figure 2 and Figure 3)[2]
- Passing as many of the large farms and businesses in the County as possible along the fiber routes (See "Middle Mile Sites" in Figure 3)
- Connecting to KentuckyWired to provide Internet access to the network by interconnecting along a shared fiber path (Figure 4)

The resulting network architecture, illustrated in Figure 2, is comprised of approximately 113 route miles of fiber passing more than 230 farms and businesses, and connecting all 62 priority sites (see Appendix A). CTC estimates the cost of constructing the middle mile fiber network to be approximately $11.3 million, inclusive of outside plant (OSP)[3] construction labor, materials, engineering, permitting, testing, and network electronics and configuration.

[2] Lateral fiber construction will be required at each farm and business purchasing service at an additional cost.

[3] The outside plant (OSP) is the physical portion of a network (also called "layer 1") that is constructed on utility poles (aerial) or in conduit (underground).

Figure 2: System-Level Fiber Network Architecture and Priority Sites

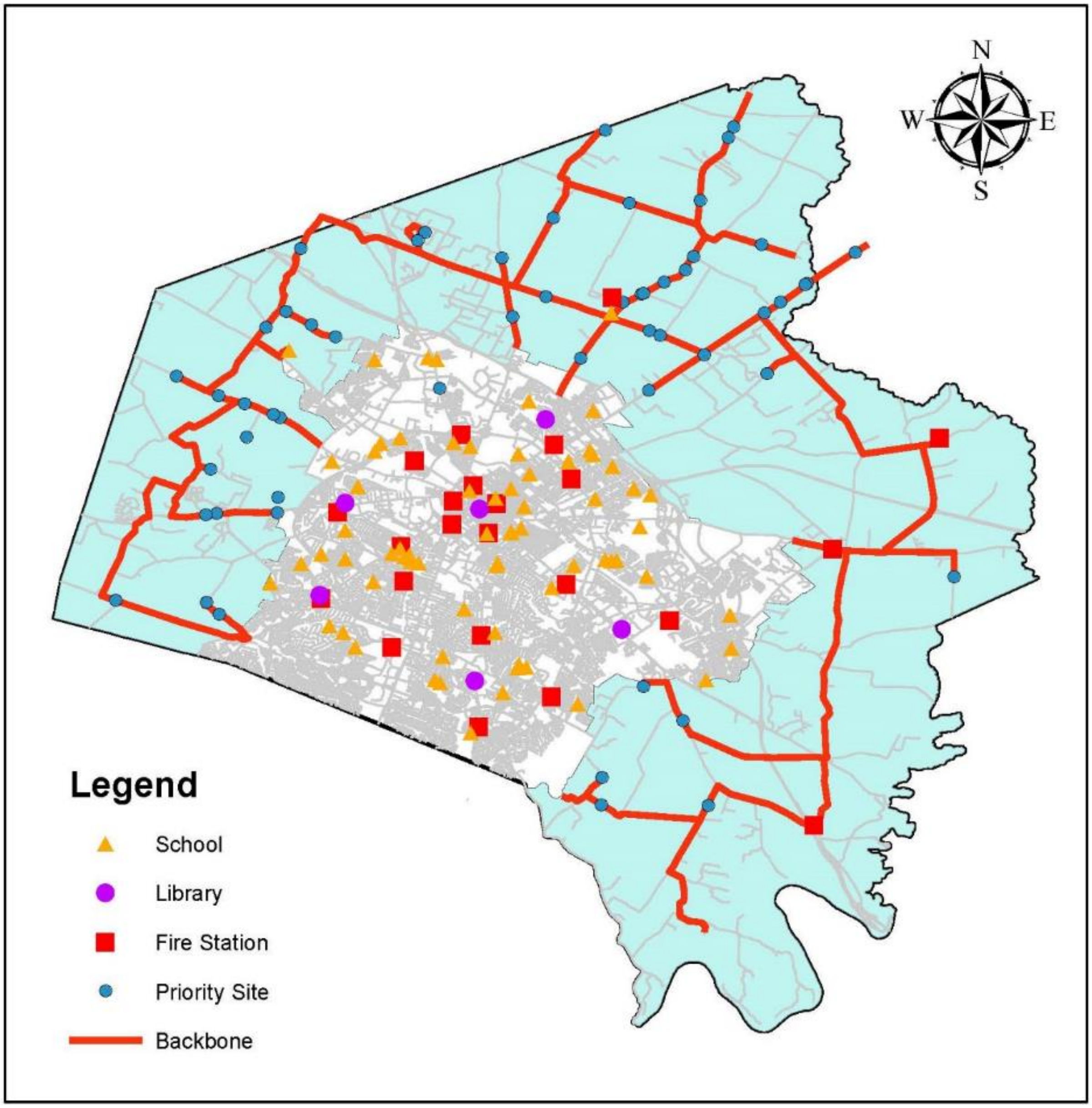


Figure 3: Fiber Optic Routing Showing Proximity to Identified Farms

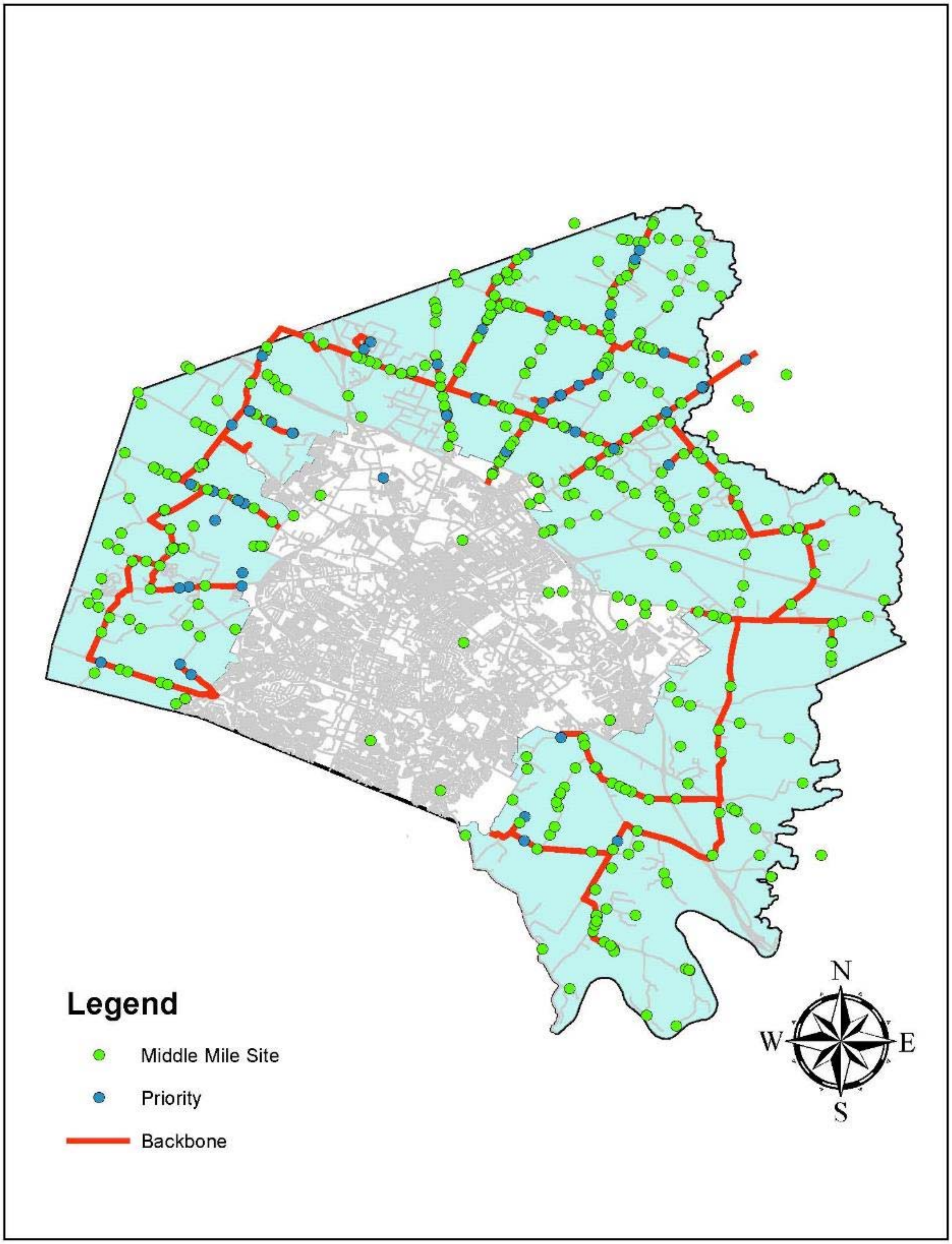
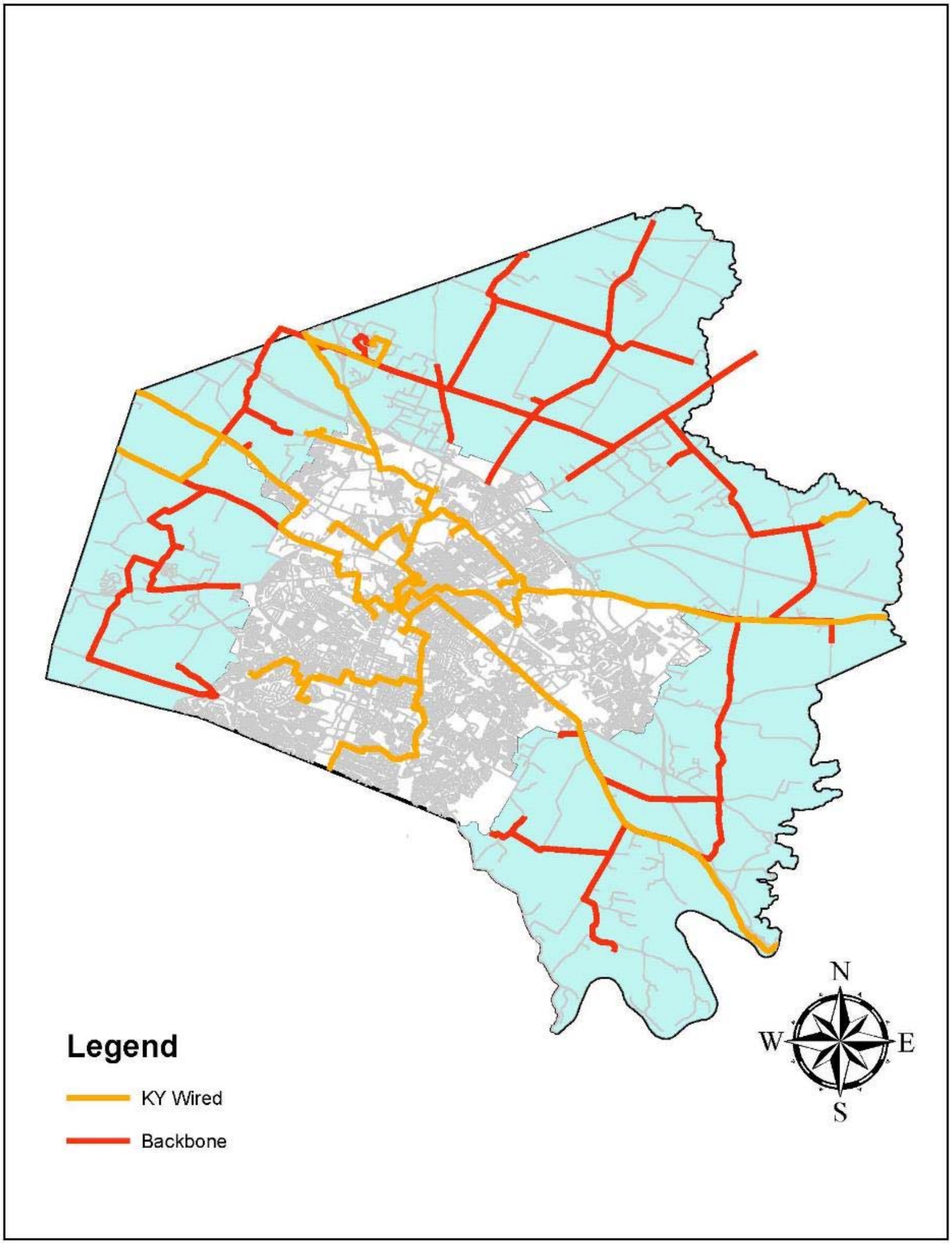


Figure 4: Overlay of KentuckyWired and Middle Mile Network



1.3.2 Summary of FTTP Design and Cost Estimate

An FTTP network deployment in the rural areas of Fayette County will cost approximately $43 million,[4] inclusive of OSP construction labor, materials, engineering, permitting, network electronics, customer premises equipment (CPE),[5] and testing (see Table 1).

Table 1: Breakdown of Estimated Total Cost

Cost Component	Total Estimated Cost
Outside Plant	$40.8 million
Central Network Electronics	0.9 million
Customer Premises Equipment	1.0 million
FTTP Service Drop and Lateral Installations	TBD
Total Estimated Cost:	$42.7 million

The cost estimate also includes the construction of a network backbone that shares the routing of the middle mile network; the backbone would interconnect the fiber distribution cabinets (FDCs)[6] and connect them to the network core, where KentuckyWired would provide Internet connectivity.

This estimate does not include the customer drops,[7] which would add at least $866,000 to the estimate at a 35 percent take-rate. As explained in Section 5.1.6, drop and lateral costs cannot be reasonably estimated at this time due to the wide variation in potential costs to construct to individual farms.

As with any utility, the design and associated costs for construction will vary with the unique physical layout of the service area—no two streets are likely to have the exact same configuration of utility poles, existing utilities, soil conditions, and special crossings. To estimate costs for the network, we developed a high-level FTTP sample design based on street mileage and passings[8] (see Figure 5, below). As much of the County has aerial utilities, we assumed that 90 percent of the FTTP network would be constructed aerially, which is generally more cost effective than underground construction.

[4] This design assumes a 35 percent “take rate” (i.e., the percentage of customers who subscribe to the service, otherwise known as the penetration rate). Capital costs will increase or decrease as the take rate increases or decreases.

[5] The customer premises equipment (CPE) is the electronic equipment installed at a subscriber’s home or business.

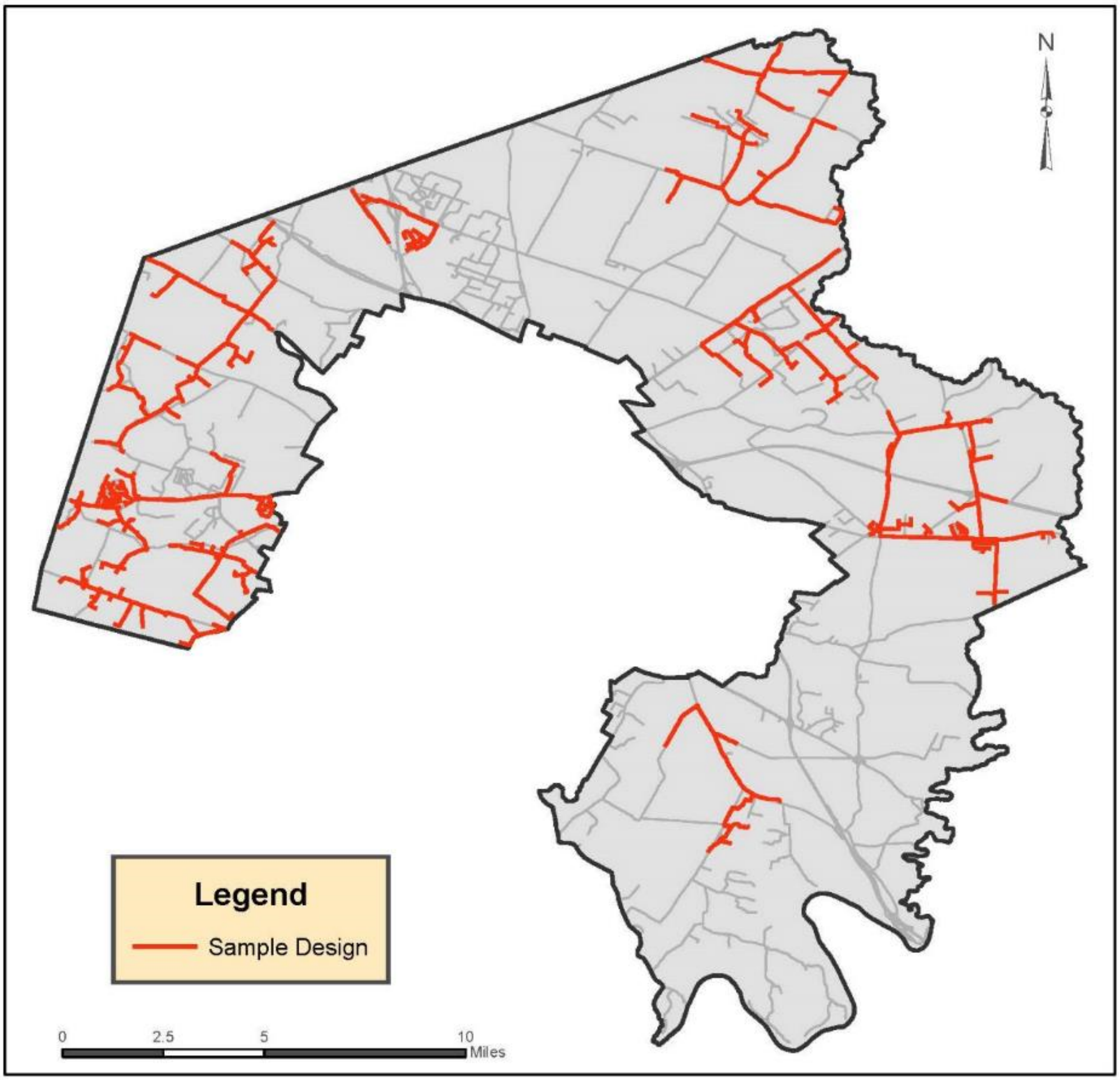
[6] The fiber distribution cabinet (FDC) houses the fiber connections between the distribution fiber and the access fiber. FDCs, which can also house network electronics and optical splitters, can sit on a curb, be mounted on a pole, or reside in a building.

[7] The drop is the fiber connection from an optical tap in the right-of-way (ROW) to the customer premises.

[8] A passing is a potential customer address (e.g., an individual home or business).

The assumptions, sample design, and cost estimates were used to estimate a cost per passing for the OSP. This number was then multiplied by the number of homes and businesses based on the LFUCG's GIS data. The actual cost to construct FTTP to every premises could differ from the estimate due to changes in the assumptions underlying the model. Further extensive analysis would be required to refine this cost estimate.

Figure 5: High-Level FTTP Sample Design Overview



1.4 Summary of Financial Analysis

CTC's financial analysts developed financial models for both the middle mile and the FTTP scenarios. The purpose of the financial models is to understand the scale of risk, necessary revenues, and potential financial positions the LFUCG would face if it were to undertake either the middle mile or FTTP strategy.

The financial analyses include a base case, which represents a minimum requirement for the LFUCG to break even each year,[9] and sensitivity scenarios that illustrate the effect of altering selected assumptions in each model.

Middle mile: In the base case scenario in which the LFUCG builds and operates a middle mile network, the model works so long as each of the end users (i.e., the priority sites identified by the LFUCG) pays a $20,000 connection fee and $3,000 per month for services.

This approach represents a costly solution for the end users—reflecting the fact that building and operating a network in such a rural area is extremely expensive. The LFUCG might earn additional revenues from private entities that lease some of this fiber, but those revenues are likely to be extremely modest relative to the revenues needed for this model to cash flow.

FTPP: In the base case scenario for constructing an FTTP network, the LFUCG would need to secure a $35 million grant and a $13 million bond, and would require high levels of dark fiber lease revenues and high per-passing fees from a retail provider.

This breakeven scenario is based on the highly unrealistic assumption that the great majority of capital cost is paid with grant funding. The grant amount was chosen to illustrate the funding needed to equalize the LFUCG's per-customer costs for fiber construction in Fayette County as compared to fiber construction in Lexington.

To our knowledge, such grant funding does not currently exist (though we note that as of this writing, President Trump is proposing significant infrastructure spending that may include broadband and new opportunity for public-private partnerships in the County). And even under this grant-funded scenario, the economics to make this model self-sustaining are exceptionally challenging.

[9] The base cases illustrate the types of costs that the LFUCG should expect and the level of revenues required each year to maintain a positive cash flow while operating the fiber enterprise. The base case does not imply that the LFUCG will be able to achieve the required revenues.

1.4.1 Middle Mile Financial Analysis

In this model, the LFUCG would deploy and "light" a middle mile network, connecting the 62 LFUCG and priority sites (collectively referred to as "priority sites"), installing network electronics, and offering a lit 1 Gbps transport service[10] to each site.

For our projections, we assumed 30 priority sites will be connected in year one and 32 will be connected in year two. (A list of sites can be found in Appendix A.) The customer would be responsible for any further fiber, wireless, or other construction required from the demarcation point.

1.4.1.1 Base Case

Our base case scenario proposes a model in which:

- LFUCG obtains a 20-year, $12.5 million bond
- Each priority site pays a one-time $20,000 connection fee
- Each priority site pays a $3,000 monthly fee

In other words, as one approach to developing a sustainable business model for the middle mile network (based on a range of other financial assumptions), the LFUCG would finance $12.5 million in capital expenses, and the LFUCG sites and large farms that would receive service would each pay a $20,000 connection fee and $36,000 in annual fees.

These financial projections do not include any economic development or other indirect benefits, which are not easily quantifiable and do not accrue to the financial statements of the broadband enterprise.

Table 2 shows a condensed income and cash flow statement for this model.

[10] Includes 1 Gbps of direct Internet access (DIA) with an oversubscription rate of 10 to 1.

Table 2: Middle Mile Base Case Financial Summary

Income Statement	Year 1	Year 3	Year 5	Year 10
Total Revenues	$1,140,000	$2,232,000	$2,232,000	$2,232,000
Total Cash Expenses	(499,100)	(1,012,900)	(1,012,900)	(1,012,900)
Depreciation	(532,000)	(662,900)	(662,900)	(662,900)
Interest Expense	(750,000)	(727,780)	(679,270)	(530,120)
Net Income	$ (641,100)	$ (171,580)	$ (123,070)	$ 26,080

Cash Flow Statement	Year 1	Year 3	Year 5	Year 10
Unrestricted Cash Balance	$2,044,000	$357,580	$395,260	$489,460
Depreciation Operating Reserve	-	160,000	320,000	34,000
Debt Service Reserve	625,000	625,000	625,000	625,000
Total Cash Balance	$2,669,000	$1,142,580	$1,340,260	$1,148,460

Please note that our analysis follows a "flat-model," which excludes inflation and operating cost increases (including salaries), because we assume that operating cost increases will be offset by increases in operator lease payments over time (and likely passed on to subscribers in the form of increased prices).

1.4.1.2 Sensitivity Scenarios

In the sensitivity scenarios, we explore the impact of raising or lowering the connection fee, the monthly fee, the financing amount, staffing expenses, and other parameters. In reality, it is likely that all of these assumptions would be either higher or lower than the assumed amounts; the sensitivity analysis illustrates the relative impact of each—and the sensitivity of the middle mile project as a whole to fluctuations in costs and revenue.

For example, if the LFUCG were to eliminate the $20,000 initial connection fee, the model projects a relatively modest cash balance deficit of $91,000 by year 10. In contrast, if the initial connection fee were retained but the subscriber fee were dropped to $2,000 per month, the network would end year 10 with a total cash balance deficit of more than $5.5 million. Table 3 shows a condensed income and cash flow statement for this model.

Table 3: Middle Mile Scenario 4 Financial Summary – Service Fees Decreased to $2,000 per Month

Income Statement	Year 1	Year 3	Year 5	Year 10
Total Revenues	$960,000	$1,488,000	$1,488,000	$1,488,000
Total Cash Expenses	(499,100)	(1,012,900)	(1,012,900)	(1,012,900)
Depreciation	(532,000)	(662,900)	(662,900)	(662,900)
Interest Expense	(750,000)	(727,780)	(679,270)	(530,120)
Net Income	$ (821,100)	$ (915,580)	$ (867,070)	$ (717,920)
Cash Flow Statement				
Unrestricted Cash Balance	$1,864,000	$ (1,124,420)	$ (2,574,740)	$ (6,200,540)
Depreciation Operating Reserve	-	160,000	320,000	34,000
Debt Service Reserve	625,000	625,000	625,000	625,000
Total Cash Balance	$2,489,000	$ (339,420)	$ (1,629,740)	$ (5,541,540)

Smaller changes to the model strike a middle ground in projected outcomes. If the LFUCG were to eliminate the initial connection fee but raise the monthly fee slightly, to $3,200, the financial outcome is projected to be much rosier: In this model, the increased monthly fee offsets the loss of initial connection fees, resulting in positive cash flow and a total cash balance of $1.2 million in year 10. (See Table 4.)

Table 4: Middle Mile Scenario 2 Financial Summary – Eliminate Connection Fee and Raise Monthly Fee to $3,200

Income Statement	Year 1	Year 3	Year 5	Year 10
Total Revenues	$ 576,000	$2,380,800	$2,380,800	$2,380,800
Total Cash Expenses	(499,100)	(1,012,900)	(1,012,900)	(1,012,900)
Depreciation	(532,000)	(662,900)	(662,900)	(662,900)
Interest Expense	(750,000)	(727,780)	(679,270)	(530,120)
Net Income	$ (1,205,100)	$ (22,780)	$ 25,730	$ 174,880
Cash Flow Statement				
Unrestricted Cash Balance	$1,480,000	$ (585,620)	$ (250,340)	$ 587,860
Depreciation Operating Reserve	-	160,000	320,000	34,000
Debt Service Reserve	625,000	625,000	625,000	625,000
Total Cash Balance	$2,105,000	$199,380	$ 694,660	$ 1,246,860

Operating expenses also play a key role in the network's financial outcome. If the LFUCG were able to trim its network staffing costs by 25 percent, the network's total cash balance at year 10—leaving all costs and financing the same as in the base case—would be almost $2.5 million.

1.4.2 FTTP Financial Analysis

The financial analysis in this section assumes that the LFUCG constructs and owns the FTTP infrastructure up to a demarcation point at the optical tap near each residence or business, and leases the dark fiber backbone and distribution fiber to a private partner that would then provide retail service to customers.

1.4.2.1 Base Case

The base case scenario for FTTP network construction illustrates a breakeven scenario in which the LFUCG:

- Bonds for $13 million with a 20-year term
- Secures $35.39 million in funding (i.e., 86.6 percent of the total OSP cost estimate) from grants or other sources that do not need to be paid back
- Earns $1 million per year in dark fiber revenues (e.g., leasing 24 fiber strands over the entire 474 route miles at $88.50 per month per strand mile)
- Receives $34.75 per passing per month from the retail provider

We note that with the exception of the bond requirement, these base assumptions are unrealistic. It is highly unlikely that the great majority of capital cost will be paid with grant funding; dark fiber pricing in rural areas is typically in the range of $30 to $50 per month per strand mile; and the required per-passing fee is almost five times the fees that we have seen elsewhere.

The funding and revenue assumptions were selected to create a model that has positive cash flow, given the LFUCG's estimated capital and operating expenses for the FTTP network. These levels are a baseline for sensitivity analyses that show the effect of reduced grant funding (i.e., higher financing requirements) or lower revenue.

Table 5 shows a condensed income and cash flow statement for the base case scenario.

Table 5: FTTP Base Case Financial Summary

Income Statement	Year 1	Year 5	Year 10	Year 15	Year 20
Total Revenues	$9,470	$2,897,840	$2,897,840	$2,897,840	$2,897,840
Total Cash Expenses	(754,790)	(1,671,560)	(1,671,560)	(1,671,560)	(1,671,560)
Depreciation	(650,910)	(2,102,550)	(2,102,550)	(2,102,550)	(2,140,750)
Interest Expense	(180,000)	(724,320)	(575,920)	(377,340)	(112,070)
Taxes	-	-	-	-	-
Net Income	$ (1,576,230)	$ (1,600,590)	$ (1,452,190)	$ (1,253,610)	$ (1,026,540)

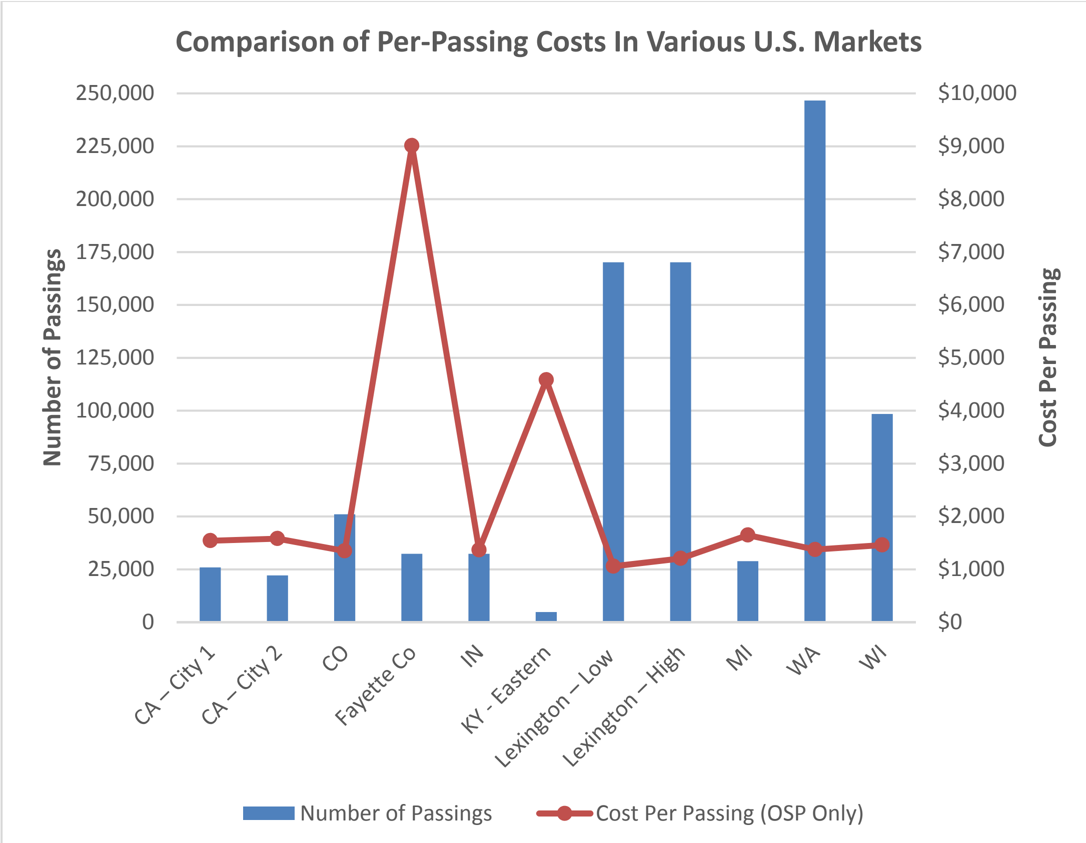
Cash Flow Statement	Year 1	Year 5	Year 10	Year 15	Year 20
Unrestricted Cash Balance	$1,269,580	$3,122,240	$3,122,280	$3,122,480	$3,117,350
Depreciation Reserve	-	189,240	203,640	218,040	45,350
Interest Reserve	180,000	-	-	-	-
Debt Service Reserve	150,000	650,000	650,000	650,000	650,000
Total Cash Balance	$1,599,580	$3,961,480	$3,975,920	$3,990,520	$3,812,700

1.4.2.1.1 Grant Funding Assumption

Our base case assumes $35.39 million in funding because that amount would bridge the gap between the cost to construct fiber in the rural areas of Fayette County and the more densely populated neighborhoods of the City of Lexington.

As we describe in Section 6.2, we estimate the FTTP deployment without electronics would cost $9,013 per passing in Fayette County. This cost is significantly higher than in many localities nationwide, due to the low density of potential subscribers (i.e., the high fiber mileage per passing). A comparison to other U.S. market per-passing costs is provided in Figure 20. This cost is also significantly higher than deployment in Lexington, where our projected costs for an FTTP deployment range from $1,058 to $1,025 per passing (see Figure 1 above).

Figure 6: Comparison of Per-Passing Costs in Various U.S. Markets



In order to bring the LFUCG's effective per-passing cost estimate down to equal that of Lexington, a grant or other funding of $35.39 million (86.6 percent of the OSP costs) would be required. We note, though, that while this funding would reduce deployment costs, it would not lower the high ongoing operations and maintenance costs such as pole attachments and fiber repairs that LFUCG would see due to the low premises density. Operations and maintenance costs have a high dependency on total fiber line miles and, as such, would be higher for Fayette County.

1.4.2.1.2 Operating and Maintenance Expense Assumptions

The cost to deploy a dark FTTP network goes far beyond fiber implementation. Network deployment requires sales and marketing, network maintenance and technical operations, and other functions. In this model, we assume that the LFUCG's partner will be responsible for lighting the fiber and selling service. As such, the LFUCG's financial requirements are limited to expenses related to OSP infrastructure and network administration.

Table 32 shows operating expenses for years one, five, 10, 15, and 20. As seen, some expenses will remain constant while others will increase as the network matures and the customer base increases.

Table 6: Operating Expenses – FTTP Base Case

	Year 1	Year 5	Year 10	Year 15	Year 20
Operating Expenses					
Insurance	$50,000	$75,000	$75,000	$75,000	$75,000
Office Expenses	2,400	2,400	2,400	2,400	2,400
Locates & Ticket Processing	10,700	42,700	42,700	42,700	42,700
Contingency	10,000	25,000	25,000	25,000	25,000
Fiber & Network Maintenance	61,270	204,240	204,240	204,240	204,240
Legal and Lobby Fees	100,000	25,000	25,000	25,000	25,000
Consulting	100,000	20,000	20,000	20,000	20,000
Education and Training	7,490	20,020	20,020	20,020	20,020
Pole Attachment Expense	38,430	256,200	256,200	256,200	256,200
Sub-Total	$380,290	$670,560	$670,560	$670,560	$670,560
Labor Expenses	$374,500	$1,001,000	$1,001,000	$1,001,000	$1,001,000
Sub-Total	$374,500	$1,001,000	$1,001,000	$1,001,000	$1,001,000
Total Expenses	$754,790	$1,671,560	$1,671,560	$1,671,560	$1,671,560
Principal and Interest	$180,000	$1,014,570	$1,162,940	$1,162,900	$1,163,330
Facility Taxes	-	-	-	-	-
Sub-Total	$180,000	$1,014,570	$1,162,940	$1,162,900	$1,163,330
Total Expenses, P&I, and Taxes	$934,790	$2,686,130	$2,834,500	$2,834,460	$2,834,890

1.4.2.2 Sensitivity Scenarios

In the sensitivity scenarios, we explore the impact of decreasing or increasing the amount of grant funding, and of eliminating the dark fiber revenue. These are not the only project parameters that might change, but they offer important illustrations of the LFUCG's potential long-term costs if it were to construct an FTTP network.

Our first sensitivity scenario removes the $35.39 million in grant funding (or funding from other sources that do not need to be repaid). Dark fiber revenues remain the same.

In this model, per-passing fees must increase to $97.50. For reference, if a private partner managed to obtain a 35 percent take rate with a per-passing fee of $97.50 per month, the partner would then need to pay the LFUCG $278.85 per subscriber for the network to maintain positive cash flow. *These numbers are an order of magnitude higher than we have seen any private partner agree to pay in any market in the U.S.* There simply does not exist a scenario in which public debt at this level could be serviced with fees from any partner. Rather, the fees at best would cover a small fraction of the LFUCG's financing costs.

In other words, with grant funding (as in the base case), the FTTP network model would be unbelievably challenging for the LFUCG to sustain. Without grant funding, the FTTP model is inconceivable.

Table 7 shows a condensed income and cash flow statement for this scenario.

Table 7: FTTP Scenario 1 – No Grant Funding Financial Summary

Income Statement	Year 1	Year 5	Year 10	Year 15	Year 20
Total Revenues	$26,560	$6,310,440	$6,310,440	$6,310,440	$6,310,440
Total Cash Expenses	(754,790)	(1,671,560)	(1,671,560)	(1,671,560)	(1,671,560)
Depreciation	(650,910)	(2,102,550)	(2,102,550)	(2,102,550)	(2,140,750)
Interest Expense	(966,000)	(2,856,860)	(2,276,460)	(1,499,760)	(460,850)
Taxes	-	-	-	-	-
Net Income	$ (2,345,140)	$ (320,530)	$259,870	$1,036,570	$2,037,280

Cash Flow Statement	Year 1	Year 5	Year 10	Year 15	Year 20
Unrestricted Cash Balance	$28,670	$584,410	$598,460	$612,680	$621,550
Depreciation Reserve	-	189,240	203,640	218,040	45,350
Interest Reserve	966,000	-	-	-	-
Debt Service Reserve	805,000	2,555,000	2,555,000	2,555,000	2,555,000
Total Cash Balance	$1,799,670	$3,328,650	$3,357,100	$3,385,720	$3,221,900

In our second sensitivity scenario, we increase the initial startup funds to equal the OSP cost. With dark fiber revenues remaining the same as in the base case, per-passing fees decrease to $26.25 per month. Even with that decrease, however, the required per passing fee is still quite high. This scenario (Table 8) projects an unrestricted cash balance of $800,000 in year one, increasing to roughly $4 million in year five and beyond.

Table 8: FTTP Scenario 2 – Grant Funding Equal to Total OSP Cost Financial Summary

Income Statement	Year 1	Year 5	Year 10	Year 15	Year 20
Total Revenues	$7,150	$2,435,580	$2,435,580	$2,435,580	$2,435,580
Total Cash Expenses	(754,790)	(1,671,560)	(1,671,560)	(1,671,560)	(1,671,560)
Depreciation	(650,910)	(2,102,550)	(2,102,550)	(2,102,550)	(2,140,750)
Interest Expense	-	(449,240)	(359,150)	(238,590)	(77,760)
Taxes	-	-	-	-	-
Net Income	$ (1,398,550)	$ (1,787,770)	$ (1,697,680)	$ (1,577,120)	$ (1,454,490)

Cash Flow Statement	Year 1	Year 5	Year 10	Year 15	Year 20
Unrestricted Cash Balance	$807,260	$4,446,730	$4,372,830	$4,299,130	$4,220,080
Depreciation Reserve	-	189,240	203,640	218,040	45,350
Interest Reserve	-	-	-	-	-
Debt Service Reserve	-	400,000	400,000	400,000	400,000
Total Cash Balance	$807,260	$5,035,970	$4,976,470	$4,917,170	$4,665,430

Our third sensitivity scenario assumes that LFUCG does not obtain any dark fiber revenue, but proceeds with the same initial startup funding as our base case scenario. For this model to be viable, the per-passing fee needs to be increased to $53.50, or more than seven times the amount paid by Google Fiber in Huntsville.

Table 9: FTTP Scenario 3 – No Dark Fiber Revenue Financial Summary

Income Statement	Year 1	Year 5	Year 10	Year 15	Year 20
Total Revenues	$14,520	$2,898,670	$2,898,670	$2,898,670	$2,898,670
Total Cash Expenses	(754,790)	(1,671,560)	(1,671,560)	(1,671,560)	(1,671,560)
Depreciation	(650,910)	(2,102,550)	(2,102,550)	(2,102,550)	(2,140,750)
Interest Expense	(180,000)	(724,320)	(575,920)	(377,340)	(112,070)
Taxes	-	-	-	-	-
Net Income	$ (1,571,180)	$ (1,599,760)	$ (1,451,360)	$ (1,252,780)	$ (1,025,710)

Cash Flow Statement	Year 1	Year 5	Year 10	Year 15	Year 20
Unrestricted Cash Balance	$1,274,630	$3,280,890	$3,285,080	$3,289,430	$3,288,450
Depreciation Reserve	-	189,240	203,640	218,040	45,350
Interest Reserve	180,000	-	-	-	-
Debt Service Reserve	150,000	650,000	650,000	650,000	650,000
Total Cash Balance	$1,604,630	$4,120,130	$4,138,720	$4,157,470	$3,983,800

This model projects a cash balance of $1.3 million in year one, and an unrestricted cash balance of $3.2 million in years five and beyond.

1.5 Summary of Federal Funding Opportunities

As part of this project, CTC evaluated the full range of federal funding sources for broadband to determine whether there exists any potential for securing federal funding, either to support capital or operating costs, for an initiative such as that contemplated here.

We evaluated the full range of federal programs, including those administered by the Federal Communications Commission and supported by the Universal Service Fund, and the broadband-specific program administered by the U.S. Department of Agriculture. We also looked at the potential for funding from the Appalachian Regional Commission and the Economic Development Administration of the U.S. Department of Commerce.

All of these federal entities have been the traditional sources of funding for broadband initiatives in rural areas.

Unfortunately, there does not currently appear to exist any program for which the Fayette County areas are competitive for securing grant funding. The current era represents a time when there is relatively modest federal support for broadband expansion, and most of those programs are targeted toward very low income areas—or areas facing particular forms of economic crisis such as the decline in coal-related jobs. The most substantial form of federal funding for broadband projects is the Universal Service Fund's Connect America Fund, which is not focused on income level, but is focused on degree of rurality and the Fayette County areas are not eligible.

There does exist the potential for new federal funds to support broadband infrastructure projects as part of the much-discussed potential infrastructure bill that President Trump has stated as a priority. As of the current writing, however, there is little definition around what such legislation might look like—or whether it would include broadband as an eligible infrastructure form.

1.6 Summary of Interest of Private Internet Service Providers

In the course of this project, CTC analysts conducted discussions with multiple private sector service providers in order to identify strategies for working with private entities in service of the goals of this initiative.

We held discussions with competitive fiber and wireless providers as well as with incumbent phone and cable service providers. These included Windstream (Uniti Fiber), Charter Communications, Lightower, Level 3 Communications, Crown Castle, Lumos, Zayo, USA Fiber, FiberLight, WOW Fiber, Unite Private Networks, and QX.net.

While these companies have varied amounts of existing and planned infrastructure in the Fayette County area, all expressed potential interest in further partnership discussions, but would require substantial public sector investment. None of the companies was willing to commit to new investment, though they were open to further discussions.

1.7 Recommendations

As the engineering and financial analyses in this document demonstrate, the cost of solving the broadband deficit in Fayette County is enormous. A comprehensive FTTP solution to all homes and businesses would have to be heavily subsidized through (hypothetical) federal or state grants or by the LFUCG, given that the private providers with which we consulted were adamant that there was insufficient return for them to build comprehensively in the County through private investment. Even though the individual businesses and farms are very attractive customers, the cost of reaching them is too high to incent private investment absent some very substantial form of support.

The scale of this last mile challenge is very large, and the upfront capital expense that would be required of the LFUCG and/or the stakeholders in the County area is significant. That solution represents the best and fastest way to solve the problem—but it comes at enormous expense. This finding is consistent with low-density areas throughout the United States, and even with high-density communities where better broadband is not emerging.

However, there are viable alternative paths that are less comprehensive but still impactful that the LFUCG can take—ideally in collaboration with the key stakeholders in Fayette County. These represent more modest but possibly important steps along the path to a long-term solution. It is important to note that none of these steps would solve in one fell swoop the significant economic challenge of deploying broadband in a low-density region, no matter how attractive the market or the customer base.

1.7.1 Consider the Middle Mile Strategy, Which Will Be Costly but More Viable Than a Comprehensive Solution

The middle mile strategy is without question costly—but it entails less risk, both in its size and with respect to potential demand, than the last mile strategy. For this reason, it is worth considering as a substantial step toward addressing the broadband challenge in the County. Under this strategy, the community would get fiber connectivity to key LFUCG businesses and farms that are critical to the economic well-being of the area,[11] and by doing so would also create a platform for additional expansion of the network over time, whether public or private.

Our financial analysis suggests that the middle mile model would work if all of the target sites identified by the LFUCG and the Fayette Alliance for this analysis purchase, on an ongoing basis, a gigabit Dedicated Internet Access (DIA) service at $3,200 per month. That number would be lower, as is discussed above, if the users were to pay an upfront connection fee. But we anticipate that market interest would be greater absent the connection fee.

[11] Please see Appendix A for a list of the locations in the middle mile scenario. This list was developed in consultation with the LFUCG and the Fayette Alliance.

$3,200 is well within the range of market pricing for this type of product that we see in other areas of the country, including in some metropolitan areas. For example, 1 Gbps DIA is priced for business customers at around $3,000 in northern Virginia in the Washington, DC suburbs, in Baton Rouge, LA, and in Portland, OR (for a multi-year term). In the rural areas of Virginia and Maryland, pricing ranges from $3,000 to $9,000. In Newport News, VA, commercial providers offer 1 Gbps DIA service at a monthly recurring charge of $6,000.

With this pricing to these customers, this model will cash flow, even taking into account financing costs, operations, and maintenance. Because of the relatively modest number of potential customers, the LFUCG would not need to proceed until it had binding commitments from all of the customers—thus eliminating market risk in the short term and mitigating it in the medium to long term. The willingness of the larger employers in the Fayette County area to commit to those kinds of prices, in light of the fact that the network is not viable at substantially lower service fees, will be the test of the viability of going forward with this strategy.[12]

In contrast, in a fiber-to-the-home and -business environment, the large number of potential customers—many of them interested in much more modest products and prices—would deliver considerable market risk, as well as considerably higher capital costs.

While the middle mile strategy will not get connectivity to every home and business in the county, what it will do is address the needs of the key entities identified by the LFUCG and the Fayette Alliance as critical to economic activity in the County, as well as public sector sites. And at the same time, based on the system-level design completed by our engineers, it will serve as a strategically routed platform for expansion of connectivity—either over wires or wirelessly—over time. It would also provide opportunity for any qualified, credit-worthy entity—whether public, for profit, or not for profit—to access these middle mile roads as a means of reaching areas of the County where they are interested in investing in the last mile.

We note that the follow-on last mile investment is hardly guaranteed by the existence of the middle mile. But in the long run, there is little doubt that this infrastructure could prove extremely valuable to expansion of broadband in the County.

Obviously, any state or federal contribution toward the capital cost of building the network will bring down the necessary service fees for the users. While to our knowledge no such source of grant funding currently exists, we recommend that the LFUCG engage with its State and federal representatives, particularly in light of the strong potential for federal infrastructure funding in the coming years.

[12] The online survey suggests some significant interest in such a network, even with the high costs involved, but that interest was highly sensitive to pricing and diminished as pricing increased.

1.7.2 Pursue Potential Fiber Access in Coordination with Lightower's Fiber-to-the-Tower Project

Wireless backhaul is a critical driver of fiber construction across the country, in rural, suburban, and urban communities. In researching the state of the LFUCG wireless market, we found that Lightower recently won a fiber-to-the-tower contract to provide backhaul for a national wireless carrier.

A company such as Lightower will generally build 144-count fiber for backhaul. Given that the construction is already planned, there may be an opportunity for the LFUCG to cost-effectively secure a certain number of fiber strands along Lightower's routes. While this would be an imperfect solution, in terms of completing a full fiber backbone to meet the LFUCG's needs, it might help on an incremental basis.

We recommend that the LFUCG initiate discussions with Lightower to determine whether, and under what financial parameters, the company would install fiber for the LFUCG's use.

1.7.3 Pursue KentuckyWired Fiber Access

The statewide KentuckyWired network also represents a potential source of middle mile fiber throughout parts of Fayette County. As with the Lightower fiber described above, gaining access to KentuckyWired would be an incomplete solution—but could provide some portion of a fiber backbone.

Accordingly, we recommend that the LFUCG work with KentuckyWired to identify the routes and number of strands that might be available for the LFUCG's use, and to incorporate that fiber into future middle mile planning.

1.7.4 Engage Large Farms in Discussions about Collective Fiber Planning and Buildout

In conjunction with, or instead of, potential partnerships with Windstream and Lightower, the LFUCG should also engage directly with representatives of the horse farms that are the driving force behind both the LFUCG's economy and this study. If the LFUCG determines that constructing a middle mile network is its preferred path, the LFUCG could mitigate its risk by securing commitments in advance from the largest farms. (The large farms might also become hub locations for network aggregation if the LFUCG were to construct middle mile or FTTP.)

Large enterprise customers often drive the expansion of fiber infrastructure to corporate campuses or business parks; in this scenario, the LFUCG's largest horse farms would play that role. Fiber construction to serve the LFUCG's largest enterprises would then over time enable more cost-effective service to the surrounding, mid-size and smaller farms.

1.7.5 Support Large Farms in Connecting to Fiber

Many equine property owners have access to trenching and backhoe equipment that they use when installing conduit for other utilities and services on their property (e.g., frost-free lines for water and electricity to out buildings); it is conceivable that many of these property owners would be able to self-provision given the right guidance and specifications.

As a next step in engaging the farm owners or operators, then, the LFUCG might also consider developing a "last-mile how-to kit" and standards for installation of conduit. This would be particularly helpful for the farms that have long easements or driveways to get to the public right-of-way (ROW).

We note, too, that if the LFUCG were to foster a "DIY" solution for private property extension from the public ROW, it might also consider a cooperative procurement and distribution strategy for conduit, fiber cabling, termination equipment, underground spice enclosure boxes, and other materials.

Most utility operators receive an easement that offers a legal right to install facilities, and to access and maintain or upgrade those facilities in the future. These easements often ensure adherence to the National Electric Safety Code. For large farms that were not originally served as part of the rural electrification efforts in the last century, the property owner or developer is often responsible for installation of facilities.

These parameters generally exist in what electric utilities refer to as "Applicant Owned Line Extensions"[13] or in cable provisions as "long drop" policies generally defined in their franchise agreement. The franchisee or utility operator generally provides the technical specifications required to be met for the property owner to dig/trench or install appropriate conduit, consistent with the operator's technical specifications. These specifications exist to ensure that the presence of such facilities in the conduit complies with all applicable safety and technical codes.

1.7.6 Engage National Wireless Carriers

The four national Mobile Network Operators (MNOs)—Verizon Wireless, AT&T Wireless, Sprint, and T-Mobile—develop construction strategies independently of one another unless there is a specific catalyst for a buildout. Should the LFCUG engage in the middle mile strategy, these companies are all potential customers for the dark fiber.

[13] "Rates, Terms and Conditions for Furnishing Electric Service," Kentucky Utilities Company, July 10, 2015, https://psc.ky.gov/tariffs/Electric/Kentucky%20Utilities%20Company/Tariff.pdf

In addition to the national MNOs, Charter and Windstream have aggressive plans for market buildout in the coming years and also look to develop their own MNO offering rather that rebranding an offering from one of the other national MNOs.

It is important to engage the MNOs directly; including them in the discussion will help them prioritize their planned expansion requests and network planning efforts.

We recommend that the LFUCG send a request for information (RFI) to the national MNOs, Charter, and Windstream for their input on a coordinated rural broadband infrastructure strategic plan for the region.

1.7.7 Continue to Maintain Lines of Communication with Windstream and Charter

We think there is exists a modest opportunity to work with Charter or Windstream. Frankly, these are not companies that invest significantly in rural areas. Charter does not have a rural footprint almost anywhere in the country but Windstream does, so the chances may be somewhat greater with Windstream.

Windstream recently sold its fiber assets to a Real Estate Investment Trust known as Uniti Fiber, previously CS&L, which now leases the fiber back to Windstream. Based on our discussions with company representatives, Windstream is considering a fiber demonstration project; the rural parts of Fayette County might be well-suited to that initiative. As of this writing, CTC is working to facilitate discussions between Windstream and the LFUCG.

We stress that these are remote possibilities. That said, we recommend that the LFUCG's internal team continue these conversations—recognizing that any agreement with Charter or Windstream is likely to involve very high levels of public investment and risk. In the event that the LFUCG is considering making an investment of the scale described in the engineering sections of this report, these companies may be viable partners (in terms of public funding of privately owned infrastructure). But this is not typical of their business plans or how they have worked with the public sector. Smaller, competitive, more entrepreneurial companies tend to be more creative in working with the public sector on projects such as this.

2 Broadband Challenges in Fayette County

Fayette County is the center of the international thoroughbred raising and racing industries. The equine farms in this area—many of which are large, complex, and lucrative operations—are centers of employment and economic growth (especially through the ancillary businesses that they support in the region), and attract visitors from around the world.

Building on the University of Kentucky's earlier research into the value of the equine industry in the Agriculture Cluster,[14] we focused our analysis on the LFUCG's rural farms. (We also drew on the knowledge of the broadband market and construction factors that we developed in our past work on behalf of the City of Lexington.)

We developed a picture of broadband gaps through discussions with a range of sources, including LFUCG staff, representatives of the Fayette Alliance and the University of Kentucky, and owners and managers of some of the largest farms in the study area. We engaged with representatives of the farms and related area businesses through an online survey conducted in partnership with LFUCG and the Fayette Alliance (see Appendix C).

We also gathered data on the farms through the Kentucky Thoroughbred Association.[15] Using the association's data, we identified the largest farms by property value and plotted their locations on a map of the County to establish the critical points of broadband infrastructure needs. We also plotted smaller farm, which dot the landscape around the larger farms and establish a baseline for counting potential customers.

By overlaying the known fiber routes in the County, we developed a picture of the existing infrastructure in the County. This conceptual map of the LFUCG's equine farms and existing fiber assets formed the basis for the high-level network designs we developed as potential solutions (see Section 4).

As expected, the presence of fiber and other communications infrastructure diminishes as locations get further from Lexington. The University of Kentucky has some fiber that it has constructed to research parks. Windstream, the LFUCG's incumbent local exchange carrier (ILEC), delivers voice telephone and limited DSL service throughout the County. Charter, the incumbent cable company, delivers limited cable modem service. Both companies operate aging infrastructure.

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[14] See, for example: Alison Davis, Lori Garkovich, Leigh Maynard, James Allen, Shaheer Burney, and Tarrah Dunaway, "The Influence of the Agricultural Cluster on the Fayette County Economy," University of Kentucky, College of Agriculture, January 2013.

[15] http://www.kentuckybred.org/

3 Potential Public–Private Partnership Approaches

CTC conducted discussions with multiple private sector service providers looking for synergies that would make them viable potential partners.

CTC held discussions with competitive fiber providers, and incumbent telecommunications and cable service providers. These included Windstream (Uniti Fiber), Charter Communications, Lightower, Level 3 Communications, Crown Castle, Lumos, Zayo, USA Fiber, FiberLight, WOW Fiber, and Unite Private Networks.

While these companies have varied amounts of existing and planned infrastructure in the Fayette County area, all expressed potential interest in further partnership discussions.

Industrywide, these companies are all actively pursuing partnerships with the four national Mobile Network Operators (MNOs)—Verizon Wireless, AT&T Wireless, Sprint, and T-Mobile—for fiber build-out. Support of wireless network infrastructure is the largest driver for private sector fiber expansion across the country. Presently, most of that major expansion is occurring in major metro areas, but the continuing trend is for the MNOs to look at third-party companies to provide future expansion in rural areas, as well.

This is occurring via direct investment or through sponsored investment as the competitive fiber providers serve as neutral-host operators, leveraging fiber assets and connections to serve multiple MNOs. This strategy is increasingly important in rural areas, where singular investment is not warranted.

3.1 Communications Carriers

3.1.1 Uniti Fiber/Windstream

Uniti Fiber is a division of Communications Sales and Leasing, Inc. (CS&L), a publicly traded real estate investment trust (REIT). CS&L was formed in early 2015 when Windstream spun off certain telecommunications assets across the country, primarily fiber assets. Uniti Fiber now provides wholesale transport to Windstream across the legacy Windstream backbone.

Uniti is a provider of infrastructure solutions including cell site backhaul and small cell for wireless operators, and Ethernet, wavelengths and dark fiber for telecom carriers and enterprises.

The company specialize in custom-designed, technology- and access-agnostic bandwidth solutions and primarily focuses in what is considered lower-tier and rural markets where it is often difficult to find reliable, scalable, and affordable solutions.

In discussions with Christopher Parra, Uniti Fiber's Vice President of Corporate Development, under the direction of Uniti Fiber President Ron Mudry and Windstream CEO Tony Thomas, we were told that Uniti Fiber is looking to identify Windstream markets for redevelopment and network reinvestment.

The LFUCG is one of the potential markets identified as a pilot.

Several factors would need to be taken into consideration. Uniti is in the process of evaluating the conceptual design provided by CTC and identifying what the market impact would be.

Having the ability to overbuild on existing routes for which Windstream already owns the pole attachments would result in a significant reduction in total network deployment costs.

CTC highly recommends pursuit of follow-ups as a rural market demonstration by Uniti Fiber/Windstream.

Figure 7: Uniti Fiber/Windstream Assets

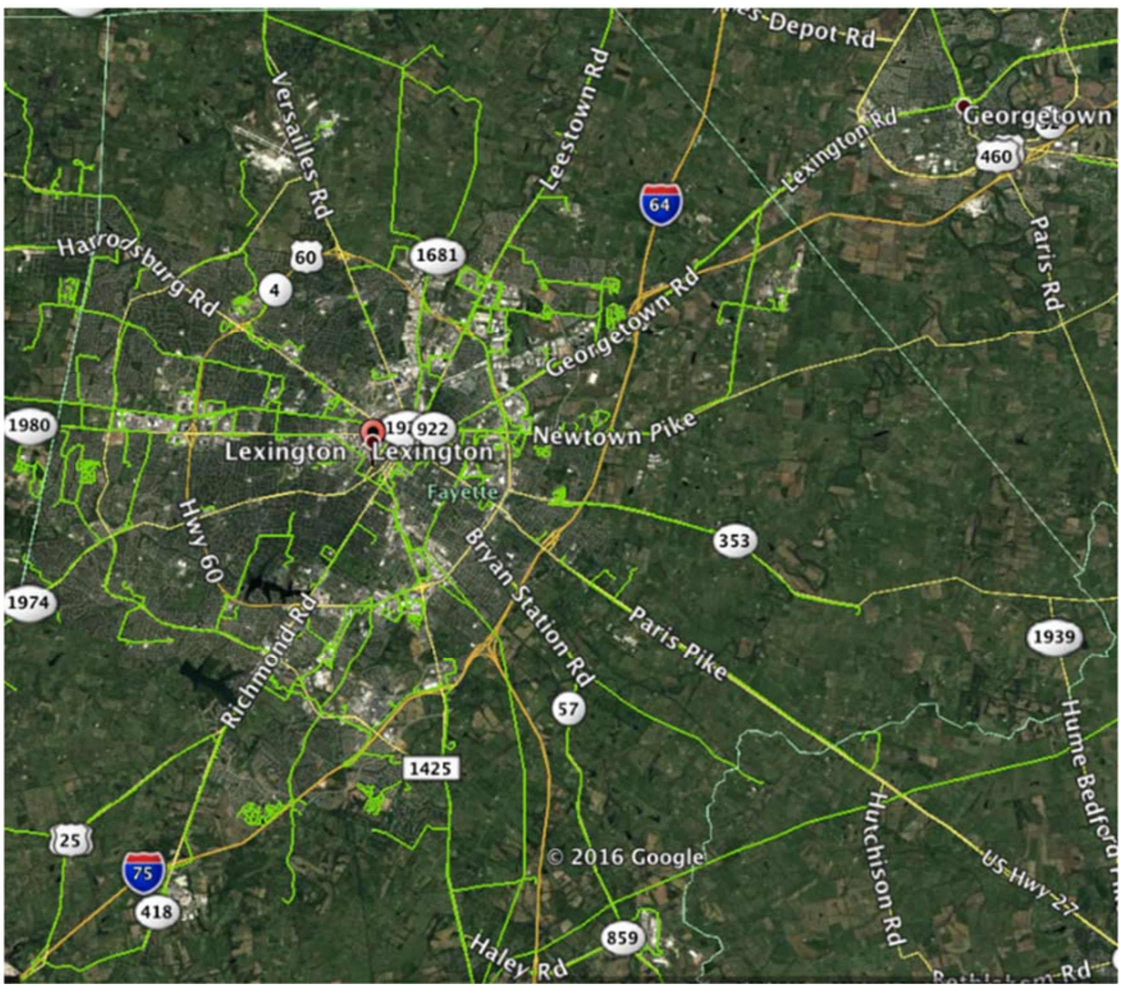
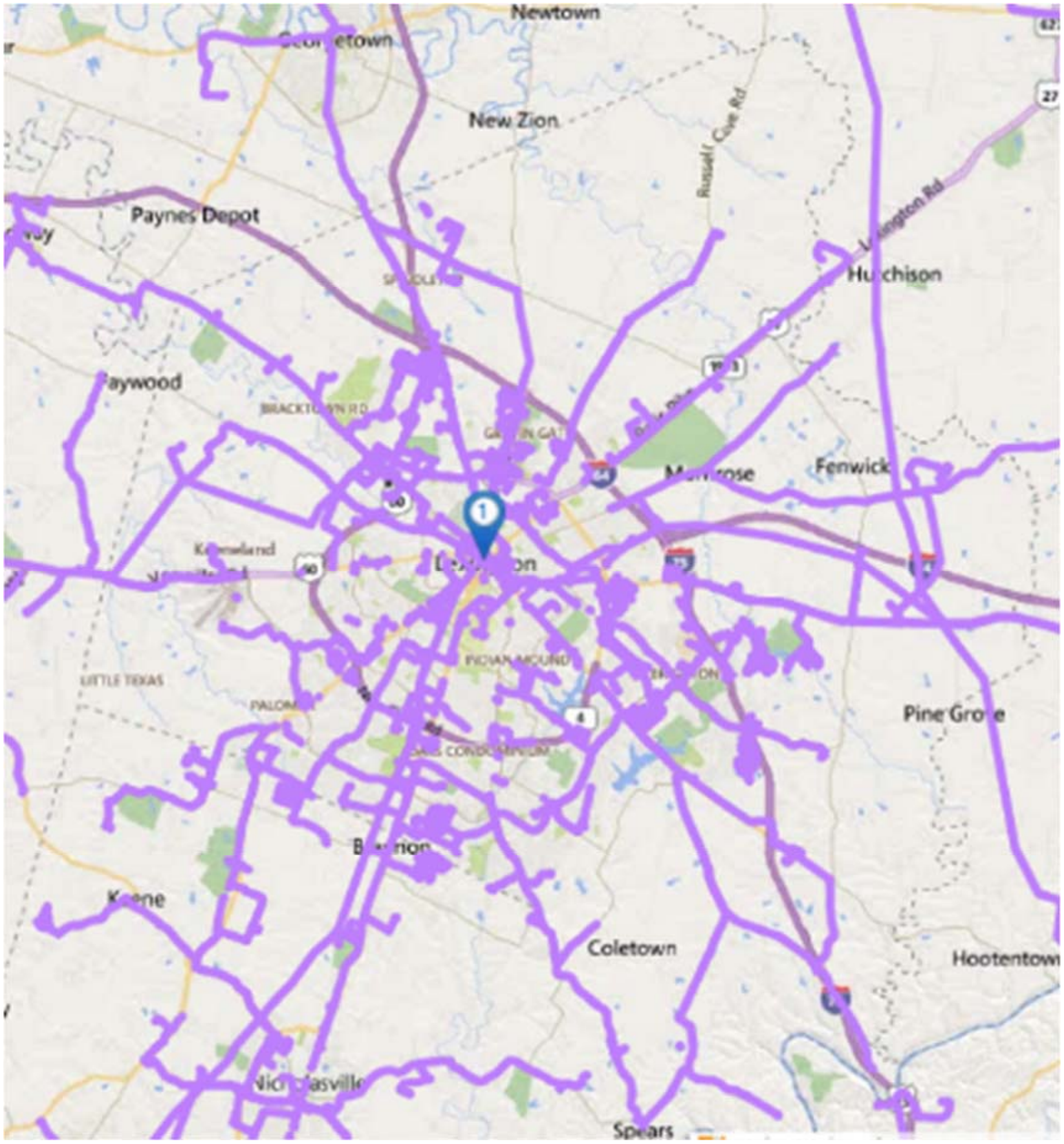


Figure 8: Windstream Fiber[16]



3.1.2 Charter Communications

Charter Communications, through the acquisition of assets from Time Warner Cable (which were legacy Comcast assets) is the primary provider of cable service in Lexington and Fayette County.

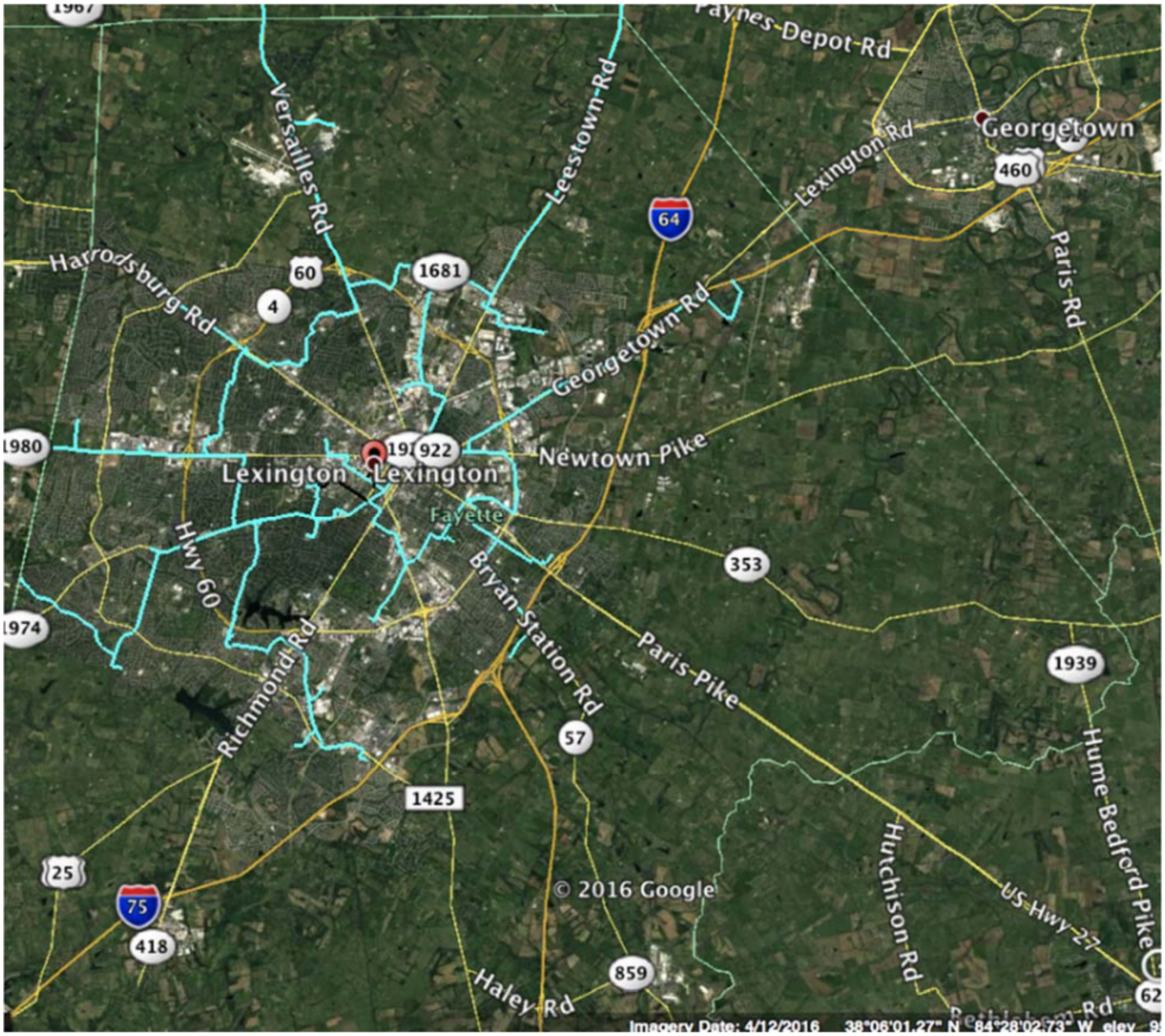
We have held multiple discussions with Charter representatives, but the company has not been forthcoming with maps or data on its existing infrastructure in the area.

[16] Source: FiberLocator

3.1.3 Lightower Communications

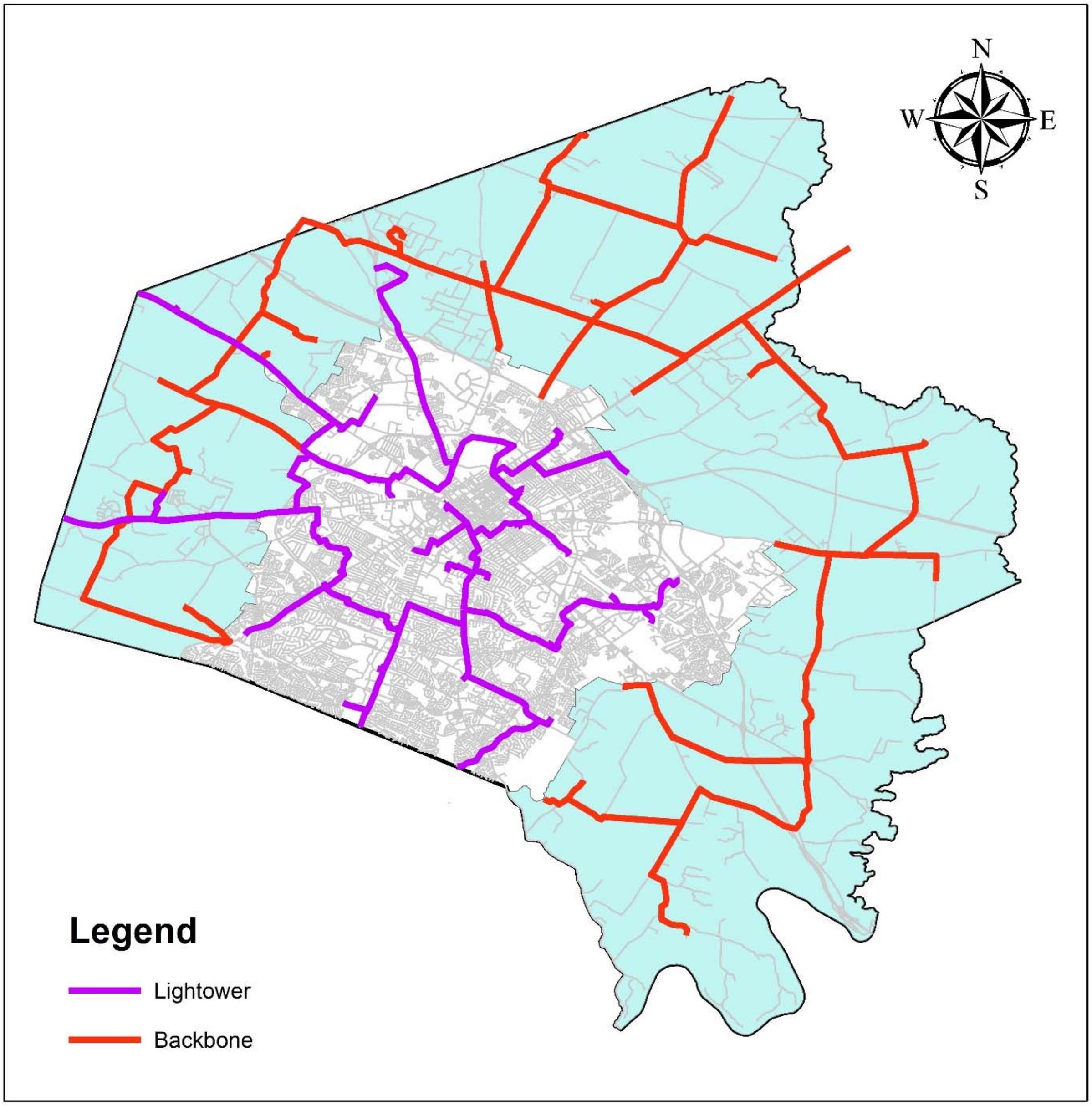
Lightower has won a fiber-to-the-tower contract with a national wireless carrier in Lexington. We have identified that its planned construction project would represent a substantial middle mile backbone into various parts of rural Fayette County that could save the LFUCG significant buildout.

Figure 9: Lightower Proposed FTT Network[17]



[17] Source Lightower-provided KMZ file

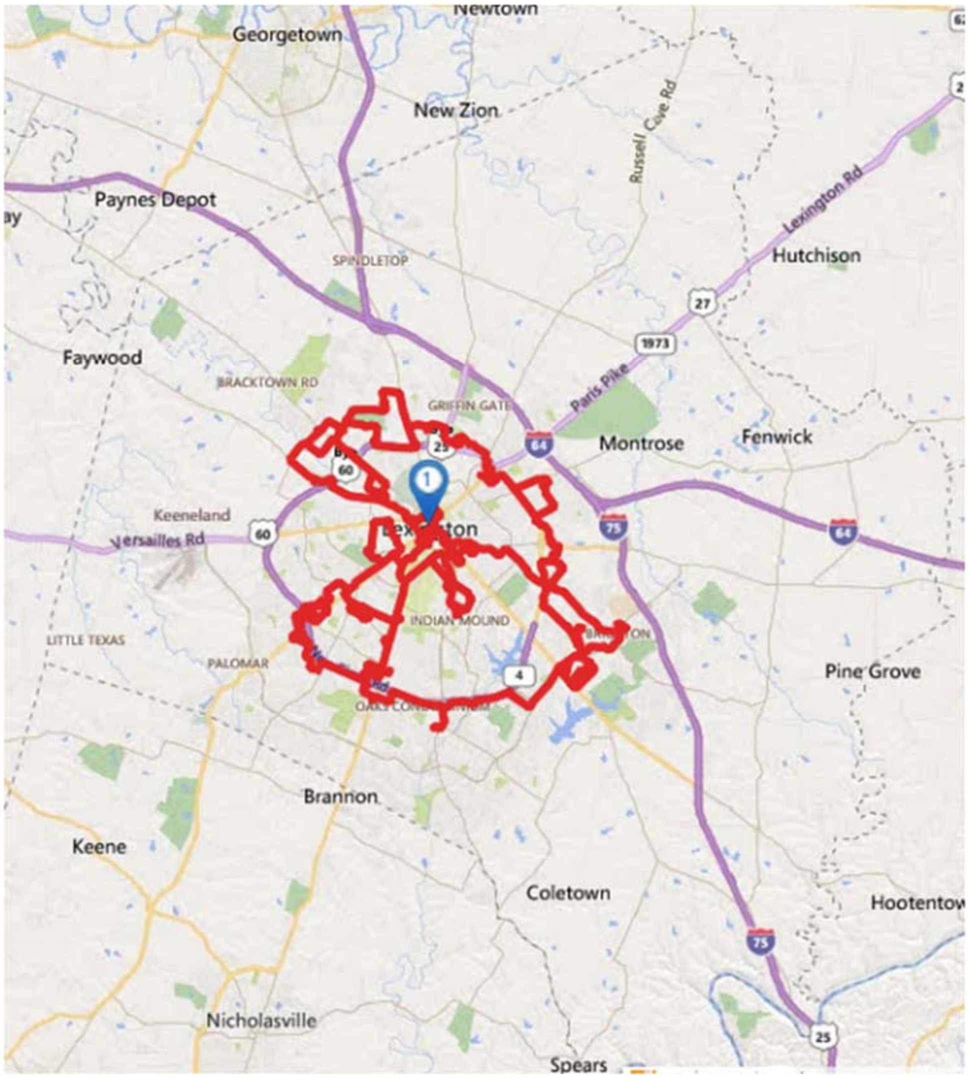
Figure 10: Lightower Proposed Fiber Overlaid Against Proposed Backbone Fiber



3.1.4 Level 3 Communications

Level 3 has a very dense fiber network in Lexington, but its network does not extend into the non-urban areas of Fayette County.

Figure 11: Level 3 Fiber



3.2 Non-Carrier Entities

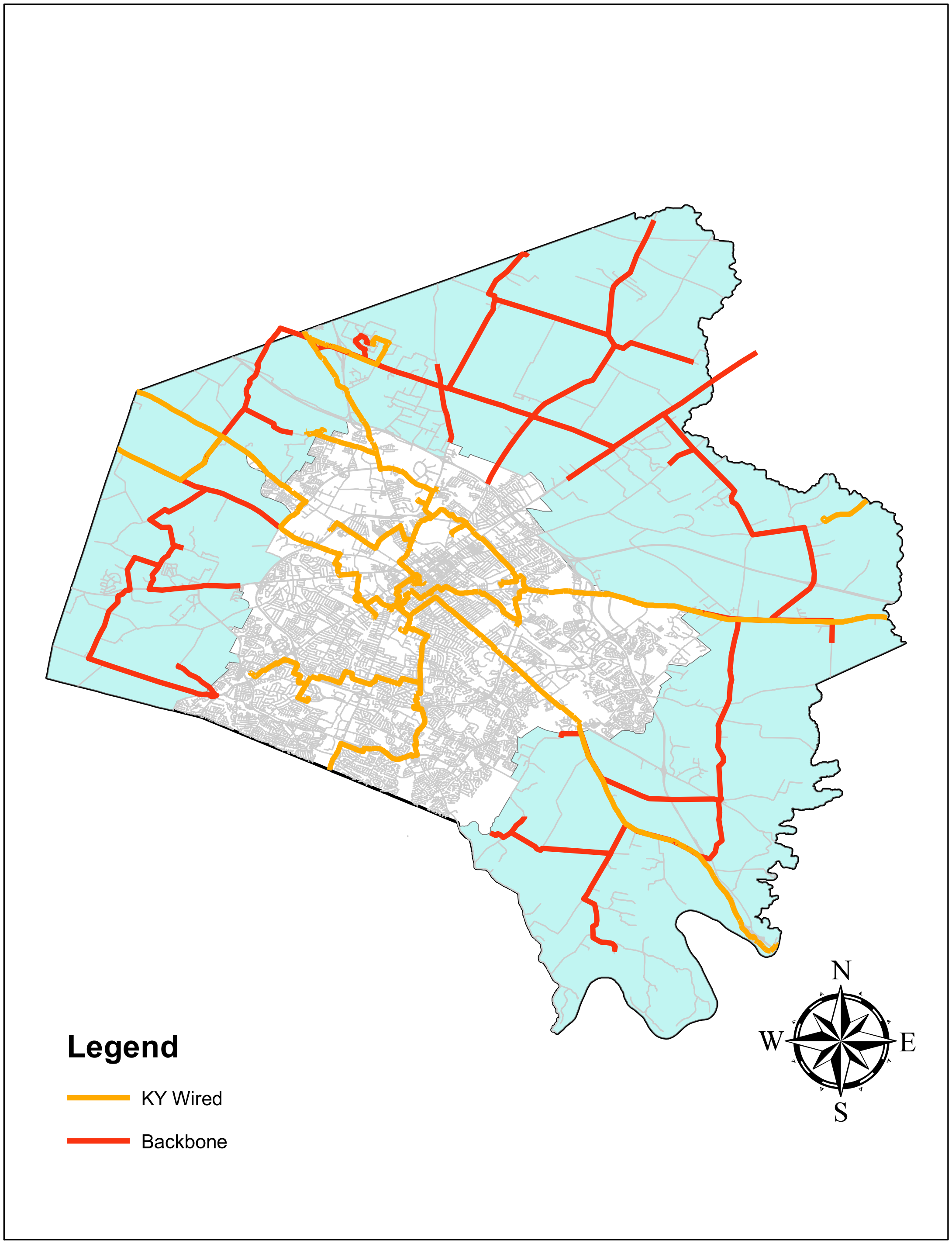
3.2.1 KentuckyWired Network

Lexington has contracted with the Kentucky Communications Network Authority (KCNA) to build 31 miles of 144-count fiber for the City as part of the KentuckyWired build out.

The City's fiber will be included as part of the same routes where KentuckyWired fiber is built and will be primarily within the Urban Services Area, but the KentuckyWired network will also traverse much of the rural area of Fayette County (Figure 12).

With the spare capacity available for lease, the LFUCG could potentially utilize parts of that planned network for middle mile backbone.

Figure 12: KentuckyWired Routes in Fayette County



3.2.2 QX.Net

QX.Net is a Lexington-based wireless provider that has been operating in Fayette County since 2006. One possible scenario for last-mile service in the County would be the utilization of fiber to some of the largest farms with a QX.Net wireless solution to neighboring properties.

The biggest challenges that QX.Net faces in serving rural Fayette County is distance, because of the high cost of backhaul. Much of QX.Net's backhaul is delivered over leased-line carrier Ethernet. Within its backbone is fiber from AT&T, Charter (Time Warner Cable), and Windstream. QX.Net has 30 existing backbone PoPs. Its service area is comprised equally of Lexington and the surrounding counties.

The company offers traditional TDM services including T-1 (up to 1.5 Mbps), DS3 (up to 45 Mbps) and OC3 (up to 155 Mbps); in select areas it offers Windstream DSL backhaul (up to 6 Mbps). In metro areas QX.Net is primarily using Siklu millimeter wave wireless gear, with an average of two miles from each end user location to the nearest PoP. Its average customer connection is 25 Mbps (upload and download) and averages about $800 per month.

3.2.3 University of Kentucky

The University of Kentucky has invested significant resources to provide fiber to its campuses and research facilities, and has also invested heavily in wireless in all buildings and common areas. Most of this deployment has been driven by investment from its various research departments through programmatic or grant-related funding. The fiber has been installed and is maintained by the university's Central Campus IT Services group; the end user departments pay a prorated share of those costs.

The university has deployed fiber to facilities including the stallion barn, the Applied Research lab, the Farm research facility, and the South Farm/Horticulture research property. If the LFUCG were to build its own network, the South Farm could potentially be used as an aggregation node.

3.2.4 Kentucky Utilities Company

Additionally, investment in new fiber as part of Smart Grid infrastructure strategy is occurring by major electric suppliers. CTC held discussions with Kentucky Utilities Company (KU) parent company PPL. Mathew Green is their director of Asset Management and Strategy, responsible for strategic planning initiatives related to Smart Grid improvements across their various electric partner companies. While most of the substation upgrades have been complete in the City of Lexington, continued transmission upgrades and rural substation upgrades will continue.

A report generated by the Department of Energy's Pacific Northwest Laboratory[18] examined the advanced communication infrastructure that will be critical in wide-scale deployment of complete automation technology associated with smart grid infrastructure.

[18] Source: Pacific Northwest National Laboratory – "The emerging interdependence of the electric power grid & information and Communication Technology" Aug2015 http://gridarchitecture.pnnl.gov/media/white-papers/Electric%20Power%20Grid%20Interdependencies.pdf

Like many utilities that making investments in enabling infrastructure for full scale shift to smart grid, KU/PPL are making investments that include fiber optic and LTE communications systems, support of distributed energy resources (DERs). The enormous amounts of data that will be generated will demand a highly reliable, high capacity, low latency, prioritize grid data communications network with low.

Additionally, as KU has developed its network hardening strategy after several severe weather events, several elements adopted are complimentary to broadband deployment and should be explored. These investment strategies include.[19]

- Significant undergrounding including converting all laterals to underground constructions
- Increasing ROW width around distribution circuits
- Replacement of large groups of aging assets with new poles

[19] Source: eei.org/ep Article related to LG&E and Kentucky Utilities Enhanced Storm Hardening Investment Strategy http://daviescon.com/wp-content/uploads/2015/09/98-03-Electric-Perspectives-LGE-KU-Hardening-2015-09-28.pdf

4 Middle Mile Fiber Network Design and Cost Estimate

This section examines the cost and feasibility of making a public investment in a middle mile fiber optic communications network to serve governmental facilities and to pass the priority farms and other businesses located in the County.[20] The LFUCG's goals include meeting its internal communications needs, increasing economic development opportunities, and expanding service options for residents and businesses.

CTC estimates the cost of constructing the middle mile fiber optic network to be approximately $11.3 million, inclusive of outside plant (OSP) construction labor, materials, engineering, permitting, testing, and network electronics and configuration. The middle mile fiber network is approximately 113 miles and passes more than 230 farms and businesses in the County as well as 62 priority sites identified by the LFUCG (see Appendix A).

Actual costs may vary due to unknown factors, including costs of private easements, pole attachment agreements with the pole owners, make ready costs, variations in labor and material costs, and subsurface hard rock. We have incorporated suitable assumptions to address these items based on our experience developing fiber-to-the-premises (FTTP) build cost estimates for the City of Lexington.

4.1 Technical Approach

CTC developed a system-level design for a fiber optic network to serve as the basis for estimating costs. Design priorities targeted by this conceptual design include:

- Providing fiber connectivity to all County facilities for which leased service fees can be avoided (see "School and Fire Station Sites" in Figure 13)
- Providing fiber connectivity to 54 priority farms to spur economic development (see "Priority" sites in Figure 13 and Figure 14)[21]
- Passing as many of the large farms and businesses in the County as possible along the fiber routes (See "Middle Mile Sites" in Figure 14)
- Connecting to KentuckyWired to provide Internet access to the network by interconnecting along a shared fiber path (Figure 15)
- Minimizing costly railroad and interstate crossings to meet basic connectivity objectives

[20] Lateral fiber construction will still be required to provide services to subscribers at an additional cost.

[21] Lateral fiber construction will be required at each farm and business purchasing service at an additional cost.

The resulting network architecture, illustrated in Figure 13, is comprised of approximately 113 route miles of fiber connecting all 62 County and priority sites (Appendix A). While not fully vetted in the manner necessary for permitting and construction, this fiber optic design is likely to closely approximate a final design meeting the stated design objectives.

Figure 13: System-Level Fiber Network Architecture and Priority Sites

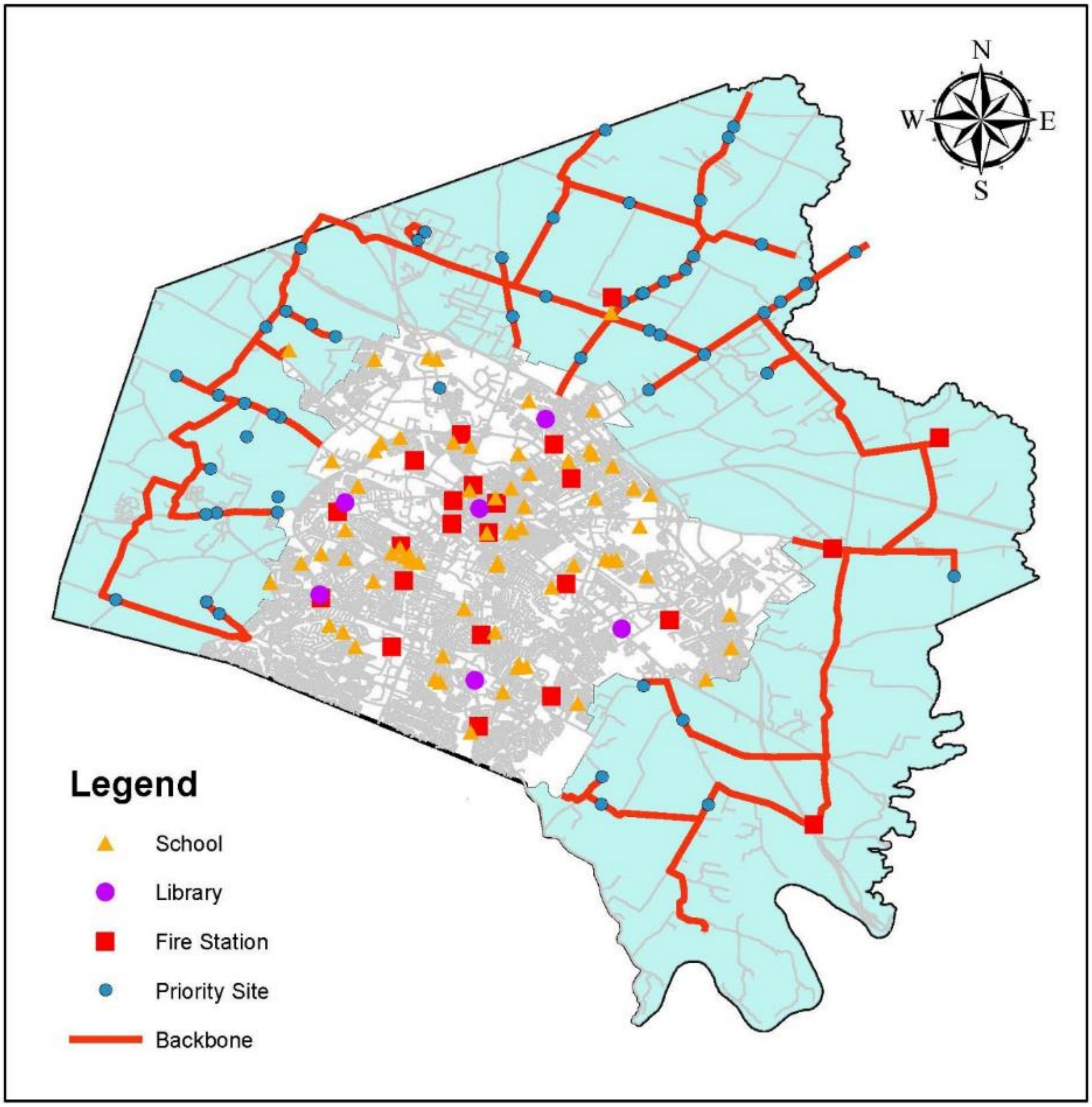


Figure 14: Fiber Optic Routing Showing Proximity to Identified Farms

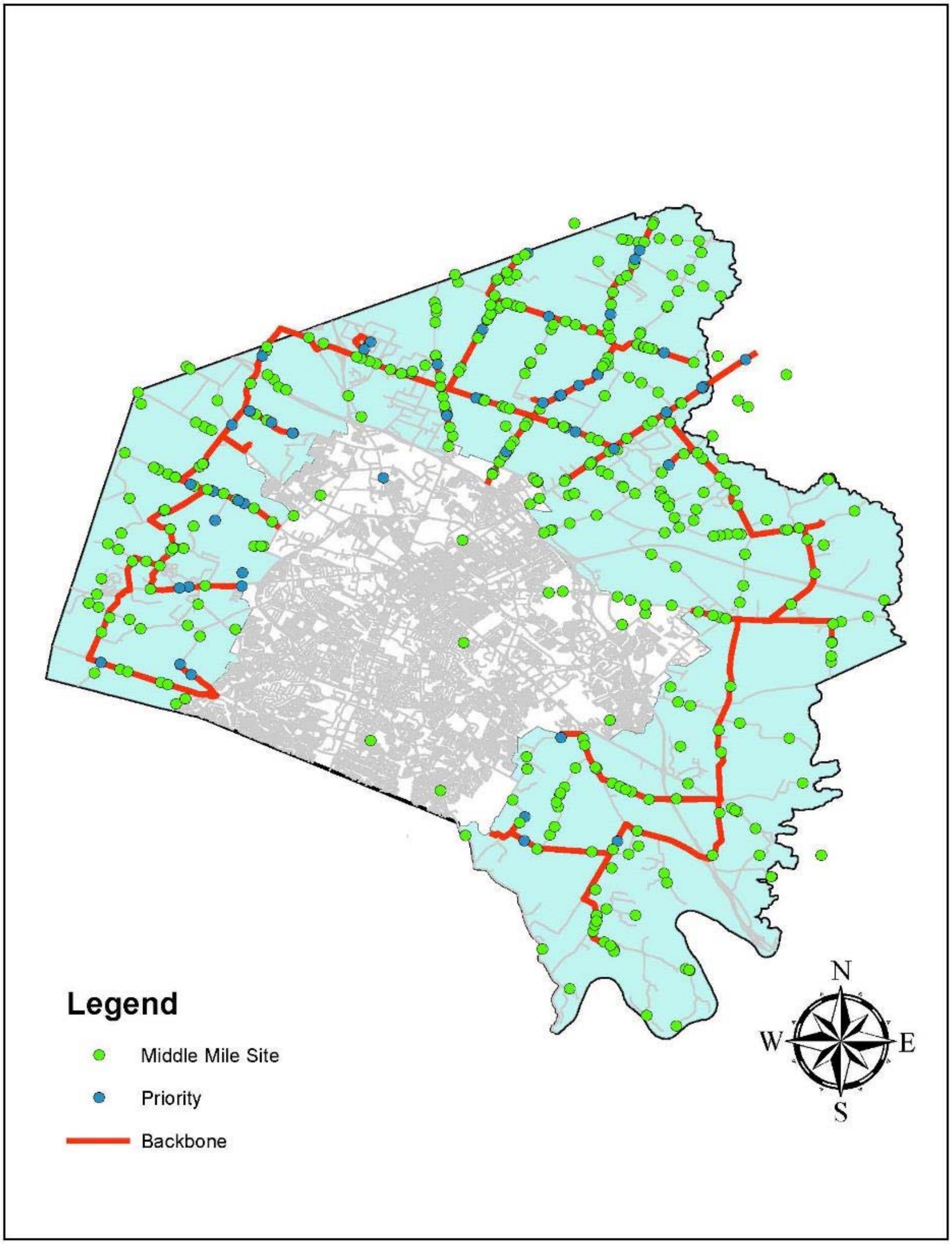
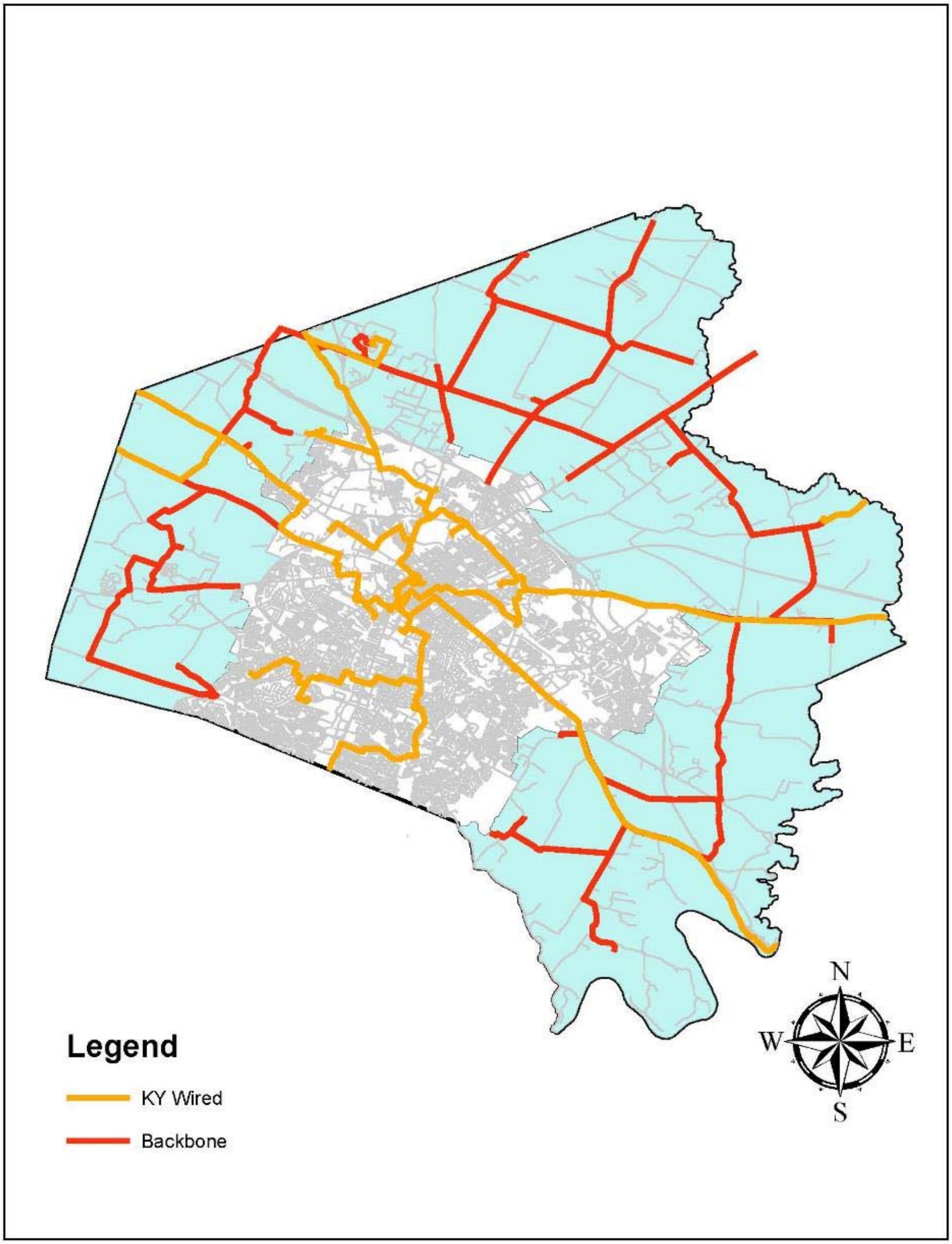


Figure 15: Overlay of KentuckyWired and Middle Mile Network



A wide range of logical topologies are feasible given the physical architecture of the proposed network. Depending on splicing configurations, connections can be established with or without route diversity over backbone rings (where available), and provide dedicated paths between any sites without the need for "patching" between intermediate sites. The network can also serve as a method of providing connectivity to farms and businesses as shown in Figure 14. The fiber backbone comes very close to many of the homes and businesses in the County and can be expanded further in future phases.

The cost estimates are based on a flexible approach to splicing and fiber termination, providing a backbone consisting of a 288-strand cable attached to messenger wire on existing utility poles and using one two-inch conduit where utility pole attachments are not feasible.

4.1.1 Fiber Optic Technical Design

Beyond the physical fiber optic cable routing, there are several technical design and construction attributes impacting costs, including the following:

- **Fiber strand count:** The number of individual fiber strands provided in a single cable correlates to the capacity of the cable. Due to the vast effective bandwidth of fiber, it is feasible to scale the rate of data transmission carried by even a single fiber strand to meet all of the LFUCG's needs indefinitely; however, the cost of network electronics increases exponentially with this capacity.

  On the other hand, the material cost of fiber strands represents a very minor component of the overall cost of fiber construction (about $0.01 per strand per foot, compared to $15 to $20 per foot for the total cost of typical construction). It is thus prudent to install a cable of sufficient size to meet any conceivable requirements to ensure these needs can be met with a configuration of electronics that are as low-cost as possible. In fact, with sufficient fiber strands, the LFUCG can increase network capacity many orders of magnitude above current levels with little or no change to its network electronics.

  While we anticipate no portion of the network will require more than a few dozen strands, cost estimates are based on the installation of a 288-count cable along most segments of the network. This will ensure sufficient capacity for nearly any conceivable expansion of internal needs, fiber leasing, or even future support of business or residential services.

- **Aerial construction:** The cost estimate anticipates using the existing utility poles to the greatest extent possible and only constructing conduit where necessary. Since the LFUCG does not own its own utility poles, aerial construction will require negotiating pole attachment agreements with the pole owners. These agreements generally require recurring fees per pole, and generally require the attacher to pay the cost of any upgrades or modifications to the utility poles necessary to support the new attachment. These "make-ready" costs can vary drastically depending on the crowding on the poles, the condition and age of the poles, and the pole owner's technical standards.

The following assumptions were made regarding subsurface rock, aerial construction costs, and make ready (Table 10). The assumptions are based on our previous work in Lexington and our Google Earth review of the utility poles in the County.

Table 10: Summary of Cost Assumptions

Description	Assumption
Percentage of Intermediate Rock:	15%
Percentage of Hard Rock:	5%
Percentage of Routes Aerial:	90%
Make Ready Cost per move:	$450
Average moves per pole:	2
Average poles per mile:	30
Percentage of poles requiring make ready:	20%
Percentage of poles requiring replacement:	12%
Average pole replacement cost:	$4,000

- **Conduit size and quantity:** While it is possible to install fiber cable directly underground, this complicates installation and makes repairs difficult to implement without creating permanent impairments to the communications path. Instead, the cost estimates are based on the installation of a single flexible plastic conduit that provides a path into which fiber cable can be installed, cable slack can be pulled to accommodate repairs, or new cable can be installed to expand capacity. While cost estimates are based on the placement of a single 2-inch conduit, it should be noted that simultaneously placing additional conduits results in relatively minor increases in cost, within limits. Depending on material prices, 2-inch conduit is preferable along backbone routes, as it can accommodate one or more additional large-strand-count fiber cables with sufficient remaining space for placing additional smaller cables for purposes of placing "lateral" connections to future locations.

- **Handhole placement and size:** Handholes are enclosures installed underground in which conduit terminates. Handholes provide access for installing cable in the conduit, as well as housing cable splice enclosures and cable slack loops required for future repairs. Handholes generally must be placed at intersections of multiple conduit paths, or where the conduit path makes a sharp change in direction.

While cable can be pulled upwards of several thousand feet at a time, cost estimates for the LFUCG network assume installation of handholes every 500 feet on average, ensuring that the infrastructure supports cost-effective expansion to new sites, including access to businesses that might be targets of commercial network operators seeking to lease County fiber.

- **Right-of-way (ROW) restoration and fees**: The network cost estimates assume that the LFUCG may have to pay encroachment fees for construction along or under Commonwealth roads and for railroad crossing application and licensing fees, which can total upwards of $15,000 per crossing, not including special construction costs, which generally entail steel encasement of conduit. The cost estimates assume that the LFUCG will incur typical costs for permanent asphalt and concrete restoration required for utility "test pitting"—necessary to verify the location of other utilities in the path of the fiber to prevent damage. Generally this consists of excavation within small areas of less than two feet in diameter.

4.1.2 Network Electronics Technical Approach

The fiber optic physical architecture will support a variety of network logical architectures. The cost estimate includes carrier-grade redundant routers and aggregation switches at a single core site that connects the LFUCG's sites to the LFUCG's internal network and the farms and businesses to the Internet. The network electronics should support carrier-grade Ethernet services to customers using technologies such as Metro Ethernet, MPLS, PBB-TE, or T-MPLS.

We assume that Internet access will be provided by the KentuckyWired project and that the two fiber optic networks will be interconnected and connectivity will be provided to the core. The core site would house the network electronics and for cost estimates is assumed to be a free-standing telecommunications shelter located on County-owned land.

The routers will connect the KentuckyWired interconnection to the aggregation switches, and the switches will connect to the access electronics at each facility. Connections will be made using Gigabit Ethernet small form pluggable (SFP) network adapters. These can be upgraded to Ten Gigabit Ethernet as need arises for relatively low cost compared to the price of the fiber optics.

Providing Gigabit Ethernet connectivity to these sites using these technologies and the ability to upgrade to 10 Gbps Ethernet is far superior to the services provided over cable modem and DSL. This technology platform is comparable to the Metro Ethernet services offered by providers in urban areas.

Although it increases the network electronics costs, we highly recommend that a network with one core site have redundant routers and aggregation switches to prevent a single equipment failures from causing a network-wide outage.

Gigabit Ethernet access electronic costs have also been included for the 62 priority sites. These access electronics connect each farm or business LAN with the fiber optic network.

4.2 Cost Estimates

CTC estimates the cost to construct the middle mile fiber network and light the network with electronics as described in the previous section to be $11.3 million (Table 11).

Table 11: Summary of Fiber Network Costs

Outside Plant Fiber Construction	
Engineering	$2,049,000
Project Management / Quality Assurance	784,000
General Outside Plant Construction	6,875,000
Railroad, Bridge, and Interstate Crossings	225,000
Outside Plant Fiber Splicing	342,000
Fiber Termination	196,000
Fiber Construction Subtotals:	$10,470,000
Network Electronics	
Core Electronics	$233,000
Equipment Shelter	75,000
Aggregation and Access Electronics	501,000
Network Electronics Subtotals:	809,400
Total:	***$11,279,400***

4.2.1 Cost Estimate Breakdown

The cost estimates are inclusive of all engineering, project management, quality assurance, construction labor, network design, network electronics, and network installation anticipated to be necessary to implement the network on a turnkey basis, and are based on relatively conservative pricing assumptions. The following summarizes the scope anticipated by each of the cost components itemized in the table above:

- ***Engineering:*** Includes system-level architecture planning, preliminary designs, and engineering field walk-outs to determine candidate fiber routing; development of detailed engineering prints and preparation of permit applications; and post-construction "as-built" revisions to engineering design materials

- ***Project Management / Quality Assurance****:* Includes expert quality assurance field review of final construction for acceptance, review of invoices, tracking progress, and coordination of field changes

- ***General Outside Plant Construction****:* Consists of all labor and materials related to "typical" underground outside plant construction, including conduit placement, utility pole make-ready construction, fiber installation, and surface restoration; includes all work area protection and traffic control measures inherent to all roadway construction activities

- ***Railroad, Bridge, and Interstate Crossings****:* Consists of specialized engineering, permitting, and incremental construction (material and labor) costs associated with crossings of railroads, bridges, and interstate/controlled access highways

- ***Outside Plant Fiber Splicing****:* Includes all labor related to fiber splicing of outdoor fiber optic cables

- ***Fiber Termination****:* Consists *only* of costs related to fiber termination and fiber testing; fiber lateral construction costs are discussed below

- ***Network Electronics:*** Costs related to the design, configuration, and installation of network electronics required to leverage the fiber infrastructure (not including operational and support costs beyond year one)

4.2.2 Construction to Large Farms and Businesses

In a residential fiber network model, each home installation is relatively similar to its neighbors—making it easier to come up with an average across many homes. In contrast, the extent and cost of lateral fiber construction on the farms will need to be estimated on a case-by-case basis. Each farm will be different in terms of the distance from the road (i.e., the location where the fiber passes the private property) to the location on the farm where service is needed. The availability of utility poles, the number of locations on the farm that require service, and the inside wiring required at each location will also vary by farm.

A site survey and engineering design will be needed for each farm and business requesting service. *The lateral cost will have significant impacts on the financial feasibility of the network.*

The following scenarios describe potential construction parameters for connecting farms in the County:

1. A farm is located on the street that the fiber passes and the fiber is constructed aerially in this location. The farm has only one location to connect to the service and that location is close to the road. The farm has private utility poles that run from the utility poles in the

ROW to the network location. In this scenario the cost of construction the lateral could as low as $1,000 to $2,000 to add drop to the existing poles. Cost will vary with distance and the amount of inside wiring needed to reach the network location.

2. A farm is located on the street that the fiber passes and the fiber is constructed aerially in this location. The farm has only one location to connect to the service and that location is close to the road. The farm does not have utility poles or existing conduit to pull the fiber to the location. In this scenario new conduit and fiber would need to be installed or fiber could be direct buried to the location. Depending on the distance and construction method, the cost could be up to $20 per foot.

3. A farm is not located on the street that the fiber passes and shares a private road with other farms. The farm has multiple locations where service is needed. The farm does not have utility poles or existing conduit to pull the fiber to the location. In this scenario, first a private easement would be needed and then new conduit and fiber would need to be installed or fiber could be direct buried to each location. The cost for the laterals could quickly reach over $100,000 in these scenarios.

5 High-Level Fiber-to-the-Premises Design and Cost Estimate

This section presents a cost estimate and high-level network design for deploying a gigabit fiber-to-the-premises (FTTP) network to serve all farms, homes, and businesses in the rural area of Fayette County. The FTTP network, in which fiber optics are used to provide broadband services all the way to each subscriber's property line, will promote economic development in the LFUCG where residents and businesses have traditionally had limited options for telecommunication services.

The CTC cost estimate provides data relevant to assessing the financial viability of network deployment and developing potential business models.

The CTC design and cost estimate are underpinned by data and insight gathered by CTC engineers through a number of related steps, including our previous work developing cost estimates for the Lexington FTTP project.

5.1 FTTP Cost Estimate

This FTTP network deployment, assuming a 35 percent take-rate,[22] will cost approximately $43 million, inclusive of outside plant (OSP)[23] construction labor, materials, engineering, permitting, network electronics, customer premises equipment (CPE)[24], and testing (see Table 12).

This estimate does not include the customer drops,[25] which will add at least $866,000 to the estimate at a 35 percent take-rate. As explained below (Section 5.1.6), drop and lateral costs cannot be reasonably estimated at this time due to the wide variation in potential costs to construct to individual farms.

Table 12: Breakdown of Estimated Total Cost

Cost Component	Total Estimated Cost
Outside Plant	$40.8 million
Central Network Electronics	0.9 million
Customer Premises Equipment	1.0 million
FTTP Service Drop and Lateral Installations	TBD
Total Estimated Cost:	$42.7 million

[22] The percentage of customers who subscribe to the service, otherwise known as the penetration rate.
[23] The outside plant (OSP) is the physical portion of a network (also called "layer 1") that is constructed on utility poles (aerial) or in conduit (underground).
[24] The customer premises equipment (CPE) is the electronic equipment installed at a subscriber's home or business.
[25] The drop is the fiber connection from an optical tap in the ROW to the customer premises.

For an "FTTP Dark Fiber Lease" model like the one being considered in Lexington, the OSP cost estimate is $40.8 million. Actual costs may vary due to a variety of factors including the costs of private easements, congestion in the public right-of-way (ROW),[26] variations in labor and material costs, the presence of subsurface hard rock, and the LFUCG's operational and business model (including the take rate). We have incorporated suitable assumptions to address these items based on our experiences in similar markets, as well as in the Lexington area.

5.1.1 Cost Estimate Breakdown

The cost components for OSP construction include the following tasks:

- ***Engineering:*** Includes system-level architecture planning, preliminary designs and field walk-outs to determine candidate fiber routing, development of detailed engineering prints and preparation of permit applications, and post-construction "as-built" revisions to engineering design materials

- ***Quality Control/Quality Assurance:*** Includes expert quality assurance field review of final construction for acceptance

- ***General Outside Plant Construction:*** Consists of all labor and materials related to "typical" underground outside plant construction, including conduit placement, fiber installation, and surface restoration; includes all work area protection and traffic control measures inherent to roadway construction activities

- ***Special Crossings:*** Consists of specialized engineering, permitting, and incremental construction (material and labor) costs associated with crossings of railroads, bridges, and interstate/controlled access highways

- ***Backbone and Distribution Plant Splicing:*** Includes all labor related to fiber splicing of outdoor fiber optic cables

- ***Backbone Hub, Termination, and Testing:*** Consists of the material and labor costs of placing hub shelters and enclosures, terminating backbone fiber cables within the hubs, and testing backbone cables

- ***FTTP Service Drop and Lateral Installations:*** Consists of all costs related to fiber service drop installation, including outside plant construction on private property, building penetration, and inside plant construction to a typical backbone network service

[26] The ROW refers to land reserved for the public good such as utility construction. ROW typically abuts public roadways.

"demarcation" point; the cost includes all materials and labor related to the termination of fiber cables at the demarcation point[27]

The cost estimate also includes the construction of a network backbone that shares the routing of the "middle mile network" to interconnect the fiber distribution cabinets (FDCs)[28] and connect them to the core, where KentuckyWired would provide Internet connectivity.

5.1.2 OSP Cost Estimation Methodology

As with any utility, the design and associated costs for construction will vary with the unique physical layout of the service area—no two streets are likely to have the exact same configuration of utility poles, existing utilities, soil conditions, and special crossings. To estimate costs for the network, we developed a high-level FTTP sample design based on street mileage and passings[29] (see Figure 16, below). Since much of the County has aerial utilities, we assumed that the 90 percent of FTTP network would be constructed aerially.

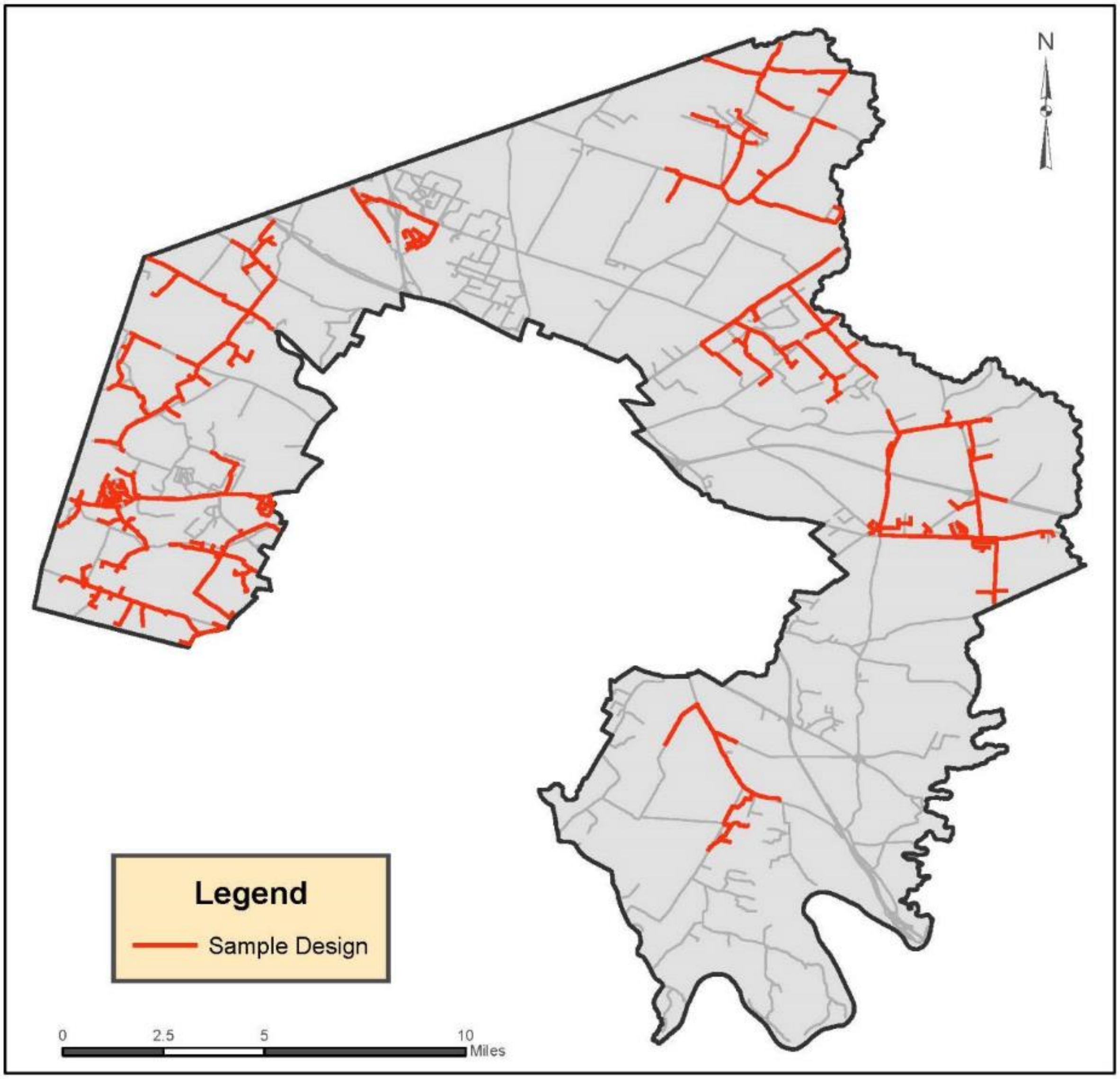
The assumptions, sample design, and cost estimates were used to estimate a cost per passing for the OSP. This number was then multiplied by the number of homes and businesses in the service area based on the LFUCG's GIS data. The actual cost to construct FTTP to every premises could differ from the estimate due to changes in the assumptions underlying the model. Further extensive analysis would be required to develop a more accurate cost estimate.

[27] A take-rate of 35 percent was assumed for standard fiber service drops. A more detailed estimate would require a complete engineering design for each farm and home.

[28] The fiber distribution cabinet (FDC) houses the fiber connections between the distribution fiber and the access fiber. FDCs, which can also house network electronics and optical splitters, can sit on a curb, be mounted on a pole, or reside in a building.

[29] A passing is a potential customer address (e.g., an individual home or business).

Figure 16: High-Level FTTP Sample Design Overview



5.1.3 Detailed OSP Costs

In terms of OSP, the estimated cost to construct the proposed FTTP network is approximately $40.8 million, or $9,010 per passing.[30] As discussed above, our model assumes 90 percent aerial fiber construction. The table below provides a breakdown of the estimated OSP costs (note that the costs have been rounded).

[30] The passing count includes individual single-unit buildings and units in small multi-business buildings as single passing. It treats larger multi-tenant farms as single passings.

Table 13: Estimated OSP Costs for FTTP

Area	Distribution Plant Mileage	Total Cost	Passings	Cost per Passing	Cost Per Plant Mile
Countywide	474	$40,800,000	4,532	$9,010	$86,000

Costs for aerial placement were estimated using available unit cost data for materials and estimates on the labor costs for make ready, strand placement, and lashing.

The material costs were generally known with the exception of unknown economies of scale and inflation rates, and barring any sort of phenomenon restricting material availability and costs. The labor costs associated with the placement of fiber were estimated based on similar construction projects.

Based on our observations, we assumed that the utility poles were in generally good condition and that make ready would be minimal. We also assumed that there would not be much congestion on the poles which would decrease the number of moves on each pole. Table 3 below outlines our construction and make ready assumptions.

Table 14: Summary of Construction Assumptions

Description	Assumption
Percentage of Intermediate Rock	15%
Percentage of Hard Rock	5%
Percentage of Routes Aerial	90%
Make Ready Cost per move	$450
Average moves per pole	2
Average poles per mile	30
Percent of poles requiring make ready	20%
Percent of poles requiring replacement	12%
Average pole replacement cost	$4,000

5.1.4 Central Network Electronics Costs

Central network electronics will cost an estimated $870,000, or $190 per passing, based on an assumed take rate of 35 percent.[31] These costs may increase or decrease depending on take rate, and the costs may be phased in as subscribers are added to the network. The central network electronics consist of the electronics to connect subscribers to the FTTP network at the core, hub, and cabinets. Table 4 below lists the estimated costs for each segment.

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[31] The take rate affects the electronics and drop costs, but also may affect other parts of the network, as the LFUCG may make different design choices based on the expected take rate. A 35 percent take rate is typical of environments where a new provider joins the telephone and cable provider in a given market.

Table 15: Estimated Central Network Electronics Costs

Network Segment	Subtotal	Passings	Cost per Passing
Core and Distribution Electronics	$363,000	4,530	$80
FTTP Access Electronics	$509,000	4,530	$110
Central Network Electronics Total	**$873,000**	**4,530**	**$190**

5.1.4.1 Core Electronics

The core electronics connect the FTTP network to the Internet. The core electronics consist of high performance routers, which handle all of the routing on both the FTTP network and to the Internet. The core routers should have modular chassis to provide high availability in terms of redundant components and "hot swappable"[32] modular line cards in the event of an outage. Modular routers also provide the ability to expand the routers as demanded for additional bandwidth increases.

The cost estimate assumes redundant routers located at the core site.

The cost of the core routing equipment is $260,000—excluding the service provider's Operational Support Systems (OSS)[33] such as provisioning platforms, fault and performance management systems, remote access, and other systems for FTTP operations. The service providers and/or their content providers may already have these systems in place.

5.1.4.2 Distribution Electronics

The distribution network electronics aggregate the traffic from the FDCs and send it to the core to access the Internet. The distribution electronics consist of high performance aggregation switches, which consolidate from the traffic from the many access electronics and send it to the core for route processing. The distribution switches typically are modular switch chassis that can accommodate many line cards for aggregation. The switches should also be modular to provide redundancy in the same manner as the core switches.

The cost estimate assumes that the aggregation switches connect to the access network electronics with 10 Gbps links to each distribution switch. The aggregation switches would then connect to the core switches over single or multiple 10 Gbps links as needed to meet the demand of the FTTP users in each service area.

[32] Hot swappable means that the line cards or modular can be removed and reinserted without the entire device being powered down or rebooted. The control cards in the router should maintain all configurations and push them to a replaced line card without the need for reconfirmation.

[33] OSS is housed in a network's core locations.

The cost of the distribution switching equipment is about $100,000, excluding the service provider's OSS or other management equipment.

5.1.4.3 Access Electronics

The access network electronics at the FDCs connect the subscribers' CPEs to the FTTP network. We recommend deploying access network electronics that can support both Gigabit passive optical network (GPON)[34] and Active Ethernet subscribers to provide flexibility within the FDC service area. We also recommend deploying modular access network electronics for reliability and the ability to add line cards as more subscribers join in the service area. Modularity also helps reduce initials capital costs while the network is under construction or during the roll out of the network.

The cost of the access network electronics for the network is about $510,000, based on a take rate of 35 percent (and the optical splitters at the FDCs required for that take rate).

5.1.5 Customer Premises Equipment (CPE) Costs

CPEs are the subscriber's interface to the FTTP network. For this cost estimate, we selected CPEs that provide only Ethernet data services (however, there are a wide variety of CPEs offering other data, voice, and video services). Using the estimated take rate of 35 percent, we estimate the CPEs for home and business customers will cost $1 million.

The CPE estimate includes an ONT with backup power, installation and cabling, and provisioning. For a residential customer the CPE costs are estimated at $630 and the CPE costs for business are estimated at $700. These estimates are averages and will vary depending on the type of premises and the internal wiring available at each premises.

In addition OLT[35] costs will be incurred as customers are added. These costs are included in the FTTP Access Electronics estimate indicated in Table 15. As indicated in the table, the average cost per passing is $110 at 35 percent take-rate ($321 per subscriber at a 35 percent take-rate). This average number will be higher for lower take-rates and lower for higher take-rates.

5.1.6 Lateral and Drop Installation Costs

The cost estimation of lateral or drop construction to a specific home or business taking service will need to be estimated on a case-by-case basis. Each location will differ in terms of distance to

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[34] Gigabit passive optical network (GPON) is the most commonly provisioned FTTP service—used, for example, by Verizon (in its FiOS systems), Google Fiber, and Chattanooga Electric Power Board (EPB). GPON uses passive optical splitting, which is performed inside FDCs, to connect fiber from the Optical Line Terminals (OLTs) to multiple customer premises over a single GPON port.

[35] Optical Line Terminal (OLT) is the upstream connection point (to the provider core network) for subscribers. The choice of an optical interface installed in the OLT determines whether the network provisions shared access (one fiber split among multiple subscribers in a GPON architecture) or dedicated Active Ethernet access (one port for one subscriber).

the fiber/road, availability of utility poles, number of locations to provide service, and inside wiring required.

In a standard residential model where each home is located a similar distance from the ROW, every home installation is relatively similar, making it easier to come up with an average across many homes. By comparison, the farms and businesses set back from the ROW on private driveways will present challenges in estimating an average lateral cost. The following lays out several scenarios for connecting facilities that may occur in the County:

1. A house is located on the street that the fiber passes and the fiber is constructed aerially in this location. The home is served by a utility pole in the ROW that has a fiber optic tap. In this scenario, an aerial drop would be installed to the house for less than $1,000.

2. A farm is located on the street that the fiber passes and the fiber is constructed aerially in this location. The farm has only one location to connect to the service and that location is close to the road. The farm has private utility poles that run from the utility poles in the ROW to the network location. In this scenario, the cost of constructing the lateral could be as low as $1,000 to $2,000 to add a drop on the existing poles. Cost will vary with distance and the amount of inside wiring needed to reach the network location.

3. A farm is located on the street that the fiber passes and the fiber is constructed aerially in this location. The farm has only one location to connect to the service and that location is close to the road. The farm does not have utility poles or existing conduit to pull the fiber to the location. In this scenario, new conduit and fiber would need to be installed or fiber could be direct buried to the service location on the farm. Depending on the distance and construction method, the cost could be up to $20 per foot.

4. A farm is set back from the ROW and shares a private road with other farms. The farm has multiple locations where service is needed. The farm does not have utility poles or existing conduit to pull the fiber to the location. In this scenario, first a private easement would be needed and then new conduit and fiber would need to be installed or fiber could be direct buried to each location. The cost for the laterals could quickly reach over $100,000 in these scenarios.

A site survey and engineering design will be needed for each farm and business requesting service. The lateral cost will have significant impacts on the financial feasibility of the network.

5.2 FTTP Network Design

5.2.1 Technical Specifications

Outside plant (OSP, also referred to as the physical layer, or layer 1) is the most expensive part of the network and the longest lasting. The architecture of the physical plant determines the network's scalability for future uses and how the plant will need to be operated and maintained; the architecture is also the main determinant of the total cost of the deployment.

Figure 17 (below) provides a logical representation of the high-level FTTP network architecture we recommend. This design is open to a variety of architecture options. The figure illustrates the primary functional components in the FTTP network, their relative position to one another, and the flexibility of the architecture to support multiple subscriber models and classes of service.

The recommended architecture is a hierarchical data network that provides critical scalability and flexibility, both in terms of initial network deployment and its ability to accommodate the increased demands of future applications and technologies. The characteristics of this hierarchical FTTP data network are:

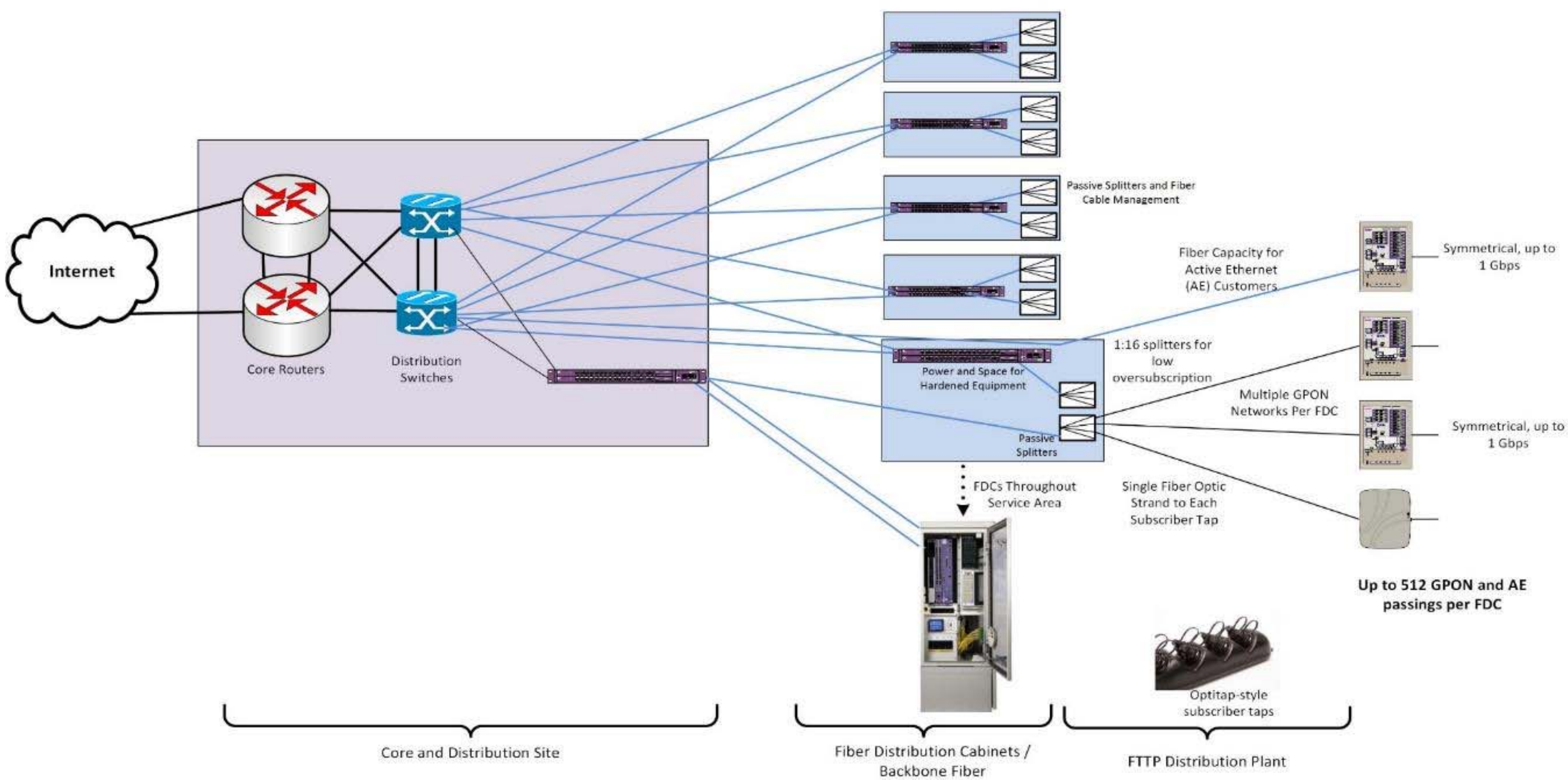
- ***Capacity*** – ability to provide efficient transport for subscriber data, even at peak levels.
- ***Availability*** – high levels of redundancy, reliability, and resiliency; ability to quickly detect faults and re-route traffic.
- ***Diversity*** – physical path diversity to minimize operational impact resulting from fiber or equipment failure.
- ***Efficiency*** – no traffic bottlenecks; efficient use of resources.
- ***Scalability*** – ability to grow in terms of physical service area and increased data capacity, and to integrate newer technologies.
- ***Manageability*** – simplified provisioning and management of subscribers and services.
- ***Flexibility*** – ability to provide different levels and classes of service to different customer environments; can support an open access network or a single-provider network; can provide separation between service providers on the physical layer (separate fibers) or logical layer (separate virtual local area network or VPN).
- ***Security*** – controlled physical access to all equipment and facilities, plus network access control to devices.

This architecture offers scalability to meet long-term needs. It is consistent with best practices for an open access network model that might potentially be required to support multiple network operators or multiple retail service providers requiring dedicated connections to certain customers. This design could support a combination of shared GPON and direct Active Ethernet (AE)[36] services with the addition of electronics at the Fiber Distribution Cabinets (FDCs), which would enable the network to increase capacity for users by migrating to AE connections to each customer, or reducing the number of customers served on a shared PON segment on an as-needed basis. GPON and AE technologies are described in more detail in the report.

The design assumes placement of manufacturer-terminated fiber tap enclosures within the ROW or easements, providing water-tight fiber connectors for customer service drop cables and eliminating the need for service installers to perform splices in the field. This is an industry-standard approach to reducing both customer activation times and the potential for damage to distribution cables and splices. The model also assumes the termination of standard lateral fiber connections within larger multi-tenant business locations.

[36] Active Ethernet (AE) is a technology that provides a symmetrical (upload/download) Ethernet service and does not share optical wavelengths with other users. For subscribers that receive AE service—typically business customers that request a premium service or require greater bandwidth—a single dedicated fiber goes directly to the subscriber premises with no optical splitting.

Figure 17: High-Level FTTP Architecture



5.2.2 Network Design

The network design and cost estimates assume the LFUCG will:

- Construct a backbone like the middle mile network in conjunction with the FTTP build to connect the FTTP network to KentuckyWired for Internet access;
- Use existing County land or ROW to locate a hub facility with adequate environmental and backup power systems to house network electronics;
- Construct fiber to connect the hub to the FDCs;
- Construct fiber optics from the FDCs to each resident and business (i.e., from termination panels in the FDC to tap locations in the ROW or on County easements); and

The FTTP network and service areas were defined based on the following criteria:

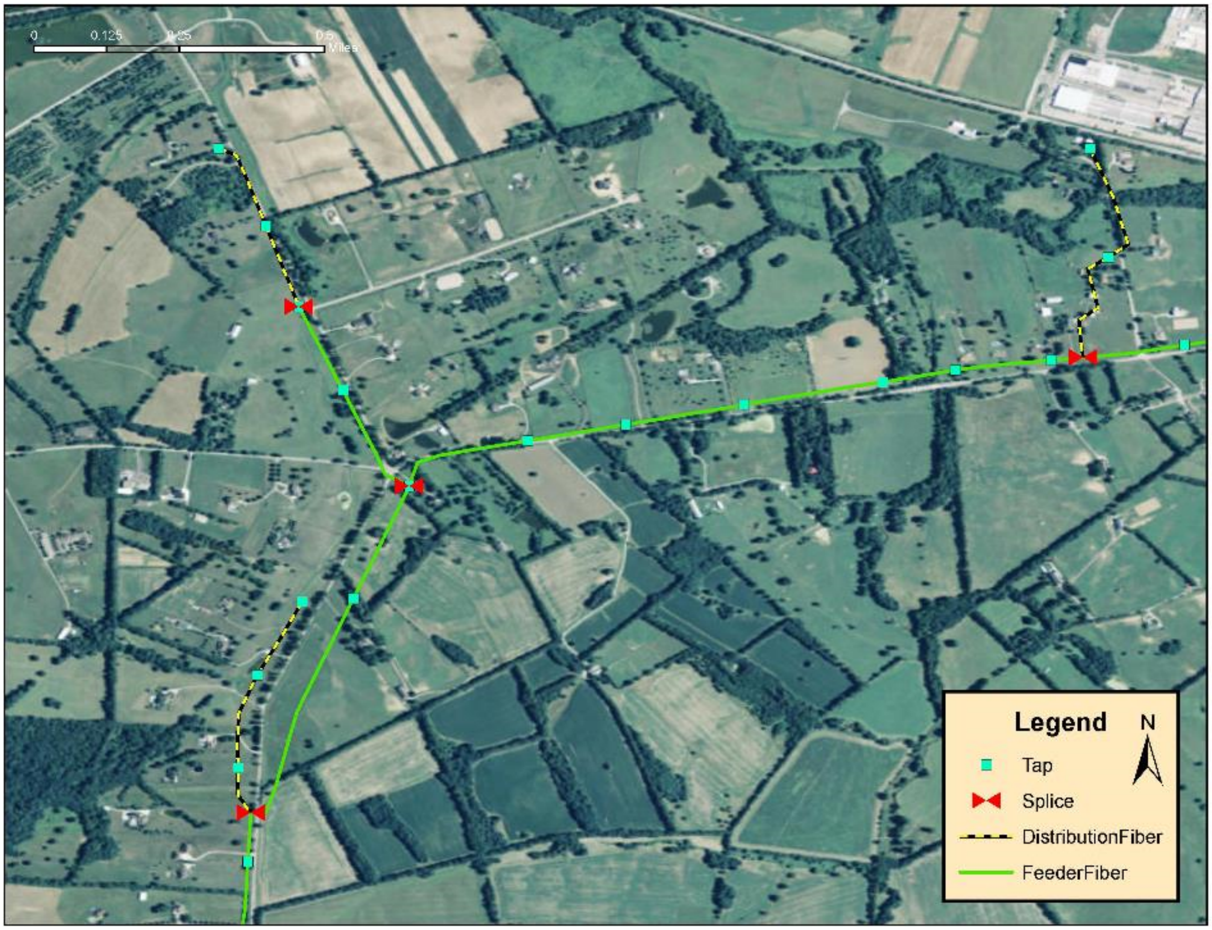
- Targeting 256 passings per FDC;
- FDCs suitable to support hardened network electronics, providing backup power and an active heat exchange;[37] and
- Avoiding the need for distribution plant to cross major roadways and railways.

Coupled with an appropriate network electronics configuration, this fiber design serves to greatly increase the reliability of services provided to customers as compared to that of more traditional cable and telephone networks.

The access layer of the network, which encompasses the fiber plant from the FDCs to the customers, dedicates a single fiber strand from the FDC to each passing (i.e., potential customer address). This traditional FTTP design allows either network electronics or optical splitters in the FDCs. See Figure 18 below for a sample design.

[37] These hardened FDCs reflect an assumption that the distance between the FDCs and the core may be significant and that hardened electronics will need to be placed in the field to meet the distance requirements of the access electronics.

Figure 18: Detail Showing FTTP Access Layer Design



This architecture offers scalability to meet long-term needs. It is consistent with best practices for an open access network model that might potentially be required to support multiple network operators, or at least multiple retail service providers requiring dedicated connections to certain customers.

5.2.3 Network Core and Hub Site

The core site is the bridge that links the FTTP network to the public Internet and delivers all services to end users. The proposed network design includes a single core location given the size of the network; however, if consumer demand dictates it, a second Internet POP could be added to increase redundancy to the network.

For the cost estimate we assumed that the core site electronics would be located on County land within a telecommunications shelter.

The core will also house the providers' Operational Support Systems (OSS) such as provisioning platforms, fault and performance management systems, remote access, and other operational support systems for FTTP operations. The core location is also where any business partner or content/service providers will gain access to the subscriber network with their own point-of-presence. This may be via remote connection, but colocation is recommended.

The core network electronics run in a high availability configuration, with fully meshed and redundant uplinks to the public Internet and/or all other content and service providers. It is imperative that core network locations are physically secure and allow unencumbered access 24x7x365 to authorized engineering and operational staff.

The operational environment of the network core and hub locations is similar to that of a data center. This includes clean power sources, UPS batteries, and diesel power generation for survival through sustained commercial outages. The facility must provide strong physical security, limited/controlled access, and environmental controls for humidity and temperature. Fire suppression is highly recommended.

Equipment is to be mounted securely in racks and cabinets in compliance with national, state, and local codes. Equipment power requirements and specification may include -48 volts DC and/or 120/240 volts AC. All equipment is to be connected to conditioned/protected clean power with uninterrupted cutover to battery and generation.

For the cost estimate, we assumed that the core and distribution hub will be located on existing County land.

5.2.4 Distribution and Access Network Design

The distribution network is the layer between the hub and the FDCs, which provide the access links to the taps. The distribution network aggregates traffic from the FDCs to the core. Fiber cuts and equipment failures have progressively greater operational impact as they happen closer to the network core, so it is critical to build in redundancies and physical path diversities in the distribution network, and to seamlessly reroute traffic when necessary.

The distribution and access network design proposed in this report is flexible and scalable enough to support two different architectures:

1. Housing both the distribution and access network electronics at the hub, and using only passive devices (optical splitters and patches) at the FDCs; or

2. Housing the distribution network electronics at the hub and pushing the access network electronics further into the network by housing them at the FDCs.

By housing all electronics at the hub, the network will not require power at the FDCs. Choosing a network design that only supports this architecture may reduce costs by allowing smaller, passive FDCs in the field. However, this architecture will limit the redundancy capability from the FDCs to the hub and the distance between the core and some of the FDCs may require active electronics in the field to reach customers.

By pushing the network electronics further into the field, the network gains added redundancy by allowing the access electronics to connect to two distribution switches. In the event one distribution switch has an outage, the subscribers connected to the FDC would still have network access via the other distribution switch. Choosing a network design that only supports this architecture may reduce costs by reducing the size of the hub.

Selecting a design that supports both of these models would allow the LFUCG to accommodate many different service operators and their network designs. This design would also allow service providers to start with a small deployment (i.e., placing electronics only at the hub site) and grow by pushing electronics closer to their subscribers.

5.2.4.1 Access Network Technologies

FDCs can sit on a curb, be mounted on a pole, or reside in a building. Our model recommends installing sufficient FDCs to support higher than anticipated levels of subscriber penetration. This approach will accommodate future subscriber growth with minimal re-engineering. Passive optical splitters are modular and can be added to an existing FDC as required to support subscriber growth, or to accommodate unanticipated changes to the fiber distribution network with potential future technologies.

Our FTTP design also includes the placement of indoor FDCs and splitters to support large-tenant businesses. This would require obtaining the right to access the equipment for repairs and installation in whatever timeframe is required by the service agreements with the customers. Lack of access would potentially limit the ability to perform repairs after normal business hours, which could be problematic for commercial services.

In this model, we assume the use of GPON electronics for the majority of subscribers and Active Ethernet for a small percentage of subscribers (typically large business customers) that request a premium service or require greater bandwidth. GPON is the most commonly provisioned FTTP service, used by Verizon (in its FiOS systems), Google Fiber, and Chattanooga EPB, for example.

Furthermore, providers of gigabit services typically supply these services on GPON platforms. Even though the GPON platform is limited to 1.2 Gbps upstream and 2.4 Gbps downstream for the subscribers connected to a single PON, operators have found that the variations in actual subscriber usage generally means that all subscribers can obtain 1 Gbps on demand (without provisioned rate-limiting), even if the capacity is aggregated at the PON. Furthermore, many GPON manufacturers have a development roadmap to 10 Gbps and faster speeds as user demand increases.

GPON supports high-speed broadband data, and is easily leveraged by triple-play carriers for voice, video, and data services. The GPON OLT uses single-fiber (bi-directional) SFP modules to support multiple (most commonly less than 32) subscribers.

GPON uses passive optical splitting, which is performed inside FDC, to connect fiber from the OLTs to the customer premises. The FDCs house multiple optical splitters, each of which splits the fiber link to the OLT between 16 to 32 customers (in the case of GPON service).

AE provides a symmetrical (up/down) service that is commonly referred to as Symmetrical Gigabit Ethernet. AE can be provisioned to run at sub-gigabit speeds, and like GPON easily supports legacy voice, voice over IP, and video. AE is typically deployed for customers who require specific service level agreements that are easier to manage and maintain on a dedicated service.

For subscribers receiving Active Ethernet service, a single dedicated fiber goes directly to the subscriber premises with no splitting. Because AE requires dedicated fiber (home run) from the OLT to the CPE, and because each subscriber uses a dedicated SFP on the OLT, there is significant cost differential in provisioning an AE subscriber versus a GPON subscriber.

Our fiber plant is designed to provide Active Ethernet service or PON service to all passings. The network operator selects electronics based on the mix of services it plans to offer and can modify or upgrade electronics to change the mix of services.

5.2.4.2 Expanding the Access Network Bandwidth

GPON is currently the most commonly provisioned FTTP technology, due to inherent economies when compared with technologies delivered over home-run fiber[38] such as Active Ethernet. The cost differential between constructing an entire network using GPON and Active Ethernet is 40 percent to 50 percent.[39] GPON is used to provide services up to 1 Gbps per subscriber and is part of an evolution path to higher-speed technologies that use higher-speed optics and wave-division multiplexing.

This model provides many options for scaling capacity, which can be done separately or in parallel:

1. Reducing the number of premises in a PON segment by modifying the splitter assignment and adding optics. For example, by reducing the split from 16:1 to 4:1, the per-user capacity in the access portion of the network is quadrupled.

[38] Home run fiber is a fiber optic architecture where individual fiber strands are extended from the distribution sites to the premises. Home run fiber does not use any intermediary aggregation points in the field.
[39] "Enhanced Communications in San Francisco: Phase II Feasibility Study," CTC report, October 2009, at p. 205.

2. Adding higher speed PON protocols can be accomplished by adding electronics at the FDC or hub locations. Since these use different frequencies than the GPON electronics, none of the other CPE would need to be replaced.

3. Adding WDM-PON electronics as they become widely available. This will enable each user to have the same capacity as an entire PON. Again, these use different frequencies than GPON and are not expected to require replacement of legacy CPE equipment.

4. Option 1 could be taken to the maximum, and PON replaced by a 1:1 connection to electronics—an Active Ethernet configuration.

These upgrades would all require complementary upgrades in the backbone and distribution Ethernet electronics, as well as in the upstream Internet connections and peering, but they would not require increased fiber construction.

5.2.4.3 Customer Premises Equipment (CPE) and Subscriber Services

In the final segment of the FTTP network, fiber runs from the FDC to customers' buildings, where it terminates at the subscriber tap, a fiber optic housing located in the ROW closest to the premises. The service installer uses a pre-connectorized drop cable to connect the tap to the subscriber premises without the need for fiber optic splicing.

The drop cable extends from the subscriber tap (in a handhole underground) to the building, enters the building, and connects to CPEs.[40]

[40] This description is for standard homes and businesses close to the ROW. As discussed in this report, lateral construction method and cost will be determined once a customer requests service.

6 Financial Analysis

We conducted financial modeling on a base case middle mile model[41] with eight additional sensitivity scenarios, as well as a base case dark FTTP model[42] with three additional sensitivity scenarios. The scenarios illustrate the sensitivity of selected assumptions in each model.

The base case financial analyses presented in this section represent a minimum requirement for the LFUCG to break even each year, excluding any potential revenue from other dark fiber lease opportunities that may be available to the LFUCG.

The base case for each model illustrates the types of costs that the LFUCG should expect and the level of revenues required each year to maintain a positive cash flow while operating the fiber enterprise. The base case does not imply that the LFUCG will realistically be able to achieve the required revenues.

6.1 Middle Mile Fiber Network

This section demonstrates the financial implications of the middle mile model described in Section 4. In this model, LFUCG deploys and "lights" a middle mile network, connecting the 62 County and priority sites (collectively referred to in this section as "priority sites"). For our projections, we assume 30 priority sites will be connected in year one and 32 will be connected in year two. A list of these sites can be found in Appendix A.

For this design, LFUCG constructs and owns fiber up to a demarcation point at each priority site. LFUCG installs network electronics and offers a lit 1 Gbps transport service[43] to each site.

The site is then responsible for any further fiber, wireless, or other connection distribution at the site. Each site would pay a one-time connection fee and a monthly fee for services.

We modeled nine scenarios: one "base case" and eight scenarios that show the sensitivities of key assumptions.

6.1.1 Middle Mile Base Case Financial Analysis

Our base case scenario proposes a model where:

- Each priority site pays a one-time $20,000 connection fee
- Each priority site pays a $3,000 per-month fee
- LFUCG obtains a 20-year bond in the amount of $12.5 million

[41] LFUCG installs fiber that connects identified anchor facilities and offers a 1 Gbps data connection to each.
[42] LFUCG installs, owns, and operates a FTTP network than passes all households and businesses in the County areas. A private partner adds electronics and offers services over the FTTP network.
[43] Includes 1 Gbps of direct Internet access (DIA) with an oversubscription rate of 10 to 1.

We have provided the LFUCG with a complete financial model in Excel format.

These financial projections do not include any economic development or other indirect benefits, which are not easily quantifiable.

Table 16 shows a condensed income and cash flow statement for this model. The complete statements are included in the Excel spreadsheet.

Table 16: Middle Mile Base Case Financial Summary

Income Statement	Year 1	Year 3	Year 5	Year 10
Total Revenues	$1,140,000	$2,232,000	$2,232,000	$2,232,000
Total Cash Expenses	(499,100)	(1,012,900)	(1,012,900)	(1,012,900)
Depreciation	(532,000)	(662,900)	(662,900)	(662,900)
Interest Expense	(750,000)	(727,780)	(679,270)	(530,120)
Net Income	$ (641,100)	$ (171,580)	$ (123,070)	$ 26,080

Cash Flow Statement	Year 1	Year 3	Year 5	Year 10
Unrestricted Cash Balance	$2,044,000	$357,580	$395,260	$489,460
Depreciation Operating Reserve	-	160,000	320,000	34,000
Debt Service Reserve	625,000	625,000	625,000	625,000
Total Cash Balance	$2,669,000	$1,142,580	$1,340,260	$1,148,460

Please note that our analysis follows a "flat-model," which excludes inflation and operating cost increases (including salaries), because we assume that operating cost increases will be offset by increases in operator lease payments over time (and likely passed on to subscribers in the form of increased prices).

6.1.1.1 Financing Costs

This financial analysis assumes a combination of bonds and loans will be necessary to deploy the middle mile network. We expect that the LFUCG will seek 20-year bonds with principal repayments starting the year after the bond issuance.

We project that the bond issuance costs will be equal to 1.0 percent of the principal borrowed. For the bond, a debt service reserve account is maintained at 5.0 percent of the total issuance amount. An interest reserve account equal to years one and two interest expense is maintained for the first two years.

Our analysis estimates total bonding requirements to be $12.5 million, and we assume that bonds are issued at a 6 percent interest rate.

6.1.1.2 Operating and Maintenance Expenses

The cost to deploy a middle mile network goes far beyond fiber implementation. Network deployment requires additional staffing for sales and marketing, network operations, and other functions. The addition of new staff and inventory requirements will require office and warehousing space:

- Expanded office facilities for management, technical and clerical staff.
- Warehousing for receipt and storage of cable and hardware for the installation and on-going maintenance of the broadband infrastructure.
- Location to house servers, switches, routers, and other core-network equipment.

Training new and existing staff is important to fully realize the economies of starting the middle mile network. The training will be particularly important in the short-term as the new enterprise establishes itself as a unique entity providing services distinct from services provided by the County today.

The expanded business and increased responsibilities will require the addition of new staff. It is important to be proactive in setting expectations, addressing security concerns, and educating the community on how to obtain and leverage services.

The initial additional positions, staffing levels, and base salaries are shown in Table 17. Please note that in the financial model, a 40 percent overhead is added to the salaries listed below.

Table 17: Middle Mile Base Case Labor Expenses

	Year 1	Year 2	Year 3	Labor Cost
New Employees				
Fiber Plant O&M Technicians	0.5	1.0	1.0	90,000
Customer Service Representative/Help Des	0.5	1.0	1.0	90,000
Service Technicians/Installers	1.5	2.0	2.0	70,000
GIS	0.5	1.0	1.0	80,000
Total Staff	3.0	5.0	5.0	

6.1.1.3 Summary of Operating and Maintenance Expenses

Additional key operating and maintenance assumptions include:

- Insurance is estimated to be $25,000 in year one and $50,000 from year two on.
- Office expense allocations are estimated to be $2,400 for year one, and $3,600 per year starting in year two.
- Locates and ticket processing start in year one at $5,100, increase to $10,200 in year two on (based on $3,750 per month for every 50 miles of underground fiber).

- Contingency is estimated to be $10,000 per year.
- Billing and maintenance contract fees are $10,000 in year one, then $20,000 each year.
- Legal and consulting fees are estimated to be $10,000 per year.
- Fiber Maintenance Fees (not including utilities and pole attachments) are $78,500 from year two onward (0.75 percent of accrued fiber investment each year).
- Direct Internet Access (DIA) is acquired at $3.00 per Mbps per month. The services offered use a 10-1 oversubscription rate.
- Salaries and benefits are based on estimated market wages. See Table 17 for a list of staffing requirements. Benefits are estimated at 35 percent of base salary.

A summary of operating and maintenance expenses is presented in Table 18.

Table 18: Middle Mile Base Case Operating and Maintenance Expenses

Operating & Maintenance Expenses	Year 1	Year 3	Year 5	Year 7	Year 9
Locates & Ticket Processing	$5,100	$10,200	$10,200	$10,200	$10,200
DIA	55,800	223,200	223,200	223,200	223,200
Insurance	25,000	50,000	50,000	50,000	50,000
Office Expense	2,400	3,600	3,600	3,600	3,600
Legal & Consulting Support	10,000	10,000	10,000	10,000	10,000
Fiber Maintenance Fees (not including utilities and pole attachments)	-	78,500	78,500	78,500	78,500
Contingency	10,000	10,000	10,000	10,000	10,000
Total	108,300	385,500	385,500	385,500	385,500
Operating Expenses - Training, Attachments, Utilities					
Attachment Fees	$61,200	$61,200	$61,200	$61,200	$61,200
Education and Training	-	5,600	5,600	5,600	5,600
Utilities	600	600	600	600	600
Long Term Lease	-	-	-	-	-
Total	$61,800	$67,400	$67,400	$67,400	$67,400
Salaries					
Fiber Plant O&M Technicians	$63,000	$126,000	$126,000	$126,000	$126,000
Network Engineer	63,000	126,000	126,000	126,000	126,000
Service Technicians/Installers	147,000	196,000	196,000	196,000	196,000
GIS	56,000	112,000	112,000	112,000	112,000
Total Staff	$329,000	$560,000	$560,000	$560,000	$560,000

The income statement for years one, three, five, seven, and nine is presented in Table 19. The cash flow statement for years one, three, five, seven, and nine is shown in Table 20.

Table 19: Middle Mile Base Case Income Statement

Income Statement	Year 1	Year 3	Year 5	Year 7	Year 9
a. Revenues					
Anchor Connectivity Services	$540,000	$2,232,000	$2,232,000	$2,232,000	$2,232,000
Priority Site Capital Contributions	600,000	-	-	-	-
Total	$1,140,000	$2,232,000	$2,232,000	$2,232,000	$2,232,000
b. Operating Expenses - Cash (not including taxes)					
Operating & Maintenance Expenses	$108,300	$385,500	$385,500	$385,500	$385,500
Operating Expenses - Training, Attachments, Utilities	61,800	67,400	67,400	67,400	67,400
Salaries	329,000	560,000	560,000	560,000	560,000
Total	$499,100	$1,012,900	$1,012,900	$1,012,900	$1,012,900
c. Revenues less Cash Operating Expenses (a-b)	$640,900	$1,219,100	$1,219,100	$1,219,100	$1,219,100
d. Operating Expenses - Non-Cash					
Depreciation	$532,000	$662,900	$662,900	$662,900	$662,900
e. Operating Income (d-c)	$108,900	$556,200	$556,200	$556,200	$556,200
f. Non-Operating Income					
Interest Income	$ -	$ -	$ -	$ -	$ -
Interest Expense (Long-Term))	(750,000)	(727,780)	(679,270)	(624,770)	(563,530)
Total	$ (750,000)	$ (727,780)	$ (679,270)	$ (624,770)	$ (563,530)
g. Net Income	$ (641,100)	$ (171,580)	$ (123,070)	$ (68,570)	$ (7,330)
h. Taxes	$ -	$ -	$ -	$ -	$ -
i. Net Income After Fees & In Lieu Taxes	$ (641,100)	$ (171,580)	$ (123,070)	$ (68,570)	$ (7,330)

Table 20: Middle Mile Base Case Cash Flow Statement

Cash Flow Statement		Year 1	Year 3	Year 5	Year 7	Year 9
a. Net Income (From Income Statement)		$ (641,100)	$ (171,580)	$ (123,070)	$ (68,570)	$ (7,330)
b. Cash Outflows						
Debt Service Reserve		$ (625,000)	$ -	$ -	$ -	$ -
Interest Reserve		(1,500,000)	-	-	-	-
Depreciation Operating Reserve		-	(80,000)	(80,000)	(80,000)	(80,000)
Financing		(125,000)	-	-	-	-
Capital Expenditures		$ (8,846,900)	$ -	$ -	$ -	$ -
	Total	$ (11,096,900)	$ (80,000)	$ (80,000)	$ (80,000)	$ (80,000)
c. Cash Inflows						
Interest Reserve		$ 750,000	$ -	$ -	$ -	$ -
Depreciation Operating Reserve		-	-	-	-	-
Debt Service Reserve		-	-	-	-	-
Long Term Financing (Bond)		12,500,000	-	-	-	-
	Total	$13,250,000	$ -	$ -	$ -	$ -
d. Total Cash Outflows and Inflows (b+c)		$2,153,100	$ (80,000)	$ (80,000)	$ (80,000)	$ (80,000)
e. Non-Cash Expenses - Depreciation		$532,000	$662,900	$662,900	$662,900	$662,900
f. Adjustments (Proceeds from)						
Short Term Financing		$ -	$ -	$ -	$ -	$ -
Long Term Financing (Bond)		(12,500,000)	-	-	-	-
	Total	$ (12,500,000)	$ -	$ -	$ -	$ -
g. Adjusted Available Net Revenue		$ (10,456,000)	$411,320	$459,830	$514,330	$575,570
h. Principal Payments on Debt						
Long Term Bond Principal		-	392,480	440,990	495,490	556,730
	Total	$ -	$392,480	$440,990	$495,490	$556,730
i. Net Cash		$2,044,000	$18,840	$18,840	$18,840	$18,840
Adjusted Net Cash		$2,044,000	$18,840	$18,840	$18,840	$18,840
Cash Balance (Enterprise)						
Unrestricted Cash Balance		$2,044,000	$357,580	$395,260	$432,940	$470,620
Depreciation Operating Reserve		-	160,000	320,000	295,000	(46,000)
Debt Service Reserve		625,000	625,000	625,000	625,000	625,000
	Total Cash Balance	$2,669,000	$1,142,580	$1,340,260	$1,352,940	$1,049,620

Significant network expenses—known as "capital additions"—are incurred in the first few years during the construction phase of the network. These represent the equipment and labor expenses associated with building a fiber network. This analysis projects that capital additions in year one will total approximately $8.8 million. These costs will total approximately $2.6 million in year two. This totals just over $11.4 million in capital additions for years one and two. Table 21 shows capital additions for years one through three.

Table 21: Middle Mile Base Case Capital Additions

Capital Additions	Year 1	Year 2	Year 3
a. Fiber Implementation Costs			
Fiber (20 year depreciation)	$7,852,500	$2,617,500	$ -
Headend and Hub Equipment (10 year depreciation)	308,400	-	-
Headend and Hub Equipment Software (7 year depreciation)	501,000	-	-
Total	$8,661,900	$2,617,500	$ -
b. Support Equipment (5 year depreciation)			
Misc. Equipment	$ -	$ -	$ -
Vehicles	50,000	-	-
Emergency Restoration Kit	50,000	-	-
Fiber OTDR and Other Tools	85,000	-	-
Additional Annual Capital Costs	-	-	-
Total	$185,000	$ -	$ -
Total Capital	$8,846,900	$2,617,500	$ -
Total Accrued Capital	$8,846,900	$11,464,400	$11,464,400

6.1.2 Middle Mile Scenario 1 – Eliminate Initial Connection Fee

In our first sensitivity scenario, we eliminate the initial connection fee for each priority site. Other conditions remain the same:

- Each priority site pays a $3,000 per-month fee
- LFUCG obtains a 20-year bond in the amount of $12.5 million

Table 22 shows the financial summary for this model.

Table 22: Middle Mile Scenario 1 Financial Summary – No Initial Connection Fee

Income Statement	Year 1	Year 3	Year 5	Year 10
Total Revenues	$540,000	$2,232,000	$2,232,000	$2,232,000
Total Cash Expenses	(499,100)	(1,012,900)	(1,012,900)	(1,012,900)
Depreciation	(532,000)	(662,900)	(662,900)	(662,900)
Interest Expense	(750,000)	(727,780)	(679,270)	(530,120)
Net Income	$ (1,241,100)	$ (171,580)	$ (123,070)	$ 26,080
Cash Flow Statement				
Unrestricted Cash Balance	$1,444,000	$ (882,420)	$ (844,740)	$ (750,540)
Depreciation Operating Reserve	-	160,000	320,000	34,000
Debt Service Reserve	625,000	625,000	625,000	625,000
Total Cash Balance	$2,069,000	$ (97,420)	$100,260	$ (91,540)

By eliminating the initial connection fee, this model projects a net income of $26,080 by year 10, and a cash balance deficit of $91,000 by year 10.

6.1.3 Middle Mile Scenario 2 – Eliminate Connection Fee and Raise Monthly Fee to $3,200

Our second scenario maintains initial bonding requirements, but eliminates the initial connection fee and raises the priority site's monthly fee to $3,200. This scenario also assumes that LFUCG obtains a 20-year, $12.5 million bond.

Table 23: Middle Mile Scenario 2 Financial Summary – Eliminate Connection Fee and Raise Monthly Fee to $3,200

Income Statement	Year 1	Year 3	Year 5	Year 10
Total Revenues	$ 576,000	$2,380,800	$2,380,800	$2,380,800
Total Cash Expenses	(499,100)	(1,012,900)	(1,012,900)	(1,012,900)
Depreciation	(532,000)	(662,900)	(662,900)	(662,900)
Interest Expense	(750,000)	(727,780)	(679,270)	(530,120)
Net Income	$ (1,205,100)	$ (22,780)	$ 25,730	$ 174,880
Cash Flow Statement				
Unrestricted Cash Balance	$1,480,000	$ (585,620)	$ (250,340)	$ 587,860
Depreciation Operating Reserve	-	160,000	320,000	34,000
Debt Service Reserve	625,000	625,000	625,000	625,000
Total Cash Balance	$2,105,000	$199,380	$ 694,660	$ 1,246,860

In this model, the increased monthly fee offsets the loss of initial connection fees, resulting in a net income of $25,000 by year five, and a positive cash flow, decreasing to $199,000 in year three, and increasing to $1.2 million by year 10.

6.1.4 Middle Mile Scenario 3 – Increase Bond to $13.5 Million

Our third scenario maintains the changes proposed in scenario two, but increases the 20-year bond to a total of $13.5 million. Table 24 shows the financial summary for this scenario.

Table 24: Middle Mile Scenario 3 Financial Summary – Increase Bond to $13.5 Million

Income Statement	Year 1	Year 3	Year 5	Year 10
Total Revenues	$576,000	$2,380,800	$2,380,800	$2,380,800
Total Cash Expenses	(499,100)	(1,012,900)	(1,012,900)	(1,012,900)
Depreciation	(532,000)	(662,900)	(662,900)	(662,900)
Interest Expense	(810,000)	(786,010)	(733,620)	(572,530)
Net Income	$ (1,265,100)	$ (81,010)	$ (28,620)	$132,470
Cash Flow Statement				
Unrestricted Cash Balance	$2,300,000	$115,140	$271,180	$661,280
Depreciation Operating Reserve	-	160,000	320,000	34,000
Debt Service Reserve	675,000	675,000	675,000	675,000
Total Cash Balance	$2,975,000	$950,140	$1,266,180	$1,370,280

By increasing the initial bond, LFUCG maintains a cash balance roughly equivalent to the additional bond amount, and will obtain a net income of $130,000 by year 10.

6.1.5 Middle Mile Scenario 4 – Service Fees Decreased to $2,000 per Month

Scenario four projects the effect of reducing the monthly priority site subscriber fee to $2,000. Other base case variables (including the one-time $20,000 connection fee and $12.5 million bond) remain the same. Table 25 shows the financial summary for years one, three, five, and 10 for this scenario.

Table 25: Middle Mile Scenario 4 Financial Summary – Service Fees Decreased to $2,000 per Month

Income Statement	Year 1	Year 3	Year 5	Year 10
Total Revenues	$960,000	$1,488,000	$1,488,000	$1,488,000
Total Cash Expenses	(499,100)	(1,012,900)	(1,012,900)	(1,012,900)
Depreciation	(532,000)	(662,900)	(662,900)	(662,900)
Interest Expense	(750,000)	(727,780)	(679,270)	(530,120)
Net Income	$ (821,100)	$ (915,580)	$ (867,070)	$ (717,920)
Cash Flow Statement				
Unrestricted Cash Balance	$1,864,000	$ (1,124,420)	$ (2,574,740)	$ (6,200,540)
Depreciation Operating Reserve	-	160,000	320,000	34,000
Debt Service Reserve	625,000	625,000	625,000	625,000
Total Cash Balance	$2,489,000	$ (339,420)	$ (1,629,740)	$ (5,541,540)

This reduction in service fees causes a significant financial impact, resulting in a total cash balance shortfall of $5.5 million in year 10.

6.1.6 Middle Mile Scenario 5 – Decrease Staffing Costs by 25 Percent

Scenario five proposes a 25 percent decrease in staffing costs, while other conditions from the base case remain the same.

- Each priority site pays a one-time $20,000 connection fee
- Each priority site pays a $3,000 per-month fee
- LFUCG obtains a 20-year bond in the amount of $12.5 million

Table 26 shows the financial summary for years one, three, five, and 10 for this scenario.

Table 26: Middle Mile Scenario 5 Financial Summary – Decrease Staffing Costs by 25 Percent

Income Statement	**Year 1**	**Year 3**	**Year 5**	**Year 10**
Total Revenues	$1,140,000	$2,232,000	$2,232,000	$2,232,000
Total Cash Expenses	(416,900)	(872,900)	(872,900)	(872,900)
Depreciation	(532,000)	(662,900)	(662,900)	(662,900)
Interest Expense	(750,000)	(727,780)	(679,270)	(530,120)
Net Income	$ (558,900)	$ (31,580)	$ 16,930	$ 166,080
Cash Flow Statement				
Unrestricted Cash Balance	$2,126,200	$719,780	$1,037,460	$1,831,660
Depreciation Operating Reserve	-	160,000	320,000	34,000
Debt Service Reserve	625,000	625,000	625,000	625,000
Total Cash Balance	$ 2,751,200	$ 1,504,780	$ 1,982,460	$ 2,490,660

By decreasing staffing costs, net income will be $16,000 by year five, and total cash balance will remain greater than $1.5 million.

6.1.7 Middle Mile Scenario 6 – Increase Staffing Costs by 25 Percent

Scenario six proposes a 25 percent increase in staffing costs, while other conditions from the base case remain the same:

- Each priority site pays a one-time $20,000 connection fee
- Each priority site pays a $3,000 per-month fee
- LFUCG obtains a 20-year bond in the amount of $12.5 million

Table 27 shows the financial summary for years one, three, five, and 10 for this scenario.

Table 27: Middle Mile Scenario 6 Financial Summary – Increase Staffing Costs by 25 Percent

Income Statement	Year 1	Year 3	Year 5	Year 10
Total Revenues	$1,140,000	$2,232,000	$2,232,000	$2,232,000
Total Cash Expenses	(581,400)	(1,152,900)	(1,152,900)	(1,152,900)
Depreciation	(532,000)	(662,900)	(662,900)	(662,900)
Interest Expense	(750,000)	(727,780)	(679,270)	(530,120)
Net Income	$ (723,400)	$ (311,580)	$ (263,070)	$ (113,920)
Cash Flow Statement				
Unrestricted Cash Balance	$1,961,700	$ (4,720)	$ (247,040)	$ (852,840)
Depreciation Operating Reserve	-	160,000	320,000	34,000
Debt Service Reserve	625,000	625,000	625,000	625,000
Total Cash Balance	$2,586,700	$780,280	$697,960	$ (193,840)

The 25 percent increase in staffing costs results in a cash balance deficit by year 10.

6.1.8 Middle Mile Scenario 7 – Decrease Non-Staffing Expenses by 25 Percent

Scenario seven proposes a 25 percent decrease in non-staffing expenses (e.g. attachment fees, locates and ticket processing, etc.). Conditions from the base case remain the same.

- Each priority site pays a one-time $20,000 connection fee
- Each priority site pays a $3,000 per-month fee
- LFUCG obtains a 20-year bond in the amount of $12.5 million

Table 28 shows the financial summary for years one, three, five, and 10 for this scenario.

Table 28: Middle Mile Scenario 7 Financial Summary – Decrease Non-Staffing Expenses by 25 Percent

Income Statement	Year 1	Year 3	Year 5	Year 10
Total Revenues	$1,140,000	$2,232,000	$2,232,000	$2,232,000
Total Cash Expenses	(499,100)	(1,012,900)	(1,012,900)	(1,012,900)
Depreciation	(532,000)	(662,900)	(662,900)	(662,900)
Interest Expense	(750,000)	(727,780)	(679,270)	(530,120)
Net Income	$ (641,100)	$ (171,580)	$ (123,070)	$26,080
Cash Flow Statement				
Unrestricted Cash Balance	$2,086,500	$611,080	$875,160	$1,535,360
Depreciation Operating Reserve	-	160,000	320,000	34,000
Debt Service Reserve	625,000	625,000	625,000	625,000
Total Cash Balance	$2,711,500	$1,396,080	$1,820,160	$2,194,360

By decreasing non-staffing expenses by 25 percent, LFUCG will have a net income of $26,000 by year 10, and a total cash balance of $1.4 million by year three, increasing to roughly $2.2 million by year 10.

6.1.9 Middle Mile Scenario 8 – Increase Non-Staffing Expenses by 25 Percent

Scenario eight proposes a 25 percent increase in non-staffing expenses (e.g. attachment fees, locates and ticket processing, etc.). Conditions from the base case remain the same.

- Each priority site pays one-time $20,000 connection fee
- Each priority site pays $3,000 per-month fee
- LFUCG obtains 20-year bond in the amount of $12.5 million

Table 29 shows the financial summary for years one, three, five, and 10 for this scenario.

Table 29: Middle Mile Scenario 8 Financial Summary – Increase Non-Staffing Expenses by 25 Percent

Net Income Statement	Year 1	Year 3	Year 5	Year 10
Total Revenues	$1,140,000	$2,232,000	$2,232,000	$2,232,000
Total Cash Expenses	(499,100)	(1,012,900)	(1,012,900)	(1,012,900)
Depreciation	(532,000)	(662,900)	(662,900)	(662,900)
Interest Expense	(750,000)	(727,780)	(679,270)	(530,120)
Net Income	$ (641,100)	$ (171,580)	$ (123,070)	$26,080
Cash Flow Statement				
Unrestricted Cash Balance	$2,001,400	$103,780	$ (85,140)	$ (557,440)
Depreciation Operating Reserve	-	160,000	320,000	34,000
Debt Service Reserve	625,000	625,000	625,000	625,000
Total Cash Balance	$2,626,400	$888,780	$859,860	$101,560

While net income remains the same as scenario seven, total cash balance consistently decreases to just over $100,000 by year 10.

6.2 Dark FTTP Model

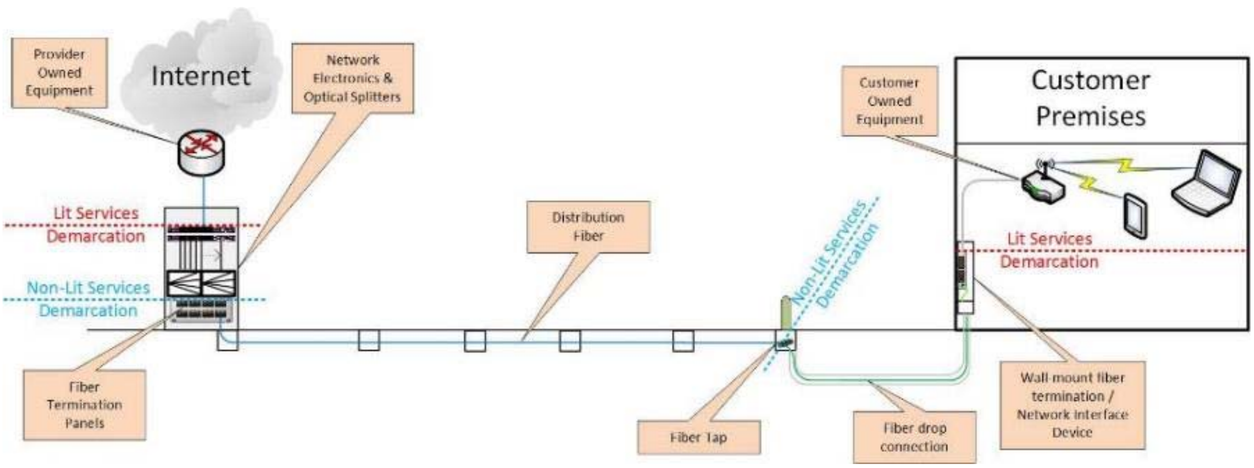
This section presents an overview of the FTTP financial model, based on the cost estimates in Section 5. We have provided the LFUCG with a complete financial model in Excel format that can be modified to show the impact of changing assumptions. The spreadsheet will also be an important tool for the LFUCG to use if it negotiates with a private partner.

These financial projections do not include any economic development or other indirect benefits, which are often not easily quantifiable.

The financial analysis in this section assumes that the LFUCG constructs and owns the FTTP infrastructure up to a demarcation point at the optical tap near each residence or business, and leases the dark fiber backbone and distribution fiber to a private partner that would then provide retail service to customers. The private partner would be responsible for all network electronics, fiber drops to subscribers, and customer premises equipment (CPE)—as well as network sales, marketing, and operations.[44] This model is being used in Huntsville, Alabama, where Huntsville Utilities is deploying a dark FTTP network that will be leased by Google Fiber.

Figure 19 shows the demarcation between LFUCG and partner network elements.

Figure 19: Demarcation Between LFUCG and Partner Network Elements



Assuming a mix of 10 percent aerial and 90 percent underground construction, the countywide FTTP network deployment will cost more than $42.7 million, inclusive of outside plant (OSP) construction labor, materials, engineering, permitting, and pole attachment licensing. This estimate does not include and electronics, subscriber equipment, drops, or laterals.

[44] In a related vein, we note that some network operators suggest that the network's optical splitters should be a part of the Layer 1 or dark fiber assets. We caution against this approach. The network operator (i.e., the LFUCG's partner) should maintain the splitters because, as operator of the electronics, it must determine and control the GPON network split ratio to meet the network's performance standards. This may involve moving power users to GPON ports with lower split ratios, or moving users to different splitters to manage the capacity of the GPON ports. The LFUCG should not be involved in this level of network management. Also, the LFUCG should not have to inventory various sized splitters or swap them as the network operator makes changes. Even if the LFUCG were to decide to purchase some of the optical splitters for the network, we believe it should be the network operator's responsibility to manage and maintain the splitters.

Table 30: Breakdown of Estimated FTTP Cost (aerial and underground construction)

Cost Component	Total Estimated Cost
OSP Engineering	$7,471,000
Quality Control/Quality Assurance	1,784,000
General OSP Construction Cost	29,242,000
Special Crossings	863,000
Backbone and Distribution Plant Splicing	777,000
Backbone Hub, Termination, and Testing	710,000
Total Estimated Cost:	$40,847,000

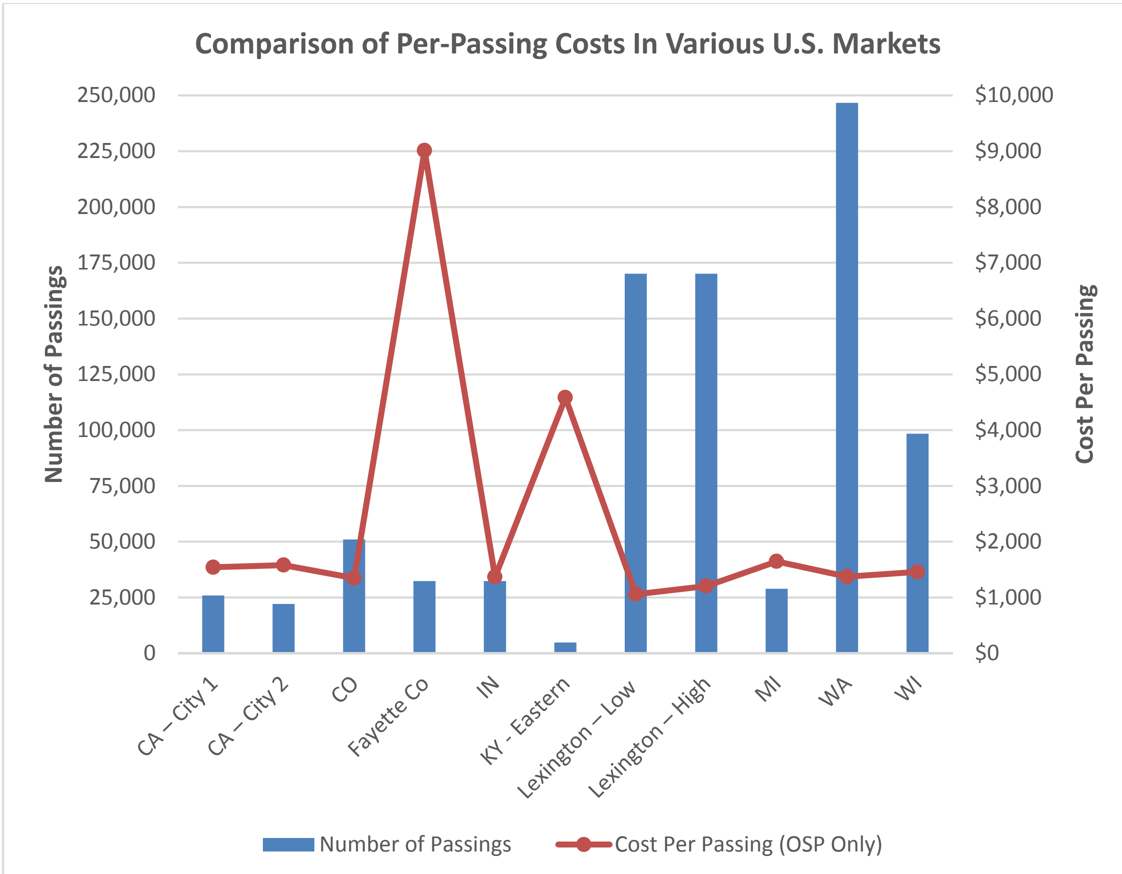
This is a "best-case" estimate, assuming construction can occur with low make-ready fees for attaching fiber to utility poles, and private easements can be easily obtained. It should be noted that private easements can be a huge obstacle to connecting homes and farms located far from the public ROW.

It should also be noted that the above costs do not include drop and lateral costs, as we anticipate a wide variation in final cost, depending on the specifics of each drop and lateral installation. For our business modeling, we estimated $546 per drop as a realistic placeholder. While this price is representative of the majority of drops in the area, it should be noted that due to the topography of the County, some drops will be significantly more expensive. Such outliers would be priced on a case-by-case basis, the specifics of which lie beyond the scope of this report. As such, the final total drop cost will likely be higher.

Following the above models, we calculated a total of 4,352 passings in Fayette County, 80 percent of which are residential and 20 percent of which are commercial. We estimate the FTTP deployment without electronics would cost $9,013 per passing. This cost is significantly higher than in many localities nationwide, due to the low density of potential subscribers (i.e., the high fiber mileage per passing).

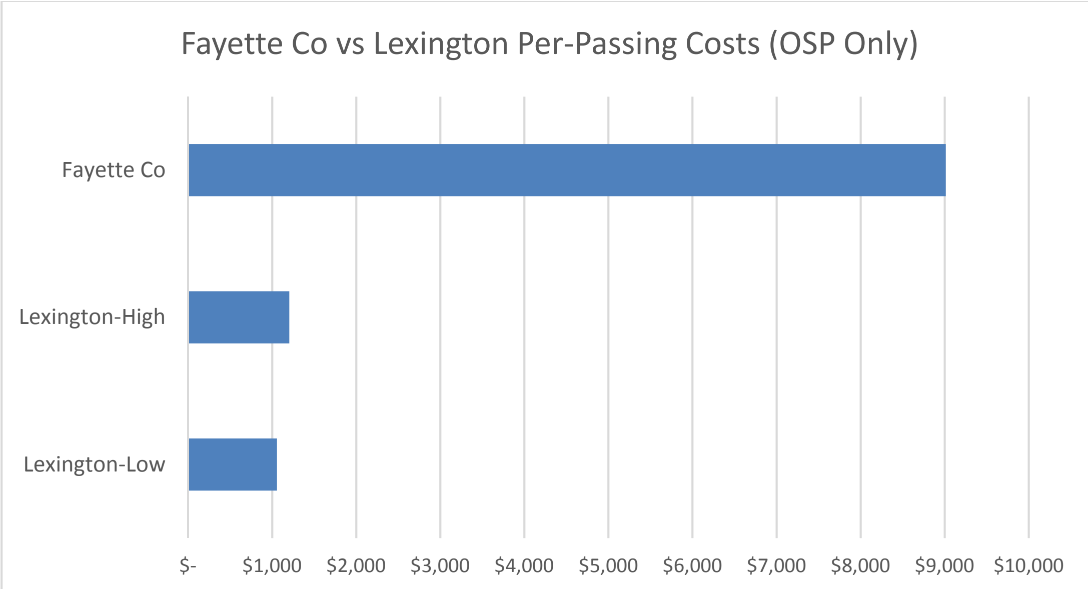
For reference, a comparison to other U.S. market per-passing costs is provided in Figure 20.

Figure 20: Comparison of Per-Passing Costs in Various U.S. Markets



This cost is also significantly higher than deployment in Lexington. Our projected costs for a Lexington deployment range from $1,058 to $1,025 per passing. As referenced above, this difference arises from the low premises density seen in the County. Figure 21 depicts the relation in costs.

Figure 21: Fayette County vs Lexington Per-Passing Costs



In order to bring the LFUCG's effective per-passing cost estimate down to equal that of Lexington, a grant or other funding of $35.39 million (86.6 percent of the OSP costs) would be required. We note, though, that while this funding would reduce deployment costs, it would not lower the high ongoing operations and maintenance costs such as pole attachments and fiber repairs that LFUCG would see due to the low premises density. Operations and maintenance costs have a high dependency on total fiber line miles and, as such, would be higher for Fayette County.

6.2.1 FTTP Base Case Financial Analysis

The base case scenario proposes that:

- LFUCG obtains a 20-year, $13 million bond
- LFUCG obtains $35.39 million in funding (i.e., 86.6 percent of the total OSP cost estimate) from grants or other sources that do not need to be paid back.
- LFUCG obtains $1 million per year in dark fiber revenues (e.g., leasing 24 fiber strands over the entire 474 route miles at $88.50 per month per strand mile).
    - This assumption is aggressive in both price and quantity. Dark fiber pricing in rural areas is typically in the range of $30 to $50 per month per strand mile.
- LFUCG obtains $34.75 per passing per month from the retail provider.
    - The required fee is 4.6 times the effective per passing fee that Google will pay Huntsville Utilities ($7.50 per passing per month).

- If the provider is able to obtain a take rate of 35 percent, the per-passing fee would translate to a cost of $99.39 per month per subscriber, an excessively high cost.

With the exception of the bond requirement, these base assumptions are aggressive and quite unlikely.

Table 31 shows a condensed income and cash flow statement for the base case scenario. (The complete statements are included in the spreadsheet.) The negative net income reflects, in part, the effect of equipment depreciation, a non-cash expense.

Table 31: FTTP Base Case Financial Summary

Income Statement	Year 1	Year 5	Year 10	Year 15	Year 20
Total Revenues	$9,470	$2,897,840	$2,897,840	$2,897,840	$2,897,840
Total Cash Expenses	(754,790)	(1,671,560)	(1,671,560)	(1,671,560)	(1,671,560)
Depreciation	(650,910)	(2,102,550)	(2,102,550)	(2,102,550)	(2,140,750)
Interest Expense	(180,000)	(724,320)	(575,920)	(377,340)	(112,070)
Taxes	-	-	-	-	-
Net Income	$ (1,576,230)	$ (1,600,590)	$ (1,452,190)	$ (1,253,610)	$ (1,026,540)

Cash Flow Statement	Year 1	Year 5	Year 10	Year 15	Year 20
Unrestricted Cash Balance	$1,269,580	$3,122,240	$3,122,280	$3,122,480	$3,117,350
Depreciation Reserve	-	189,240	203,640	218,040	45,350
Interest Reserve	180,000	-	-	-	-
Debt Service Reserve	150,000	650,000	650,000	650,000	650,000
Total Cash Balance	$1,599,580	$3,961,480	$3,975,920	$3,990,520	$3,812,700

Please note that we used a "flat-model" in the analysis. In a "flat-model," inflation and operating cost increases (including salaries) are not used in the analysis, as we assume that operating cost increases will be offset by increases in operator lease payments over time (and likely passed on to subscribers in the form of increased prices). We anticipate that the LFUCG will apply an inflation factor, typically based on a Consumer Price Index (CPI), to the portion of the per-subscriber fee covering projected operating expenses during negotiations with a private partner. Please note that it is not appropriate to apply a CPI to the entire passing fee because the majority of the fee is to support the principal and interest on the debt service.

6.2.1.1 Financing Costs

This financial analysis assumes a combination of bonds and loans will be necessary to deploy the FTTP network. We expect that the LFUCG will seek 20-year bonds with principal repayments starting the year after the bond issuance.

We project that the bond issuance costs will be equal to 1.0 percent of the principal borrowed. For the bond, a debt service reserve account is maintained at 5.0 percent of the total issuance amount. An interest reserve account equal to the projected interest expense is maintained for the first two years.

Our analysis estimates total bonding requirements to be $13 million, and we assume that bonds are issued at a 5 percent interest rate. The bond is in addition to the $35.39 million in grant or other funding.

6.2.1.2 Operating and Maintenance Expenses

The cost to deploy a dark FTTP network goes far beyond fiber implementation. Network deployment requires sales and marketing, network maintenance and technical operations, and other functions. In this model, we assume that the LFUCG's partner will be responsible for lighting the fiber and selling service. As such, the LFUCG's financial requirements are limited to expenses related to OSP infrastructure and network administration.

The model assumes a straight-line depreciation of assets, and that the OSP and materials will have a 20-year life span while network test equipment will need to be replaced after five years.

These expanded responsibilities will require the addition of new staff. We assume the LFUCG will add a total of eight full-time-equivalent (FTE) positions within the first three years, and will then maintain that level of staffing. Our assumptions include one FTE for OSP management, one FTE for administrative support, one FTE for accounting/HR support, one FTE for GIS and record keeping, and four FTEs for fiber plant maintenance and operations. Salaries and benefits are based on estimated market wages, and benefits are estimated at 40 percent of base salary.

Locates and ticket processing will be significant ongoing operational expenses for the LFUCG. Based on our experience in other jurisdictions, we estimate that a contract for locates will cost $10,700 in year one, increase to $21,400 in year two, and increase to $42,700 from year three on. If the LFUCG decides to perform this work in house, the contract expense would be eliminated—but staffing expenses would increase.

Additional key operating and maintenance assumptions include the following:

- Pole attachment fees are $20 per year per pole
- Insurance is estimated to be $50,000 in year one and $75,000 from year two on
- Office expenses are estimated to be $2,400 annually
- Contingency expenses are estimated at $10,000 in year one and $25,000 in subsequent years
- Legal fees are estimated to be $100,000 in year one, $50,000 in year two, and $25,000 from year three on
- Consulting fees are estimated at $100,000 in year one and $20,000 from year two on

Fiber network maintenance costs are calculated at 0.5 percent of the total construction cost, per year. This is in addition to staffing costs to maintain the fiber.

Table 32 shows operating expenses for years one, five, 10, 15, and 20. As seen, some expenses will remain constant while others will increase as the network matures and the customer base increases.

Table 32: Operating Expenses – FTTP Base Case

	Year 1	Year 5	Year 10	Year 15	Year 20
Operating Expenses					
Insurance	$50,000	$75,000	$75,000	$75,000	$75,000
Office Expenses	2,400	2,400	2,400	2,400	2,400
Locates & Ticket Processing	10,700	42,700	42,700	42,700	42,700
Contingency	10,000	25,000	25,000	25,000	25,000
Fiber & Network Maintenance	61,270	204,240	204,240	204,240	204,240
Legal and Lobby Fees	100,000	25,000	25,000	25,000	25,000
Consulting	100,000	20,000	20,000	20,000	20,000
Education and Training	7,490	20,020	20,020	20,020	20,020
Pole Attachment Expense	38,430	256,200	256,200	256,200	256,200
Sub-Total	$380,290	$670,560	$670,560	$670,560	$670,560
Labor Expenses	$374,500	$1,001,000	$1,001,000	$1,001,000	$1,001,000
Sub-Total	$374,500	$1,001,000	$1,001,000	$1,001,000	$1,001,000
Total Expenses	$754,790	$1,671,560	$1,671,560	$1,671,560	$1,671,560
Principal and Interest	$180,000	$1,014,570	$1,162,940	$1,162,900	$1,163,330
Facility Taxes	-	-	-	-	-
Sub-Total	$180,000	$1,014,570	$1,162,940	$1,162,900	$1,163,330
Total Expenses, P&I, and Taxes	$934,790	$2,686,130	$2,834,500	$2,834,460	$2,834,890

Table 33 shows the income statement for years one, five, 10, 15, and 20.

Table 33: Income Statement – FTTP Base Case

Income Statement	Year 1	Year 5	Year 10	Year 15	Year 20
a. Revenues					
Per Passing	$9,470	$1,889,840	$1,889,840	$1,889,840	$1,889,840
Fiber Leases	-	1,008,000	1,008,000	1,008,000	1,008,000
Total	$9,470	$2,897,840	$2,897,840	$2,897,840	$2,897,840
c. Operating Costs					
Operation Costs	$380,290	$670,560	$670,560	$670,560	$670,560
Labor Costs	374,500	1,001,000	1,001,000	1,001,000	1,001,000
Total	$754,790	$1,671,560	$1,671,560	$1,671,560	$1,671,560
d. EBITDA	$(745,320)	$1,226,280	$1,226,280	$1,226,280	$1,226,280
e. Depreciation	650,910	2,102,550	2,102,550	2,102,550	2,140,750
f. Operating Income (EBITDA less Depreciation)	$(1,396,230)	$(876,270)	$(876,270)	$(876,270)	$(914,470)
g. Non-Operating Income					
Interest Income	$ -	$2,100	$2,130	$2,170	$1,740
Interest Expense (10 Year Bond)	-	-	-	-	-
Interest Expense (20 Year Bond)	(180,000)	(726,420)	(578,050)	(379,510)	(113,810)
Interest Expense (Loan)	-	-	-	-	-
Total	$(180,000)	$(575,920)	$(575,920)	$(377,340)	$(112,070)
h. Net Income (before taxes)	$(1,576,230)	$(1,600,590)	$(1,452,190)	$(1,253,610)	$(1,026,540)
i. Facility Taxes	$ -	$ -	$ -	$ -	$ -
j. Net Income	$(1,576,230)	$(1,600,590)	$(1,452,190)	$(1,253,610)	$(1,026,540)

Table 34 shows the cash flow statement for years one, five, 10, 15, and 20.

Table 34: Cash Flow Statement – FTTP Base Case

Cash Flow Statement	Year 1	Year 5	Year 10	Year 15	Year 20
a. Net Income	$ (1,576,230)	$ (1,600,590)	$ (1,452,190)	$ (1,253,610)	$ (1,026,540)
b. Cash Outflows					
Debt Service Reserve	$ (150,000)	$ -	$ -	$ -	$ -
Interest Reserve	(360,000)	-	-	-	-
Depreciation Reserve	-	(63,080)	(63,080)	(63,080)	(64,220)
Financing	(30,000)	-	-	-	-
Capital Expenditures	(12,445,100)	-	-	-	-
Total	$ (12,985,100)	$ (63,080)	$ (63,080)	$ (63,080)	$ (64,220)
c. Cash Inflows					
Interest Reserve	$180,000	$ -	$ -	$ -	$ -
Depreciation Reserve	-	-	-	-	-
Investment Capital	-	-	-	-	-
Start Up Funds	12,000,000	-	-	-	-
20-Year Bond Proceeds	3,000,000	-	-	-	-
Loan Proceeds	-	-	-	-	-
Total	$15,180,000	$ -	$ -	$ -	$ -
d. Total Cash Outflows and Inflows	$2,194,900	$ (63,080)	$ (63,080)	$ (63,080)	$ (64,220)
e. Non-Cash Expenses - Depreciation	$650,910	$2,102,550	$2,102,550	$2,102,550	$2,140,750
f. Adjustments					
Proceeds from Additional Cash Flows (20 Year Bond)	$ (3,000,000)	$ -	$ -	$ -	$ -
Proceeds from Additional Cash Flows (Loan)	-	-	-	-	-
g. Adjusted Available Net Revenue	$ (1,730,420)	$438,880	$587,280	$785,860	$1,049,990
h. Principal Payments on Debt					
10 Year Bond Principal	$ -	$ -	$ -	$ -	$ -
20 Year Bond Principal	-	438,650	587,020	785,560	1,051,260
Loan Principal	-	-	-	-	-
Total	$ -	$438,650	$587,020	$785,560	$1,051,260
j. Cash Balance					
Unrestricted Cash Balance	$1,269,580	$3,122,240	$3,122,280	$3,122,480	$3,117,350
Depreciation Reserve	-	189,240	203,640	218,040	45,350
Interest Reserve	180,000	-	-	-	-
Debt Service Reserve	150,000	650,000	650,000	650,000	650,000
Total Cash Balance	$1,599,580	$3,961,480	$3,975,920	$3,990,520	$3,812,700

Significant network expenses—known as "capital additions"—are incurred in the first few years during the construction phase of the network. These represent the equipment and labor expenses associated with building a fiber network. This analysis projects that capital additions in year one will total approximately $12.4 million. These costs will total approximately $20.4 million in year two, and $8.2 million in year three. This totals just under $41 million in capital additions for years one through three. Table 35 shows capital additions for years one through three.

Table 35: Capital Additions – FTTP Base Case

Capital Additions		Year 1	Year 2	Year 3
Outside Plant and Facilities				
Total Backbone and FTTP		$12,254,100	$20,423,500	$8,169,400
Additional Annual Capital		-	-	-
	Total	$12,254,100	$20,423,500	$8,169,400
Miscellaneous Implementation Costs				
Vehicles		$50,000	$50,000	$-
Emergency Restoration Kit		50,000	50,000	-
Work Station, Computers, and Software		6,000	4,000	6,000
Fiber OTDR and Other Tools		85,000	-	-
Additional Annual Capital		-	-	-
	Total	$191,000	$104,000	$ 6,000
	Total Capital Additions	$12,445,100	$20,527,500	$8,175,400

6.2.2 FTTP Scenario 1 – No Grant Funding Is Obtained

Our first sensitivity scenario removes the $35.39 million in grant (or other sources which do not need to be repaid) funding, while dark fiber revenues remain the same. In this model, per-passing fees must increase to $97.50.

For reference, if a private partner managed to obtain a 35 percent take rate with a per-passing fee of $97.50 per month, the partner would need to pay the City $278.85 per subscriber. It is highly unlikely that the LFUCG can obtain such a high fee.

Table 36: FTTP Scenario 1 – No Grant Funding Financial Summary

Income Statement	Year 1	Year 5	Year 10	Year 15	Year 20
Total Revenues	$26,560	$6,310,440	$6,310,440	$6,310,440	$6,310,440
Total Cash Expenses	(754,790)	(1,671,560)	(1,671,560)	(1,671,560)	(1,671,560)
Depreciation	(650,910)	(2,102,550)	(2,102,550)	(2,102,550)	(2,140,750)
Interest Expense	(966,000)	(2,856,860)	(2,276,460)	(1,499,760)	(460,850)
Taxes	-	-	-	-	-
Net Income	$ (2,345,140)	$ (320,530)	$259,870	$1,036,570	$2,037,280

Cash Flow Statement	Year 1	Year 5	Year 10	Year 15	Year 20
Unrestricted Cash Balance	$28,670	$584,410	$598,460	$612,680	$621,550
Depreciation Reserve	-	189,240	203,640	218,040	45,350
Interest Reserve	966,000	-	-	-	-
Debt Service Reserve	805,000	2,555,000	2,555,000	2,555,000	2,555,000
Total Cash Balance	$1,799,670	$3,328,650	$3,357,100	$3,385,720	$3,221,900

This scenario projects a net income of almost $260,000 by year 10, and an unrestricted cash balance of $28,000 in year one, increasing to $580,000 in year five and roughly $600,000 in year 10 and beyond. It should be noted, however, that the per-passing fee of $97.50 per month is excessive, and LFUCG is extremely unlikely to be able to obtain such a high fee from a private partner.

6.2.3 FTTP Scenario 2 – Grant Funding Obtained to Equal Total OSP Cost

In our next scenario, we increase the initial startup funds to equal the OSP cost. Per-passing fees decrease proportionally to $26.25 per month, and dark fiber revenues remain the same. The required per passing fee is still high, over 3.5 times the amount paid in Huntsville.

Table 37: FTTP Scenario 2 – Grant Funding Equal to Total OSP Cost Financial Summary

Income Statement	Year 1	Year 5	Year 10	Year 15	Year 20
Total Revenues	$7,150	$2,435,580	$2,435,580	$2,435,580	$2,435,580
Total Cash Expenses	(754,790)	(1,671,560)	(1,671,560)	(1,671,560)	(1,671,560)
Depreciation	(650,910)	(2,102,550)	(2,102,550)	(2,102,550)	(2,140,750)
Interest Expense	-	(449,240)	(359,150)	(238,590)	(77,760)
Taxes	-	-	-	-	-
Net Income	$ (1,398,550)	$ (1,787,770)	$ (1,697,680)	$ (1,577,120)	$ (1,454,490)

Cash Flow Statement	Year 1	Year 5	Year 10	Year 15	Year 20
Unrestricted Cash Balance	$807,260	$4,446,730	$4,372,830	$4,299,130	$4,220,080
Depreciation Reserve	-	189,240	203,640	218,040	45,350
Interest Reserve	-	-	-	-	-
Debt Service Reserve	-	400,000	400,000	400,000	400,000
Total Cash Balance	$807,260	$5,035,970	$4,976,470	$4,917,170	$4,665,430

This scenario projects an unrestricted cash balance of $800,000 in year one, increasing to roughly $4 million in year five and beyond. The negative net income reflects, in part, the effect of equipment depreciation, a non-cash expense.

6.2.4 FTTP Scenario 3 – No Additional Dark Fiber Revenue Is Obtained

Our third sensitivity scenario assumes that LFUCG does not obtain any dark fiber revenue, but proceeds with the same initial startup funding as our base case scenario. For this model to be viable, the per-passing fee needs to be increased to $53.50, over seven times the amount paid by Google in Huntsville.

Table 38: FTTP Scenario 3 – No Dark Fiber Revenue Financial Summary

Income Statement	Year 1	Year 5	Year 10	Year 15	Year 20
Total Revenues	$14,520	$2,898,670	$2,898,670	$2,898,670	$2,898,670
Total Cash Expenses	(754,790)	(1,671,560)	(1,671,560)	(1,671,560)	(1,671,560)
Depreciation	(650,910)	(2,102,550)	(2,102,550)	(2,102,550)	(2,140,750)
Interest Expense	(180,000)	(724,320)	(575,920)	(377,340)	(112,070)
Taxes	-	-	-	-	-
Net Income	$ (1,571,180)	$ (1,599,760)	$ (1,451,360)	$ (1,252,780)	$ (1,025,710)

Cash Flow Statement	Year 1	Year 5	Year 10	Year 15	Year 20
Unrestricted Cash Balance	$1,274,630	$3,280,890	$3,285,080	$3,289,430	$3,288,450
Depreciation Reserve	-	189,240	203,640	218,040	45,350
Interest Reserve	180,000	-	-	-	-
Debt Service Reserve	150,000	650,000	650,000	650,000	650,000
Total Cash Balance	$1,604,630	$4,120,130	$4,138,720	$4,157,470	$3,983,800

This model projects a cash balance of $1.3 million in year one, and an unrestricted cash balance of $3.2 million in years five and beyond. The negative net income reflects, in part, the effect of equipment depreciation, a non-cash expense.

Appendix A: County and Priority Sites for Middle Mile Fiber Network

Site No	Name	Address	Category
1		4105 BRYAN STATION RD	Agriculture Farm
2		1601 JACKS CREEK PIKE	Agriculture Farm
3		5175 5307 PARIS PIKE	Agriculture Farm
4		3221 3501 COMBS FERRY RD	Agriculture Farm
5		3992 RUSSELL CAVE RD	Agriculture Farm
6		4959 OLD RICHMOND RD	Agriculture Farm
7		4675 RUSSELL CAVE RD	Agriculture Farm
8		1110 BARBARIKA DR	Agriculture Farm
9		886 IRON WORKS PIKE	Agriculture Farm
10		4545 OLD FRANKFORT PIKE	Agriculture Farm
11		3744 RUSSELL CAVE RD	Agriculture Farm
12		4915 4919 PARIS PIKE	Agriculture Farm
13		2525 DELONG RD	Agriculture Farm
14		120 DELONG RD	Agriculture Farm
15		3801 4081 VERSAILLES RD	Agriculture Farm
16		6000 MT HOREB PIKE	Agriculture Farm
17		2815 OLD LEMONS MILL RD	Agriculture Farm
18		3000 OLD FRANKFORT PIKE	Agriculture Farm
19		3295 3305 VERSAILLES RD	Agriculture Farm
20		2469 IRON WORKS PIKE	Agriculture Farm
21		3901 Van Meter Rd	Sport Horse
22	Spy Coast Farm	3646 Newtown Pike	Sport Horse
23	Poplar Hill Farm	Russell Cave Road	Sport Horse
24		2941 Paris Pike	Sport Horse
25	NORMANDY FARM	4701 Paris Pike	Thoroughbred
26	CALUMET FARM	3301 Versailles Road	Thoroughbred
27	SPENDTHRIFT FARM	884 Iron Works Pike	Thoroughbred
28	STONESTREET FARM	3530 Old Frankfort Pike	Thoroughbred
29	THOROUGHBRED RETIREMENT FOUNDATION/MAKER'S MARK SECRETARIAT CENTER	Kentucky Horse Park	Thoroughbred
30	UNIVERSITY OF KY EQUINE FARM, MAINE CHANCE FARM	2815 Newtown Pike	Thoroughbred
31	WINCHESTER FARM	4468 Mt. Horeb Pike	Thoroughbred
32	WINTER QUARTER FARM	4153 Military Pike	Thoroughbred
33	CASTLETON LYONS	2469 Iron Works Pike	Thoroughbred
34	CLEARSKY FARMS	6575 Russell Cave Road	Thoroughbred
35	CRESTWOOD FARM, LLC	3933 Spurr Road	Thoroughbred
36	DARBY DAN FARM	3225 Old Frankfort Pike	Thoroughbred
37	DARLEY USA - JONABELL FARM	3333 Bowman Mill Rd	

Site No	Name	Address	Category
38	DIXIANA FARM	1301 Dixiana / Domino Road	Thoroughbred
39	DON ALBERTO	4241 Spurr Road	Thoroughbred
40	DROMOLAND FAR, NORTH	1920 North Yarnallton Pike	Thoroughbred
41	DROMOLAND FARM INC.	3601 Spurr Road	Thoroughbred
42	FINISH LINE FARMS/ a division of HANOVER MEADOWS	5508 Russell Cave Road	Thoroughbred
43	GAINESWAY FARM	3750 Paris Pike	Thoroughbred
44	HILL 'N' DALE FARM	640 N. Yarnallton Pike	Thoroughbred
45	BLUEWATER FARM & SALES	3951 Old Frankfort Pike	Thoroughbred
46	JUDDMONTE FARMS	3082 Walnut Hill Road	Thoroughbred
47	KENTUCKY HORSE PARK	4089 Iron Works Parkway	Thoroughbred
48	MAGDALENA FARM	2651 Russell Cave Road	Thoroughbred
49	MARULA PARK STUD	6721 Russell Cave Road	Thoroughbred
50	MILL RIDGE FARM	2800 Bowman Mill Road	Thoroughbred
51	MILLENNIUM FARMS KENTUCKY	5275 Paris Pike	Thoroughbred
52	MONTICULE	977 Harp Innis Pike	Thoroughbred
53	MT. BRILLIANT FARM, LLC	3314 Huffman Mill Road	Thoroughbred
54	Keenland	4201 Versailles Rd	Horse Park
55	Rood and Riddle	2150 Georgetown Rd	Hospital
56	Park Equine Hospital	5455 Lexington Rd	Hospital
57	RUSSELL CAVE ELEMENTARY	3375 Russell Cave Rd	School
58	LOCUST TRACE AGRI-SCIENCE FARM	3591 Leestown Rd	School
59	FIRE STATION 23	5751 Briar Hill Rd, 19	Fire Station
60	FIRE STATION 19	3360 Huffman Mill Pike	Fire Station
61	FIRE STATION 17	4075 Royster Rd	Fire Station
62	FIRE STATION 18	1098 S Cleveland Rd	Fire Station

Appendix B: Potential Partner Engagement Contacts

Carrier	Public Map	KMZ Files	Planned Network	Sell DF	IRU	Lease Only	BD Contact
Zayo	Y	Y	Y	Y	Y		Randy Dunbar VP Metro Dark Fiber cell 720-938-2144 randy.dunbar@zayo.com
Lightower	Y	Y	X	Y	Y	N	J. Drew Mullin Senior VP – Business Development & Strategy Lightower Fiber Networks 585 697 5160 [office] 585 749 9821 [mobile] dmullin@lightower.com
FIberLight	Y	N	N	Y	Y		Ron Kormos, Chief Strategy Officer 214-649-7224 ron.kormos@fiberlight.com
Uniti Fiber (Windstream/ Tower Cloud)	Y	N	N	Y	Flexib	Flexib	Chris Para VP Corporate Development 727-471-5655 cparra@towercloud.com
Level 3	Y	N	N	???	N	???	Craig M. Cupach Director, Sales Government Markets Group Level 3 Communications 216.496.2141
Crown Castle	Y	Y	N	Y	Y		Alan Katz EVP, Sunesys Ph: 267-927-2013 akatz@sunesys.com
Charter	N	N	N	N	N	???	Jason Keller Sr. Director, Government Affairs CHARTER COMMUNICATIONS 502.867.2207
Qxnet	N	Y	N/A	N/A	N/A	N/A	Zachary R. Murray President QX.net 859-721-0200 Direct Line 859-255-1928 x240 zachary@qx.net
WOW Business	Y	Y	N	Y	Y	Y	Cathy Kuo EVP Strategy & Engagement 630.536.3100 (720) 479-3518 cathy.kuo@wowway.net
NON-CARRIERS							**BD Contact**
UKY							Steve Workman, Assoc Dean of Research 859-218-4974 steve.workman@uky.edu
Solarity							Terry S. Barnes, PMP, terry@solarity.com 859-361-0435
PPL Corp/Kentucky Electric Utilities							Matthew Green Director - Asset Management and Strategy mgreen@pplweb.com +1.610.774.5151

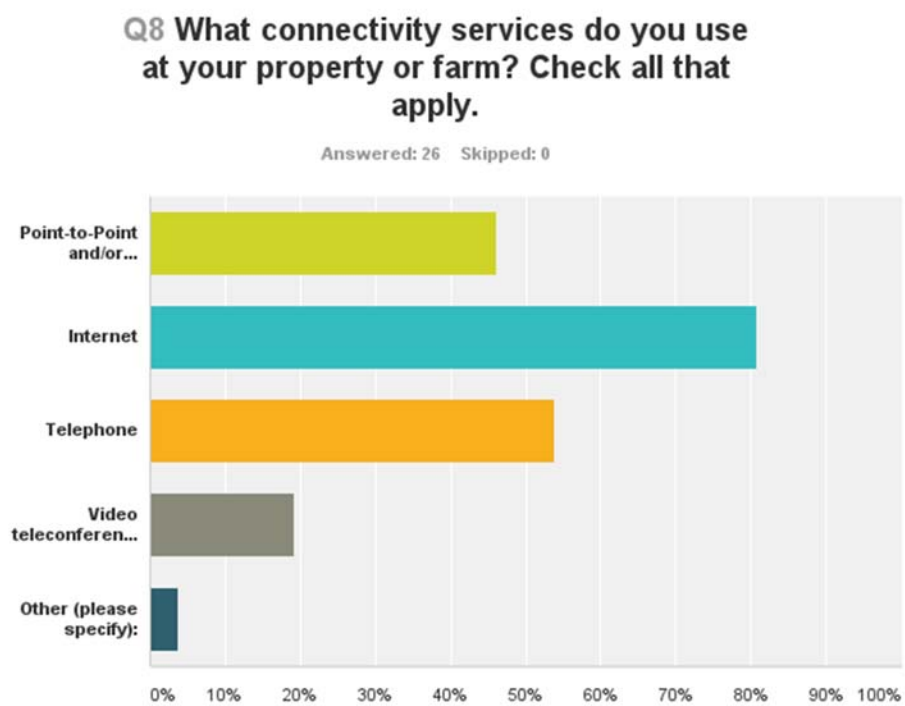
Appendix C: Selected Survey Results

In early 2017, CTC conducted an online survey in partnership with LFUCG and the Fayette Alliance in an effort to understand the potential interest among key Fayette County businesses in the middle mile model considered in this report. With the help and guidance of the Fayette Alliance, 47 key stakeholders were identified and invited to participate in an online survey.

In total, 26 of the 47 responded, representing a 55 percent response rate. Thoroughbred farms accounted for 85 percent of survey respondents. The remaining 15 percent own sport horse farms or businesses. The vast majority of those responding have less than 50 employees working or living onsite. The majority of respondents (67 percent) indicate they do not employ dedicated IT staff. Only two respondents have more than 500 visitors per year to their farm or business. The largest percentage have less than 50 visitors per year.

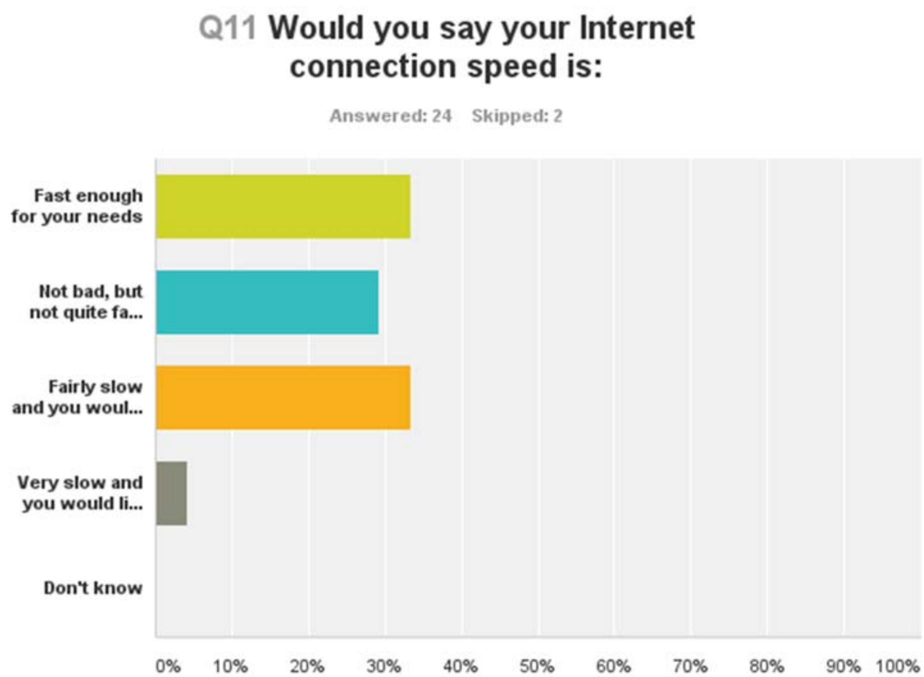
When asked about whether they have a contract with an Internet service provider (ISP) or telecommunications provider for data connectivity services, 96 percent indicated affirmatively that they do have a contract with a provider. When asked about their top uses, responses such as email, large file transfer, banking and financial services, and streaming were most often cited.

Respondents were asked which connectivity services were used at the farm or business (Q8). The top uses included Internet, telephone, and point-to-point and/or point-to-multi-point data.



When asked what they have for their primary Internet connection, the largest responses were digital subscriber line (DSL), wireless, and fiber. Sixty-two percent of respondents indicated that they do not have a back-up or secondary connection.

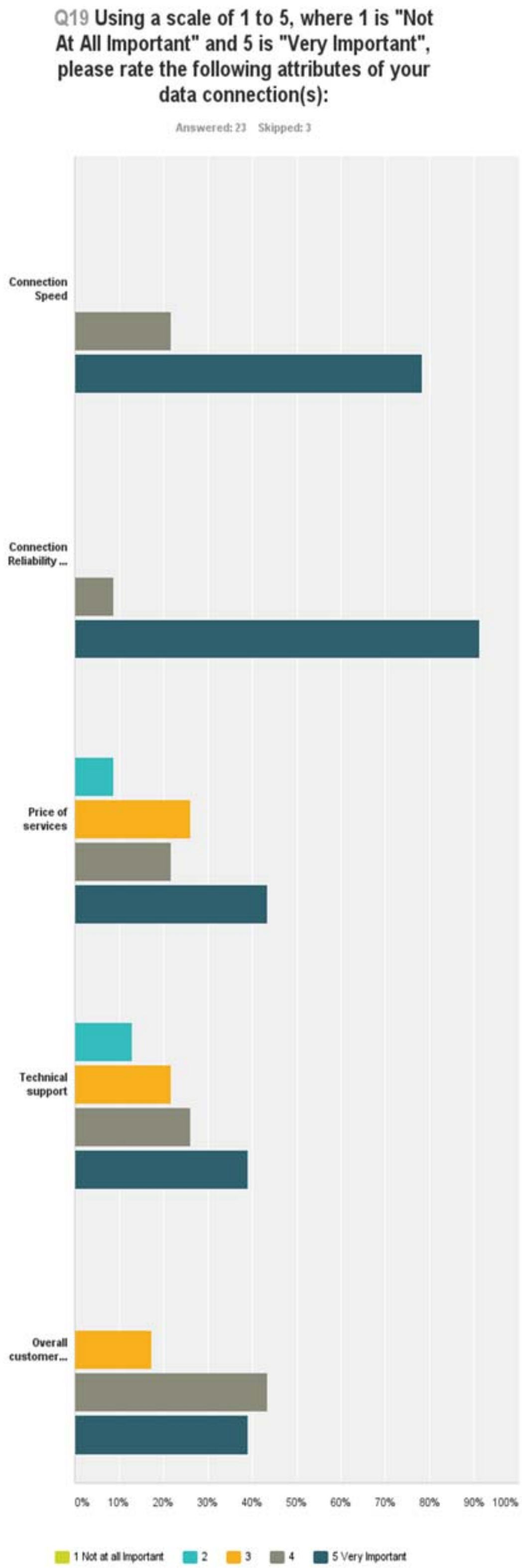
Respondents were asked their opinion about their Internet connection speeds and answers were fairly evenly split (Q11).

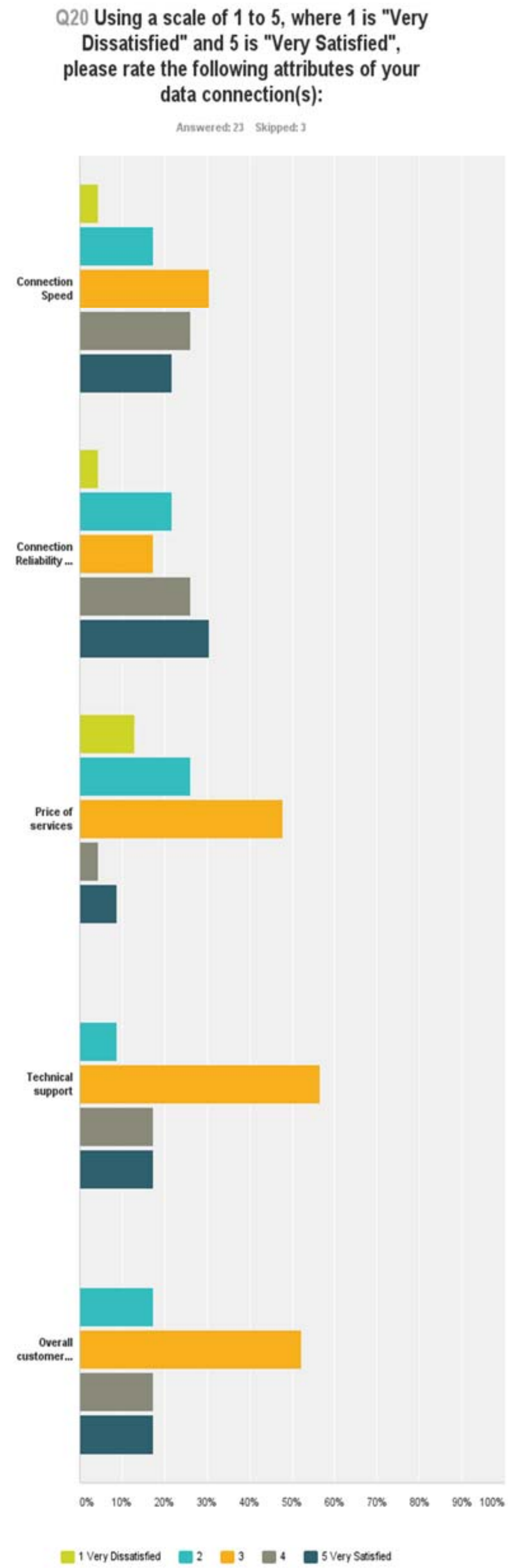


When asked about download speeds, the majority of respondents indicated they receive less than 100 Mbps. When asked about upload speeds, many were not sure of the speed, and the majority indicated they are receiving 50 Mbps or less.

Respondents were asked how much they pay per month for Internet service and 25 percent indicated that they pay $1,000 or more per month. Another 21% indicated that they pay $50 to $99 per month, and the next largest response was 17% who pay $200 to $299 per month.

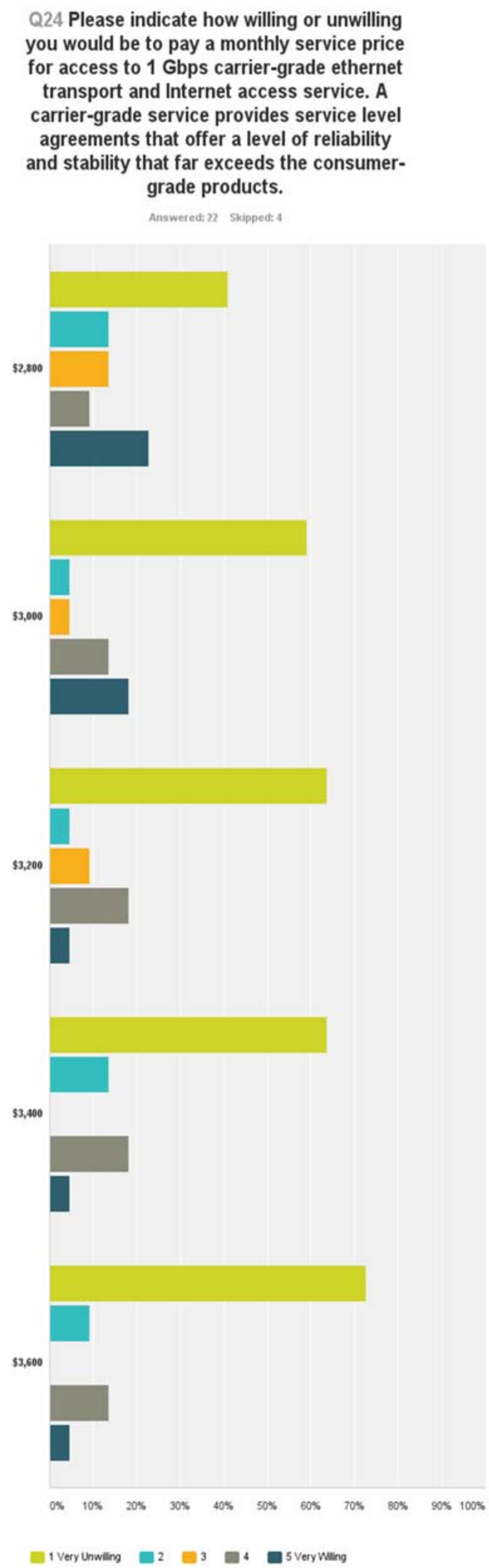
It is important to note that respondents placed a higher importance on many aspects of their service (Q19), but in the satisfaction levels with those service aspects (Q20), they are not as satisfied or are neutral for what they are currently offered in most categories.

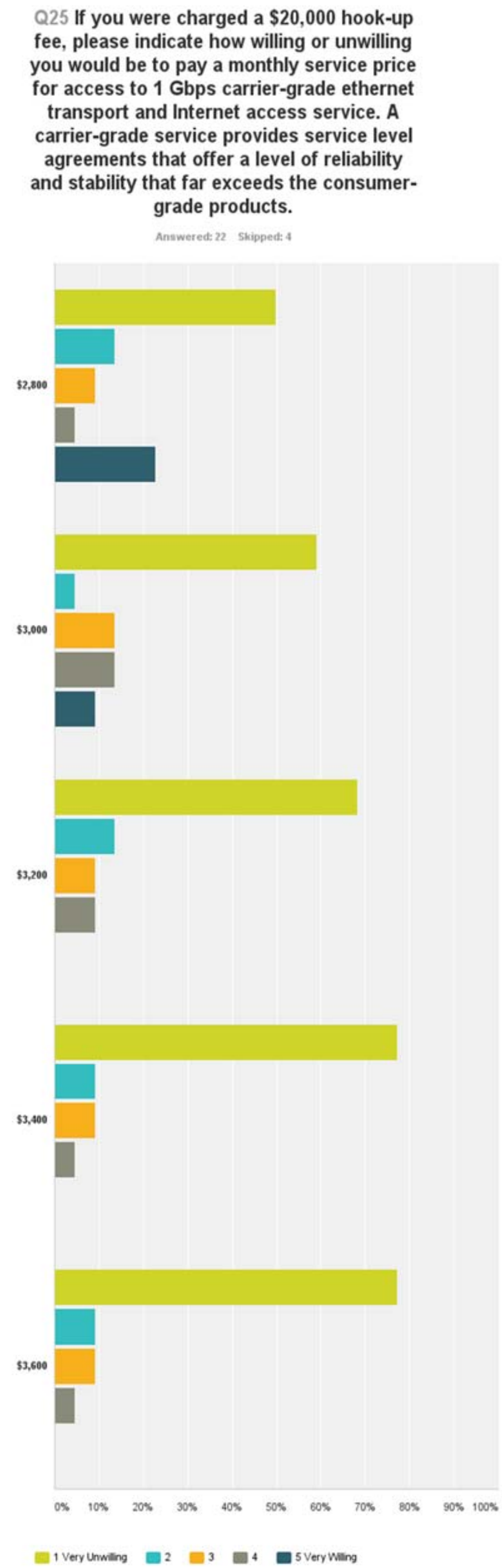

Q19 Using a scale of 1 to 5, where 1 is "Not At All Important" and 5 is "Very Important", please rate the following attributes of your data connection(s):
Answered: 23 Skipped: 3
Connection Speed
Connection Reliability ...
Price of services
Technical support
Overall customer...
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
1 Not at all Important
2
3
4
5 Very Important


Q20 Using a scale of 1 to 5, where 1 is "Very Dissatisfied" and 5 is "Very Satisfied", please rate the following attributes of your data connection(s):
Answered: 23 Skipped: 3
Connection Speed
Connection Reliability ...
Price of services
Technical support
Overall customer...
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
1 Very Dissatisfied
2
3
4
5 Very Satisfied

When asked about the interest level in purchasing services on a new high-speed network, were it to be constructed, 91 percent of respondents were either potentially interested or very interested. In follow-up questions, respondents were asked about service pricing on a potential new network.

When queried about how willing or unwilling they would be to pay a monthly service price for access to 1 Gbps carrier-grade ethernet transport and Internet access service, the majority were less likely to purchase or pay as the suggested price rose (Q24). A follow-up question (Q25) asked whether, if they were charged a $20,000 hook-up fee, they would be willing or unwilling to pay a monthly service price for access to 1 Gbps carrier-grade ethernet transport and Internet access service. The majority were very unwilling at all price points, but at the $2,800 per month price point, 28 percent indicated they were somewhat willing to very willing.


Q24 Please indicate how willing or unwilling you would be to pay a monthly service price for access to 1 Gbps carrier-grade ethernet transport and Internet access service. A carrier-grade service provides service level agreements that offer a level of reliability and stability that far exceeds the consumer-grade products.
Answered: 22 Skipped: 4
$2,800
$3,000
$3,200
$3,400
$3,600
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
1 Very Unwilling
2
3
4
5 Very Willing


Q25 If you were charged a $20,000 hook-up fee, please indicate how willing or unwilling you would be to pay a monthly service price for access to 1 Gbps carrier-grade ethernet transport and Internet access service. A carrier-grade service provides service level agreements that offer a level of reliability and stability that far exceeds the consumer-grade products.
Answered: 22 Skipped: 4
$2,800
$3,000
$3,200
$3,400
$3,600
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
1 Very Unwilling
2
3
4
5 Very Willing