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The Next Generation Kentucky Information Highway: Building Fiber Optic Infrastructure

Prepared for the Commonwealth of Kentucky
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1 Introduction

CTC prepared this planning document to assist the Commonwealth of Kentucky and its partners and stakeholders to build a fiber optic infrastructure to meet a range of stakeholder and market needs. The document provides recommendations for governance, develops a financial model, recommends a technical architecture, and presents a migration plan to a next generation network—the Next Generation Kentucky Information Highway (NG-KIH).

The NG-KIH stakeholders use managed services from commercial telecommunications operators and fiber leases and IRUs in limited areas where they are available. The IRUs limit the use of the network to educational and governmental use. The managed services have a mixed reliability record, and stakeholders report lengthy delays in moving, adding and changing services.

With the direction and assistance of NG-KIH stakeholders, CTC developed an infrastructure assessment—documenting existing services, network performance, areas of risk, and a high-level assessment of fiber build costs and risks. The report outlines recommended practices for next-generation infrastructure. CTC conducted a high-level field survey and identified challenges and costs in constructing new fiber. Recommendations include: early coordination with pole owners, identification of opportunities for fiber trades, and consideration of construction in interstate highway medians.

CTC developed a financial assessment and proposed financial model. The model is sustainable under conservative assumptions. The base model provides a worst-case understanding of new network costs as compared to existing spending with no dark fiber or partner revenue assumptions. CTC developed scenarios including fiber lease revenue, reductions in construction costs, and financing arrangements that would decrease new network per site spending. The scenarios are hypothetical, pending the outcome of RFPs and potential partnerships. The model is easily adaptable to understand implications as new data emerges regarding bids and potential partnerships.

The model assumes that fiber is installed over three years to reach 1,263 community anchor institutions. Customer drops and electronics are added as sites are connected. The estimated cost of operations is $11.8 million for the full statewide network and is comparable to current costs for managed services and current staffing levels. The estimate encompasses all costs including FTE management, electronics maintenance, facilities and utilities, office, NOC and outside plant maintenance, pole attachment, and a suitable contingency.

Postalized service fees were developed for Ethernet and dense wavelength division multiplexing (DWDM) services starting at 100 Mbps, at prices based on current assumptions that are likely to be 27 percent less than prices for comparable services under KIH3. Assuming construction to all designated sites within three miles of the proposed backbone, rates for the worst-case base model are lower than existing postalized rates. Pricing is very sensitive to increased lease revenues, reduced construction costs, or reduced financing costs. The financial model will be a powerful tool in analyzing and evaluating the value of potential partnerships with concessionaires and infrastructure providers.

CTC proposes a framework for governance, derived from stakeholder goals, input from stakeholders, and CTC's experience with other statewide and regional networks. The proposed governance starts with the Leadership Committee and recommends it become a Leadership Board that takes a central role in ongoing decision-making. The report then discusses advantages and disadvantages of state-led, non-profit and higher education led models. It discusses how the Finance Cabinet and the Center for Rural Development have funding accountability for the network and how other stakeholders can play key roles through the Leadership Board and crucial committees where much decision-making is likely to happen.

CTC presents a technical architecture to provide both middle mile services and last mile service to community anchor institutions. CTC began with the high-level "airline" map interconnecting the major cities and developed a network that provides lit services over a 2,311-mile fiber backbone. The sites include state government, higher education, and K-12 districts. The fiber backbone is also in close proximity to local government institutions and economic development target areas, and is connected directly to major commercial and Internet(2) peering points.

The network architecture uses scalable DWDM technology and is capable of providing layer 2 and layer 3 Ethernet services from 100 Mbps to 10 Gbps and a range of OTU DWDM services.

2 Infrastructure Assessment

CTC used standards and procedures that we have used in our work with public safety-grade infrastructure to assess the current infrastructure, including key risk factors in relation to the existing network environment, identified through examination of as-built documentation, surveys of stakeholder network managers, and site surveys.

In the sections below, we describe our assessment in detail. At a high level, we note the following:

- Of the infrastructure not owned or controlled by the Commonwealth or stakeholders, there is little documentation of network physical routes or interface level documentation
- Statewide wide-area networking (WAN) is outsourced to telephone companies
- Statewide contracts provide for connectivity statewide, but service level agreements are neither well defined nor easily enforceable
- There is no independent State documentation of WAN performance by the telephone companies
- Public safety facilities, such as state police posts and public safety communications sites, have intrusion alarms and backup generator power. Data centers also have backup generator power and intrusion alarms
- Primary university facilities report having intrusion detection alarms, generator and UPS power backup, but report that many satellite campuses are in leased locations and are typically less well hardened.

2.1 Inventory of network sites

CTC gathered information through a series of stakeholder interviews, site visits, reviews of design maps, reviews of service provider contracts and service descriptions, and follow-up with service providers.

2.1.1 Information gathering process

CTC engineers and analysts scheduled and facilitated discussions with stakeholders representing relevant Cabinets, higher education institutions, existing networks, service providers, and other vendors. These included the following:

<u>Commonwealth Government</u>

- Cabinet for Economic Development

- Center for Rural Development (CRD)
- Commercial Mobile Radio Service Emergency Telecommunications Board (CMRS)
- Commonwealth Office of Technology (COT)—including COT network architect
- Commonwealth Office of Broadband Outreach and Development
- Kentucky Department for Libraries and Archives (KDLA)
- Kentucky Department of Education (KDE)
- Kentucky Educational Network (KEN)
- Cabinet for Health and Family Services (CHFS)
- Kentucky Educational Television (KET)
- Kentucky Emergency Warning System (KEWS)
- State Police/FirstNet State and Local Planning
- Kentucky Transportation Cabinet (KYTC)
- 9-1-1 operators

Higher Education

- Kentucky Council on Postsecondary Education (CPE)
- CIO roundtable discussion
- Kentucky Community and Technical College System (KCTCS)
- Murray State University
- Northern Kentucky University
- University of Kentucky
- University of Louisville
- Western Kentucky University

Networks

- Kentucky State Police (KSP)
- Kentucky Emergency Warning System (KEWS)
- Kentucky Department of Education (KDE)

Service Providers and Vendors

- AT&T
- Avaya
- Ciena
- Duo County Telephone
- East Kentucky Network (EKN)
- East Kentucky Power Cooperative (EKPC)
- Gearheart Communications
- LG&E and KU
- MuniNet
- Windstream

In our meetings with the Commonwealth and higher education stakeholders, we discussed their current connectivity, network operations, anticipated future requirements, costs, and cost sensitivity. We also discussed the types of applications they currently use and their likely future applications.

To establish an understanding of key network locations, we made site visits to:

- Cold Harbor network facility operated by Commonwealth Office of Technology
- Capitol Annex facility
- Kentucky Emergency Warning System at the Boone National Guard facility

We also reviewed the written submittals provided in response to the surveys we prepared and sent to stakeholders.

Through all of these methods, we generated a comprehensive list of sites to be connected, including those sites' current services and current monthly recurring costs. The site list includes:

- Commonwealth government facilities
- Higher education facilities
- KEWS and KET
- K-12 school district buildings
- Local government facilities

The complete list is provided in Appendix B.

2.1.2 Current services

Figure 1 illustrates a high-level view of the Commonwealth government and K-12 network; Figure 2 illustrates the higher-education network.

Figure 1: Overview of Commonwealth Government and K-12 Network

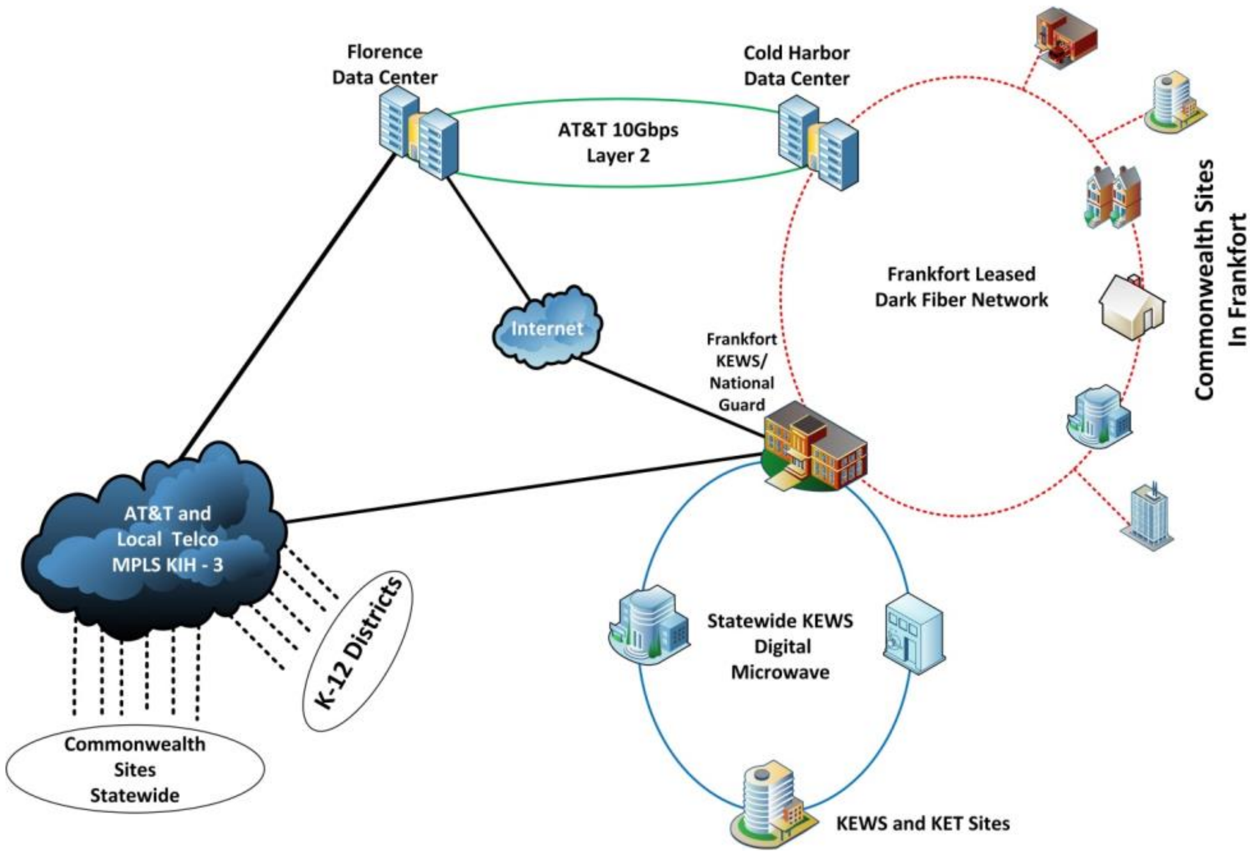
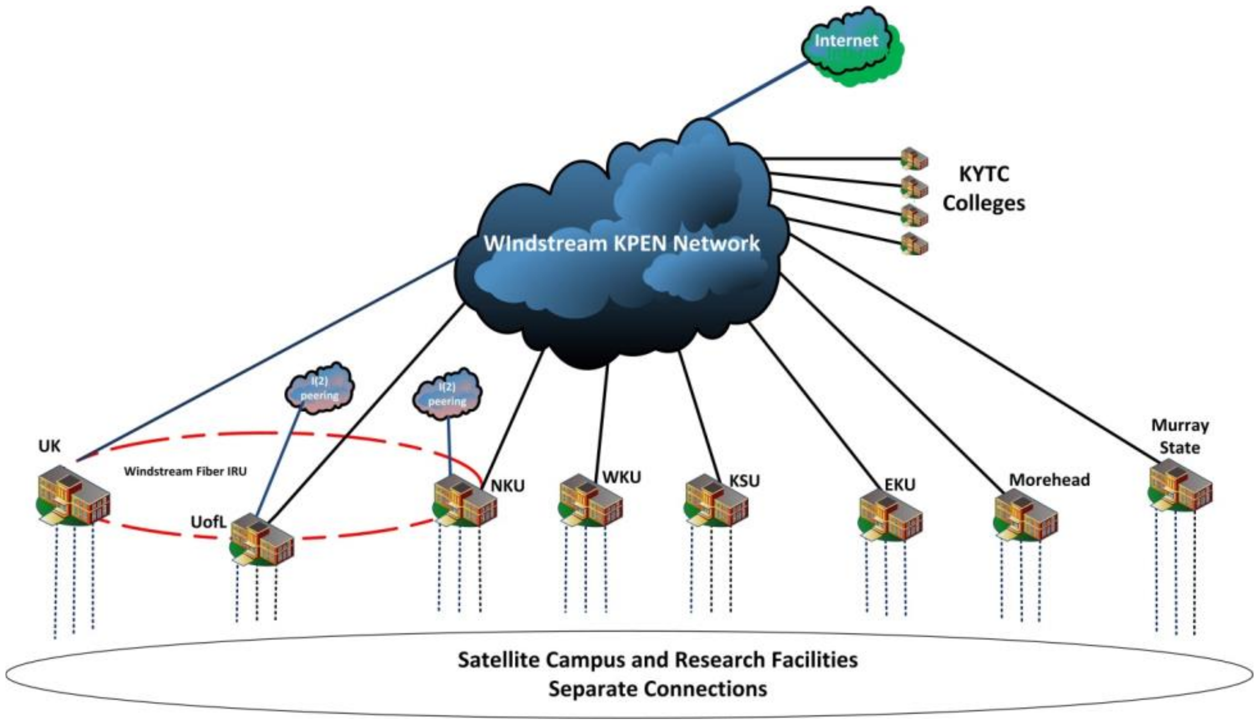


Figure 2: Overview of Higher Education Networks



In general, the stakeholders use managed routed services; there are some limited dark fiber leases, but none of the stakeholders own their own dark fiber, except within campuses and very localized environments.

The stakeholders' current connectivity is as follows:

- For the Commonwealth network, AT&T managed services are provided under KIH3 contract for government, K-12, and public safety
- For the higher education network, Windstream provides managed services under KPEN contract for higher education

In areas where AT&T and Windstream do not have service, those services are provided under KIH3 or KPEN contracts—subcontracted, generally, to telephone cooperatives.

KEWS also operates a digital microwave point-to-point network. And for both the Commonwealth and higher education network, there are limited dark fiber leases or IRUs in place from:

- Frankfort Utility Board in Frankfort
- Windstream in Louisville-Lexington-Cincinnati triangle
- Municipal power utilities within their service areas

2.1.3 Overview of network performance

The Commonwealth does not have, and service providers do not generally provide, routes or document details of CO and hubs—so there is no independent assessment of infrastructure resilience or survivability.

Portions of the service-level agreement for the AT&T KIH3 contract are difficult to enforce and do not provide much leverage. Provisioning of new circuits is required by "Agreed to Due Date," and the sliding penalty for outages up to nine hours is only one month's worth of the site's monthly recurring cost, which may be only a few hundred dollars penalty for a site not being connected for an entire month.

We also note that the majority of the KIH3 sites are connected with copper lines, not fiber optics. The copper-served sites can be expected operate at a lower reliability standard that fiber lines providing the same service, and considerable time and effort will be needed if the State requests an upgrade at those sites beyond copper speeds.

The service-level agreement for Frankfort dark fiber requires a two-hour response time, but with service restoration required only "as soon as practicable." The amount of the penalty is not clearly stated in terms of dollars per unit time, and is limited to only $20,000 per month in total. The Commonwealth reports that the Frankfort network has had relatively few problems, relative to the KIH network.

In terms of actual performance, the Commonwealth does not independently measure outages and has not calculated a percent uptime, but reports that there are delays in adding and upgrading service and regularly reports "ups and downs."

The universities report outages of the KPEN—as an example, the NKU connection to commodity Internet—down six times per month, with SIP down once per month.

The KPEN Windstream network is not sufficiently reliable on its own, for the needs of the universities. WKU pays $36,000 per year for a backup circuit from Time Warner Cable for Internet connectivity because of the need for redundancy. Murray State gets backup from AT&T at a cost of $48,000 per year.

2.2 Network availability risk assessment

CTC defined and characterized candidate risks to network availability, ranging from simple hardware failure and fiber cuts to cyber-attacks and natural disasters, based on the likelihood of associated threats and potential impact to network availability.

We identified these potential areas of risk and key risk factors through examination of as-built documentation and the site inventory process described in the previous section. Note that these areas of risk do not necessarily represent material weaknesses in the existing Commonwealth infrastructure or particular systems and processes; certain threats exist regardless of any network-specific factors. These are presented as forward-looking guidelines, for the operation of the new NG-KIH.

2.2.1 Physical site access controls

Uncontrolled access to physical network assets, especially network routers and other network electronics, can pose significant risks to network availability and application security. This is a risk presented either from unintended movement, cable disconnection, or misconfiguration of network devices, or from malicious attempts to disrupt the network or compromise data integrity or secrecy. Aside from causing physical damage to network electronics or cabling that might cause an outage to Commonwealth services, gaining physical access to network routers by an individual with malicious intent can allow for relatively unsophisticated means to intercept data and/or modify device configuration passwords directly through physical console management ports.

To effectively mitigate this risk, site access must be controlled both physically and as a matter of policy. Sites housing NG-KIH network equipment should provide reasonable physical security in the form of locked doors, active intrusion detection and alarming systems, and ideally, electronic access controls and video surveillance that provide positive identification and logging of all individuals gaining access to the site. Policies should mandate logging of access to spaces containing network equipment, as well as specifying methods for proper vetting of personnel (e.g., background checks and employment status) who are allowed unescorted access to the equipment.

2.2.2 Backbone link redundancy and fiber restoration

Outdoor physical cable plant is an exposed asset that is at risk of damage from a number of sources. Underground cable, whether directly buried or installed in conduit, is most frequently damaged by underground construction activities unrelated to the cable, typically occurring accidently. While proper utility locating in response to “one-call” center laws can help mitigate this risk, damage of this type is not uncommon. Cable installed on aerial utility poles is more prone to breaks caused by bad weather, particularly as a result of trees falling onto these utility lines, and damage to utility poles from traffic accidents. Cables can also be damaged by rodents and other animals that chew through cable. Although outdoor cable is somewhat anonymous among the thousands of miles of communications cabling within the Commonwealth’s public rights of way, malicious physical attacks are possible, whether targeted or random vandalism.

When network electronics are configured to leverage redundancy of network links to provide path protection switching or load-balancing, geographically diverse physical fiber paths can provide effective protection against malicious or accidental breaks, and can mitigate, in many cases, the risk of delayed fiber restoration. While generally less at risk, this diversity, where feasible, should extend to the indoor cable plant pathways through an NG-KIH network site to the termination panel.

2.2.3 Electrical power supply resiliency

A lack of electrical power resiliency is one of the more common causes of service outages for nearly any type of communications network. Network hardware generally requires well-conditioned electrical power, and in fact, power voltage fluctuations can reduce the mean time between failures (MTBF) of network hardware. Even a momentary power outage or significant drop in voltage can cause network hardware to reboot, incurring a few minutes of outage in many cases (or longer if the outage results in a system crash, or if proper configurations are not restored upon a subsequent power-up). Ultimately, the impact can be equivalent to a hardware failure or fiber cut.

Short-term outages are more common, even during mild storms, with aging public power infrastructure often susceptible to ice storms, wind-related damage, power demand spikes, and other disruptions. To reduce the risk of short-term power-related threats, Uninterruptible Power Supply (UPS) systems are generally sufficient. If properly maintained (batteries replaced every three to four years) and not overloaded, UPS hardware will effectively mitigate the risk of short-term outages and voltage fluctuations.

Longer-term outages, although less common, pose a more substantial potential impact to the network, as backup power generation is generally required for outages lasting from more than a few minutes to a few hours of total outage. Backup power generation is more costly, and the equipment requires rigorous maintenance to reliably offer backup power. Moreover, fuel supply, particularly during large scale emergencies that strain public fuel supply chain infrastructure, must be mitigated through fuel storage reserves or fuel service contracts with appropriate guarantees tied to suitable fuel storage and delivery resources.

2.2.4 Climate control resiliency

Proper climate control is critical for most network electronics to operate reliably. The network electronics that are not environmentally hardened must operate within typical environmental ranges (32 to 104 degrees F, 5 to 90 percent humidity, non-condensing). Datacenter and wiring closet temperatures can reach temperatures well above this typical range, even when outside temperatures are mild, simply due to the heat dissipation from the network electronics in a relatively closed environment with minimal circulation from external environments. Network equipment can reach critical temperature levels and begin to malfunction or shut down in a matter of hours after the failure of air conditioning systems.

Even if all hardware is located in spaces with HVAC systems capable of maintaining required environmental ranges, these systems likely are not redundant; if a non-redundant HVAC system were to fail, the time required to repair that system may have an impact on network connectivity.

2.2.5 Network electronics redundancy

Network electronics represent potential points of failure for network connectivity. We can assume that a single provider router failure will reduce total annual network availability for a particular jurisdiction to approximately 99.9-percent availability (roughly 8 hours of downtime), or less, depending on the amount of time required to replace the failed component. We recommend that the Commonwealth deploy redundant routers and firewalls at locations where diverse paths exist.

2.2.6 Site access for network support

Network site access is an essential factor impacting the ability of the support team to support the network and expeditiously resolve problems. Simply put, unfettered access can lessen the impact of other threats, particularly when hardware replacement or onsite diagnostics are required. Site access, in this context, refers to both out-of-band management and physical access for support personnel.

Out-of band management, provided through standard telephone circuits or wireless connections, allows remote control and configuration of systems even in the event that primary, in-band management traffic is negatively impacted by some other failure. For example, out-of-band management can be instrumental in diagnosing the status of remote hardware when the cause of a link failure is unknown (e.g. hardware failure or fiber break), and can enable hardware to be rebooted in the event that a configuration error or hardware glitch is negatively impacting normal traffic flows.

Physical site access varies by site, and is sometimes dependent upon third-party site owners. Unless immediate access is guaranteed, the specific timeframes for access must be considered a risk factor to the overall resiliency of a network site.

2.3 System-level assessment of planned fiber build

CTC performed physical surveys of selected routes to verify price estimates and verify that the schedule is consistent with potential areas of risk. In addition, CTC held discussions with the Kentucky Transportation Cabinet (KYTC) and utility pole owners; reviewed responses from potential partners (including service providers, utility owners, municipal utilities, and infrastructure owners); met with stakeholders (see list in Section 2.1); reviewed written responses from stakeholders; and reviewed contractor pricing.

2.3.1 Field survey findings

CTC performed a field survey of 539 route miles. At the direction of COT, this was focused primarily on the central and eastern parts of the state; our route is illustrated in Appendix C.

Based on our field survey, we found that aerial construction is possible in the rights-of-way for most corridors, totaling approximately 75 percent of the route.

Most of the routes had separate power poles. Separate telecommunications poles, usually on the other side of the road, support the telephone cables. Cable TV and other fiber providers may be either on the power poles or telecommunications poles.

In other areas, poles were joint use, with all utilities on the pole. The joint use and telecommunications poles have the least space for new attachment.

Some poles are set far from the road, especially where roads have been improved and cut into hills, while the utility line remains on the hilltop. It will be necessary to trim foliage and cut brush in many areas, especially where utility poles are set far from the road or in woods and have not been trimmed for years.

Even if an existing utility allows NG-KIH to lash its fiber to existing cables, the opportunities are limited in many areas because the existing fiber is self-supporting and thus cannot support an additional cable.

The poles have substantial need for movement of existing utilities to create space (also known as “make ready”). Approximately 60 percent require some degree of make ready, with 35 percent requiring minor make ready, 15 percent requiring moderate make ready, and 10 percent requiring more extensive make ready. Power-only poles had the most available space and the least need for make ready. Based on our experience with costs charged by utilities for similar work, this will range from $500 to $2,500 per pole, with an average cost of $22,000 per mile (including the cost charged by the pole owner for its engineering). The make ready is required throughout the design areas—a typical route will require some make ready within almost every mile.

There is also a need for pole replacement where poles are too old, worn out, or damaged to accommodate a new attachment. We estimate that 5 percent of poles will need replacement. Pole replacement itself (digging a hole, acquiring a new pole, placing it) is not terribly costly, but in our experience the costs can be high when existing utilities, especially power lines and transformers, need to be transferred. We have found that utility companies quote costs of $15,000 to a new attacher to perform the work—usually leading that attacher to instead find another route or go underground for that part of the route.

The cost of make ready and pole attachment is determined by the pole owner and the existing utilities. The new attacher (in this case, NG-KIH) or its contractors have little control.

There are many different power companies in the proposed fiber corridors—including Louisville Gas and Electric, Duke Energy, and many utility cooperatives and municipal power companies. While we can outline a general approach as a starting point, the Commonwealth will need to approach each company individually to get agreement, propose routes, determine route-specific issues (e.g., land ownership, available space), develop a make ready schedule and cost, determine engineering costs, and so on.

Based on the Commonwealth's discussion with the PSC regarding pole attachment and the regulatory status of NG-KIH, we understand that the PSC will advocate for Commonwealth attachment under the same terms as the telcos: For electric utility poles, these very based on the pole owner and range from $2.59 to $10.08 per year for a two-party attachment and $2.03 to $5.89 for a three-party attachment. For telephone utility poles, these range from $1.64 to $13.45 for two-party and $1.22 to $8.05 for three-party. We also understand that the PSC will not require NG-KIH to act as a common carrier as long as the NG-KIH remains a wholesaler of the fiber and does not provide retail services to the private sector.

We recommend:

1) A more extensive survey of the proposed cable routes to assess the extent to which what we have surveyed is valid statewide. Most of our survey was in Eastern Kentucky. Because of its terrain and foliage, that may be a worst-case scenario

2) In-depth discussions with individual utility owners along the needed routes, to assess costs and procedures for make ready and pole replacement. There are over twenty investor-owned and rural power utilities across the state and 20 municipal systems, each with its own procedures and its own individuals leading this process. It is necessary to explain what routes are desired, determine costs and schedules, and identify potential problem areas. Problem areas may include lack of staff to perform surveys, engineering and make ready, or poles on private property requiring agreement of property owners. Discussions may also provide alternative opportunities—such as locations for overlash to existing fiber, opportunities for fiber trades, available underground conduit pathways, and options for NG-KIH to augment utility staff to manage staffing bottlenecks in make ready. Discussions may also enable NG-KIH to mutually agree on ground rules that forestall negative practices that some utilities have used in the past—such as unfairly charging NG-KIH the full cost of replacing rotted poles and rectifying other longstanding utility problems that may have evolved over decades.

Photos of representative poles along the field survey routes are included in Appendix D. A summary of the field survey routes and cost estimates, as well as construction assumptions, are below.

2.3.2 Overall assessment of build and pole attachment issues

As an overall assessment, we believe that the proposed build is workable but costly, with significant potential delays due to negotiating pole attachment agreements, engineering, performing make ready surveys, and determining the most cost-effective strategy for make ready.

We generated a high-level cost estimate based on field surveys and the following assumptions:

For aerial plant:

- 30 poles per mile
- Slack coil in snow shoe every 1,500’
- Splice case placed every two miles
- Joint-use poles are 40 percent of total pole lines
- More than 80 percent of joint-use poles (more than 30 percent of total poles) need make ready work; many will need extensive make ready

For buried pant:

- Handholes placed every mile
- Slack coil in every handhole
- Splice cases in every other handhole
- Two 2” HDPE conduits priced in build
- Handholes are Tier 22, 24”x36”x36”

Table 1: Aerial Construction Assumptions

Aerial Construction Assumptions	**Per Mile**
Installation Labor and Materials ($3.80/foot)	$20,064
Tree Trimming/Brush Clearing (75% of poles) ($2/foot)	$7,920
Make Ready (32.5% at $500, 15% at $1,200, 10% at $2,500)	$22,515
Pole Replacement (5% at $15,000/pole)	$29,640
Splicing	$1,045
Total	**$81,184**

Underground construction will be required in areas without pole lines or where aerial construction is too complicated, expensive or time-consuming. Rocky terrain will increase costs in many areas. (Our field survey indicates that directional boring or drilling below a certain depth will be difficult in some areas, especially the eastern part of the state, because the limestone layer is not covered by a deep layer of soil.) We estimate costs of approximately $80,000—again, derived from typical nationwide material and labor costs.

KYTC has designated staff to review the NG-KIH design and expedite processes, provide feedback on routes, and coordinate with KYTC districts on permitting. We expect this assistance will help provide a unified approach across the KYTC districts and make underground construction a desirable alternative where aerial construction is costly or complex.

2.3.3 Areas of focus for reducing costs

In addition to the strategies identified above, we note that there is frequently space for a new attacher at the bottom of the communications space; placing fiber there eliminates the need for make ready on the pole. This space is customarily reserved for the incumbent telephone company but this is not a requirement of law or code. If NG-KIH can work with pole owners to have access to that space, it may substantially reduce make ready costs relative to our estimate.

We also note that the Commonwealth's interstate corridors provide a clear path and less complex construction; placing the backbones in the median of the major routes—I-64 east to west, I-75 north to south, and I-71 from Louisville to Cincinnati—and using low cost plowing techniques, where possible—would lower the project cost and reduce the likelihood of some potential delays.

According to KYTC, an interstate build has not been done in Kentucky—and KYTC is clear in its permitting manual that no utility other than storm drains are to be placed in the median strips. If this restriction could be lifted for this project, it could bring down the overall cost by providing a quicker path to drill than the outside of the ROW where there will be limestone.

As an alternative to drilling in the median, securing fiber conduit and cables to the interior wall of the storm drain would also reduce the project costs. This can be done without breaking through the drainpipe wall.

NG-KIH would need to work with KYTC to socialize these ideas, plan the project, design the routes—and work with private carriers who would place fiber in conduit bank as part of a one-dig arrangement.

As a point of comparison, we note that In the Maryland, Level(3) and others negotiated an agreement to build in the interstate median and shoulders in exchange for 48 fibers along all new routes. The state granted the right to build under a dig-once arrangement—and the fiber it secured became the basis for a statewide network. In this way, Maryland has built a statewide fiber network with only a $10 million capital investment.

Finally it is important to note that the majority of the community anchor institutions are not located near the interstates, and therefore the majority of the construction will still have to happen on other routes.

3 Current State – Spend Analysis and Financial Assessment

CTC examined the participating stakeholders' current connectivity services, including their current costs, contract commitments, and other factors that would impact the transition to NG-KIH services. We used this current state of stakeholder spending as the baseline for potential operating and debt service costs of the NG-KIH network in Section 4 below.

CTC received lists of connected sites and their current costs from the Commonwealth, KPEN, KEWS, KDE, KET, and universities. The full list of sites is provided in Appendix B.

The total current monthly recurring cost (MRC) for services to these sites ranges from $55 to $10,000 per month and is roughly $1,000 per month on average. Neither KIH3 nor KPEN has minimum service term commitments, installation fees or termination fees. There is a $375 or $750 one-time termination fee for the KIH3 managed router service. This applies primarily to the K-12 sites.

These sites should be considered a lower bound on the actual costs, however, because many community anchor locations were not in the lists we received. These include local government anchors, university and college locations using service contracts other than KPEN, individual schools within districts that may be more effectively served with NG-KIH, economic development areas, health care institutions, and facilities receiving services from municipal utilities, telcos, or cable companies outside the KIH3 and KPEN contracts.

In addition to the costs of connecting the sites on this list, we identified two other significant recurring costs:

- Fiber leased from the Frankfort Plant Board: $85,000 per month
- Fiber obtained through IRU from Windstream Communications for the University of Louisville-Frankfort-University of Kentucky-Northern Kentucky University triangle: $500,000 per year

There is no minimum term commitment or termination fee for the Frankfort Plant Board dark fiber service. There was a one-time installation fee approximately 25 percent of the construction cost.

3.1 E-rate

We also note that the federal E-rate program has a significant impact on network financial analysis relative to schools and libraries. The service providers connecting K-12 and library facilities receive E-rate reimbursement based on the percentage of local children receiving subsidized school lunches.

NG-KIH should be structured so that the institutions currently receiving E-rate discounted services continue to do so. This can be accomplished in several ways—including becoming a service provider, with NG-KIH responding to a competitive bid process initiated by the institutions, or by aiding other service providers utilizing the NG-KIH fiber to provide advanced services over the NG-KIH to those institutions.

If the intent is to become a service provider, NG-KIH should plan for an administrative process that at times will be paperwork intensive. For a statewide effort, at least one full-time staff-person will be needed, depending on the time of year, and ongoing customer support will be required. Additionally, the proposal process will require monitoring and the input of a network engineer with a deep understanding of the NG-KIH network architecture. Administrative processes should include invoicing, budgeting, process tracking, data entry, RFP research, and proposal preparation.

There should also be an effort each funding cycle to review the eligible services list published annually by the Universal Service Administrative Company (USAC) to determine how E-rate funding might aid in overall network completion, including in paying a portion of the costs for construction of fiber laterals from the network backbone to the school and library premises. We recommend at a minimum that NG-KIH consider hiring a consultant that specializes in E-rate processes to advise the effort.

3.2 Scalability

One of the main benefits of the fiber capacity proposed for NG-KIH is that it can easily scale to higher speeds without requiring additional construction.

Needs will continue to grow at almost all locations. KDE has projected a doubling of the capacity need per student in the next few years. Most universities are operating with throttled (internally speed-limited) Internet connections to control their spending on the circuits between their campuses, and from their campuses to Internet(2) peering points and their commercial Internet service providers.

State government is currently limiting the extent of its migration to more efficient and reliable IT technologies, such as cloud outsourcing, in part because of the lack of affordable options between sites. One way to gauge pre- and post-migration capacity needs is to look at comparably sized states that have made the migration, and compare their aggregate Internet needs. Maryland, for example, has migrated many systems to the cloud, has widely adopted video and media technologies, and has a robust state-operated fiber optic network. Comparable to Kentucky in population, Maryland state government uses on average 35 Gbps of Internet capacity, while the Commonwealth uses on average 1 Gbps, primarily for Web browsing and research and e-government operations. Clearly, a typical site in the Commonwealth will have capacity needs grow by more than a factor of ten, on average, in order to adopt cloud technology on a wide scale.

4 NG-KIH Financial Model

4.1 Overview

This step of the analysis focused on developing a cash-flow positive business model for this network. Based on the model's conservative assumptions and estimates for construction, operations, and revenue (described in Section 4.2), we project that the statewide network would have an approximate 15-year payoff period. (See the crossover point in Figure 3. Our model includes projections through year 10; the figure also illustrates cumulative trend lines.) Highlights of the model include:

- Operations costs for the new network are comparable to current spending—suggesting that stakeholders cannot assume that their aggregate spending will remain static; rather, spending will rise, as will service levels and bandwidth
- Base model provides 100 Mbps services for 27 percent less spending than equivalent under existing contracts—and costs are substantially reduced with the inclusion of outside revenues and other assumptions
- More savings and value on 1 Gbps and higher-end services
- Requires collective action—assumes all stakeholders buy in order to realize the economies of scale contemplated by the model
- The level of service pricing required to maintain cash flow is very sensitive to increased lease revenues, reduced construction costs, or reduced financing costs

Service costs under a range of assumptions are as follows:

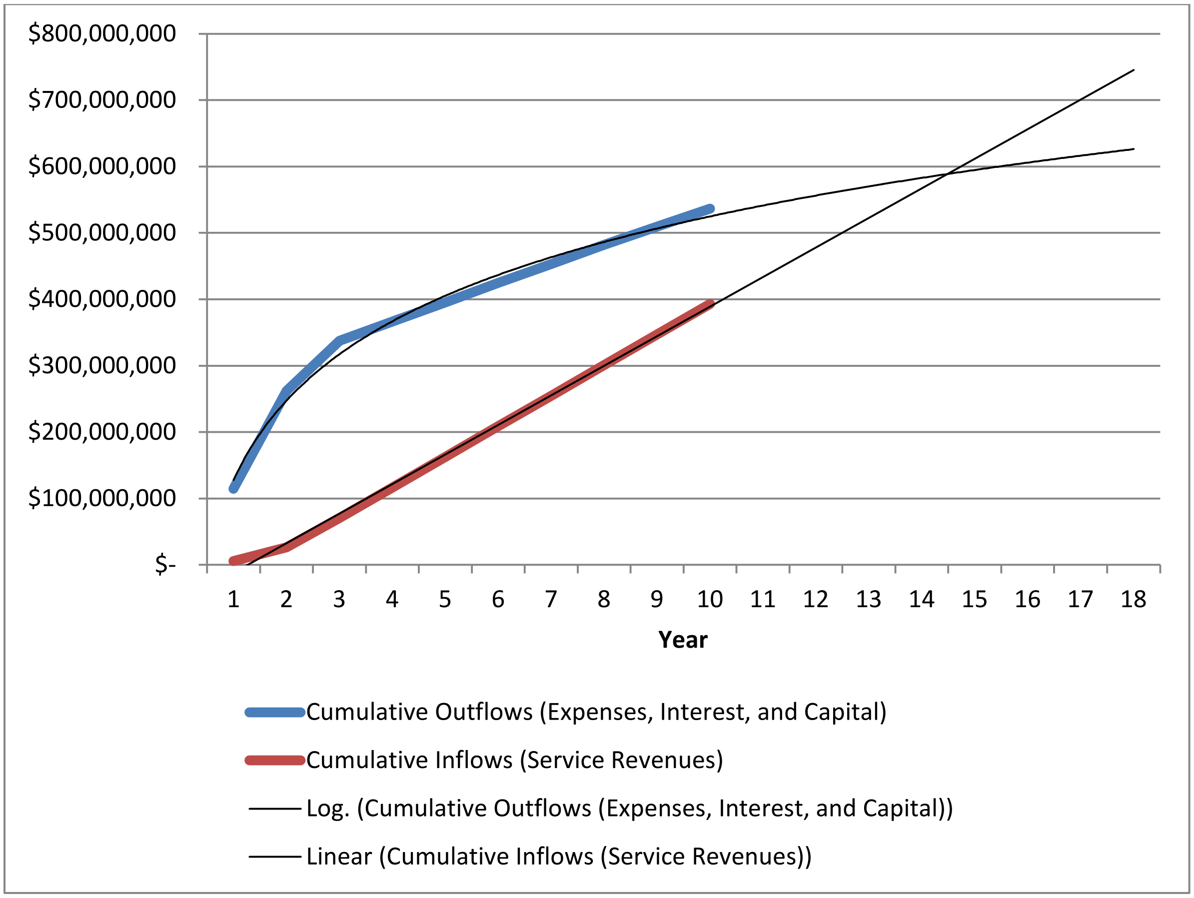
Table 2: Service Costs Under Various Assumptions

Service	KIH3 Contract Price (with CPE)[1]	Base Model Service Fee (with CPE)	Assuming 30% lower fiber constr. costs	Assuming dark fiber revenue and $50M grant	Assuming dark fiber revenue, $25M grant, and 30% lower fiber constr. cost
100 Mbps	$3,417	$2,640	$2,297	$1,610	$1,399
250 Mbps	$3,964	$3,168	$2,756	$1,932	$1,679
500 Mbps	$5,306	$3,802	$3,308	$2,319	$2,015
1 Gbps	$6,596	$4,562	$3,969	$2,783	$2,418
10 Gbps	$15,709	$7,984	$6,946	$4,870	$4,232
10 Gbps Lambda	N/A	$14,000	$12,180	$8,540	$7,420

[1] *The 2011-2013 KPEN contract negotiated by higher education institutions provides different rates, which are still higher than the proposed model rates. KPEN MRC for service plus port cost is: 100 Mbps at $4,808.70; 1 Gbps at $6,338.70.

We note that this base case model is a worst-case scenario, in that the base analysis deliberately does not include a range of potential opportunities to increase revenue (such as leasing out excess fiber) or decrease costs (such as seeking partnerships to share construction costs, conducting fiber swaps, or overlashing to existing fiber). We explore these scenarios and illustrate the impact of those opportunities separately, after presenting the base case.

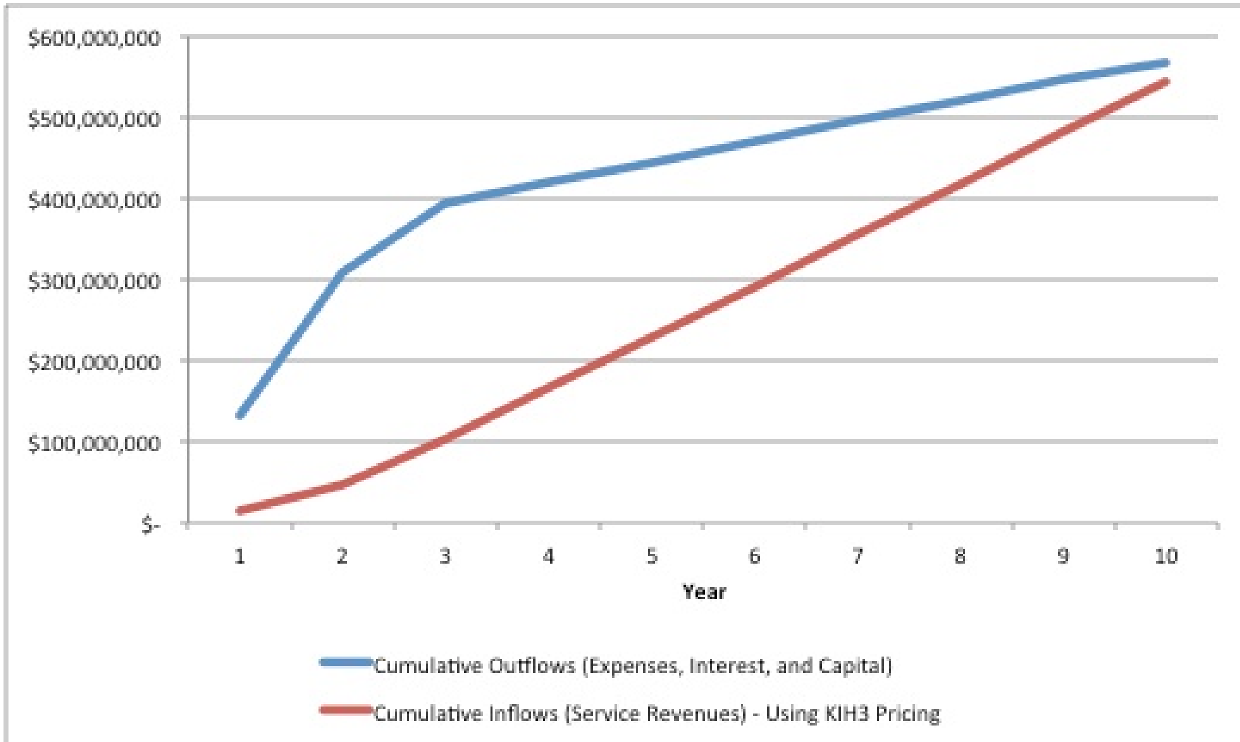
Figure 3: Base Case Payoff Period



This payoff period is a function of the revenues generated from the services delivered at each site. The proposed service rates, in turn, were set at a level to maintain a positive cash flow during each year of the proposed fiber enterprise—in other words, we set pricing at the lowest level possible that would still sustain the network.

Under the base case, the proposed service pricing is approximately 27 percent below the current KIH3 rate schedule for 100 Mbps services. If we instead charged rates equal to KIH3's schedule, it would be possible to further reduce the network's comparative payoff period to approximately 10 years (Figure 4).

Figure 4: Payoff Period Using KIH3 Price Schedule

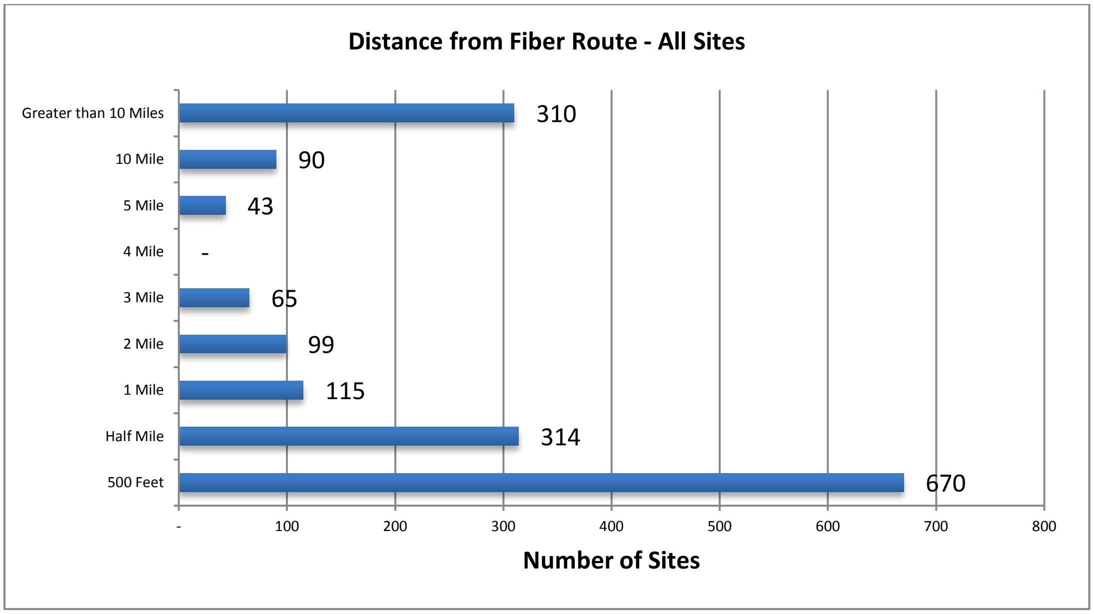


As discussed in detail in Section 4.2, the base model includes operations and finance expenses. It includes all estimated interest payments, financing costs, and reserve funds required for bonding. Further the costs of replenishment of electronics and other equipment is included and is funded with a depreciation reserve fund.

A key element of our financial analysis was the determination of which sites will initially be served by the network. The Commonwealth identified 1,706 candidate sites including state government, K-12 districts, and higher education. As discussed in Section 7.2, we designed a network backbone across the state. The distribution of sites relative to the backbone is shown in Figure 5.

We optimized the model to include as many sites as possible while controlling the total cost of lateral fiber between the backbone and sites. We chose an optimal maximum lateral distance of three miles based on the following analysis.

Figure 5: Distance Boundary from Fiber Route



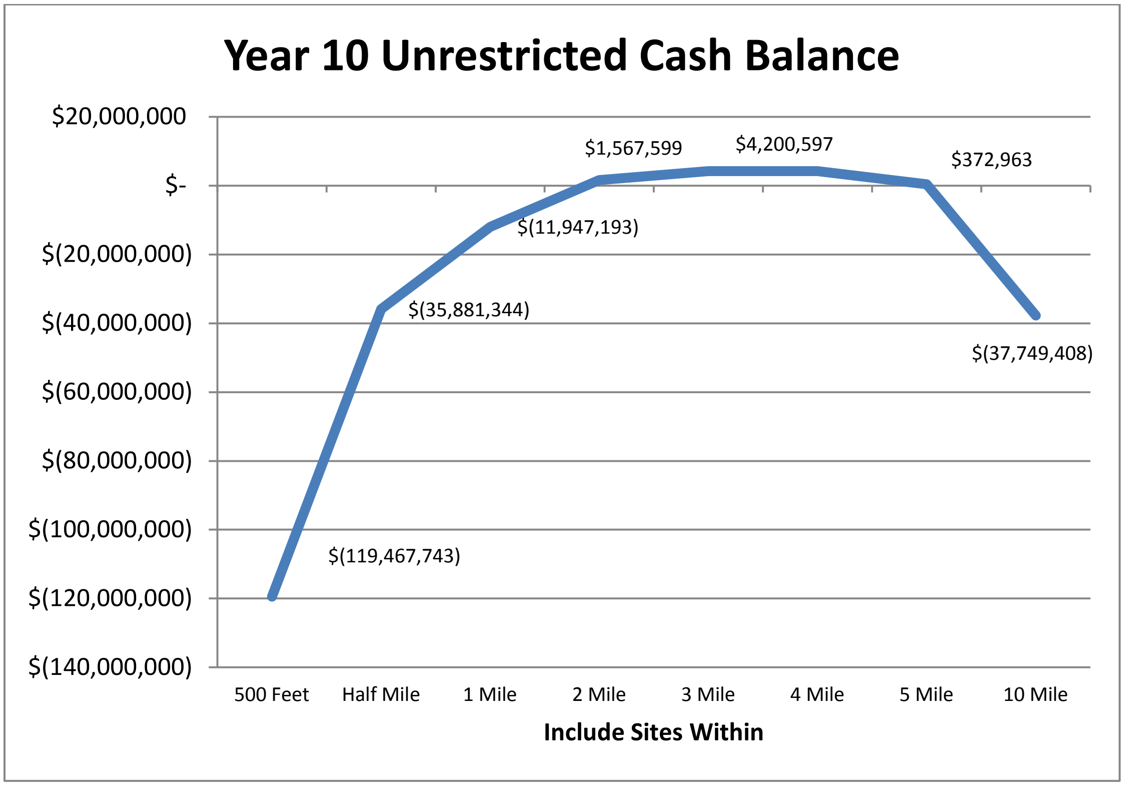
We calculated the current monthly recurring charges (MRC) for the sites at each distance, which comprises the total revenue that would be received by connecting the sites at that distance (see Table 3).

Table 3: Comparison of Existing Fees by Distance from Fiber

Distance Boundary (from Fiber Route)	Number of Sites	Total Current Monthly Recurring Charges (MRC)	Current MRC Average
500 Feet	670	$595,683	$889
Half Mile	314	$357,630	$1,139
1 Mile	115	$83,458	$726
2 Mile	99	$70,110	$708
3 Mile	65	$37,332	$574
4 Mile	-	-	N/A
5 Mile	43	$27,060	$629
10 Mile	90	$40,732	$453
Greater than 10 Miles	310	$260,398	$840
Total	1,706	$1,499,463	$879

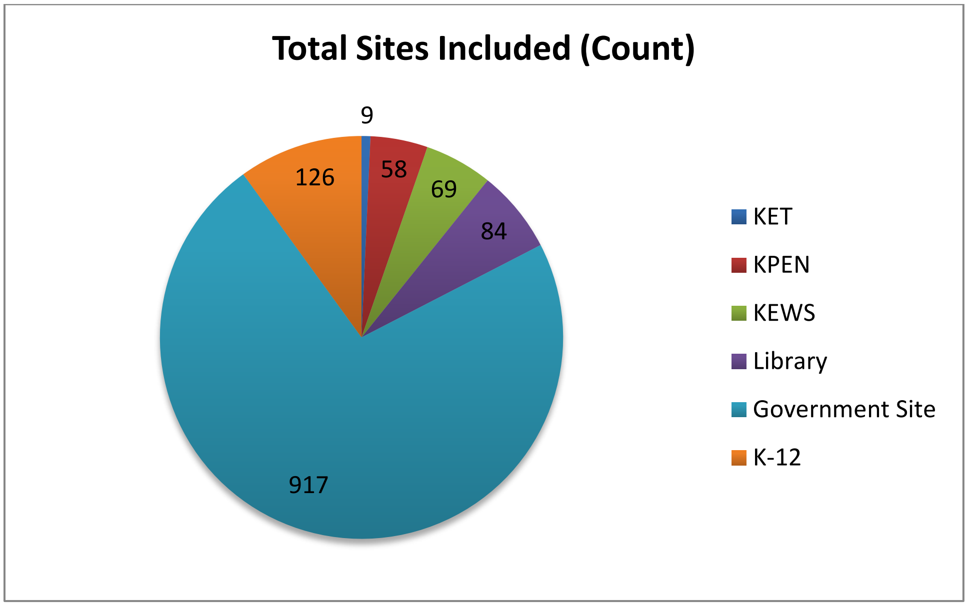
This data allowed us to identify a relative distance from the fiber beyond which the benefit of serving a facility would be outweighed (from a purely financial standpoint) by the cost of building fiber to connect the facility. Figure 6 below illustrates this analysis. Including all sites that are within three miles of the fiber is the most financially prudent approach. Connecting sites that are further away would require monthly service pricing that would be challenging for many stakeholders (and potentially higher than that offered by existing contracts)—while setting the cutoff at a shorter distance reduces the total number of sites served too much, and the network would not be able to cover its fixed costs.

Figure 6: Distance of Site Impact on Projections



As a result of this analysis, our base case model includes all sites that are within three miles of the fiber. Figure 7 illustrates the breakdown among categories, and a complete site list is in Appendix B.

Figure 7: Total Sites Included

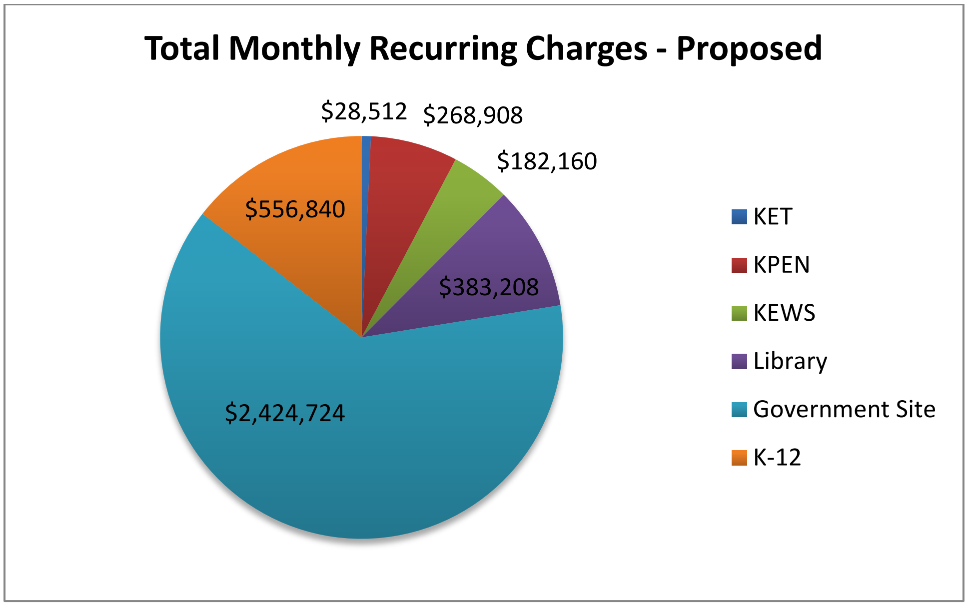


Based on this site selection, the proposed service levels (see Table 4), and the proposed service rates, we calculate that the network's total monthly recurring charges (MRC) for all sites combined will be approximately $3.8 million, or $46.1 million per year. (See Figure 8.)

Table 4: Summary of Proposed Sites and Services

Entity	100 Mbps	250 Mbps	500 Mbps	1 Gbps	10 Gbps	10 Gbps Lambda	Total Sites
KET	-	9	-	-	-	-	9
KPEN	12	-	-	38	8	-	58
KEWS	69	-	-	-	-	-	69
Library	-	-	-	84	-	-	84
Government Site	915	-	-	2	-	-	917
K-12	53	-	-	52	19	2	126
Total	1,049	9	-	176	27	2	1,263

Figure 8: Proposed Monthly Recurring Charges



We assume that the E-rate reimbursement is 76 percent (the number provided by the Kentucky Department for Libraries and Archives (KDLA)), although we note that E-rate reimbursement does not impact the fiber enterprise's financials. In the above costs, the fees received for service to K-12 school sites and libraries will be the same for the enterprise, but 76 percent of these revenues will come from the federal government and 24 percent will come from the K-12 schools and libraries.

Adding potential dark fiber lease revenues will have a significant impact on the service prices required to maintain cash flow. For example, making assumptions based on our observations of leasing costs in comparable markets, if the Commonwealth were to lease 22,200 strand miles (24 stands on 40 percent of the routes) at $50 per month per strand mile, the required services can drop by 28 percent.

Table 5: Potential Pricing – Assuming Dark Fiber Revenue

Service	Service Fee (assumes dark fiber revenue)
100 Mbps	$1,900
250 Mbps	$2,280
500 Mbps	$2,737
1 Gbps	$3,284
10 Gbps	$5,747
10 Gbps Lambda	$10,077

4.1.1 Financial analysis framework

The Commonwealth's financial analysis framework is based on the following objectives:

- Constructing and activating a statewide network that will meet the stakeholders' needs.
- Providing a foundational analysis to better understand the value and benefits that will be proposed by respondents to the upcoming concessionaire Request for Proposal (RFP).
- Establishing benchmark postalized rates for sustainable operations.
- Understanding which potential sites can be cost-effectively served by the proposed statewide network.

We have paid particular attention to evaluating financial risk over time, and to achieving policy goals while minimizing that risk. One significant area of risk is that of doing nothing—that is, continuing to lease services rather than building and provisioning for the future.

We have included our estimates of market pricing (i.e., KIH3 rates) as a point of comparison in the financial model, and have calculated the potential payback period for the network as compared to leasing services at those market rates. Based on our extensive discussions with stakeholders about their communications needs and our understanding of the evolution of applications, we are certain that the stakeholders' needs for communications services will only increase in the future. Cloud computing and video applications are just a few examples.

So the network that the stakeholders envision represents not just a way to meet functional requirements but also an opportunity to control all the stakeholders' connectivity capabilities and costs over the long term.

4.1.2 Financial summary

This financial analysis is based on a range of assumptions, our understanding of the project objectives, and our industry experience. The financial model allows identification of the interplay among the range of inputs, because the projected results are directly impacted by key assumptions in the model.

We prepared a complete set of pro forma statements including income statements, cash flow states, and detailed sheets showing revenues and expenses. These pro forma statements are included as Appendix G. (In addition, we have separately provided the Commonwealth with Excel version of the spreadsheet that can be used during the refinement of the business model and evaluation of the RFP submittals.)

The assumptions we made in our financial analysis are presented in Section 4.2. We assumed that the fiber route is installed over three years, and that customer fiber drop and electronics costs are added as customers are added.

For revenue representation in the model, we assume that the fiber enterprise will receive a monthly payment for each site served. This will be structured as a fee-based service, though for Commonwealth cabinets and departments, it may involve a charge back mechanism through department budgets. The fee-based approach in the model allows for a snapshot of the overall cash impact. In terms of fee assumptions, we set the network's initial service pricing at a breakeven level (i.e., to cover the network's costs, not to realize excess revenues).

The income and cash flow balances for our base case scenario are shown in Table 6. Under these assumptions, the network would be financially stable. In year 10 of this base case scenario, the network would have an unrestricted cash balance of about $4.2 million.

Table 6: Condensed Income and Cash Flow Statement (Base Assumptions)

Attribute	Year			
	1	3	5	10
Total Revenues	$9,716,000	$42,775,000	$46,132,000	$46,132,000
Total Cash Expenses	(3,503,700)	(12,690,388)	(12,912,688)	(13,090,688)
Depreciation	(7,530,573)	(19,804,725)	(19,804,725)	(18,985,406)
Interest Expense	(5,202,321)	(13,959,396)	(12,765,737)	(9,312,224)
Net Income	$(6,520,594)	$(3,679,509)	$648,850	$4,743,682
Unrestricted Cash Balance	$35,945	$105,845	$3,061,382	$4,200,597
Depreciation Operating Reserve	-	-	7,922,000	22,613,191
Debt Service Reserve	4,996,130	14,841,300	14,841,300	14,841,300
Total Cash Balance	$5,032,075	$14,947,145	$25,824,682	$41,655,088

This model assumes that each site is charged a monthly fee for services. The fees were set to enable a cash break-even point if the network served all identified sites within three miles of the proposed fiber route—resulting in required fees that are 73 percent of the current KIH3 contract rates (as indicated in Table 2 above).

The estimated funding requirements are show in Table 7 below. The funding and financing assumptions are discussed in Section 4.2.3.

Table 7: Summary of Funding Requirements

Loan	Year		
	1	2	3
Short-Term Bond	$23,197,930	$16,577,930	$1,995,550
20-Year Term Bond	99,922,600	142,015,600	54,887,800
Internal Loan	9,250,000	4,600,000	-
Total	$132,370,530	$163,193,530	$56,883,350

We also conducted a sensitivity analysis under a number of scenarios to show how the network's cash balance is affected by changing assumptions. Starting with our base assumptions, we selectively altered the model to illustrate a variety of situations that may evolve as the business model is refined and, later, when the plan is executed.

For example, adding dark fiber lease revenues has a profound impact on the service prices required to maintain cash flow. If the enterprise were to lease 22,200 strand miles (24 stands on 40 percent of the routes) at $50 per month per strand mile, the required service pricing can drop by 28 percent and still maintain cash flow. This scenario is shown in Table 8 below.

Table 8: Condensed Income and Cash Flow Statement (Including Dark Fiber Revenue and Service Reduced Fees)

Attribute	Year			
	1	3	5	10
Total Revenues	$6,993,577	$50,747,845	$53,164,214	$53,164,214
Total Cash Expenses	(3,503,700)	(18,677,908)	(18,900,208)	(19,078,208)
Depreciation	(7,530,573)	(19,804,725)	(19,804,725)	(18,985,406)
Interest Expense	(5,286,321)	(14,045,396)	(12,827,963)	(9,334,189)
Net Income	$(9,327,017)	$(1,780,184)	$1,631,318	$5,766,411
Unrestricted Cash Balance	$29,522	$39,022	$4,249,808	$8,823,741
Depreciation Operating Reserve	-	-	7,922,000	22,613,191
Debt Service Reserve	4,996,130	14,841,300	14,841,300	14,841,300
Total Cash Balance	$5,025,652	$14,880,322	$27,013,108	$46,278,232

If the Commonwealth were also able to obtain $50 million in grant funding, the network's long-term bonding requirements would be reduced and the Commonwealth would be able to charge lower rates to its internal customers for network services. Including this grant funding and the dark fiber revenues in the projections, the Commonwealth would be able to reduce its service fees to 53 percent of the KIH3 rates. These impacts are shown in Table 9 and Table 10 below.

Table 9: Condensed Income and Cash Flow Statement with $50 Million Grant Funding (Including Dark Fiber Revenue and Reduced Service Fees)

Attribute	Year			
	1	3	5	10
Total Revenues	$5,926,760	$46,051,150	$48,098,920	$48,098,920
Total Cash Expenses	(3,503,700)	(18,677,908)	(18,900,208)	(19,078,208)
Depreciation	(7,530,573)	(19,804,725)	(19,804,725)	(18,985,406)
Interest Expense	(3,104,821)	(11,952,196)	(10,911,163)	(7,915,855)
Net Income	$(8,212,334)	$(4,383,679)	$(1,517,176)	$2,119,451
Unrestricted Cash Balance	$94,205	$26,816	$2,731,494	$3,466,009
Depreciation Operating Reserve	-	-	7,922,000	22,613,191
Debt Service Reserve	2,496,130	12,341,300	12,341,300	12,341,300
Total Cash Balance	$2,590,335	$12,368,116	$22,994,794	$38,420,500

Table 10: Potential Pricing – Assuming Dark Fiber Revenue and Grant Funding

Service	Service Fee
100 Mbps	$1,610
250 Mbps	$1,932
500 Mbps	$2,319
1 Gbps	$2,783
10 Gbps	$4,870
10 Gbps Lambda	$8,540

In addition to the impact of increasing revenue, changing our assumptions about the cost of network construction will have an impact on the enterprise's projected financial outcomes. If fiber construction costs can be decreased by 30 percent—from $80,000 per mile in the base case to $56,000 per mile—the enterprise's unrestricted cash balance increases to $57.6 million in year 10 (see Table 11).

Table 11: Condensed Income and Cash Flow Statement with 30 Percent Lower Fiber Route Cost

Attribute	Year			
	1	3	5	10
Total Revenues	$9,716,000	$42,775,000	$46,132,000	$46,132,000
Total Cash Expenses	(3,503,700)	(12,690,388)	(12,912,688)	(13,090,688)
Depreciation	(6,511,428)	(16,407,575)	(16,407,575)	(15,588,256)
Interest Expense	(4,387,005)	(11,241,676)	(10,250,287)	(7,377,638)
Net Income	$(4,686,133)	$2,435,361	$6,561,450	$10,075,418
Unrestricted Cash Balance	$2,889,722	$12,894,307	$27,075,611	$57,594,471
Depreciation Operating Reserve	-	-	6,564,000	17,858,191
Debt Service Reserve	3,976,985	11,444,150	11,444,150	11,444,150
Total Cash Balance	$6,866,707	$24,338,457	$45,083,761	$86,896,812

Alternatively, the same decline in fiber costs would allow the Commonwealth to lower its service prices by 13 percent while maintaining an unrestricted cash balance similar to the base case. (See Table 12 for cash flow and Table 13 for the corresponding pricing.)

Table 12: Condensed Income and Cash Flow Statement with 30 Percent Lower Fiber Route Cost and a 13 Percent Reduction in Site Fees

Attribute	Year			
	1	3	5	10
Total Revenues	$8,452,920	$37,214,250	$40,134,840	$40,134,840
Total Cash Expenses	(3,503,700)	(12,690,388)	(12,912,688)	(13,090,688)
Depreciation	(6,511,428)	(16,407,575)	(16,407,575)	(15,588,256)
Interest Expense	(4,387,005)	(11,241,676)	(10,250,287)	(7,377,638)
Net Income	$(5,949,213)	$(3,125,389)	$564,290	$4,078,258
Unrestricted Cash Balance	$1,626,642	$2,965,557	$5,152,541	$5,685,601
Depreciation Operating Reserve	-	-	6,564,000	17,858,191
Debt Service Reserve	3,976,985	11,444,150	11,444,150	11,444,150
Total Cash Balance	$5,603,627	$14,409,707	$23,160,691	$34,987,942

Table 13: Potential Pricing – Assuming 30 Percent Lower Fiber Route Costs

Service	Service Fee (assumes 30 percent lower fiber route costs)
100 Mbps	$2,297
250 Mbps	$2,756
500 Mbps	$3,308
1 Gbps	$3,969
10 Gbps	$6,946
10 Gbps Lambda	$12,180

In another scenario, the fiber enterprise can lower its service fees by 47 percent—to prices corresponding to just 41 percent of the KIH3 fee for 100 Mbps service—if the model includes dark fiber revenues, a grant of $35 million, and a 30 percent reduction in fiber route costs. (See Table 14 for cash flow and Table 15 for the corresponding pricing.)

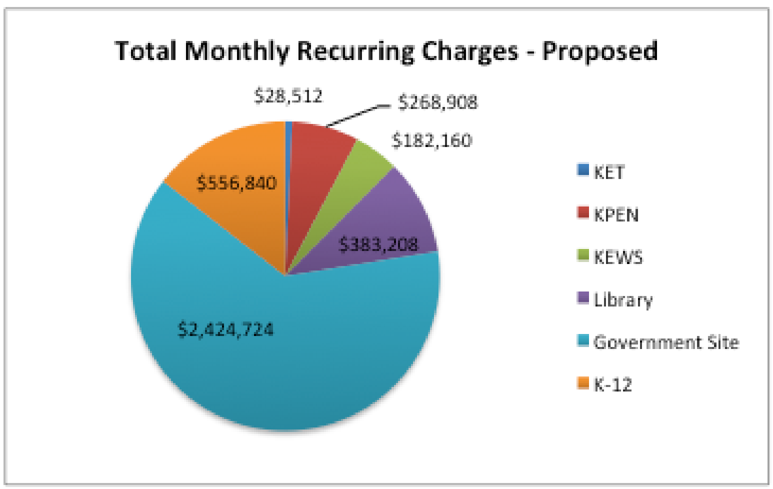
Table 14: Condensed Income and Cash Flow Statement with Dark Fiber Revenues, 25 Million Grant, 30 Percent Lower Fiber Route Cost, 1 and a 47 Percent Reduction in Site Fees

Attribute	Year			
	1	3	5	10
Total Revenues	$5,149,480	$42,629,150	$44,408,360	$44,408,360
Total Cash Expenses	(3,503,700)	(18,677,908)	(18,900,208)	(19,078,208)
Depreciation	(6,511,428)	(16,407,575)	(16,407,575)	(15,588,256)
Interest Expense	(3,331,505)	(10,194,176)	(9,282,573)	(6,657,492)
Net Income	$(8,197,153)	$(2,650,509)	$(181,996)	$3,084,404
Unrestricted Cash Balance	$28,702	$21,134	$2,917,863	$5,438,463
Depreciation Operating Reserve	-	-	6,564,000	17,858,191
Debt Service Reserve	2,726,985	10,194,150	10,194,150	10,194,150
Total Cash Balance	$2,755,687	$10,215,284	$19,676,013	$33,490,804

Table 15: Potential Pricing – Assuming with Dark Fiber Revenues, 25 Million Grant, 30 Percent Lower Fiber Route Cost

Service	Service Fee (assumes dark fiber revenues, 25 million grant, and 30 percent lower fiber route costs)
100 Mbps	$1,399
250 Mbps	$1,679
500 Mbps	$2,015
1 Gbps	$2,418
10 Gbps	$4,232
10 Gbps Lambda	$7,420

Figure 9: Potential MRC with Dark Fiber Revenues, Grants, and Cost Reductions



4.2 Assumptions

4.2.1 Construction cost assumptions

Construction will entail non-recurring costs in three basic categories:

- Fiber costs (backbone, laterals, customer drops)
- Fiber lateral and drop cost
- Network electronics costs (customer premises and hub)

The estimated cost to construct 2,311 miles of fiber and connect all identified sites within three miles—including site-specific costs (e.g., laterals, edge electronics) and costs spread across all sites (e.g., core electronics, fiber splicing, construction oversight staffing)—is $340 million. The breakdown is shown in Table 16.

Table 16: Implementation Cost Estimate

Item	Year		
	1	2	3
Fiber Route	$67,943,400	$113,239,000	$45,295,600
Buildings & Facilities	6,400,000	-	-
Fiber Laterals	25,579,200	28,776,600	9,592,200
Hub Equipment	19,860,000	13,240,000	-
CPE	1,252,930	1,252,930	1,250,550
Drops	2,085,000	2,085,000	2,145,000
Total	$123,120,530	$158,593,530	$58,283,350

Fiber route costs

We estimate the total fiber lateral construction costs for the selected sites at $64 million. This is based on a lateral cost of $16.63 per foot with a high percentage of underground construction.

The identified fiber routes are shown in Appendix E. The proposed route covers 2,311 miles along highway and other corridors. We estimate that 75 percent of the construction is aerial. The estimated cost for this construction is $80,000 per mile included estimated project management and make-ready costs. In addition we have added 12.50 percent for engineering and a 10 percent contingency.

Fiber lateral and drop costs

We estimate the total fiber lateral construction costs for the selected sites at $64 million. This is based on a lateral cost of $16.63 per foot and a high percentage of underground construction.

The enterprise will also incur the cost of connecting facilities with fiber drops. This expense, which we estimate at $5,000 per site, will total $6.3 million for the selected sites.

Table 17 lists the estimated fiber lateral and drop costs.

Table 17: Estimated Fiber Lateral and Drop Costs

Fiber	Fiber Drops	Total
$63,948,000	$6,315,000	$70,263,000

The drop costs are depreciated over seven years, and have a replenishment cost of 30 percent of the original value. This assumption is to cover building entrance moves, replacement of damaged cable, and other events. The lateral costs are depreciated over 20 years.

Network electronics costs

Network electronics (i.e., hub and customer equipment) represent one of the primary network implementation expenses because they need replenishment quite frequently.

We estimate that the customer premises equipment (CPE) electronics will range from $4,000 to $20,000 per user site, for a total of $3.8 million. We have assumed that one-third of the CPE electronics costs (sites connected) will be incurred in each of the first three years.

Table 18: Estimated CPE Costs

Service	CPE Cost
100 Mbps	$1,720
250 Mbps	$1,720
500 Mbps	$1,720
1 Gbps	$9,150
10 Gbps	$9,150
10 Gbps Lambda	$39,600

Following a five-year depreciation cycle for CPE, we calculate that the Commonwealth will incur replacement costs in years 6 and 7. We have estimated those replacement costs at 75 percent of the current equipment cost, to account for an expected decline in equipment pricing over time.

We estimate that hub electronics will cost $33.1 million, with $19.9 million paid in year 1 and the remaining amount in year 2. Following a 10-year depreciation cycle for hub electronics, we calculate that the Commonwealth will incur replacement costs in year 11 and year 12. We have estimated those replacement costs at 75 percent of the current equipment costs. The depreciation account balance is targeted to be sufficient to cover this expense (see year 10 depreciation reserve projection).

To support the hub and other aggregation points, we estimate a total of $6.4 million in facilities, representing $200,000 each for 32 sites.

4.2.2 Operating expense assumptions

Costs for technical operations of the fiber enterprise will include staffing (technicians, program manager, locates), electronics maintenance, and customer support. The summary below lists the cost categories and estimated total costs for each.[2]

- Maintenance fees starting in the year after electronics deployed
  - $796,300 for hub and network equipment
  - $242,200 for CPE
- Facilities and utilities: $48,000 per year
- Office allocations: $24,000 per year
- Contracted Network Operations Center (NOC) and outside plant maintenance:
  - $9.4 million per year, based on a comparable contract the State of Maryland holds for its statewide network
- Pole attachment fees: $638,300 per year once all routes and laterals are completed
  - $10 per year per attachment
  - 75 percent aerial
  - 28 poles per mile
- Direct Internet Access (DIA) of $144,000 per year
  - Direct Internet Access (DIA) requirements will increase to 3 Gbps by year 3
  - $4 per Mbps per month
- Contingency: $500,000 per year.

A summary of the above operating expenses is shown in Table 19. In the sections that follow the table, we discuss other expenses, including depreciation and staffing.

[2] We use a "flat" model because incremental growth assumptions, regardless of being applied evenly to both income and expense, can skew long-term estimates. For example, increasing revenue and expense by three percent annually also increases operating margins by three percent per year. In reality, the network's cost increases will likely be higher than its revenue growth. Margins will likely remain flat—or even shrink—over time.

Table 19: Summary of Estimated Operating Costs

Expense	Year			
	1	3	5	10
Electronics Maintenance & License Fees	$-	$876,200	$1,038,500	$1,038,500
Facilities and Utilities	48,000	48,000	48,000	48,000
Office	24,000	24,000	24,000	24,000
Contracted Operation & Maintenance (NOC and Outside Plant)	1,882,200	9,410,888	9,410,888	9,410,888
Attachment Fees	191,500	638,300	638,300	638,300
Internet Connection Fee	48,000	144,000	144,000	144,000
Contingency	500,000	500,000	500,000	500,000
Total	$2,693,700	$11,641,388	$11,803,688	$11,803,688

Staffing expenses

In addition to the expenses listed in the table above, we recommend that the enterprise hire or contract additional full-time-equivalent (FTE) staff in three key roles:

1. Bid management – start at two FTEs, declining to one in year 3. Average burdened cost is $90,000 per year per FTE.

2. Customer service – start at two FTEs, increasing to five by year 3. Average burdened cost is $90,000 per year per FTE.

3. Project and other management – start and maintain at three FTEs Average burdened cost is $150,000 per year per FTE.

The burdened cost for FTEs is increased by three percent per year. The resulting costs are shown in Table 20.

Table 20: Summary of Estimated Staffing Expenses

Staff	Year			
	1	3	5	10
Contract and Bid Management	$180,000	$95,000	$101,000	$117,000
Customer Service Representative	180,000	477,000	504,000	585,000
Management	450,000	477,000	504,000	585,000
Total	$810,000	$1,049,000	$1,109,000	$1,287,000

Depreciation expenses

Depreciation is a non-cash expense, but it is included in the income statement to estimate the "use" of the capital equipment to deliver services. In the model, fiber is depreciated over 20 years, hub equipment and electronics are depreciated over 10 years, fiber drops[3] are depreciated over seven years, and customer premises equipment (CPE) is depreciated over five years.

Replacement capital

Costs for replenishments are included in the financial model for hub equipment and CPE. Replenishment of hub equipment is assumed to be at 100 percent of original purchase cost, but replacement CPE is estimated at 75 percent of original purchase cost, reflecting the assumption that prices for those electronics will drop over time. In addition, drop replacements are estimated at 30 percent, to reflect potential location or service entrance changes and replacements due to damage.

To limit risk, we have included in the financial model an annual payment into a depreciation operating reserve account, starting in year 3 and based on a percent of the total annual depreciation (year 3 is set at 10 percent, then increases to 12 percent in year 4). This level was set so that the reserve fund never goes negative (see the cash flow statement in Appendix G); the balance that accrues in this account will fund the capital needs for ongoing capital replenishments.

4.2.3 Financing assumptions

In the base case financial model, the Commonwealth's new fiber is financed with a bond over 20 years (i.e., the depreciable lifespan of the fiber assets), while the remaining initial capital requirement is financed through a short-term bond over 10 years. Early operational costs are financed with a 10-year internal loan.

The funding requirements are shown in Table 21.

[3] For drop replenishments we assume a 30 percent replacement; this is to account for the potential of locations or service entrances being moved.

Table 21: Summary of Funding Requirements

Loan	Year		
	1	2	3
Short-Term Bond	$23,197,930	$16,577,930	$1,995,550
20-Year Term Bond	99,922,600	142,015,600	54,887,800
Internal Loan	9,250,000	4,600,000	-
Total	$23,197,930	$16,577,930	$1,995,550

We selected a 20-year bond as the base case because it is the most expensive, worst case way to finance the network—and thus presents the most conservative scenario for projecting network sustainability. We set the financing amounts at the level needed to have breakeven cash flow for the enterprise.

We assume that the 20-year fiber financing will be at 4 percent annual interest, will incur a 1 percent issuance cost, and will require both a 5 percent debt service reserve fund and a two-year interest reserve. Bonds issued in year 1 have a three-year principal moratorium, with the principal paid over 20 years starting in year 4. Bonds issued in year 2 and year 3 have a one-year principal moratorium.

The 10-year bonds will also be at 4 percent annual interest, but will have no debt service reserve, no interest reserve, and 1 percent issuance cost. As in the case of the 20-year bond we assume a scaled moratorium on principal payments.

The 10-year internal loan is set at 3 percent annual interest, but will have no debt service reserve, interest reserve, or issuance cost. As in the case of the 20-year bond, we assume a scaled moratorium on principal payments.

In Section 4.3, we explore the impact of other financing scenarios—including no-interest internal Commonwealth loans and partial grant funding.

4.2.4 Revenue assumptions

At the Commonwealth's direction, we have focused on lit services rather than dark fiber for the initial analysis. We recommend that the enterprise offer three service levels—100 Mbps, 500 Mbps, and 1 Gbps—and have established internal pricing that would, based on our other assumptions (including operational expenses and depreciation), maintain the network's cash flow while serving the identified sites.

We note that the resulting prices are approximately 73 percent of KIH3 contract rates. The price levels for each service are listed in Table 22.

Table 22: Recommended Services and Pricing (Base Model)

Service	Target Commonwealth Service Fee (with CPE)	KIH3 Contract Price (with CPE)
100 Mbps	$2,640	$3,417
250 Mbps	$3,168	$3,964
500 Mbps	$3,802	$5,306
1 Gbps	$4,562	$6,596
10 Gbps	$7,984	$15,709
10 Gbps Lambda	$14,000	$15,709

Table 23 below summarizes the number of sites and services for each category of end user. (The same information was also presented in Table 4.) The anticipated service levels are based on a combination of information gathered by interviews and an examination of current costs; they are summarized as follows:

- KET – all sites at 250 Mbps
- Libraries – all sites at 1 Gbps
- KEWS – all sites at 100 Mbps (supplement to microwave)
- KPEN – 10 Gbps if the site's existing MRC is greater than $4,000; 100 Mbps if the MRC is less than $2,000; all other sites at 1 Gbps
- Government Sites – 10 Gbps if the site's existing MRC is greater than $4,000; 100 Mbps if the MRC is less than $2,000; all other sites at 1 Gbps
- K-12 – 10 Gbps Lambda if the site's existing MRC is greater than $8,000; 10 Gbps if the MRC is greater than $3,466; 1 Gbps if the MRC is greater than $3,200; and all other sites at 100 Mbps

Table 23: Summary of Proposed Sites and Services

Entity	100 Mbps	250 Mbps	500 Mbps	1 Gbps	10 Gbps	10 Gbps Lambda	Total Sites
KET	-	9	-	-	-	-	9
KPEN	12	-	-	38	8	-	58
KEWS	69	-	-	-	-	-	69
Library	-	-	-	84	-	-	84
Government Site	915	-	-	2	-	-	917
K-12	53	-	-	52	19	2	126
Total	1,049	9	-	176	27	2	1,263

To reflect the network construction and ramp-up period, and to ensure that we do not overstate revenue, we have further assumed that in year 1 revenues are 50 percent of potential, in year 2 they are at 70 percent, and in year 3 they are at 90 percent.

4.3 Sensitivity analysis

To illustrate the impact of various assumptions on the financial results, we have calculated the network's projected cash balances under a number of different scenarios in which key assumptions are changed. In the sections below, we highlight a few examples. For reference, the following table illustrates the base case scenario.

Table 24: Condensed Income and Cash Flow Statement (Base Assumptions)

Attribute	Year			
	1	3	5	10
Total Revenues	$9,918,000	$42,568,000	$45,739,000	$45,739,000
Total Cash Expenses	(3,395,500)	(16,780,788)	(16,840,788)	(17,018,788)
Depreciation	(6,746,391)	(17,874,942)	(17,874,942)	(16,953,642)
Interest Expense	(4,587,456)	(12,842,320)	(11,767,789)	(8,624,123)
Net Income	$(4,811,347)	$(4,930,050)	$(744,519)	$3,142,447
Unrestricted Cash Balance	$7,168	$268,074	$2,821,849	$3,130,544
Depreciation Operating Reserve	-	2,145,000	6,435,000	10,627,500
Debt Service Reserve	4,463,820	13,813,600	13,813,600	13,813,600
Total Cash Balance	$4,470,988	$16,226,674	$23,070,449	$27,571,644

4.3.1 Debt service – interest

The following tables show financial projections in scenarios in which the Commonwealth does not charge interest on its internal loans and short-term bonds.

Table 25: Cash Flow with No Interest Charge on Internal Loan

Attribute	Year			
	1	3	5	10
Total Revenues	$9,716,000	$42,775,000	$46,132,000	$46,132,000
Total Cash Expenses	(3,503,700)	(12,690,388)	(12,912,688)	(13,090,688)
Depreciation	(7,530,573)	(19,804,725)	(19,804,725)	(18,985,406)
Interest Expense	(4,924,821)	(13,543,896)	(12,416,093)	(9,145,304)
Net Income	$(6,243,094)	$(3,264,009)	$998,494	$4,910,602
Unrestricted Cash Balance	$313,445	$1,036,626	$4,467,725	$6,795,845
Depreciation Operating Reserve	-	-	7,922,000	22,613,191
Debt Service Reserve	4,996,130	14,841,300	14,841,300	14,841,300
Total Cash Balance	$5,309,575	$15,877,926	$27,231,025	$44,250,336

Table 26: Cash Flow with No Interest Charge on Internal Loan or Short-Term Bond

Attribute	Year			
	1	3	5	10
Total Revenues	$9,716,000	$42,775,000	$46,132,000	$46,132,000
Total Cash Expenses	(3,503,700)	(12,690,388)	(12,912,688)	(13,090,688)
Depreciation	(7,530,573)	(19,804,725)	(19,804,725)	(18,985,406)
Interest Expense	(3,996,904)	(11,873,040)	(10,985,903)	(8,438,296)
Net Income	$(5,315,177)	$(1,593,153)	$2,428,684	$5,617,610
Unrestricted Cash Balance	$1,241,362	$4,559,787	$9,965,860	$17,147,800
Depreciation Operating Reserve	-	-	7,922,000	22,613,191
Debt Service Reserve	4,996,130	14,841,300	14,841,300	14,841,300
Total Cash Balance	$6,237,492	$19,401,087	$32,729,160	$54,602,291

4.3.2 Grant funding

The following table shows financial projections in a scenario in which the Commonwealth has obtained $50 million in grant funding.

Table 27: Cash Flow with $50 Million Grant

Attribute	Year			
	1	3	5	10
Total Revenues	$9,716,000	$42,775,000	$46,132,000	$46,132,000
Total Cash Expenses	(3,503,700)	(12,690,388)	(12,912,688)	(13,090,688)
Depreciation	(7,530,573)	(19,804,725)	(19,804,725)	(18,985,406)
Interest Expense	(3,202,321)	(11,959,396)	(10,924,829)	(7,928,186)
Net Income	$(4,520,594)	$(1,679,509)	$2,489,758	$6,127,720
Unrestricted Cash Balance	$7,035,945	$11,055,512	$21,910,383	$42,797,933
Depreciation Operating Reserve	-	-	7,922,000	22,613,191
Debt Service Reserve	2,496,130	12,341,300	12,341,300	12,341,300
Total Cash Balance	$9,532,075	$23,396,812	$42,173,683	$77,752,424

4.3.3 Service fees

The following tables show the financial projections for decreasing the Commonwealth's service fees by 10 percent and 5 percent.

Table 28: Cash Flow with Service Fees Decreased by 10 Percent

Attribute	Year			
	1	3	5	10
Total Revenues	$8,744,400	$38,497,500	$41,518,800	$41,518,800
Total Cash Expenses	(3,503,700)	(12,690,388)	(12,912,688)	(13,090,688)
Depreciation	(7,530,573)	(19,804,725)	(19,804,725)	(18,985,406)
Interest Expense	(5,202,321)	(13,959,396)	(12,765,737)	(9,312,224)
Net Income	$(7,492,194)	$(7,957,009)	$(3,964,350)	$130,482
Unrestricted Cash Balance	$(935,655)	$(7,531,655)	$(13,802,518)	$(35,729,303)
Depreciation Operating Reserve	-	-	7,922,000	22,613,191
Debt Service Reserve	4,996,130	14,841,300	14,841,300	14,841,300
Total Cash Balance	$4,060,475	$7,309,645	$8,960,782	$1,725,188

Table 29: Cash Flow with Service Fees Decreased by 5 Percent

Attribute	Year			
	1	3	5	10
Total Revenues	$9,230,200	$40,636,250	$43,825,400	$43,825,400
Total Cash Expenses	(3,503,700)	(12,690,388)	(12,912,688)	(13,090,688)
Depreciation	(7,530,573)	(19,804,725)	(19,804,725)	(18,985,406)
Interest Expense	(5,202,321)	(13,959,396)	(12,765,737)	(9,312,224)
Net Income	$(7,006,394)	$(5,818,259)	$(1,657,750)	$2,437,082
Unrestricted Cash Balance	$(449,855)	$(3,712,905)	$(5,370,568)	$(15,764,353)
Depreciation Operating Reserve	-	-	7,922,000	22,613,191
Debt Service Reserve	4,996,130	14,841,300	14,841,300	14,841,300
Total Cash Balance	$4,546,275	$11,128,395	$17,392,732	$21,690,138

4.3.4 Outsourced maintenance fees

The following tables show the financial projections for increasing and decreasing the Commonwealth's maintenance fees by 10 percent, as well as a scenario in which the maintenance fee declines by 10 percent and the service fee declines by 2 percent.

Table 30: Cash Flow with Outsourced Maintenance Fees Increased by 10 Percent

Attribute	Year			
	1	3	5	10
Total Revenues	$9,716,000	$42,775,000	$46,132,000	$46,132,000
Total Cash Expenses	(3,691,900)	(13,631,477)	(13,853,777)	(14,031,777)
Depreciation	(7,530,573)	(19,804,725)	(19,804,725)	(18,985,406)
Interest Expense	(5,202,321)	(13,959,396)	(12,765,737)	(9,312,224)
Net Income	$(6,708,794)	$(4,620,598)	$(292,239)	$3,802,593
Unrestricted Cash Balance	$(152,255)	$(1,399,844)	$(326,485)	$(3,892,715)
Depreciation Operating Reserve	-	-	7,922,000	22,613,191
Debt Service Reserve	4,996,130	14,841,300	14,841,300	14,841,300
Total Cash Balance	$4,843,875	$13,441,456	$22,436,815	$33,561,776

Table 31: Cash Flow with Outsourced Maintenance Fees Decreased by 10 Percent

Attribute	Year			
	1	3	5	10
Total Revenues	$9,716,000	$42,775,000	$46,132,000	$46,132,000
Total Cash Expenses	(3,315,500)	(11,749,299)	(11,971,599)	(12,149,599)
Depreciation	(7,530,573)	(19,804,725)	(19,804,725)	(18,985,406)
Interest Expense	(5,202,321)	(13,959,396)	(12,765,737)	(9,312,224)
Net Income	$(6,332,394)	$(2,738,420)	$1,589,939	$5,684,771
Unrestricted Cash Balance	$224,145	$1,611,634	$6,449,349	$12,294,009
Depreciation Operating Reserve	-	-	7,922,000	22,613,191
Debt Service Reserve	4,996,130	14,841,300	14,841,300	14,841,300
Total Cash Balance	$5,220,275	$16,452,934	$29,212,649	$49,748,500

Table 32: Cash Flow with Outsourced Maintenance Fees Decreased by 10 Percent and a 2 Percent Drop in Service Fees

Attribute	Year			
	1	3	5	10
Total Revenues	$9,521,680	$41,919,500	$45,209,360	$45,209,360
Total Cash Expenses	(3,315,500)	(11,749,299)	(11,971,599)	(12,149,599)
Depreciation	(7,530,573)	(19,804,725)	(19,804,725)	(18,985,406)
Interest Expense	(5,202,321)	(13,959,396)	(12,765,737)	(9,312,224)
Net Income	$(6,526,714)	$(3,593,920)	$667,299	$4,762,131
Unrestricted Cash Balance	$29,825	$84,134	$3,076,569	$4,308,029
Depreciation Operating Reserve	-	-	7,922,000	22,613,191
Debt Service Reserve	4,996,130	14,841,300	14,841,300	14,841,300
Total Cash Balance	$5,025,955	$14,925,434	$25,839,869	$41,762,520

4.3.5 Staffing expense

The following tables show the financial projections for increasing staffing expenses by 50 percent and 100 percent.

Table 33: Cash Flow with Staffing Expenses Increased by 50 Percent

Attribute	Year			
	1	3	5	10
Total Revenues	$9,716,000	$42,775,000	$46,132,000	$46,132,000
Total Cash Expenses	(3,908,700)	(13,214,888)	(13,467,188)	(13,734,188)
Depreciation	(7,530,573)	(19,804,725)	(19,804,725)	(18,985,406)
Interest Expense	(5,202,321)	(13,959,396)	(12,765,737)	(9,312,224)
Net Income	$(6,925,594)	$(4,204,009)	$94,350	$4,100,182
Unrestricted Cash Balance	$(369,055)	$(1,287,155)	$573,882	$(1,311,903)
Depreciation Operating Reserve	-	-	7,922,000	22,613,191
Debt Service Reserve	4,996,130	14,841,300	14,841,300	14,841,300
Total Cash Balance	$4,627,075	$13,554,145	$23,337,182	$36,142,588

Table 34: Cash Flow with Staffing Expenses Increased by 100 Percent

Attribute	Year			
	1	3	5	10
Total Revenues	$9,716,000	$42,775,000	$46,132,000	$46,132,000
Total Cash Expenses	(4,313,700)	(13,739,388)	(14,021,688)	(14,377,688)
Depreciation	(7,530,573)	(19,804,725)	(19,804,725)	(18,985,406)
Interest Expense	(5,202,321)	(13,959,396)	(12,765,737)	(9,312,224)
Net Income	$(7,330,594)	$(4,728,509)	$(460,150)	$3,456,682
Unrestricted Cash Balance	$(774,055)	$(2,680,155)	$(1,913,618)	$(6,824,403)
Depreciation Operating Reserve	-	-	7,922,000	22,613,191
Debt Service Reserve	4,996,130	14,841,300	14,841,300	14,841,300
Total Cash Balance	$4,222,075	$12,161,145	$20,849,682	$30,630,088

4.3.6 Fiber construction expenses

The following tables show the financial projections for increasing and decreasing fiber construction costs (not including laterals) by 10 percent and 20 percent.

Table 35: Cash Flow with Fiber Construction Costs Increased by 10 Percent

Attribute	Year			
	1	3	5	10
Total Revenues	$9,716,000	$42,775,000	$46,132,000	$46,132,000
Total Cash Expenses	(3,503,700)	(12,690,388)	(12,912,688)	(13,090,688)
Depreciation	(7,870,293)	(20,937,125)	(20,937,125)	(20,117,806)
Interest Expense	(5,474,097)	(14,865,316)	(13,604,231)	(9,957,096)
Net Income	$(7,132,090)	$(5,717,829)	$(1,322,044)	$2,966,410
Unrestricted Cash Balance	$(915,327)	$(4,156,367)	$(4,942,133)	$(13,595,923)
Depreciation Operating Reserve	-	-	8,374,000	24,197,191
Debt Service Reserve	5,335,850	15,973,700	15,973,700	15,973,700
Total Cash Balance	$4,420,523	$11,817,333	$19,405,567	$26,574,968

Table 36: Cash Flow with Fiber Construction Costs Increased by 20 Percent

Attribute	Year			
	1	3	5	10
Total Revenues	$9,716,000	$42,775,000	$46,132,000	$46,132,000
Total Cash Expenses	(3,503,700)	(12,690,388)	(12,912,688)	(13,090,688)
Depreciation	(8,210,013)	(22,069,525)	(22,069,525)	(21,250,206)
Interest Expense	(5,745,873)	(15,771,236)	(14,442,727)	(10,601,967)
Net Income	$(7,743,586)	$(7,756,149)	$(3,292,940)	$1,189,139
Unrestricted Cash Balance	$(1,866,599)	$(8,418,581)	$(12,947,651)	$(31,395,451)
Depreciation Operating Reserve	-	-	8,828,000	25,784,191
Debt Service Reserve	5,675,570	17,106,100	17,106,100	17,106,100
Total Cash Balance	$3,808,971	$8,687,519	$12,986,449	$11,494,840

Table 37: Cash Flow with Fiber Construction Costs Decreased by 10 Percent

Attribute	Year			
	1	3	5	10
Total Revenues	$9,716,000	$42,775,000	$46,132,000	$46,132,000
Total Cash Expenses	(3,503,700)	(12,690,388)	(12,912,688)	(13,090,688)
Depreciation	(7,190,853)	(18,672,325)	(18,672,325)	(17,853,006)
Interest Expense	(4,930,545)	(13,053,476)	(11,927,241)	(8,667,353)
Net Income	$(5,909,098)	$(1,641,189)	$2,619,746	$6,520,953
Unrestricted Cash Balance	$987,217	$4,368,060	$11,066,903	$21,999,133
Depreciation Operating Reserve	-	-	7,468,000	21,027,191
Debt Service Reserve	4,656,410	13,708,900	13,708,900	13,708,900
Total Cash Balance	$5,643,627	$18,076,960	$32,243,803	$56,735,224

Table 38: Cash Flow with Fiber Construction Costs Decreased by 20 Percent

Attribute	Year			
	1	3	5	10
Total Revenues	$9,716,000	$42,775,000	$46,132,000	$46,132,000
Total Cash Expenses	(3,503,700)	(12,690,388)	(12,912,688)	(13,090,688)
Depreciation	(6,851,133)	(17,539,925)	(17,539,925)	(16,720,606)
Interest Expense	(4,658,769)	(12,147,556)	(11,088,745)	(8,022,482)
Net Income	$(5,297,602)	$397,131	$4,590,642	$8,298,224
Unrestricted Cash Balance	$1,938,489	$8,632,272	$19,072,418	$39,798,653
Depreciation Operating Reserve	-	-	7,016,000	19,442,191
Debt Service Reserve	4,316,690	12,576,500	12,576,500	12,576,500
Total Cash Balance	$6,255,179	$21,208,772	$38,664,918	$71,817,344

5 Governance and Leadership Oversight Model

The essential functions of governance and leadership are first to *steer* and then to provide direction, goals, and strategic priorities to NG-KIH. The governance model should thus reflect the goals of the stakeholders. Much can be learned from the models in regional and state-wide public networks across the United States, though none by itself can serve as a self-contained model for Kentucky. What Kentucky is undertaking is unique in terms of the breadth of sectors and stakeholders it brings together as well as the associated vision to open up new markets to competition.

5.1 Strategic goals

In discussions over the past months, NG-KIH stakeholders have identified and agreed upon a number of strategic goals that should guide any governance framework:

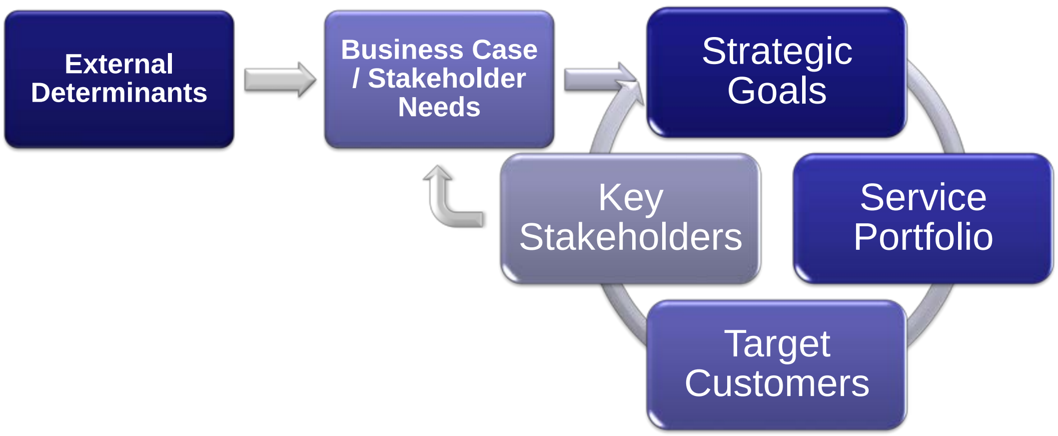
Table 39: Summary of Strategic Goals

Short-term connectivity goals:
Increase options for reliable high speed, high capacity middle-mile network connectivity lacking in many parts of the state
Increase competition for last mile services in underserved areas where costs are high
Improve service availability and reduce delays in service connectivity
Meet growing needs for broadband connectivity by important institutions delivering services, such as government, education, and medical providers
Meet need for public safety to operate the FirstNet mobile broadband network
Reduce costs and barriers of entry for rural service providers to connect their networks to the Internet backbone
Longer term connectivity goals:
Secure cost-effective Internet bandwidth statewide
Enable broadband connectivity to economically depressed areas, thereby creating new job opportunities to these communities
Improve rural broadband connectivity by enabling cost-effective network backbone services to remote areas and opening them to investment and competition
Create a public safety and emergency response network (i.e., FirstNet) to link law enforcement, homeland security and first responders

Service offerings and application goals:
Support additional capacity for long-term public and private use
Optimize public sector communications over dedicated Intranet bandwidth
Expand use of telemedicine applications by hospitals and healthcare providers
Increase monitoring capabilities including real-time video monitoring of critical infrastructure such as bridges, roads and power plants
Enhance online learning opportunities
Enhance connectivity for libraries and communities
Promote economic development by helping the private sector improve broadband connectivity, making it more desirable to locate companies in Kentucky
Support collaborative opportunities across and among the public and private sectors
Enhance research opportunities
Maximize shared services opportunities (clinical systems, advanced engineering systems, shared eLearning environments)
Operational goals:
Direct and operate the network according to best practices and sound principles
Adopt a business plan that will ensure the long-term sustainability of the network, and minimize risk
Leverage partner resources where feasible in building, expanding, and operating the network

These strategic goals frame the service portfolio and identify the users of the network (target customers). From a lifecycle perspective, external determinants such as policy mandates, economic considerations, and political exigencies will also shape stakeholder needs and the development of the network. The target customers in turn form the core customer base that determines NG-KIH's key stakeholders. Their (changing) needs, in turn, shape changes to strategic goals over time. See Figure 10 below for an illustration.

Figure 10: Identifying Key Stakeholders



5.2 NG-KIH stakeholders

The following stakeholders were identified by participants of the project and almost all of them formalized as part of the stakeholder group outlined in the Project Charter developed for management of planning and consulting services for the NG-KIH, including this document (Appendix A) (hereafter "Project Charter"). A few have been added based on our interviews with different stakeholder groups. Further, the list has been reorganized in this document to divide into different types of stakeholder groups as the network goes into operation, so entities that provide support services, such as legal and accounting services, have been moved into other groups as they fulfill other governance functions.

The core *customer* stakeholders are the intended direct customers of the NG-KIH, which include anchors and peering partners to which NG-KIH will bring connectivity. These stakeholders include:

- Commonwealth cabinets and agencies
- Public higher education institutions
- Libraries
- Healthcare facilities and hospitals
- K-12 School districts
- Local governments
- State and local public safety facilities and agencies
- Center for Rural Development (CRD)
- Municipal utility companies and utility cooperatives
- State and local government land mobile radio (LMR) operators
- Commercial Mobile Radio Service Emergency Telecommunications Board (CMRS)
- FirstNet mobile broadband network

- Homeland Security/law enforcement
- Telemedicine
- Cabinet for Economic Development

Other sectors represent potential customers but are not currently part of the NG-KIH Leadership Committee. These stakeholders are closely aligned with the strategic objectives, and NG-KIH should consider adding representatives from these groups through inclusion in the Leadership Board (as discussed in Section 6.3):

- Economic development zones and agencies
- Rural and underserved areas and community centers
- Local health clinics

In addition to the direct and indirect customers, the connectivity to customers will require the engagement of various resource-sharing stakeholders who control infrastructure assets such as fiber, conduits, rights of way, or poles. The following are such partner stakeholders who could engage in resource sharing or facilitate buildout and maintenance of the network:

- Commonwealth Transportation Cabinet (KYTC)
- Power utilities
- Regional telephone carriers
- Internet service providers (ISP)

The project charter also includes key legal resources from both Finance and COT. These continue to be key policy and compliance stakeholders. However, which legal resources should be represented depends in the final legal form that will be adopted by the stakeholders, since part of the responsibility of legal counsel is to ensure compliance with relevant legal frameworks that follow with nonprofit charter, state cabinet regulations and rules, or university policies (depending on what form is adopted). Among the many legal areas of services supporting the network are:

- Drafting and revising procurement contracts
- Advising on vendor compliance and redress
- Drafting and negotiating agreements with partners and service providers
- Drafting proposed legislative support interventions if and when needed
- Checking for regulatory, financial, and other legal compliance
- Risk management in regard to insurance, liabilities, etc. with colocations, easements, fiber relocation, joint assets or physical plant and services

The Finance Cabinet and the Center for Rural Development (CRD) will continue to be key stakeholders as the funders of NG-KIH. As the entities with the primary financial responsibility and the ones who bear the risk in case of budget shortfalls, they have a vested interest in overseeing service rates, budgeting, procurement, grants management, and invoicing processes.

Commercial service providers may provide Internet or last-mile lit services for anchors that cannot be cost-effectively connected to NG-KIH fiber. These stakeholders form an important resource for NG-KIH, and having them as allies and potential business partners is an important consideration; that said, as the risk for conflict of interest is relatively high, their inclusion in any committee should be tightly managed and reserved for specific task forces with open and voluntary membership and participation.

Power companies and incumbent local exchange carriers represent a potential customer base for dark fiber, and also control access to utility poles that NG-KIH. They are regulated by the Kentucky Public Service Commission (PSC), which would serve as an important stakeholder for identifying potential partners and also for ensuring or smoothing access to poles. The NG-KIH operational entity should continue to work closely with the PSC.

5.3 Principles for governance/assumptions

To effectively achieve the strategic goals, we recommend a unified approach to governance, with the Leadership Board representing all the stakeholders and overseeing the entire physical network. While it is possible, for example, to have multiple entities operate different geographic portions of the network and coordinate at the various operational and governance levels, such efforts may dilute political support and engagement, and hamper ability to efficiently manage and expand the network as needed. Moreover, successful networks that may have begun with distributed or bifurcated governance tend to migrate toward a single governance structure because of the efficiencies of unified governance.

5.3.1 The case for unified governance in Kentucky

Other states operate a variety of different networks, some with state/department-owned fiber, and some with leased circuits. These emerged over time in response to specialized needs from education, libraries, schools, or public safety agencies, and the technical specifications and design vary tremendously. Some of these networks are now merging into single entities, as access and bandwidth needs continue to expand, and because data needs can now be addressed through standardized IP-based designs and electronic segmentation for all types of applications and user communities. Unification results not only in efficiency, but also in greater sustainability, bandwidth, service, security, and scalability.

With thoughtful design from the outset and a focus on a unified project, NG-KIH can avoid creation of issues that may arise if separate institutions and networks were to be established. Indeed, the NG-KIH stakeholders have many advantages in terms of successfully adopting the efficient unified governance model:

- **Consensus around core principles** – All the parties have bought in to the strategic principles outlined in the Project Charter and stated earlier in this document.

- **Lack of institutional baggage** – The stakeholders do not own extensive existing fiber assets, nor do they have sharply divided constituencies, which would make unified governance difficult to integrate.

- **Lack of significant divergence of needs** – While the different stakeholders all have somewhat different needs and goals, the basic needs are the same: More bandwidth, more connectivity, more Internet, more reliability, lower costs. Specific application or service level needs can be addressed electronically and with service level agreements.

- **Lack of conflicts of interest** – While there are divergences of interest among the stakeholders, we do not see any that make unified governance impractical.

- **Lack of significant regionalization** – Local governments are by definition geographically distinct. However, the regionalization is not extreme. The major universities have extension service locations and campuses that reach widely, and Commonwealth cabinets are distributed across the state as well. The most bounded entities are CRD and the municipal networks.

- **Strong political support** – Statewide networks require broad political support from the state and need to be seen as an asset and area of investment to meet the types of diverse policy goals on which such networks can deliver. NG-KIH is experiencing this support from the highest levels and seems well poised to sustain such support in the future – which is critical to protect it from challenges from incumbents, to insulate it financially while it builds its own capacity to be self-sustainable, and to provide the capital necessary to expand and reach underserved areas for which operational revenue is not sufficient to cover capital costs.

5.3.2 Challenges to making unified governance work

While the opportunity and conditions for unified governance exist, making it all work will not be without challenges. Our experience with other networks that brought a variety of stakeholders together indicates that incremental trust and confidence must be built over time. Trust is the belief that an entity will act on your behalf in ways that preserve or promote your interests. Confidence is the belief that an entity can effectively carry out the tasks that they have been charged with. These related concepts are sometimes collectively denoted as “social capital"[4] in the social science literature, and, when high, serve to lower transaction costs,[5] or the need for instituting costly complex legal and formal arrangements to protect parties from each other prior to transactions. This largely explains why single constituency networks, such as Research and Education networks that serve higher education, are prevalent: With largely shared values, institutional cultures, and sophisticated technical competencies for their scope, both forms of social capital can remain high from the outset, making the building of collaborative networks much easier. In the case of such networks as MCNC in North Carolina, PennREN in Pennsylvania, and LONI in Louisiana, this dynamic was instrumental in building the network in the first place

Perhaps nowhere is trust and confidence more important than among the public safety community, so it is instructive to consider the National Capital Region (the multi-state Washington, DC area), where 19 local governments built a public safety grade fiber optic network specifically to support public safety needs. Like MCNC, NCRnet had the advantage of being grant-funded and therefore somewhat insulated from revenue pressures in its formative years, allowing its multiple stakeholders to focus on building its governance and operational structure. NCRnet was funded with Department of Homeland Security grants under the umbrella of the National Capital Region and Metropolitan Washington Council of Governments (MWCOG). The primary committee overseeing the building of the network and later its operation was the MWCOG CIO committee. Funding was sub-granted to a volunteer jurisdiction on a rotating basis among the larger jurisdictions that possessed capabilities with respect to internal grants management, procurement, administrative functions, project support, and expertise to take turns overseeing the day-to-day management and oversight.

A Project Management Office (PMO) was developed and staffed to oversee the various consulting teams tasked with developing requirements and architecture in networking and interoperable applications systems, and these in turn developed RFPs for the actual builds and helped oversee those scopes. The PMO was overseen by the sponsoring jurisdiction (initially, Washington DC), as well as the CIO group itself to which the PMO reported. However, the governance was firmly placed not only among the CIOs, but in various sub-committees that were formed to evaluate RFPs, security policies, and network architectures.

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[4] The notion of social capital was popularized by Putnam in a series of articles and books, and rapidly spread across political science literature and policy circles. It has an older sociological history identified with James Coleman and Pierre Bourdieu's whose definitions differ from those of Putnam.

[5] Oliver Williamson coined the term to explain why hierarchies (formal corporate organizations) emerged since traditional market theory would predict that markets should be more efficient. See North Douglass C. *Institutions, Institutional Change and Economic Performance* (1990) (Cambridge University Press, Cambridge, U.K.); Powell Walter W., Staw B., Cummings L. Neither market nor hierarchy: Network forms of organization. *Research in Organizational Behavior* (1990) 12(JAI Press, Greenwich, CT) 295–336; Williamson Oliver E. *The Economic Institutions of Capitalism* (1985) (Free Press, New York); Williamson Oliver E. Comparative economic organization: The analysis of discrete structural alternatives. *Admin. Sci. Quart.* (1991) 36:269–296

When perception arose that the PMO was being pulled in too many directions by too many stakeholders, the CIOs set up a steering committee to directly monitor both PMO and consultant teams, and put government FTEs in charge of the teams. In addition, the steering committee worked with the teams to develop prioritization of all major initiatives in terms of fiber builds, thereby ensuring that however budget framework would change, the strategic objectives were clearly articulated in prioritized initiatives.

Additional support committees included the Chief Security Officers Committee and Network Managers Committee. However, broader funding priorities in the region were managed at executive and senior public safety levels through a variety of committee to whom the CIOs reported and justified their investment requests. While there was coordination with a variety of existing public safety groups, including Emergency Managers, Fire, and Police, there was also a fair amount of trust that the CIOs built with several of them.

An Interoperability Council was formed as a steering board with participation of Chief Administrative Officers (CAO) and CIOs to ensure higher visibility of NCRnet and to integrate NCRnet into other regional projects, and CIO and NCRnet leaders now regularly coordinate with these committees. In addition, NCRnet developed a set of technical upgrades in response to security concerns from law enforcement that increased confidence sufficiently that law enforcement is now one of the most active users of NCRnet.

As a public safety network, NCRnet had to satisfy a variety of constituents with very high requirements and, as a result, trust and confidence in operations was and is critical. NCRnet found that it had to take back some of the outsourced pieces of its operation, specifically NOC operations, and staff it instead with hired staff-augmented engineers that were overseen by the hosting jurisdiction to ensure the high level of service required by public safety.

Indeed, governance is always a dynamic set of arrangements, so what starts out as separate may later change. In one regional network we have worked with, the public schools split off to operate their own network. While this was initially designed to maintain the integrity of the needs and interests of the schools, the inefficiencies of duplicate staff responsibilities and electronics and the burden on coordination of fiber maintenance and operations, hub site access, and electronics procurement and maintenance were high for all parties. As a result, the arrangement reverted to unified operations and governance. However, trust had to grow over time before the parties could successfully integrate into a cooperative and unified framework.

5.3.3 Areas of risk in shared/split governance

Governance, whether split or unified, must address decision-making, change-management, risk, and escalation. When asset ownership, services, and risks are clearly demarcated, split governance is conceivable, but in general, operational risks and transaction costs (in terms of resource time to manage issues) go up. This means demarcation of scope and responsibility need to be managed across different areas of risk and responsibility:

- Divergent strategic priorities
- Funding opportunities – especially for expansion of the network, but also for operating expenses if revenues will not cover expenses in the initial build-out phase and service ramp-up
- Interconnection and role of responsibilities for fiber plant (if one entity owns and the other operates, for example, or there is shared break and fix, or different contractors are hired by each entity)
- Clear expectations regarding hosted points of presence at each other's facilities, including power, and standards for as-built documentation
- Who can construct and would own physical plant in each other's territories if it involves extension of laterals to a primary agency/stakeholder. For example, if the Commonwealth wants to reach a state agency in the territory of a regional partner, what are the expectations regarding how to accomplish that?
- Expectations regarding servicing of electronics
- Operational level agreements (OLAs) for shared operational responsibility for end clients, including metrics of performance and break fix expectation windows.
- Standards for peering, interconnection, and electronic configuration at electronic demarcations, as well as escalation and mutual notification paths for outages and security events
- Scope of services and consulting rendered by operator, (e.g., VRFs, VLANs, segmentation, DNS, firewall configuration) and knowledge/responsibility expected by client to work on troubleshooting or change management
- Responsibilities regarding proactive and reactive maintenance and fiber or hub relocations
- Identification, tracking, and monitoring of salient service levels mapped to services rendered

5.3.4 Essential tasks and responsibilities of governance

While confidence is largely a function of effective management and operations, trust in the ability of an entity to reflect the needs and interests of its constituents is nurtured and monitored at the governance level. The responsibility of governance is therefore first and foremost governance itself: ensuring that stakeholders are adequately represented and in the right forums, and have an appropriate decision-making role, and enlarging committees with new stakeholders when needed. In addition, the governance level is responsible for setting guidance, prioritizing investments, overseeing finances and budgeting, and managing risks and opportunities, including legislative, political, or commercial challenges or new funding opportunities. The governance level is also responsible for ensuring that there is effective management that develops confidence in the network.

When it comes to the budget framework functions, NG-KIH may require a division of labor at the governance level, at least initially, due to split of funding from CRD and the Commonwealth. The Finance Cabinet and CRD are the entities that are bringing funding to the table and they have obligations attached to the funding that only they are liable for (and auditable against). There may also need to be additional funding necessary from these funding sources before NG-KIH starts producing enough revenue to cover operating costs. In addition, these agencies may also be uniquely positioned to extend capital investments, an area that public networks are not usually able to cover with operating revenue. It may therefore be necessary to establish a Financial Board of CRD and the Finance Cabinet and include a representative from the larger stakeholder group to set the overall budget framework, ensure financial and legal compliance with funding source requirements, and identify and secure additional funding when needed and/or deal with budget shortfalls. However, while this overall budget framework could be tackled there, it is an essential role of overall governance (including all represented groups) to guide budget *priorities* by giving strategic guidance to management. This responsibility should therefore still be an areas of the larger stakeholder group's responsibility.

5.4 Operational structure

Unlike some statewide networks, NG-KIH will not have the luxury to grow slowly from a few sites or a narrowly defined backbone network. As currently contemplated, it will have a large operational scope and rely almost immediately on revenues from anchor institutions without greatly increased annual appropriations from a Commonwealth budget to cover all its operational needs. In addition, NG-KIH will not have the luxury of a large-scale capital grant such as those received by some states and stakeholder groups through the American Recovery and Reinvestment Act.

NG-KIH needs immediate access to financial support, technical support, legal services, procurement services, marketing, and billing, and needs to have sufficient scope/presence and reach to effectively operate.

5.4.1 Models of institutional governance/corporate form

NG-KIH's urgent need to rapidly get its wheels on limits the options available to three relevant options in terms of governance models:[6]

State-run networks vary in scope, footprint, and whether they are owned or consist of leased circuits. One example is the Utah Educational Network (UEN). UEN is a state agency that operates a statewide backbone augmented by circuits from private-sector operators. The network is funded through a combination of state funding, e-rate reimbursement and grants. UEN serves higher education, K-12, state agencies, libraries and Head Start Centers.

Maryland is another example of a state with a multi-purpose, fiber optic network, networkMaryland, that is run by the state IT department (DoIT). networkMaryland and its sister network, the One Maryland Broadband Network (OMBN) serves state government, local government and K-12. It is funded through a combination of user fees and grants.

Other states have several single-purpose networks dedicated to public safety, transportation, or education run by different agencies or departments. State agencies have the advantage of existing governance, accounting, procurement, and legal service systems and—when connected to the IT department—have access to internal technology support. They also have closer access to political leadership, necessary to garner support against pressures from incumbent telecommunications carriers to shift contracts and services their way. They can relatively easily align with state executive-level policy priorities. They also likely have easier access to political support necessary to fund expansion. However, state networks are also vulnerable to changes in administration; a new administration may not see the network as a priority, or the network may become a target for incumbent carriers claiming unfair competition from a government entity.

It has also been our experience that state-run networks without robust stakeholder participation at a governance level run into problems with legitimacy, which in turn can harm political support and revenue options. This, however, is not unique to state-run networks, but can be equally true of non-profit and R&E networks. Due to perceived conflicts of interest, it is especially important for state-run networks to insulate network staff from other government functions and dedicate them exclusively to the network, so they are not seen as giving priority to internal resource demands at the expense of other stakeholder needs.

University-led networks/R&E networks can consist of alliances of universities who band together to connect each other, or a single university system which spans an entire state with

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[6] Further case studies are available in *Building the Broadband Future: The Communications Needs of Kansas Schools, Libraries and Hospitals*, CTC, http://www.ctcnet.us/wp-content/uploads/2014/01/KansasCAINeeds.pdf, January 31, 2013.

distributed campuses. They have almost built-in access to many of the internal staff and operational resources needed, but as a rule do not have the footprint to cover all the anchor sites represented by the NG-KIH stakeholder sectors. In fact, they focus—not surprisingly—on their existing main sites to connect each other and to access Internet or build capabilities that will support their research and academic needs. A typical model is to procure a fiber backbone through IRUs with commercial carriers to connect the higher education institutions using limited fiber count. High speed DWDM electronics make it possible to get sufficient capacity over the limited fiber count, but the limited fiber count reduces the usefulness of the networks for directly connecting other community anchor institutions along the route—these are typically connected through last mile arrangements with commercial providers. The Mid-Atlantic Crossroads (MAX) in the mid-Atlantic region, PennREN in Pennsylvania, and KanREN in Kansas are examples of this model.

It is critical to note that the dark fiber IRUs in such networks often come with limitations in use, limiting the ability to serve non-educational anchors or economic development sites, or entirely precluding the use of the fiber in an open access setting for wholesale services. In some cases, we have observed understandable reluctance to serve non-university anchors on the part of networks reliant on IRU fiber, even where it is not explicitly forbidden by contract, to avoid antagonizing the commercial entity providing the fiber.

And while they are often highly sophisticated on the technical side, university-operated networks do not necessarily work within a service or pricing approach geared toward smaller or less technically savvy users. All these are capabilities that can be grown over time, but that may not be an option available to NG-KIH in the immediate future. R&E networks are excellent at establishing nimble and technologically sophisticated networks, but most of the existing networks are strategically focused on research and education, and some have struggled to broaden stakeholder representation in the decision making forums in those cases where they try to offer services to non-R&E entities.

It is possible for the higher education community to operate a somewhat broader-based network. A model is provided by the Ohio Academic Resources Network (OARNet), which is governed by the Ohio Board of Regents and operates a 100 Gbps backbone serving higher education, research institutions, university hospitals and other private partners engaged in high-level research. OARNet also serves K-12 schools, state and local government and covers 1,850 miles of fiber.

The non-profit form has often been developed out of Research and Education missions that have expanded in scope over time, or have been constituted as a way to get around legislative restrictions imposed by state legislatures on government networks. One successful example is the Corporation for Education Network Initiatives in California (CENIC), which connects the majority of the state's educational and research locations and is considered one of the premier statewide networks. CENIC has served as a model for many others. Like OARNet, CENIC has extended its mission beyond higher educations and now serves local government and K-12 users among others. Another example is MCNC in North Carolina, which has a state-wide presence and a board structure that derives heavily from the university community that originally backed the network, but has expanded to add other stakeholders. The non-profit form enjoys a high degree of independence from regulatory and political restrictions, and can move swiftly to hire talent to take on new scopes and responsibilities, but has to scale on its own and manage substantial administrative responsibilities in-house (including HR, legal, accounting, procurement, and the back-office support necessary on software and hardware). It therefore needs to be able to grow slowly to add those capacities as the network and complexity increases and revenue comes in to cover those costs, or it needs to have a large infusion of capital to stand up such resources before revenue begins to flow in a fast enough pace to cover the administrative costs. It is however conceivable that a non-profit form could be adopted, while retaining in-kind administrative support, communications, and offices from host entities like a state cabinet or a major university. NG-KIH is unique and a creative approach borrowing from different existing models may therefore be necessary.

5.4.2 Evaluating the models

In addition to the problem of high start-up operational costs for non-profits, and the longer time needed to ramp up an effective operational infrastructure to the scale that NG-KIH needs, there are other reasons why the non-profit model may not currently be a good fit. The very flexibility and independence of a non-profit may also make it more vulnerable to loss of political support. Consistent support is inevitably needed to maintain operational funding, keep service quality high, ensure alignment with strategic goals, ensuring the customer base does not get diverted to competing networks, and cost-effectively fund network expansion to new sites.

While non-profits may have more maneuverability to compete with commercial entities and offer competitively priced services, their main customer base continues to be public institutions. A withdrawal of support from such institutions for political reasons can be disastrous for such networks requiring strategic choices that make the actual maneuvering space much smaller than the flexible non-profit form would imply.

The university-led model is less flexible and more tied to regulatory restrictions than the non-profit model. It may be as vulnerable as a state agency to direct political interference and policy changes and changes in administration as a state cabinet—likely even more so as it is subject to internal and higher education related pressures as well. On the other hand it can be as vulnerable as a non-profit to being disavowed and losing access to state support. At the same time, it has significant internal resources and capabilities, and has both prestige and technical know-how that give it other advantages in gaining legitimacy and vesting confidence from stakeholders on the client as well as support sides.

The state sponsored model continues to be attractive for long term governance if it can succeed in effectively incorporating broader stakeholder involvement and participation at the governance level. It continues to have closer access to political leadership, necessary to garner support against pressures from incumbent telecommunications carriers to shift contracts and services their way, it more easily aligns with policy priorities from administrations, and it has easier access to political support necessary to fund needed or desired expansions.

However, should the political access that can make this form so effective become dysfunctional due to political disengagement or too heavy political interference, it will heavily undermine trust and confidence and be seen to threaten the strategic integrity of the network and its stakeholders. In that case, migration to a hybrid model of state-university partnership could be conceived, or transition to a non-profit model if has sufficiently matured..

We note the Commonwealth Cabinets have advantages in scaling operations and can leverage internal state resources to support necessary operations within tight financial constraints, as revenue starts coming in and NG-KIH gains sustainability. Examples of areas that make the Cabinets an attractive choice for NG-KIH in the beginning is the ability to appropriate money, coordinate committee engagement, aggregate demand, act as a central point for procurement and external partnerships, interface with federal and Commonwealth regulators, and effectively coordinate with the Transportation Cabinet. Some areas such as invoicing and marketing may need additional external support to bolster existing capabilities.

However, at the institutional level, if a state-hosted structure is adopted initially, as we have noted, it would need to be paired with a very strong stakeholder engagement and structure at the governance level. This could face some structural challenges if this structure sits outside the state, as there doesn't seem to be an authorizing legal framework that allows an external committee to guide and oversee a state institution. However, we should note that there are many networks with formal and informal committees where the real work of decision making is done. Although their work may have no binding nature, it's rare for a governing entity to reject the recommendations of one of its expert committees where that committee has strong stakeholder participation and representation. This type of soft power can be more effective than formal enforcement mechanisms in ensuring stakeholder representation and governance participation.

As the program matures, the network may want to re-evaluate its structure and consider establishing a 501(c)(3) nonprofit structure such as California's CENIC, North Carolina's MCNC, or Pennsylvania's KINBER. The non-profit form affords significant benefits in terms of identifying new customers, partners, and revenue streams with less regulatory and policy obstacles, such as complex procurement rules, or conflicts between legislature and executive over strategic vision or revenue models, and the role of a government entity in the marketplace. However, it can still ensure in its incorporation principles that it stays within the core mission and strategic goals of its charting members. Such an entity will need to be mature enough, both in terms of time and building internal experience and capacity, to absorb the operational costs and significant staff needed to absorb all the necessary support functions. It will also need to ensure continued stakeholder engagement and codify the form of the engagement in its corporate charter. MCNC may be the closest example to a non-profit multi-purpose statewide network; it operates largely as an independent corporation with a university-dominated board serving more advisory, and mostly traditional board corporate governance functions.

5.5 Governance and committee structure

5.5.1 The work of governance and management

Regardless of form adopted, the State and CRD have financial compliance and funding authority that may be best managed in a coordinated manner in through a Finance Board. While legal and regulatory obligations may be the State's and CRD's alone, to ensure influence from the larger stakeholder group, the stakeholders might consider including representation from the stakeholder group on a rotating basis. Depending on the corporate and legal organizational form adopted, there may be other audit and compliance issues that could make accountant and legal representatives from the funders and the NG-KIH organization desirable for this Board on an *ad hoc* basis. Separating these functions away from the larger stakeholder group could alleviate some of the administrative and compliance burden from the stakeholders, so they can focus more closely on meeting stakeholder needs and strategic vision, and setting strategic budget priorities.

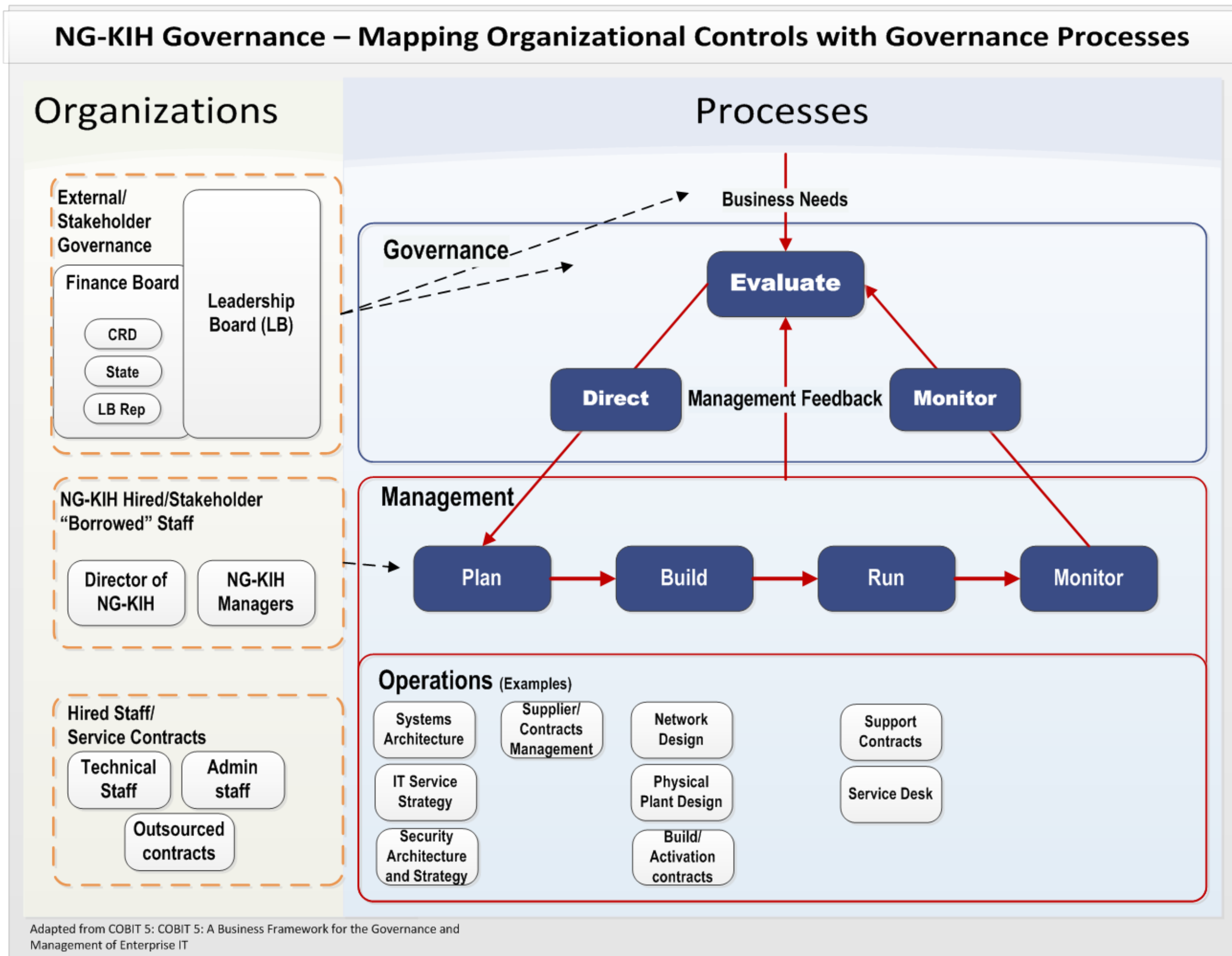
The essential governance functions that would need to be provided by the stakeholder group, which we could call a Leadership Board, include setting strategic vision, setting budget priorities, overseeing and guiding management and operations, reviewing performance based on strategic goals, and ensuring progress towards strategic goals. In addition, the Leadership Board constitutes and oversees needed support committees and task forces, which deliver recommendations to the Board for adoption.

The current Leadership Committee serves as a good basis for this Leadership Board, as most of the key stakeholder groups are already included, and because this would provide a seamless transition from the buildout to the operational phase for continued oversight. While there is always a temptation to broaden membership to capture interest and engagement with key entities, we recommend that only entities that are committed purchases of services from the network serve on the Leadership Board for now to ensure that the integrity of core mission and goals be preserved. This can always be altered later.

It is a best practice to strictly separate the management (operational) and governance (strategic) functions in organizations, and the Leadership Board's role and work should be to focus on governance tasks. However the governance job is strategic in nature, focusing on assessing risks, ensuring value for stakeholders, and resources required. If NG-KIH becomes embedded in a host organization such as a Commonwealth Cabinet, this will therefore require an active role from the Governor's office, the CIO, and the CFO. Within a state organization, such functions are set at the internal executive level, often by an internal steering committee. Similar internal hierarchies exist in universities, and such a committee would need to coordinate tightly with the governance level.

Based on feedback from other organizations, 10 to 15 members seems like an efficient number for Leadership Board membership. Much larger and it will stop being productive. Much smaller, and there will be too few resources for the work needed, and there will be gaps in core stakeholder and strategic goal representation.

Figure 11: Governance and Organizational Controls



A proposed governance framework for NG-KIH that maps essential governance and management roles to key organizational units/officers is presented in Figure 11. The proposed structure is based on COBIT 5—an IT Governance framework that extends governance to broader stakeholder and governance functions reaching outside the organization.[7] We

[7] COBIT 5 defines the role of governance as follows "Governance ensures that stakeholder needs, conditions and options are evaluated to determine balanced, agreed-on enterprise objectives to be achieved; setting direction through prioritisation and decision making; and monitoring performance and compliance against agreed-on direction and objectives." ISACA, COBIT 5: *A Business Framework for the Governance and Management of Enterprise IT*: ISACA, 2012.

recommend that NG-KIH use COBIT 5 as a framework for further operational governance development and ongoing tracking and improvement, especially at a management level, since COBIT 5 is especially well suited to ensuring ongoing alignment between stakeholder needs at the strategic level and operational performance at the management level.

For a more service-oriented approach (although not for organizational analysis and governance), ITIL can serve as a model as well, but is not recommended for a newly established organization; the primary emphasis needs to be on the strategic and stakeholder level—and ITIL typically requires some organizational maturity and training before ITIL-aligned process and functions can be developed.

Another view of the mapping focuses on functional roles from a Responsible, Accountable, Consulted, Informed (RACI) perspective; an illustration is presented in Figure 12. Note that this is a very high-level example, and the current Leadership Committee should discuss demarcation of responsibilities to adapt it to its needs.

Figure 12: Responsible, Accountable, Consulted, Informed (RACI) Matrix

	Governance		Management				
	External/ Stakeholder	Financial Authority & Legal Compliance	NG KIH Management				
Task (or Activity) \ Role	Leadership Board	Financial Board	Director	Systems Architect	Chief Security Officer	PMO	Customer Services Manager
Direct Overall Governance and structure	A	C	C/I	I	I	I	I
Establish Committees and Subcommittees and manage memberships	A	I	I	I	I	I	I
Identify additional Stakeholders (needs)	A	C	C/I	I	I	I	I
Update Strategic Goals	A	C	C	I	I	I	I
Monitor and approve Budget	R	A/R	C	I	I	I	I
Set Budget Priorities	A/R	R	C	I	I	I	I
Monitor alignment between strategic goals and service delivery	A	I	C	I	I	I	I
Develop Long term prioritization of which Stakeholders need to have connectivity	A	C	C	I	I	I	C
Evaluate feasibility of connectivity to targeted stakeholders	I	I	A/R	C	I	C	I
Ensure service delivery is aligned with strategic goals	C	I	A/R	I	I	I	R
Ensure projects are delivered on time and within budget	I	I	A	I	I	R	C
Develop Security Policy and ensure compliance	I	I	A	C	R	I	C
Ensure standards are set and met in all aspects of IT operations	I	I	A	R	C	C	C
Ensure Service levels are met and there is continual service improvement	C	I	A	C	C	C	R

5.5.2 Supporting committees

A technical committee to advise on technical matters should draw chiefly from the core agencies, but can benefit from technical expertise from the broader stakeholder groups as well. Membership should be considered more broadly from the stakeholder groups listed above.

In addition to the Leadership Board and Technical Committee, the following committees could be set up as needed to achieve continued progress toward the strategic goals:

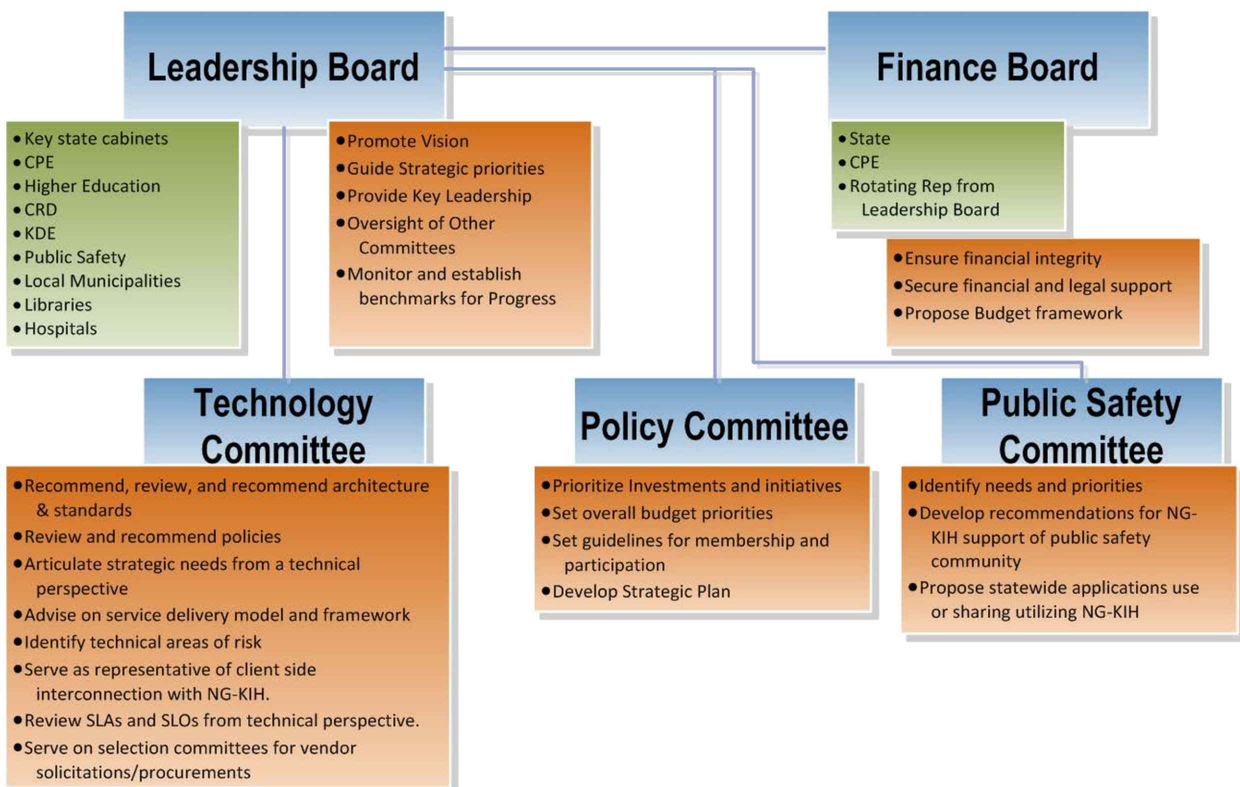
- Public Safety Committee

- Economic Development and Community Access Committee
- Health and Telemedicine Committee
- Research and Education Committee
- Policy and Standards Committee (could be subcommittee to Technical Committee)
- Security Committee (if needed as a separate committee or could be a task force drawn from the Technical Committee and Leadership Board)

If such committees already exist on their own, it may make sense to reach out to them and ask them to incorporate NG-KIH as part of their scope and include a liaison to the Leadership Board or Technical Committee to ensure efficient coordination.

Figure 13 below illustrates proposed key committees adapted from the original vision developed by the NG-KIH stakeholders as it transitions from a project-based framework, to an operational mode where governance oversight of management functions is required.

Figure 13: Key Committee Structures/Compositions



A membership fee model is used by some non-profits to create different tiers of partners as a revenue source and as a way to differentiate among (and assign voting rights to) core and non-core participants. The KINBER network in Pennsylvania and KanREN in Kansas are examples of tiered membership models. Such a model can be effective for differentiating between core members aligned with the core mission, or for ensuring participation by smaller entities who need a lower barrier of entry. However, such tiering can create potential conflicts between different levels and does not effectively tie level of usage to costs. Moreover, the revenue that would accrue is typically not large enough to offset the headaches that this might entail.

Membership in the Leadership and Finance Boards should be by charter, while for the other committees it can be more informal. In some networks, such as Prince George's County, Maryland's intergovernmental network, each participating entity has to participate in at least one committee, which has improved participation, the quality of leadership, and the sense of ownership of both problems and solutions among the participants.

5.6 Proposed leadership board composition

Some traditional board oversight roles may end up most logically being handled through established internal controls if NG-KIH is hosted by a Commonwealth Cabinet or a university. These oversight roles may include financial monitoring and compliance, risk management functions for legal compliance with applicable regulations, and other types of oversight in terms of good governance (Sarbanes-Oxley). CRD is also accountable for these controls as a funder of NG-KIH. It may therefore be advisable to form a Finance Board to oversee such controls made up of CRD, the Finance Cabinet, and a rotating member of the larger stakeholder group. This could be joined by representatives from the hosting organization once the hosting and corporate form is adopted for NG-KIH. This Board is illustrated in Figure 11. Establishment of such a Board would free up the Leadership Board to focus on strategic guidance and performance-based oversight with membership drawn from the key stakeholders that map to the strategic goals.

Below are the proposed members or partner agencies that may be well suited to serve on the Leadership Board:

- Commonwealth cabinets and agencies
  - Cabinet for Health and Family Services
  - Education and Workforce Development Cabinet/Kentucky Education Network (KEN)
  - Department of Homeland Security/Kentucky Emergency Warning System (KEWS)
  - Cabinet for Economic Development
  - Cabinet for Justice and Public Safety
  - Cabinet for Transportation
- Education
  - Council on Postsecondary Education (CPE)
  - Kentucky Educational Television (KET)
  - Kentucky Board of Education

  - Kentucky Community and Technical College System (KCTCS)
- Libraries
  - Kentucky Library Association
  - Kentucky Department for Libraries and Archives
- Healthcare facilities and hospitals
  - Kentucky Hospital Association
- Local governments
  - Kentucky League of Cities
  - Kentucky Association of Counties
- Commonwealth and local public safety facilities and agencies
  - Public safety (FirstNet)
  - Commercial Mobile Radio Service Emergency Telecommunications Board (CMRS)
- Community development and underserved areas
  - Center for Research & Development (CRD)
- Municipal utility operators
  - Kentucky Municipal Utilities Association

In the interest of keeping the standing membership to a manageable size, some of the members could be part of smaller committees and elect a chair that would serve on the Leadership Board. For example, an Education committee consisting of both the above suggested agencies under education and libraries, and a liaison from the Education Cabinet could elect a non-Cabinet chair to serve as a voting member of the Leadership Board.

A similar approach could be adopted for public safety and increase the committee to include more local representatives and additional public safety areas.

5.7 Organizing committees: Charters, mission statements, and bylaws

5.7.1 Charters

Using a Charter for the governance of NG-KIH is a best practice. It ensures discipline towards strategic objective, defines the key parties as well as external stakeholders, and establishes authorizing representatives entrusted with decision making authority, including change management of the Charter itself.

The currently adopted Project Charter in place for the NG-KIH planning process, as well as the draft Program Charter, form a good starting point for such a Charter. The Charter should update the stakeholder members and identify the authorizing participants, and reference the adopted governance structures and the key committees and assign change management process and authority to the charter itself as well as to the governance itself. A version of the RACI matrix in Figure 12, for example, would be one way to outline the different roles and responsibilities. In addition, voting rights could be assigned but need not have details regarding quorum, meeting attendance policies, meeting frequencies, or rights of delegating. These are properly reserved for the Committee Bylaws.

The NG-KIH Charter can be framed as a statement of intent by the participants, or can take the form of a formal MOU. However, a formal MOU path may be cumbersome and run into legal obstacles regarding authority of non-state participants to make decisions that are within the authority and responsibility of a hosting authority. For example, if NG-KIH becomes organized under Commonwealth auspices, there does not seem to be a clear authorizing framework in Kentucky state codes for establishing public-private decision-making entities. The statement could instead be framed in terms of intent and best efforts, and establish NG-KIH as a project to allow for the maximum amount of flexibility. This would also allow decisions within committees to be part of an ongoing project, and thus all discussions and intermediate work products can be treated as internal process documents, thereby lessening any potential burdens regarding open records laws. The flip side of such a solution, however, is that there would need to be a strong enough committee participation culture and strong enough guidelines for the committees in terms of their scopes, that there would be *de facto* teeth to recommendations and adoption of such by the Leadership Board.

A variation on the above recommendation would be to simply make the Leadership and Finance Boards the sole locus/loci of a charter/charters, and bypass the need for going into too much detail regarding a formal structure that will be evolving over the next few years.

5.7.2 Mission and scope statements

The Leadership Board and Technical Committee, as well as other supporting committees, can have separate charters or simply include statements of scope and responsibilities in the bylaws. A brief statement of scope is advisable. These two committees have a strategic function, but do not have budgetary authority at this point, which are (for now) the province of CRD and the State (and the proposed Financial Board). Delineating the different roles would help make lines of authority clear, and should therefore be outlined in the committee statements. Figure 12 and Figure 13 have examples and can serve as template language for the kind of tasks the committees should focus on.

Other taskforces and committees should follow this model. At a later point, the committees should develop a long-term strategic plan. A task force would be well suited to such an endeavor, either as directly formed by the Leadership Board, or by a Policy Committee. The statement/charter could include language that focuses on the nature of the strategic plan (e.g., to set priorities for future builds, to shift sourcing strategies for cost management, to increase public safety applications use, to expand service portfolio to cloud services), the participants, timeline, and process, and then elements similar to the charter template. A standing committee such as a public safety committee could, for example, incorporate language in the scope to promote operational readiness by utilizing the network for real-time situational awareness capabilities, business continuity, and to ensure integration between FirstNet and NG-KIH.

Such statements should be considered subject to revision and adaptation and should not be seen as set in stone to preserve the ability of the committees to adapt to changing needs. Changes should be adopted and documented to ensure transparency of goals and objectives.

5.8 Tracking Progress

5.8.1 Articulating measures of progress

Establishing metrics are usually accomplished within a mature operation and serve to measure performance against a desired service outcome. Ideally, such measures are quantifiable and more or less automatically generated. Management has responsibility for establishing Key Performance Indicators (KPIs) to be translated into metrics; accountability rests with the Director of NG-KIH.

Monitoring that the KPIs actually reflect the strategic objectives and mission of NG-KIH is the responsibility of the governance level (i.e., the Leadership Board in Figure 11). High-level KPIs can and should still be articulated by this level while NG-KIH gets its wheels on. In the build-out phase such indicators usually track by the scoped deliverables, but should have a strategic component to create an effective dashboard that also enables effective risk management: timelines met, miles of fiber constructed, number of prioritized links completed, and key anchors connected. The electronic component can be added as well for electronic activation.

Once connectivity services go live, other performance indicators can be added. These should still be tied to strategic objectives from a governance perspective. For example, an overall uptime indicator may be suitable for capturing overall reliability, and it can be expressed from a site and entity perspectives as well as to capture experienced customer downtimes. This of course links to the overall goal of a reliable network. However, different stakeholders and user groups will have different operational goals and should develop KPIs to reflect those.

For example, a public safety user group may want to have measures of performance tied to emergency operating centers, PSAPS, and 911 sites. Or they may want to track scheduled outages for certain links without redundancy so they can keep track of effective downtime. The Leadership Board as well as NG-KIH management should engage key user groups and stakeholders to articulate KPIs that are meaningful to them and adopt those that align with NG-KIH's strategic objectives.

KPIs at a strategic level should not be too detailed. For example, performance metrics for network utilization are critical for management to provision services in the most cost-effective fashion and for proper capacity management by the network operations team—but would clutter the governance function with too much information.

One useful way to engage user groups is to simply ask, "how do you know you are progressing or achieved success in…. promoting business development/connecting educational institutions with high speed internet/reaching key public safety entities?" This is where user groups and task forces as indicated earlier can be effective forums to develop, track, and ensure engagement of customer and user stakeholders.

As they become refined and formally adopted, such KPIs become a key tool the for management and operations side of NG-KIH to ensure continued service improvement and proper prioritization of services.

5.8.2 Tracking against strategically aligned priorities

In an ideal universe, every potential anchor would get unlimited connectivity for a low cost. In the real world, however, it is the job of Governance to manage risks and opportunities and balance value to different stakeholder constituencies. These principles are likely to clash and will require discussion and prioritization.

To reach sustainability faster, there will be strong temptation to target links that draw paying customers in future build-outs. But focusing only on those links will undermine some of NG-KIH's key strategic objectives—namely, to reach stakeholders in underserved areas and to build an infrastructure that lowers cost for last-mile providers to offer affordable services to end-users. Tracking progress along these different dimensions is therefore important to allow prioritization by Governance in terms of build-out, and to provide the framework for a strategic plan that can be turned into grant applications and take advantage of future opportunities as they present themselves.

6 Sustainable Sourcing Strategy

Based on a range of inputs, CTC has developed a sustainable sourcing strategy. The sustainability analysis is discussed in Section 4 and considers not just day-to-day operational costs but also network expansions, network replenishments, license fees, and debt service.

The RFI process provided input from potential partners over a wide range of areas, including the potential involvement of equity partners or concessionaires, fiber infrastructure providers, network and telecommunications service providers, utility pole owners, and construction companies. (The RFI is attached as Appendix H.)

We also reviewed existing contracts, had in-depth discussions with other service providers, and assessed relevant best practices and experiences among other statewide networks.

6.1 Potential outsourcing strategies

Because of the potential benefit of having a partner with large financial and technical scale aggregate many of the needs and functions of the network, we recommend that NG-KIH consider a comprehensive solution in which a partner or partners provide capital funding, share in financial risk, and join the Commonwealth up front to perform a comprehensive buildout and/or assemble and aggregate existing assets to build all or most of the fiber needed in the state. This would be a concessionaire or equity partner model.

At the same time, the NG-KIH should prepare for a Commonwealth-driven build, which will necessarily need to be done more incrementally over time, in the event the Commonwealth cannot find a suitable partner. In this scenario, the network should be divided into areas, such as Kentucky Area Development Districts[8] or divided into the individual network rings.

6.1.1 Concessionaire/equity partner solution

Concessionaire/equity partners are entities that invest capital and take risk to create networks. In the concessionaire model, a public–private partnership is formed in which the concessionaire builds, operates, and maintains the network in return for payment, potentially through some combination of up-front funds, user fees, and other revenues.

An equity partner invests funds, takes risk, and can have many different levels of involvement in building, operating, and maintaining the network.

We recommend that NG-KIH source and select candidates based on past performance and ability to deliver, but also the partner’s alignment with the goals of this network. For example,

[8] http://www.kyatlas.com/kentucky-adds.html

the partner will need to commit to an open access model for the fiber and will need to be responsive to the needs of the stakeholders. The partner needs to understand and provide for the needs of the community anchors, the underserved areas, and existing and emerging telecommunications service providers in Kentucky.

One equity model would be for the partner to build fiber for the Commonwealth and other stakeholders, as well as excess infrastructure for its own use—for sale or lease. This model would require that fiber be built according to Commonwealth standards, and that there be a service-level agreement (SLA) for repair.

For a successful procurement, NG-KIH needs to clearly delineate the stakeholders' needs, including sites to attach, services needed, capacity required, SLA parameters, technical standards, and schedule.

The equity partner or concessionaire may also provide lit services to the NG-KIH stakeholders. It is critical that managed services be demonstrably superior to the current arrangement—providing both higher speeds and higher reliability, with a mechanism for monitoring and enforcement, penalties for failure to deliver that are comparable to the financial impact on the state of the outage (and not simply a refund of the site monthly service fee), scalability to greater speeds, ability to add sites within short timeline, more diverse services, and an ability to have dark fiber at any point and light.

Our recommendation based on discussions with NG-KIH leadership and stakeholders is that any lit services be dense wave-division multiplexing (DWDM) and Layer 2 services as described in Section 7, with the capability of providing routed services if requested.

Lit services and dark fiber need to be provided under an SLA which provides an incentive for continued, reliable services to NG-KIH end users and the timely execution of moves, adds and changes. A new, well-engineered fiber-centered infrastructure will improve a partner's ability to provide quality services relative to existing providers, because the infrastructure will be more resilient and reliable. Still, there will be outages when fiber is cut or when electronics malfunction. SLAs where the monetary value reflects the lost value from a failure will lead the partner to design the route with the necessary amount of redundancy and to have the appropriate level of staff on hand to quickly make repairs.

Furthermore, the arrangement with the concessionaire or equity partner needs to include a mechanism for accurate and immediate discovery and documentation of faults in the network. This needs to include a 24x7 NOC and monitoring and diagnosis tools, as well as interface with the NG-KIH user networks for automatic and immediate reporting and documentation, as well as transparency into the links provided to the NG-KIH users, indicating network health, capacity used, and trend analysis.

Lit services SLAs should also include the capability for rapid upgrade of service level. Where practicable, the network electronics should facilitate software upgradability of service level.

Where new CPE is needed, the SLA should define the time for moves, adds and changes. Where a new site is needed, the SLA should outline the terms and time for adding new fiber.

Finally, the financial models in this report provide service costs that can be provided and support a sustainable network under a conservative build and operational scenario. Therefore, a concessionaire partner service costs should not exceed those service costs. The models also include the construction costs of dark fiber. Given that the concessionaire or equity partner will be obtaining revenues from other sources as well as the NG-KIH users, the service costs or fiber costs should in fact be well below the costs in this report.

6.1.2 Commonwealth design-and-build solution

In parallel to the concessionaire/equity partner RFP, we recommend that the Commonwealth pursue a design-and-build solution to maximize options in the event there is not a suitable concessionaire or equity partner, or if the Commonwealth decides to pursue different strategies in different parts of the state.

This approach would require the Commonwealth to lead procurements and perform overall program management and vendor management.

First, we recommend the Commonwealth procure a **design/engineering/QA** contractor with the resources to support a project of statewide scale. The designer/engineer should work with the Commonwealth to set standards for fiber and hub buildings; prepare detailed street-level designs; handle all necessary permitting (including environmental); and establish and manage relationships with pole and right-of-way owners, KYTC, infrastructure partners, and local transportation authorities, oversee construction, physically inspect the finished construction, develop an outside plant test plan and oversee outside plant testing.

This contractor should be separate from the construction contractor to ensure that choices of materials, routes, and techniques serve the Commonwealth's interests rather than benefiting the construction company and suppliers. Separating these roles would also enable the engineer to provide oversight of construction—as well as verifying and enforcing any performance incentives applied to other contractors.

Second, NG-KIH should procure a **materials supply and logistics** contractor to provide outside plant equipment,—to acquire, store, and supply materials equipment where needed by the project – including fiber cable, enclosures, vaults—This could be accomplished through an RFP or a selection of contractor under existing contract based on cost and performance. We recommend NG-KIH standardize on make and model of major components at the outset of project

NG-KIH needs to procure multiple **construction** companies. For a large scale project we recommend at least four contractors. A competitive environment within project will help to reduce costs and increase performance, and enable companies to handle the load if some companies become overburdened. The process must be structured so that the NG-KIH project manager has flexibility in breaking the project into segments, issuing task orders for the segments and selecting a contractor based on price and performance within the project according to defined criteria. The construction companies are also responsible for performing outside plant testing according to an NG-KIH test plan.

NG-KIH needs to issue an RFP to obtain **existing infrastructure**—such as fiber for lease or IRU and the right to overlash to existing strand. We note that infrastructure is often obtainable through direct discussions with known infrastructure owners, such as the municipal power utilities, telecommunications cooperatives, the recent KPEN RFP responders, and entities identified in the RFI process. Therefore, as long as the pricing and terms are acceptable and as long as the arrangement complies with procurement rules, infrastructure may be obtained without an RFP. An RFP is best suited for areas where multiple providers have infrastructure (in order to get competitive pricing), for areas where less formal discussions are not successful, and to identify service providers who might not have been brought into discussions.

NG-KIH needs to procure **network electronic equipment** as described in Section 7.2. The scale of the purchase will likely mean that the manufacturer (and not a reseller or integrator) will be the supplier, or that a consortium of manufacturers will join to fill the full range of needed equipment (for example, DWDM, hub and site equipment). This may be done with an RFP or through evaluating quotes from existing State or stakeholder contracts.

NG-KIH needs to procure hub **buildings, generators, and facility power supplies and physical security systems** as described in Section 7. Again, this may be done with through a competitive bid or through evaluating quotes from existing State or stakeholder contracts.

NG-KIH needs to procure a **systems integrator** to plan the integration, perform detailed design, perform cutover, and perform testing.

NG-KIH needs to procure a contractor to **operate and manage** the network—to monitor and maintain the network—operate a 24/7 NOC, and perform outside plant monitoring and repair. This contractor should also be responsible for training NG-KIH staff. This contractor may be the same as the systems integrator.

NG-KIH need to procure **marketing and business services** to publicize the network, operate as a clearinghouse and business contact for information to the public and entities leasing the fiber, and perform wholesale billing.

6.1.3 Leasing fiber

As a way to jump-start the project, especially if NG-KIH is not able to completely fund overall construction, the Commonwealth could purchase fiber IRUs or lease fiber where available. This approach would reduce start costs. NG-KIH would build fiber where no IRUs are available (either because of scarcity or because of refusal of fiber owners to provide IRUs).

This approach is not without hurdles. Most notably, it would require unencumbered IRUs—that allow NG-KIH to lease fiber. These are not currently offered, but are necessary in order that NG-KIH attain its goals and objectives to increase availability and decrease costs of services to businesses and residences in the Commonwealth. We also note that leasing fiber does not increase fiber availability, so it would be less effective in increasing capacity and reducing costs than an alternative in which new fiber capacity is built. Thus we would recommend this approach only as a stop-gap measure.

7 Technical Architecture and System-Level Design

7.1 Technical architecture

Drawing on the requirements of the NG-KIH leadership, stakeholders, potential private partners, and end users, as well as the funding that will be available through the business models we developed for this initiative, CTC developed a technical architecture for NG-KIH. We envision that NG-KIH will be a portion of the statewide network solution for community anchor institutions (CAI). The full solution will include the some of the existing networks, as well as middle-mile and last-mile solutions from other initiatives and private partners.

This architecture was developed based on discussions with stakeholders, CIOs, State and higher education network architects, network electronics manufacturers, and our review of the private partner RFI responses.

We have defined a middle-mile and community anchor network, with fiber and electronics focused on providing lit capacity for community anchors and providing wholesale dark fiber capacity to others. This is a scalable infrastructure using leading-edge technologies and leveraging lessons learned from other public and private sector middle-mile deployments.

7.1.1 Open access

The network needs to be an open access network, providing capacity for a wide range of diverse service providers to offer retail services over the network and a means for providers to access the network. An open access requirement is necessary to attain the goals of the network while limiting the role of the Commonwealth and NG-KIH to facilitator, not service provider. Open access creates a framework for partnership with private providers and municipal utilities; and promotes and enables competition.

The architecture described below supports open access in several ways:

1. Availability of fiber for lease or sale
2. Ability to collocate equipment at hub sites
3. Ability to provide lit services on wholesale basis – including wavelengths, layer 2 services
4. Ability to provide access at hub sites to bulk Internet service

7.1.2 Outside plant

Outside plant is the longest lived part of the infrastructure; for financial accounting purposes, fiber typically has a lifetime of 20 years—but in reality, its lifespan is typically significantly longer. It is also the costliest part of the network to upgrade after the network is built.

Fiber is at the center of NG-KIH's ability to increase capacity and the Commonwealth's long-term control of costs, so NG-KIH needs to have plentiful fiber that is reliable, accessible, and well-located.

As discussed in Section 5, we recommend that a single party be responsible for management and operation of all the fiber that is built, even if the revenue model is regionalized. This approach will reduce the complexity of managing the fiber because, for example, there will be no confusion as to who is responsible for fixing a break or a fault. A single management entity also reduces costs because there is not duplication of staff, equipment, or contracts.

Fiber should be built according to industry standards (e.g., Telcordia, BICSI, Society of Cable Television Engineers (SCTE)). There should be diverse physical paths for all main backbone routes. Ideally, only laterals to sites would be collapsed into single routes, and key sites such as data centers would have dual paths from building to backbone. Each aggregation site should be connected to two separate core sites over the backbone fiber.

If there are components of the outside plant that are obtained through leasing or an IRU, those routes need to be managed by the fiber owner under a service level agreement (SLA). The Commonwealth should know the exact routes, audit them through physical inspection, and document the routes and fiber for the Commonwealth and the operations and maintenance contractor.

Aerial fiber should be used where it creates an opportunity to minimize costs. It should be strand mounted so that additional fiber can be added, and in order to support the recommended fiber count.

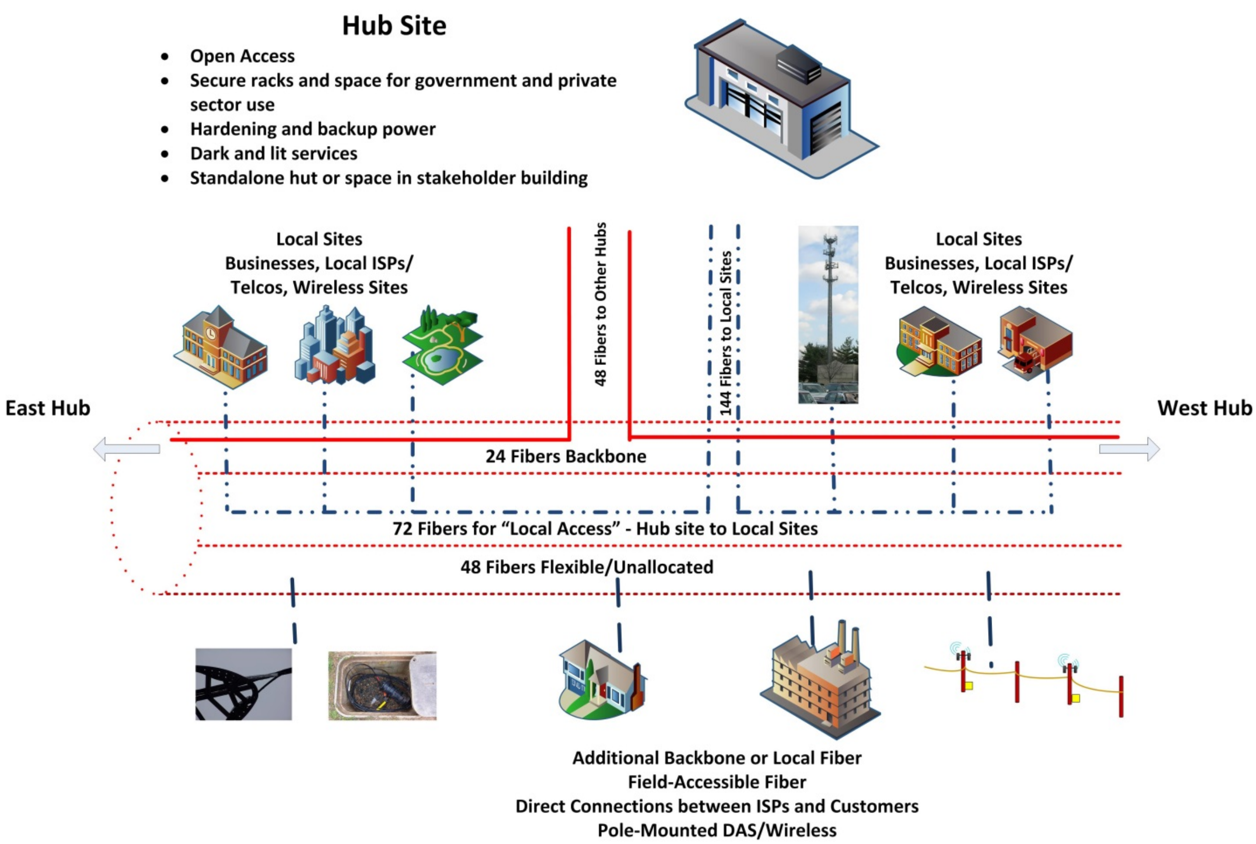
In areas where the fiber is installed underground, construction should include two 2" conduit and a minimum of 144-count (288-count over major routes in metro areas and along the primary backbone). ITU-T G.652.D-compliant fiber should be used; this specification is suitable for long distances and the network's foreseeable bandwidth needs (including DWDM).

Fiber should be designed to be accessible at core and aggregation site locations and in the field (at splice enclosures and at mid-sheath splices). We further recommend that entities meeting fiber in the field should be required to place their splice enclosure in a nearby cabinet, vault, or enclosure, and that NG-KIH will run cable to that splice enclosure.

In terms of allocation between backbone, local, and flexible use (Figure 14), we recommend a consistent allocation of fiber so that there is sufficient fiber for all uses. In our design, backbone fiber runs from aggregation hub to aggregation hub. Local fiber runs from an aggregation hub to a site within the local area. Flexible-use fiber can be assigned to any category, including fiber that may begin and end in the outside plant and not enter the aggregation hub—as when a provider or customer connects to the fiber only at outdoor splice enclosures.

Lateral fiber to sites should be a minimum of 48-count to enable flexibility in services to the site and enable multiple sites to be connected over a lateral. This count should be increased in high density areas where there may be many sites or future sites in close proximity to each other.

Figure 14: Fiber Allocation



7.1.3 Hub facilities

For core and aggregation sites, we recommend either a secure space in a robust facility or a prefabricated, concrete communications equipment shelter. The shelter is the recommended option because it provides consistency in access, security and configuration.

Some savings may be available using a space in a building, especially in areas where land costs are high and space is limited, or where zoning prohibits a small standalone building. If an indoor space is used, however, it must have the same characteristics and space as the shelter.

The shelter should be constructed of steel-reinforced concrete and designed to be vandal resistant. The shelter should be designed specifically to house network electronics, providing climate control, physical protection from weather elements, and complete electrical power supply and backup electrical generation systems.

The installed shelter and related subcomponents shall meet the minimum specifications listed in Appendix F.

7.1.4 User site standards and power

In general, electronics will be provided for service at user sites, and other NG-KIH sites will not depend on continuity at that site—therefore NG-KIH does not need to take an active role in hardening those facilities.

Electronics at user sites should be secured and have reliable power, both to protect the service to the site and for security of the network against unauthorized access. At a minimum, the following security measures should be in place for all segments:

- Locked equipment racks should be utilized to house all equipment;
- Controlled access to rooms containing equipment;
- Proper environmental conditions will be maintained, with monitoring systems in place to provide notification in the event that conditions approach levels that could result in unpredictable or unreliable operation;
- All network devices should be continuously monitored, and all management communications traffic will be carried in separate channels from other network traffic;
- All systems should be provided with uninterrupted power supplies (UPS) and electrical power generation; and
- All demarcation points to other networks for shared, layer 3 network segments should occur at a firewall to prevent unauthorized access.

7.1.5 Electronics

The network electronics platform must provide for the network's projected needs over the next five to 10 years. The electronics must:

- Support resilient services ranging from 10 Mbps Ethernet to 100 Gbps Ethernet
- Have a range of survivability—single path to protected DWDM
- Be scalable to upgrade services or reduce or eliminate oversubscription on the backbone
- Be flexible—to rapidly make moves, adds, changes, and remote upgrades
- Support software-defined networking for research applications and future networks
- Have backup power and survivable facilities at key sites

The high-level electronics architecture is illustrated in Figure 15 and Figure 16.

Figure 15: High-Level Electronics Architecture

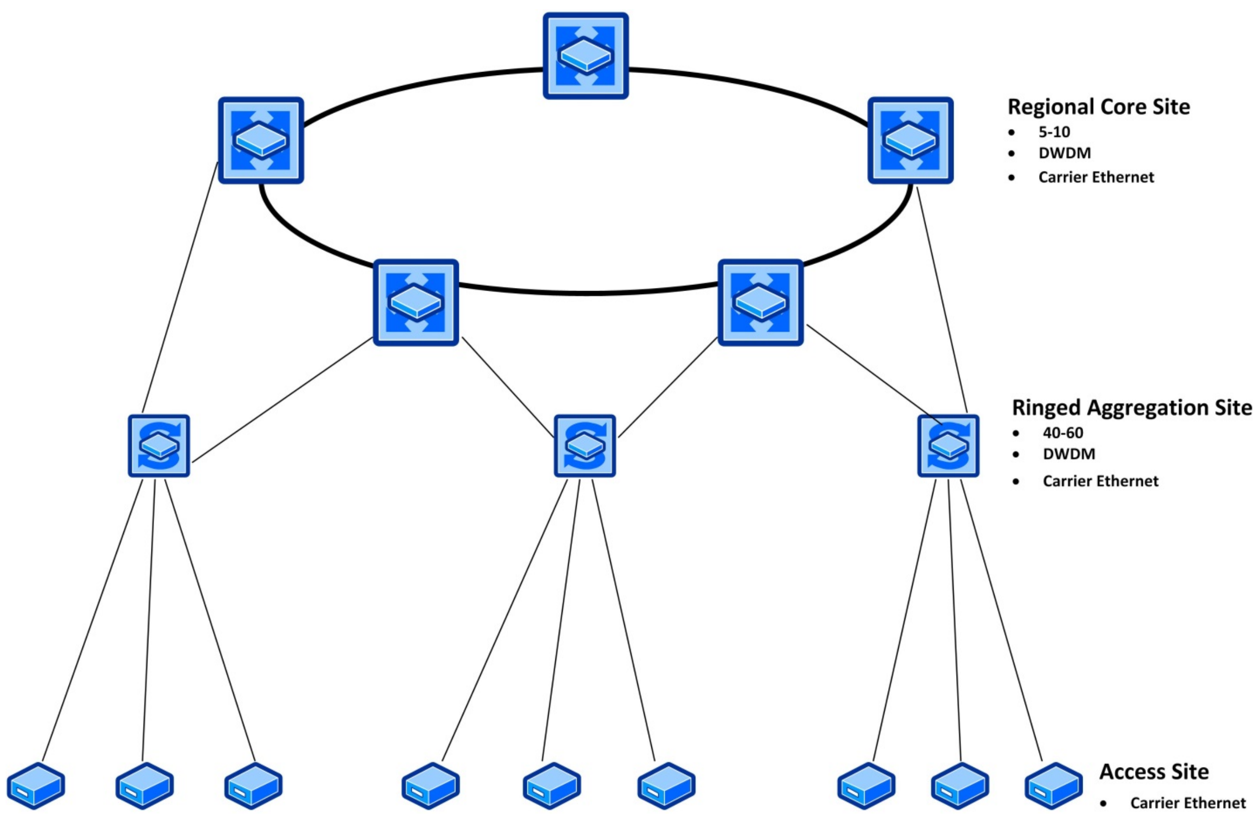
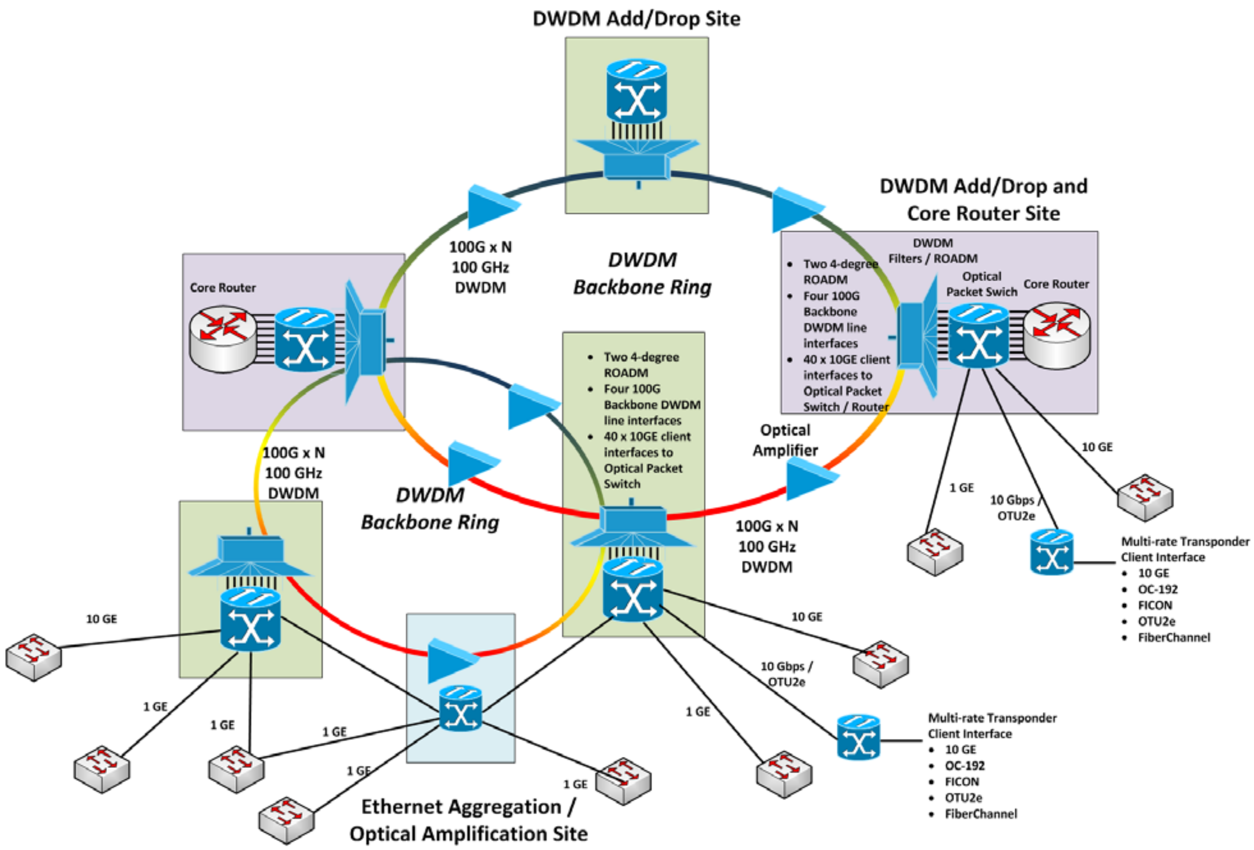


Figure 16 – Electronics Architecture



Backbone and aggregation electronics

Over the backbone there will need to be protected and unprotected DWDM services interconnecting core router DWDM add/drop sites (locations of core routers and Internet peering points) and Ethernet aggregation hubs (located approximately every 50 to 100 miles).

Core routers are at major interconnection points with outside networks. They enable the network to interface with the Internet and outside networks, as well as provide internal layer 3 service if desired. This architecture assumes the majority of services will be layer 2 services; in the event that demand for layer 3 services grows, we recommend provider-edge routers be located at the aggregation sites to reduce the distances packets need to travel for routing.

The DWDM layer will provide DWDM transport between large user sites and will aggregate layer 2 services from other sites. The majority of interface with NG-KIH user sites is Ethernet using Q-in-Q trunk ports, so that multiple logical layer 2 services can be provided on a single port, and/or a site, agency or stakeholder can maintain its own VLANs transparently.

DWDM devices at primary sites will have:

1) Wave transport available over backbone at 10, 40, and 100 Gbps, and demonstrated roadmap to 400 Gbps and higher speeds in future

2) Standards compliant interfaces at add/drop sites for access to wave services

3) Ability to access DWDM backbone through multiple services
    a. protected end-to-end DWDM service
    b. unprotected end-to- end DWDM service
    c. layer 2 ELAN, ELINE
    d. layer 3 VPN

4) Convergence time less than 50 ms in the event of fiber or optics failure

5) Standards-compliant fault and performance monitoring accessible to the NG-KIH stakeholders

6) Capability to customize services using software defined networking (Openflow)

7) Standards-compliant provisioning and management system, with access by NG-KIH to add, change and delete services and capacity up to the physical limit of the optics

Access network electronics

Additionally, the platform must provide Layer 2 Metro Ethernet services in varying topologies (point-to-point, point-to-multipoint, multipoint-to-multipoint) to meet the individual requirements of each user entity; enable connections to be protected over diverse paths and network electronics; and provide mechanisms for guaranteeing and monitoring service levels and capacity.

One strategy would be to use Multiprotocol Packet Label Switch Transport Profile (MPLS-TP), a specialized MPLS profile designed to provide L2 Ethernet services and one of the leading Metro Ethernet hardware platforms designed for the commercial carrier market. There are many different suitable protocols or approaches that provide the same functionality, and others may be better optimized for the specific vendor and management platform, so this choice should be made by NG-KIH in consultation with the systems integrator. Electronics supporting MPLS-TP require a relatively small physical footprint at distribution sites, can be hardened to operate in a wider range of environmental conditions than typical “enterprise” hardware, and provide full hardware diversity in all distribution and core layer devices.

MPLS-TP is a connection-oriented technology, which allows the network operator to provision static circuits end-to-end rather than providing best-effort or priority queuing in a shared switching infrastructure. This is a key factor in being able to guarantee performance associated with SLAs. MPLS-TP equipment platforms have the ability to support carrier-grade resiliency in the backbone, which is particularly important for public safety traffic—such as the planned nationwide interoperable public safety wireless network (FirstNet) or land mobile radio (LMR) backhaul.

Electronics need to provide:

- Carrier-grade hardware design (NEBS compliance with greater tolerance for environmental variances)
- SONET-like ring support with sub-50 ms convergence (G.8032, RPR, LACP)
- Support for varying services and protocols, such as TDM traffic
- Ethernet Virtual Circuits (EVC), MPLS-TP, and DWDM in the same chassis
- Carrier-grade network management and monitoring technologies, such as ITU Y.1731, and the ability to provide SLA reporting

Aggregation layer electronics need to be connected two other aggregation or core sites in a ring, providing full link redundancy between the distribution layer and the core network. Where distribution sites have partial or fully diverse fiber paths to the core ring, this provides protection against service outages due to fiber cuts.

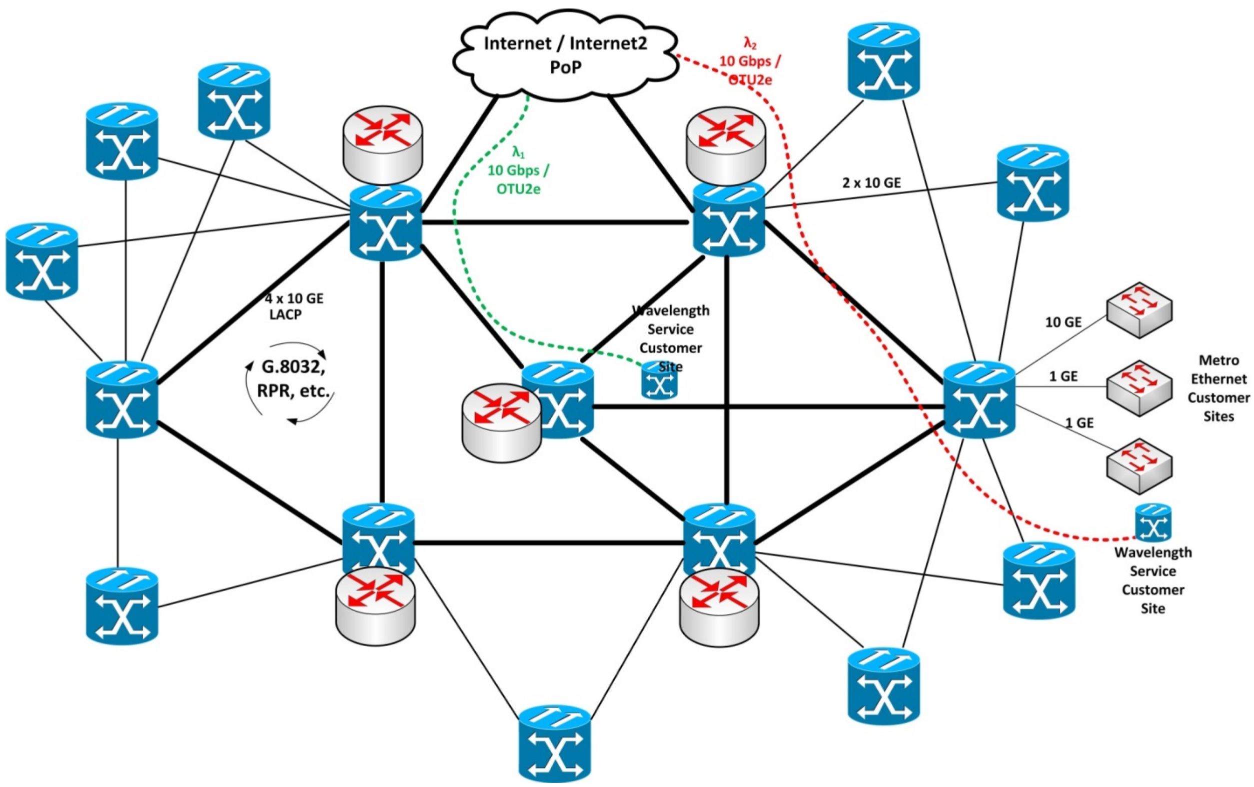
Metro Ethernet services would be provided with Virtual Private Wire Service (VPWS) and Virtual Private LAN Service (VPLS) over MPLS-TP to provide point-to-point and point-to-multipoint Ethernet services, respectively.

To ensure high-availability, aggregation electronics should include redundant fabric and control cards.

Lower-cost equipment and optics (such as edge site devices) should be stocked as spares. 24x7 replacement support should be obtained for the more expensive core and distribution equipment.

Figure 17 illustrates the layer 2 network architecture.

Figure 17 – Ethernet Architecture



7.2 System-level design

The architecture described above is the basis for the NG-KIH system-level design we describe here. We have developed recommended routing and identified electronics and systems that will provide the needed functionality. We have also estimated the capital cost and total cost of ownership, including maintenance and operations, support agreements, and training.

7.2.1 Fiber routes

The statewide network routing was selected using the high-level links planned by the Commonwealth, which had tentatively identified the universities as segment endpoints. Community anchor institutions were identified from site lists provided to us; the lists included Commonwealth government locations, K-12 school district buildings, libraries, higher education institutions (including those connected through KPEN), and KEWS and KET locations. Our lists totaled 1,706 sites.

The model includes a 2,311-mile fiber backbone route, with routing to maximize the number of sites passed, balanced with maintaining an economical number of plant miles. The route was selected based on map study and will require confirmation through field survey and further consultation with KYTC and utility pole owners. Efforts were made to focus on state roads in order to simply permitting. No limited-access highways were used. Almost all of the backbone route is in survivable rings. In addition to the CAIs, the route also connects to the Level(3) POP in Cincinnati, Ohio, just across the river.

The route passes within five miles of 1,306 community anchor locations. Table 40 details the number of sites within varying distances from the route.

Table 40: Proximity of Community Anchor Institutions to Fiber

Distance from Route	Number of CAIs
500 feet	670
0.5 miles	984
1 mile	1,099
2 miles	1,198
3 miles	1,263
5 miles	1,306

As discussed in Section 4, the model includes sites up to three miles from the route. The total lateral mileage is 800 miles.

Based on our field survey and other factors described in Section 2.3, the average cost per mile, pending a detailed survey of all routes and discussions with pole owners and contractors, is $80,000, inclusive of pole engineering, design, make ready, pole replacement, and permitting.

The assumptions underpinning this cost estimate include the following:

- 75 percent aerial and 25 percent underground
- 57.5 percent of poles requiring make ready, with costs ranging from $500 to $2,500
- Splicing at 2-mile intervals for underground, 3-mile intervals for aerial
- 5 percent of poles requiring replacement, at an average cost of $15,000
- One 144-count fiber cable on all routes
- Two 2” conduit on all underground routes

GIS map layers, including the fiber routes and site information, have been provided to the Commonwealth in separate files; for reference, maps of the statewide fiber routing and close-up views of the routes in the Cincinnati, Lexington, and Louisville areas are included in Appendix E.

7.2.2 Electronics

Figure 15 above provides an overview of core, aggregation hub and site electronics. In this model, there are five core sites. Candidate locations include:

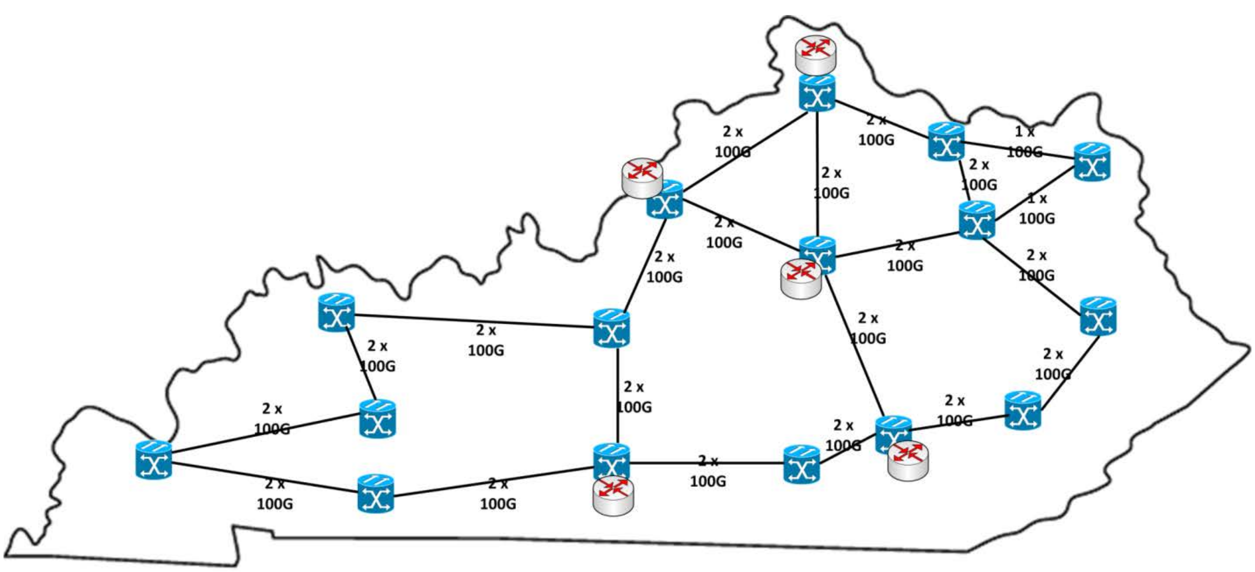
1. Cold Harbor Data Center
2. Florence Data Center
3. Boone National Guard Center
4. University of Kentucky (Internet2 peer)
5. University of Louisville
6. Northern Kentucky University (Internet2 peer)
7. Eastern Kentucky University
8. Western Kentucky University
9. Morehead University
10. Level(3) POP Cincinnati

Core site electronics are located in secure racks in existing data centers or in standalone hub facilities. Core sites provide access to core routers and Internet gateways and provide access to the lit network for private partner networks that peer or interconnect with NG-KIH.

The model has 11 DWDM add/drop sites (in addition to the core sites which each also have DWDM add/drop equipment) located at main junction points of the fiber routes, and in cities along the route. These provide access to the DWDM ring.

Figure 16 illustrates the model DWDM topology.

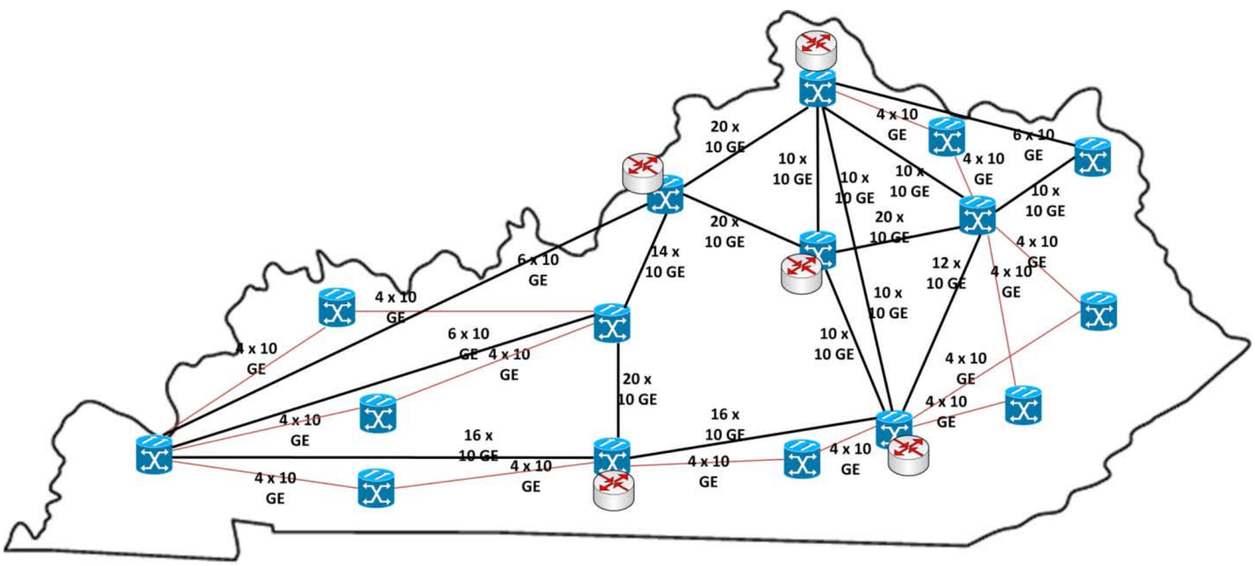
Figure 16: Model DWDM Topology



The model has 16 Ethernet aggregation sites. Aggregation sites provide access to the lit network for private partner networks that interconnect with NG-KIH and interconnect the backbone network with the access network. In other words, these are the "hub" locations where the fiber from a user site connects. They are also capable of hosting DWDM add/drop and core site electronics, although they are not designed to do so initially. Ethernet aggregation is also available at all core and DWDM add/drop sites, for a total of 32 sites.

The Model Ethernet aggregation topology is provided in Figure 17.

Figure 17: Model Ethernet Aggregation Topology



In the model, 1,263 edge sites are connected to the aggregation sites. The routes are collocated with existing fiber up to lateral routes to the site. Distances range from 150 feet to 3 miles with a median of 500 feet and a mean of 3,200 feet. A breakdown by access service and stakeholder entity is provided in Table 41.

For added resilience, any edge site can be dual-homed to two separate aggregation sites. With the exception of the lateral fiber, which is usually less than one mile long, all fiber and optics can be made diverse.

All core sites, DWDM add/drop sites, and Ethernet aggregation sites should be located in dedicated hub buildings or in secure spaces in community anchor facilities.

Table 41: Summary of Proposed Sites and Services by Entity

Entity	Phase 1 Sites (w/in 3 miles of backbone)	100 Mbps	250 Mbps	500 Mbps	1,000 Mbps (1 Gbps)	10,000 Mbps (10 Gbps)	10 G Lambda	Phase 2 sites (further than 3 miles from backbone)	Total Sites
KET	9	-	9	-	-	-	-	7	169
KPEN	58	12	-	-	38	8	-	14	72
KEWS	69	69	-	-	-	-	-	60	129
Library	84	-	-	-	84	-	-	35	119
State	917	915	-	-	2	-	-	278	1,195
K-12	126	53	-	-	52	19	2	49	175
Total	1,263	1,049	9	-	176	27	2	443	1,706

7.2.3 Staging

As discussed above, the financial model is sensitive to assumptions around revenue—so we recommend that the network be deployed in stages. By focusing on first connecting anchor sites, private partners, or service providers that will produce revenue, the Commonwealth will likely ensure that initial stages have sufficient revenue to sustain network operations.

Similarly, we recommend selecting routes where there may be ways to save money in the build—for example, where partners will provide fiber in a swap, where existing communications providers allow NG-KIH to overlash, where there is a guarantee that make ready and pole replacement will be less costly and will not impose delays, or where grant funds may be available to reduce the need to raise capital.

8 Schedule

The schedule presented in this section is for migration to a statewide NG-KIH according to the business plan and technical design in this document. It is an aggressive but achievable schedule with the assumptions below.

The schedule breaks construction into three stages of roughly equal scale. Because it is a high-level schedule, it does not assume particular geographic areas for particular phases. Three phases provide reasonably sized construction and design projects. The plan assumes that each stage is of comparable complexity.

As discussed earlier, given the delay between construction and revenues and the challenge in starting all of the processes, it makes sense, if all other considerations are equal, to start with areas of the state that may be less costly to build and where partners can provide fiber.

Stages should include complete rings, in order that activated sites have path redundancy.

This schedule assumes that funding and financing are available. The plan also does not include time that may be required for legislative or executive approval. The purpose of the schedule is to indicate the key dependencies in the project and the likely duration of the phases, so the time for these less concrete steps need to be added in.

The schedule is presented for two scenarios: 1) a buildout by a concessionaire overseen by the NG-KIH stakeholders and 2) a buildout by the NG-KIH stakeholders and contractors.

In Scenario One, the initial focus is on selecting a concessionaire partner. Upon completion the selection, the partner needs to move quickly to make all necessary arrangements to acquire and build infrastructure, source equipment and contractors, and acquire access to rights of way. This schedule (Figure 18) assumes the selected concessionaire has the scale and capabilities to move quickly, but also does not assume that the concessionaire is already a major operator in Kentucky.

In Scenario Two, the NG-KIH stakeholders need to successfully complete the procurements discussed in Section 6 and hire an FTE team to oversee the contractors. In parallel with the procurements, NG-KIH needs to pursue fiber trades and IRUs, especially for the Stage 1 area.

Detailed design can take place in parallel with negotiations with pole owners and property owners. We assume it starts one month later than negotiations and ends one month later.

We build in four months for permitting, pole design and make ready. Construction begins three months after permitting begins and lasts six months.

Outside plant testing can begin once completed routes are spliced end to end, probably two months before construction ends. It ends one month weeks after construction ends.

QA/QC starts on the make ready start date and ends when site activation ends.

Core/aggregation electronics staging should go in parallel with construction.

Site electronics staging and activation should start three months after construction starts and finish when outside plant testing finishes.

Over the duration of the buildout and transition it will be necessary to operate in a hybrid environment including the current mode of connectivity and NG-KIH. The hybrid environment will need to persist after the buildout for sites that cannot cost-effectively be connected to fiber.

As sites are connected to new network, need to be able to connect immediately to data centers, the Internet and other key locations for the users at the site. The connections to sites on legacy network need to be maintained. Therefore one of the critical path items is data center connectivity to new network—otherwise there is a risk of creating bottlenecks on the lower speed network connections on the legacy network. There needs to be a robust gateway between the legacy network and new network through data centers and potentially other core locations of new network

Figure 18: Scenario One Schedule

ID		Task Name	Duration	Start	Finish	% Complete
1		**Scenario One -- Concessionaire/ equity partner**	**83 days**	**Fri 8/1/14**	**Tue 11/25/14**	**0%**
2		Procurement RFP	44 days	Fri 8/1/14	Wed 10/1/14	0%
3		Negotiations	34 days	Thu 10/2/14	Tue 11/18/14	0%
4		Selection	5 days	Wed 11/19/14	Tue 11/25/14	0%
5		Project planning/ sourcing/ arrangements with pole owners/infrastructure partners/ incumbent/	143 days	Wed 11/26/14	Fri 6/12/15	0%
6		**Stage 1 -- 450 sites**	**381 days**	**Mon 6/15/15**	**Mon 11/28/16**	**0%**
7		Detailed outside plant design	98 days	Mon 6/15/15	Wed 10/28/15	0%
8		Permitting	87 days	Thu 10/29/15	Fri 2/26/16	0%
9		Construction	132 days	Mon 2/29/16	Tue 8/30/16	0%
10		Electronics detailed design and migration plan	98 days	Thu 10/29/15	Mon 3/14/16	0%
11		Electronics integration and migration	22 days	Wed 8/31/16	Thu 9/29/16	0%
12		Testing and verification (regular reporting to NG-KIH)	42 days	Fri 9/30/16	Mon 11/28/16	0%
13		**Stage 2 -- 450 sites**	**381 days**	**Thu 10/29/15**	**Thu 4/13/17**	**0%**
14		Detailed outside plant design	98 days	Thu 10/29/15	Mon 3/14/16	0%
15		Permitting	87 days	Tue 3/15/16	Wed 7/13/16	0%
16		Construction	132 days	Thu 7/14/16	Fri 1/13/17	0%
17		Electronics detailed design and migration	98 days	Tue 3/15/16	Thu 7/28/16	0%
18		Electronics integration and migration	22 days	Mon 1/16/17	Tue 2/14/17	0%
19		Testing and verification (regular reporting to State)	42 days	Wed 2/15/17	Thu 4/13/17	0%
20		**Stage 3 -- 450 sites**	**381 days**	**Tue 3/15/16**	**Tue 8/29/17**	**0%**
21		Detailed outside plant design	98 days	Tue 3/15/16	Thu 7/28/16	0%
22		Permitting	87 days	Fri 7/29/16	Mon 11/28/16	0%
23		Construction	132 days	Tue 11/29/16	Wed 5/31/17	0%
24		Electronics detailed design and migration	98 days	Fri 7/29/16	Tue 12/13/16	0%
25		Electronics integration and migration	22 days	Thu 6/1/17	Fri 6/30/17	0%
26		Testing and verification (regular reporting to State)	42 days	Mon 7/3/17	Tue 8/29/17	0%

Figure 19: Scenario Two Schedule

ID		Task Name	Duration	Start	Finish	% Complete
1		**Scenario Two -- State build**	**774 days**	**Fri 8/1/14**	**Wed 7/19/17**	**0%**
2		Design/ engineering/ QA procurement	60 days	Fri 8/1/14	Thu 10/23/14	0%
3		Supply and logistics procurement	60 days	Fri 8/15/14	Thu 11/6/14	0%
4		Construction companies – prequalification procurement	60 days	Fri 8/29/14	Thu 11/20/14	0%
5		Electronics supplier procurement	60 days	Fri 9/5/14	Thu 11/27/14	0%
6		Systems integration procurement	60 days	Fri 8/15/14	Thu 11/6/14	0%
7		Operate and manage procurement	60 days	Wed 10/1/14	Tue 12/23/14	0%
8		Marketing and business operations procurement	60 days	Wed 10/1/14	Tue 12/23/14	0%
9		Recruitment and hiring of FTE team	60 days	Fri 8/1/14	Thu 10/23/14	0%
10		Negotiations with infrastructure partners (fiber trades, IRUs)	87 days	Fri 8/1/14	Mon 12/1/14	0%
11		**Stage 1 -- 450 sites**	**507 days**	**Fri 8/1/14**	**Mon 7/11/16**	**0%**
12		Negotiations with pole owners and property owners	132 days	Fri 8/1/14	Mon 2/2/15	0%
13		Detailed outside plant design	132 days	Tue 2/3/15	Wed 8/5/15	0%
14		Permitting	87 days	Thu 8/6/15	Fri 12/4/15	0%
15		Pole design and make ready	87 days	Thu 8/6/15	Fri 12/4/15	0%
16		Construction	132 days	Mon 12/7/15	Tue 6/7/16	0%
17		QA/QC oversight	154 days	Mon 12/7/15	Thu 7/7/16	0%
18		Outside plant testing	132 days	Wed 1/6/16	Thu 7/7/16	0%
19		Core/ aggregation electronics staging	132 days	Fri 1/8/16	Mon 7/11/16	0%
20		Site electronics staging	110 days	Tue 2/9/16	Mon 7/11/16	0%
21		Site activation	110 days	Tue 2/9/16	Mon 7/11/16	0%
22		**Stage 2 -- 450 sites**	**643 days**	**Fri 8/1/14**	**Tue 1/17/17**	**0%**
23		Negotiations with pole owners and property owners	132 days	Fri 8/1/14	Mon 2/2/15	0%
24		Detailed outside plant design	132 days	Thu 8/6/15	Fri 2/5/16	0%
25		Permitting	87 days	Mon 2/8/16	Tue 6/7/16	0%
26		Pole design and make ready	87 days	Mon 2/8/16	Tue 6/7/16	0%
27		Construction	132 days	Wed 6/8/16	Thu 12/8/16	0%
28		QA/QC oversight	160 days	Wed 6/8/16	Tue 1/17/17	0%
29		Outside plant testing	132 days	Fri 7/8/16	Mon 1/9/17	0%
30		Core/ aggregation electronics staging	132 days	Wed 7/13/16	Thu 1/12/17	0%
31		Site electronics staging	110 days	Fri 8/12/16	Thu 1/12/17	0%
32		Site activation	110 days	Fri 8/12/16	Thu 1/12/17	0%
33		**Stage 3 -- 450 sites**	**774 days**	**Fri 8/1/14**	**Wed 7/19/17**	**0%**
34		Negotiations with pole owners and property owners	132 days	Fri 8/1/14	Mon 2/2/15	0%
35		Detailed outside plant design	132 days	Mon 2/8/16	Tue 8/9/16	0%
36		Permitting	87 days	Wed 8/10/16	Thu 12/8/16	0%
37		Pole design and make ready	87 days	Wed 8/10/16	Thu 12/8/16	0%
38		Construction	132 days	Fri 12/9/16	Mon 6/12/17	0%
39		QA/QC oversight	484 days	Mon 3/2/15	Thu 1/5/17	0%
40		Outside plant testing	133 days	Mon 1/9/17	Wed 7/12/17	0%
41		Core/ aggregation electronics staging	132 days	Tue 1/17/17	Wed 7/19/17	0%
42		Site electronics staging	110 days	Thu 2/16/17	Wed 7/19/17	0%
43		Site activation	110 days	Thu 2/16/17	Wed 7/19/17	0%

Appendix A: Project Charter

PROJECT CHARTER

MAY 2, 2014

Project Purpose and Background Information

Purpose - This charter documents the common understanding among the Next Generation Kentucky Information Highway (NG-KIH) initiative leadership team, the Commonwealth project team and CTC Technology and Energy surrounding the purpose and management of planning and consulting services for the NG-KIH. The contents of this charter will also serve as a blueprint for monitoring the major business parameters of the planning and consulting project and as an executive summary that will be shared with all project stakeholders.

The purpose of this project is to develop a Commonwealth High Speed, High Capacity Fiber Optic Infrastructure planning document. The planning document will provide recommendations for governance, develop public/private partnership options, recommend a business model, develop a technical architecture and develop a migration plan to a next generation network.

This charter was developed and agreed upon through the collaborative efforts of the NG-KIH initiative leadership team outlined in Section 2 and CTC Technology and Energy.

Background – The NG-KIH was initiated by Governor Beshear, Congressmen Rogers, executive leadership that represent institutional users of broadband in the Commonwealth, including the Center for Rural Development (CRD), public safety, higher educational institutions, K-12, and economic development.

With the support of the Finance and Administration Cabinet's Office of the Secretary the cabinet staff worked with the initiative's leadership team to develop a competitive solicitation in the winter of 2013 that resulted in a contract being awarded to CTC Technology and Energy (CTC) on March 14, 2014. This company is located in Kensington, Maryland. It focuses on the public sector and has completed similar support for the State of Maryland Inter-County Broadband Network, the District of Columbia, Los Angeles Department of Water and Power, the City of Seattle, Tennessee Valley Public Power Association, the KINBER statewide network in Pennsylvania, UC2B Urbana Champaign Big Broadband and other major cities, counties and municipal utilities. More information about CTC is available at the following website:

http://www.ctcnet.us

General Project Information, Initiative Leadership and Stakeholder Overview

Project Name: NG-KIH Planning and Consulting

Controlling Authority: Mary Lassiter**,** Secretary of the Governor's Executive Cabinet

Commonwealth Project Manager: Mike Hayden

CTC Project Manager: Tom Asp

The project support team for this initiative is staffed by employees from the FAC and COT. This team will work at the direction of the Commonwealth's Project Manager to prepare project related communications, assist in training/interviews and perform other project administration duties.

NG-KIH Initiative Leadership Team:

- **FAC** – Secretary Lori Flanery & Deputy Secretary Steve Rucker
- **CRD** – Lonnie Lawson (Larry Combs)

- **Council for Postsecondary Education (CPE)** – Al Lind
- **Kentucky Department for Education (KDE)** – David Couch

Oversight for the planning and consulting project, which will lead to a final report, is restricted to the three month period of the engagement with CTC. The Commonwealth's project manager is responsible for the management of this engagement. Any decisions which are required or will impact deliverables by CTC or acceptance thereof will be communicated by the Commonwealth's Project Manager who acts as the representative of the KG- KIH Initiative Leadership team and its stakeholders. All deliverables will be provided to the Project Manager.

Major Stakeholders: This group includes all Executive Agency Cabinet Secretaries and the following or their designate:

- Initiative Sponsors: Governor Steve Beshear and Congressman Hal Rogers
- Governor's Executive Cabinet – All Cabinet Secretaries
    - Key Cabinets include:
        - Economic Development
        - Education and Workforce Development
        - Finance and Administration
        - Justice and Public Safety
        - Health and Family Services
        - Transportation
- Center for Rural Development – Lonnie Lawson
- Higher Education – Al Lind
- K-12 – David Couch
- KCTCS – Michael McCall
- Public Safety (FirstNet) – Derek Nesselrode
- KET – Shae Hopkins
- Commercial Mobile Radio Service Emergency Telecommunications Board – Joe Barrows

Other Stakeholders:

- Office of the State Budget Director - Jane Driskell and John Hicks
- Commonwealth Chief Information Officer (CIO) – James (Jim) Fowler
- Office of Procurement Services - Don Speer
- Local Government - Tony Wilder
- Department of Military Affairs – Major General Edward W. Tonini, Adjutant General
- Kentucky Commission on Military Affairs – COL (R) David E. Thompson
- Private Colleges – Steve Dooley
- Kentucky's Businesses and Citizens

- (Potential) Commonwealth Vendor and Infrastructure Community – IT consulting firms (system integrators), networking equipment manufacturers and telecommunications, cable and utility companies

Business Rationale, Goals and Project Timing

The **business rationale** and parameters for conducting this assessment includes:

- Assurance of Objectivity - Obtain an objective third-party assessment and recommendations free from internal bias or influence
- Increase options for reliable high speed, high capacity middle-mile network connectivity, which, stakeholders report, are lacking in many parts of the state
- Increase competition - Even where high speed middle-mile services are available, such as in the Golden Triangle area, stakeholders report insufficient competition and capacity relative to other major markets in the U.S., resulting in high prices and lack of opportunities to obtain high-end services, such as leased fiber
- Improve service availability and reduce delays in service connectivity - Commonwealth cabinets and educational institutions report high capacity service is not available state-wide and also report long delays in service connection under the current wide area network services arrangement
- Meet growing needs for broadband connectivity by important institutions delivering services, such as government, education, and medical providers
- Meet need for public safety to operate the FirstNet mobile broadband network
- Reduce costs and barriers of entry for rural service providers to connect their networks to the Internet backbone
- Determine and focus needs for broadband connectivity through stakeholder interviews
- Establishing a sound foundation for directing and operating the network by obtaining best practices and recommendations for governance from an objective outside view
- Generate and adopt technical best practices and recommendations to determine how best to serve stakeholder functional needs, apportion limited funds, establish a realistic schedule, and identify participants to build and operate the network
- Generate a business plan to determine feasibility and sustainability of the network, and the conditions that will minimize risk and increase the likelihood of success
- Identify and objectively evaluate potential partners to take advantage of the many benefits to a public-private partnership in building and operating the network

Long-term **goals** include:

- Securing cost-effective Internet bandwidth statewide
- Enabling broadband connectivity to economically depressed areas, thereby creating new job opportunities to these communities
- Improved rural broadband connectivity by enabling cost-effective network backbone services to remote areas and opening them to investment and competition
- Creation of a public safety and emergency response network (i.e., FirstNet) to link law enforcement, homeland security and first responders

- Additional capacity for long-term public and private use
- Optimizing public sector communications over dedicated Intranet bandwidth
- Expanded use of telemedicine applications by hospitals and healthcare providers
- Increased monitoring capabilities including real-time video monitoring of critical infrastructure such as bridges, roads and power plants
- Enhanced online learning opportunities
- Enhanced connectivity for libraries and communities
- Promoting economic development by helping the private sector improve broadband connectivity, making it more desirable to locate companies in Kentucky
- Supporting collaborative opportunities across and among the public and private sectors
- Enhancing research opportunities
- Maximizing shared services opportunities (clinical systems, advanced engineering systems, shared eLearning environments)

The **timing** of this assessment will make it possible to begin the procurement in July 2014, complete the selection process in the third quarter of 2014, and target a construction start in 2014. All of these activities are to enable substantial construction to take place in 2015 and 2016.

Assessment Approach and Methodology

The following is an outline of the approach that CTC will use to develop the recommendations and create the final assessment recommendations. Weekly status reports will be provided to the Commonwealth Project Manager. A monthly progress report will be provided to the Initiative Leadership Team.

a) Project Initiation

- Vendor Orientation and Executive Leadership Interviews
- Develop Project Charter
- Develop Project Implementation Plan
- Develop Data Collection Templates

b) Business Assessment Data Gathering Analysis and Recommendations

- Conduct Infrastructure Assessments
- Develop Current State—Spend Analysis and Financial Assessment
- Prepare Future Network Financial Model
- Develop Public/Private Partnership Options and Recommendations
- Develop Governance and Leadership Oversight Model
- Develop Sourcing and Rollout Strategy, Including Sustainability

c) Technical Assessment—Deployment and Operational Recommendations

- Conduct Stakeholder Interviews and Analysis
- Develop Technical Architecture and Deployment Recommendations
- Develop a Migration Plan
- Develop a Recommended Organizational Model, Roles and Responsibilities

d) Final Report and Executive and Major Stakeholder Presentations

- Prepare Final Report—Draft
- Prepare Final Report
- Present to Executive Leadership and Major Stakeholders

e) Project Close-Out

- Turn-Over of All Interview Results and Project Artifacts

Project Phases/Tasks and Major Timeframes

The major project milestones and target dates for the Commonwealth include:

- Conduct the Project Kickoff Session 03/28/14
- Complete Data Collection Forms 04/18/14
- Complete the Project Charter 05/02/14
- Complete the RFI Assessment / Summary 05/23/14
- Complete Stakeholder Interviews 05/30/14
- Complete the Infrastructure Assessment 05/30/14
- Submit the First Draft of the Report 06/13/14
- NG-KIH governance group provides comments to CTC 06/23/14
- CTC Presents to Executive Leadership and Major Stakeholders 06/27/14
- Submit Final Report 07/07/14

Project Scope and Supplemental Data Sources

The project scope is defined in the RFP and in the proposal by CTC. The scope includes at least 12 in-person and at least 24 telephone stakeholder discussions. Data will be collected from discussions, follow-up submittal by stakeholders, and research of publicly available information. Data gathering will be done both using the data collection templates and through less formal guided discussions led by the consultant, depending on what is appropriate for setting and the participants.

Project Funding

The fixed cost for this project is $173,000. It is possible that additional tasks beyond the current scope may be required, such as environmental assessment and assistance in carrying out the recommendations in the study. The contract with CTC provides for procuring out of scope items on a time and materials basis, and a follow-on budget of $82,000 has been authorized.

Assumptions and Risks

The project assumes that the NG-KIH initiative Leadership Team will obtain agreement among the participating Cabinet Secretaries to review and act on the recommendations. It also assumes that the successor governance committee will be established and provide guidance, oversight, resources and funding to carry out the recommendations agreed upon from this project.

The project is on a tight schedule. It relies on the availability and cooperation of stakeholders including Commonwealth Cabinet leadership and Commonwealth staff with the appropriate technical knowledge. It relies on Commonwealth and other institutional stakeholders providing accurate and complete information about existing infrastructure, services, costs, contracts, and needs.

There is moderate project risk, because achieving progress on schedule relies on timely participation and cooperation from non-Commonwealth infrastructure providers such as telecommunications companies, municipal utilities, wireless providers and Internet service providers. The infrastructure providers will be asked indicate their level of interest in using the network, the conditions and costs, and their willingness to provide pole attachment rights.

It will not be possible with the available time and resources to directly reach all potential users, such as individual telecommunications companies, cities, counties, and school districts. This project relies on the RFI process, as well as contacts with associations of these types of users to reach those users and obtain the needed information. There is therefore risk that information will not be timely or complete, or that the project schedule will not allow for sufficient time for the associations to gather the information.

The risks can be reduced with sufficient prioritization of the critical stakeholders, and time allocated for individuals in COT to contact stakeholders, schedule meetings, and if necessary, follow up with them. Furthermore, it may be necessary for the initiative’s sponsors to indicate their support at critical points in the project, if stakeholders or infrastructure providers are not responsive.

Risks regarding the implementation of an eventual network, milestones of network construction, and the sustainability of a network will be analyzed and discussed in the study resulting from this assessment, and are outside the scope of this charter.

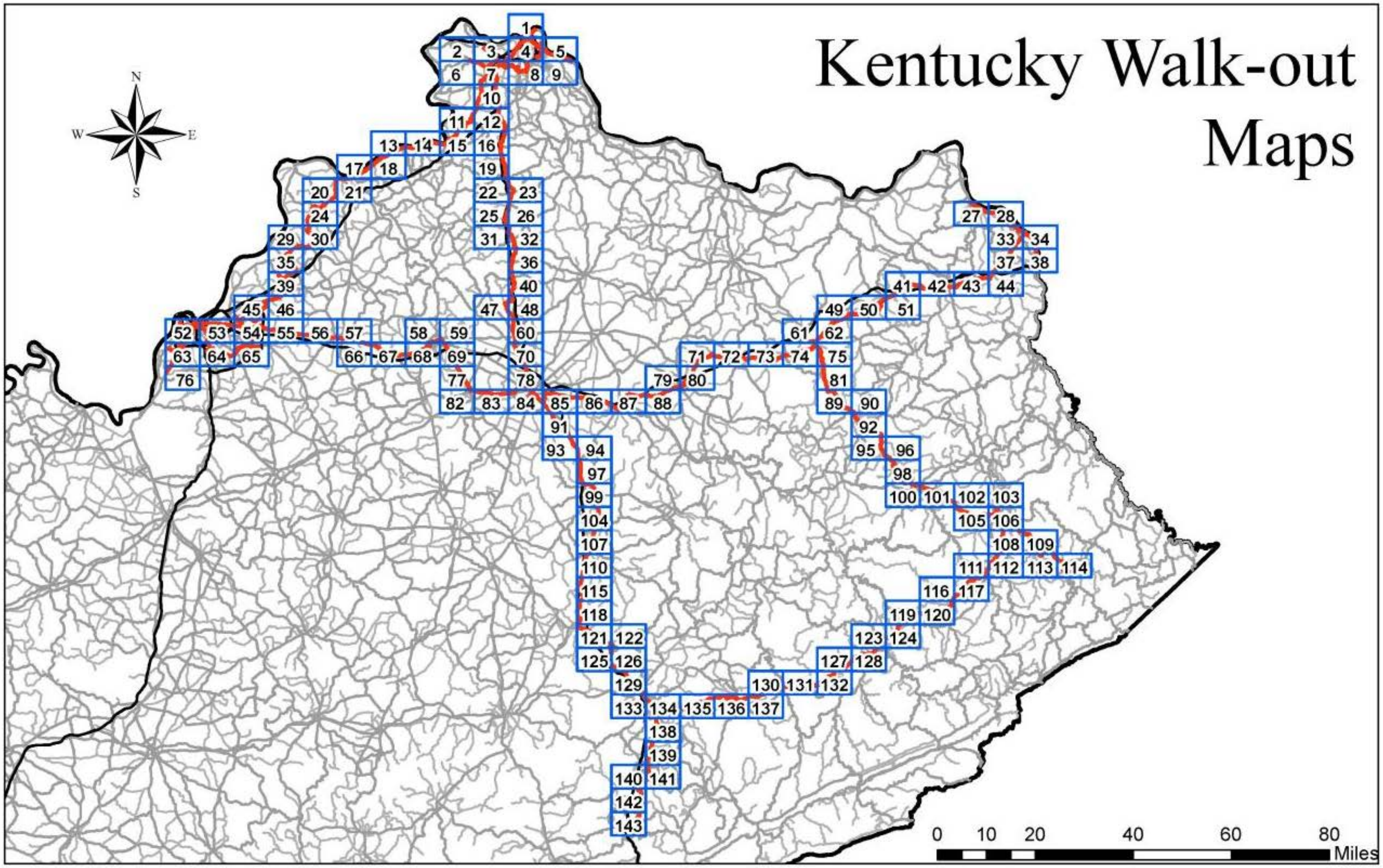
Approval Signatures

Name/Title:	***Cabinet/Agency:***	***Date:***
Mary Lassiter, Secretary	Governor's Executive Cabinet	
Lori Flanery, Secretary	Finance and Administration Cabinet	
Deputy Secretary, Steve Rucker	Finance and Administration Cabinet	
Lonnie Lawson, President & CEO	Center for Rural Development	
Al Lind, Vice President	Council for Post Secondary Education	
David Couch, Associate Commissioner	Kentucky Department for Education	
Mike Hayden, Project Manager	Finance and Administration Cabinet	
Joanne Hovis, Esq., President	CTC Technology and Energy	

Appendix B: Site List

Because of the size of the list and the need to preserve the ability to sort the data, the complete site list is contained in a companion Excel spreadsheet.

Appendix C: Field Survey Route



Appendix D: Photos of Sample Poles and Make Ready Needs

Figure 20: Sample Photos of Make Ready Need—Clearance to Power and Surface Congestion

Figure 21: Sample Photos of Make Ready Need—Poles far from Roadway and Brush Cutting

Figure 22: Sample Photos of Make Ready Need—Line in Forest and on Hill

Figure 23: Sample Photo of Make Ready Need—Pole Twisted and Bent, Clearance of Utilities

Appendix E: Route Maps

The maps below illustrate the fiber routes:

1. Statewide map
2. Cincinnati area
3. Lexington area
4. Louisville area

Figure 24: Map of Statewide Route

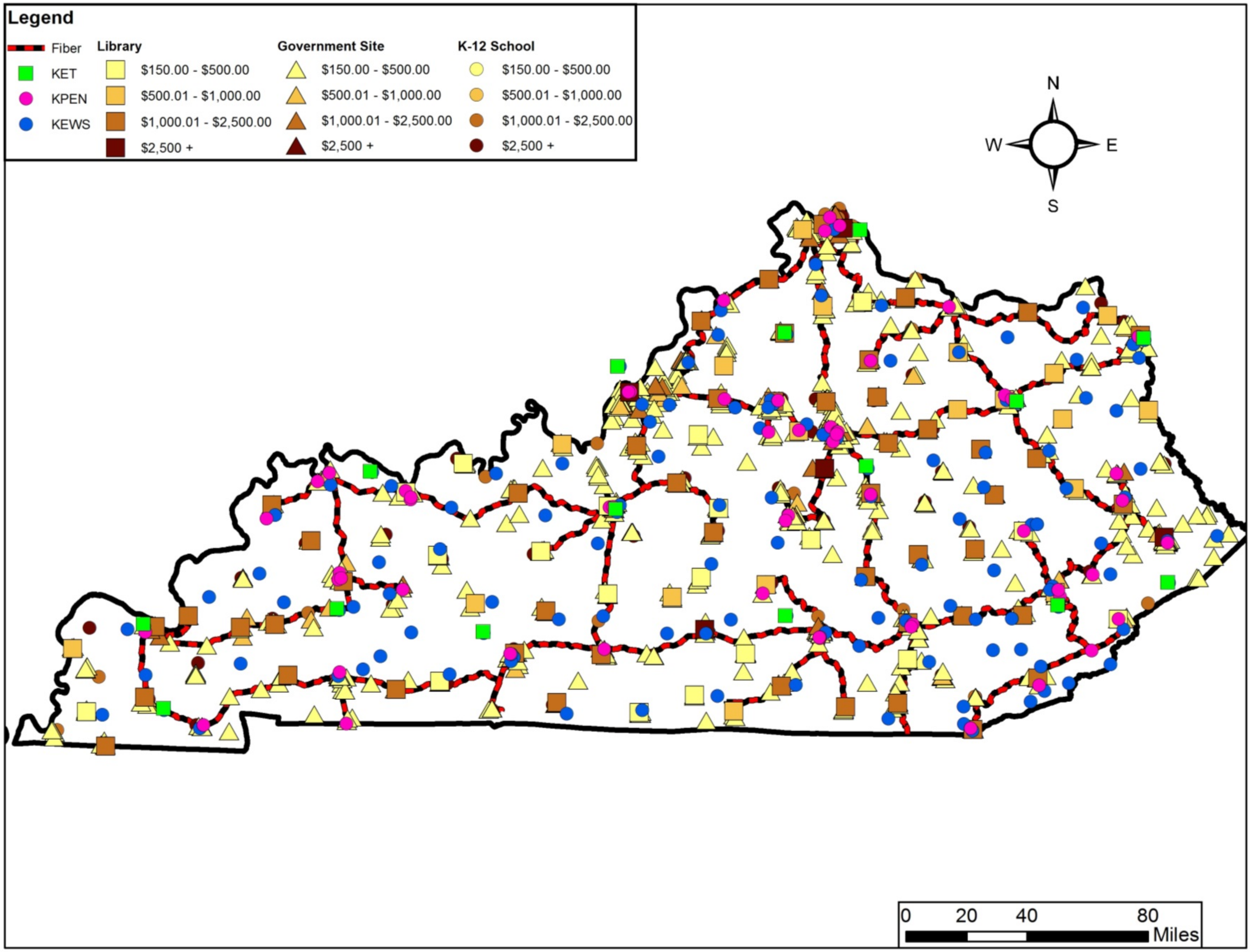


Figure 25: Map of Cincinnati Area Route

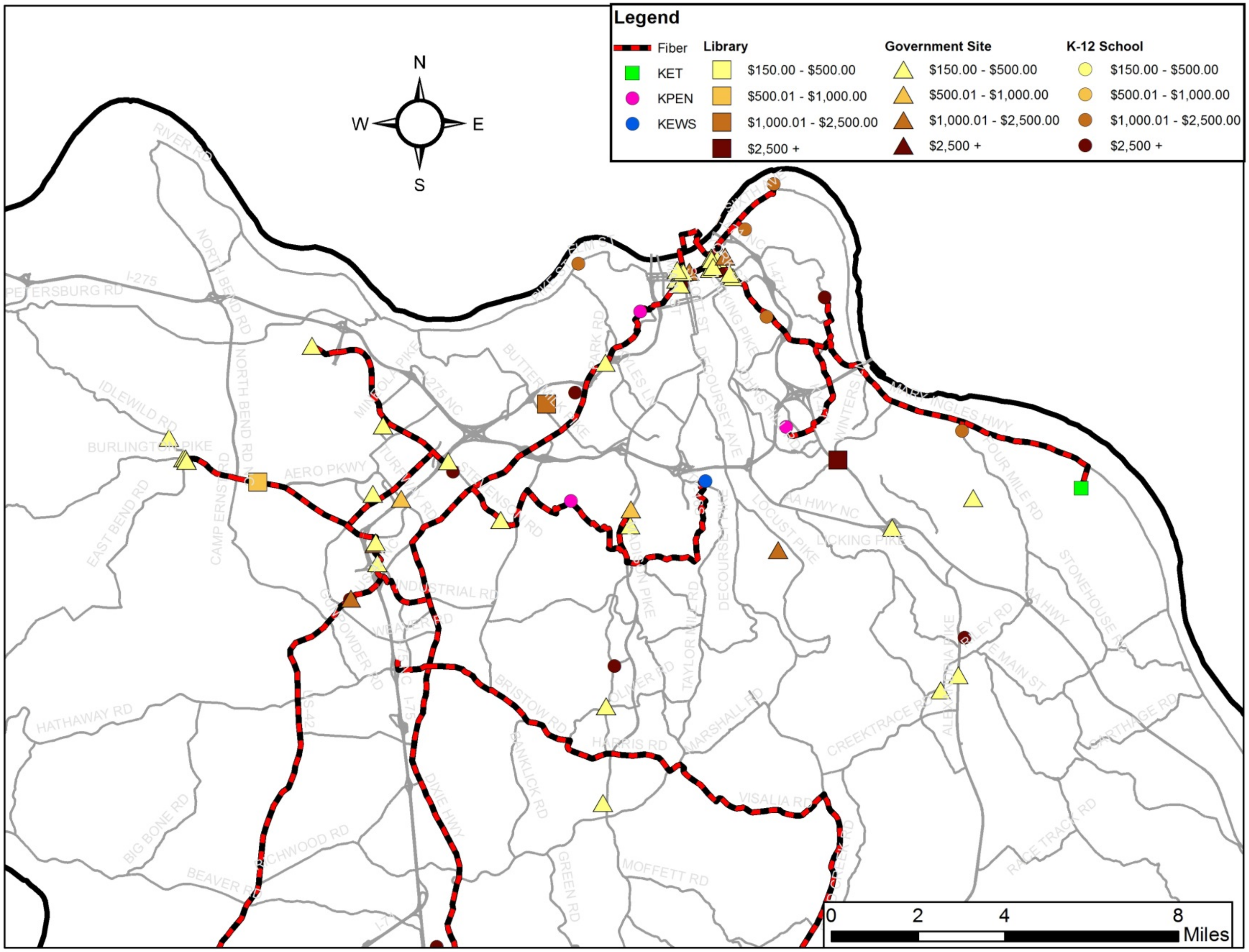


Figure 26: Map of Lexington Area Route

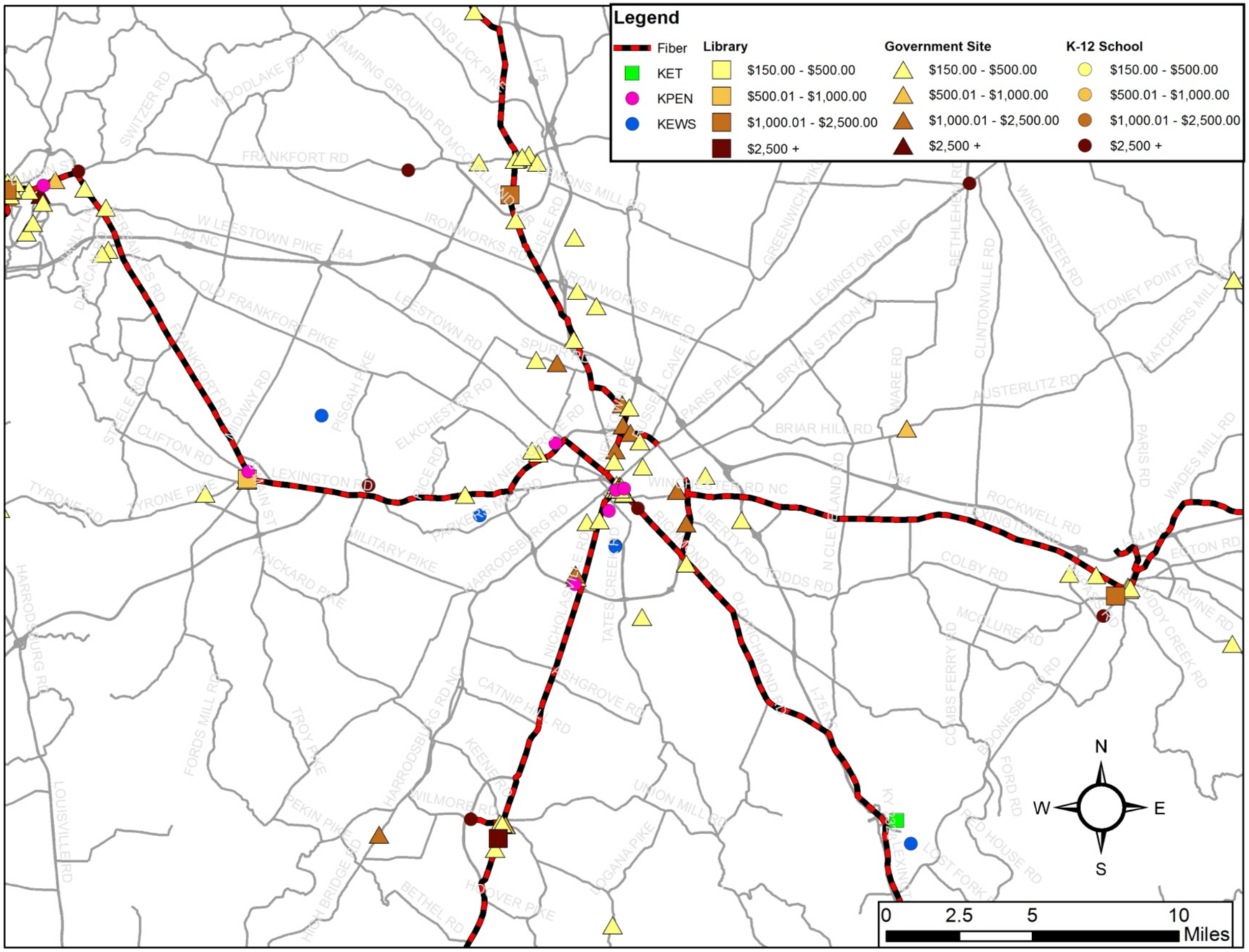
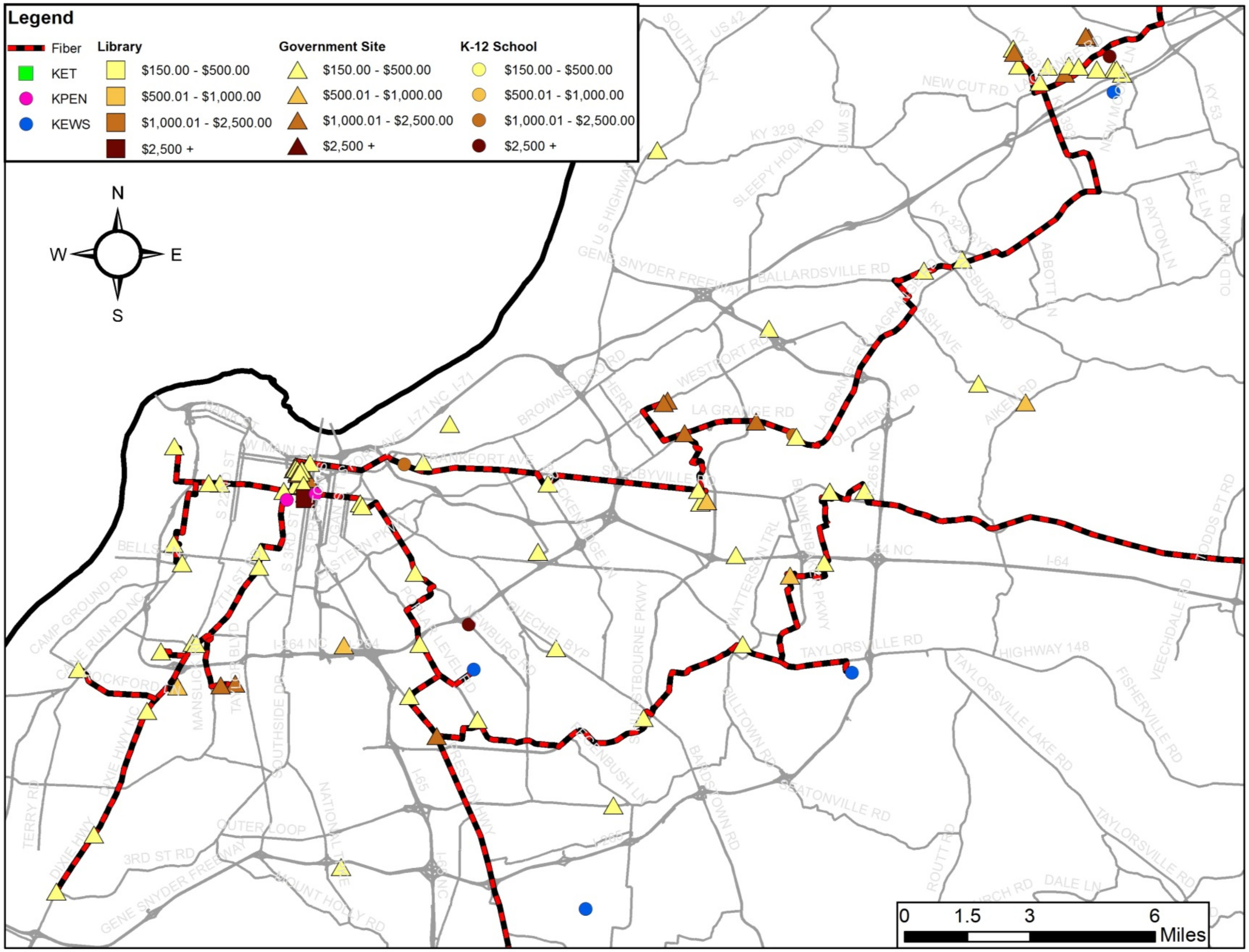


Figure 27: Map of Louisville Area Route



Appendix F: Specifications for Network Shelters

The installed shelters and related subcomponents shall meet these minimum specifications:

- Compliance with national and local code
    - Interior dimensions of at least 10 feet (width) x 12 feet (length) x 10 feet (height)
    - Structural walls and ceiling components consisting of precast, minimum 5000 PSI, steel reinforced concrete
    - Support a floor equipment load of minimum 500 PSF
    - Support a roof live load of 100 PSF
    - Building code-recognized fire rated for 2 hours
    - Withstand wind speeds of 150 MPH when secured to proper foundation
    - Bullet resistance per UL752, Level 4 (.30-06 at 15 feet)
    - Foundation comprised of a level, concrete pad with steel reinforcement
    - Two underground cable entry points for communications cable shall be provided, each equipped to support two 2-inch conduits

- Interior finishing and cable accessory specifications:
    - One wall-mounted, painted plywood board (4 ft. x 4 ft. x ¾-inch thick) for telecommunications and other wall-mounted equipment
    - Cable ladders having a width of 12-inches and a total length of approximately 22 feet ceiling/wall mounted to provide 8 feet of clearance to the floor

- Cooling and heating system specifications:
    - Two 5-ton (redundant), self-contained HVAC units with 5 kW heat strips be wall-mounted to the shelter, designed to be weather-proof, rodent-proof, and tamper-proof
    - Each HVAC unit fed from separate circuit breakers in the main distribution panel

- Electrical system specifications:
    - Main distribution load center providing a minimum of 20 positions, consisting of the main distribution panel, breakers, lug box, and related components for 200A, 120/240v, single phase electrical service
    - UL 1449 Type 1 SAD/MOV surge protection
    - Minimum of four duplex, 20 Amp wall-mounted receptacles
    - 35 kW diesel electrical generator
        - Minimum 140 gallon sub-base fuel tank
        - Automatic transfer switch

- Lighting specifications:
    - 4-foot, two bulb fluorescent fixtures with acrylic lens covers (minimum four)
    - 150 watt exterior lighting fixture with photo-cell and motion sensor control

- Alarms and fire protection systems:
  - The shelter shall equipped with the following alarms:
    - High Temperature
    - Low Temperature
    - Generator
    - Air conditioner failure
    - Primary power failure
    - Door opened/closed
    - Fire and Smoke Alarm
  - Inert gas fire suppression system (FM-200, or equivalent)

Appendix G: Pro Forma Financial Statements

Attached here are network financial statements for the fiber enterprise. The statements include a complete table of the assumptions on which the calculations are based. We have also provided Commonwealth staff with a copy of the working spreadsheet used in creating these statements.

Contents:

1. Income Statements
2. Cash Flow Statement
3. Capital Additions
4. Expenses
5. Assumptions
6. Cost Assumptions
7. Contract Operation Assumptions
8. Site List

Appendix H: RFI