ctc technology & energy

engineering & business consulting

Broadband Strategic Plan

Prepared for Charles County, Maryland
January 2020

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1 Executive Summary

Over the past several years, Charles County has undertaken an ongoing effort to ensure that all County residents and businesses have access to high-speed, affordable broadband services. The County has successfully reduced its number of unserved homes and businesses in the past few years by working with incumbent providers to expand to unserved locations—but service gaps persist.

The County hired CTC Technology & Energy (CTC) in 2019 to develop a strategic plan to address the remaining needs for broadband in unserved parts of the County. CTC performed the following tasks at the County's direction:

- Identified, at a high level, unserved areas of the County, based on data and maps provided by the County, other public data sets, and desk and field surveys
- Met with key public and private stakeholders to identify broadband needs
- Met with representatives of internet service providers (ISP) operating in the County (or with potential interest to operate in the County) to learn what market forces or County support might lead them to invest in the County
- Prepared a high-level design and cost estimate for a fiber optic network deployment to fill the identified broadband gaps in the County
- Prepared a high-level design and cost estimate for a fixed wireless network deployment that might help fill broadband gaps in the County
- Analyzed a range of federal and state funding opportunities to identify potential sources of grants or loans (to the County or to ISPs) that might support the expansion of broadband services in unserved areas
- Developed a series of potential strategies the County could pursue to leverage federal and state funding to meet its broadband goals

1.1 Project Findings

Most residents of Charles County have access to a mix of internet services, but many locations do not have robust broadband[1] services. For example, while Comcast and Verizon provide

[1] Defined by the Federal Communications Commission as an internet service delivering speeds of 25 Mbps download/3 Mbps upload. ("2018 Broadband Deployment Report," FCC, Feb. 2, 2018, https://www.fcc.gov/reports-research/reports/broadband-progress-reports/2018-broadband-deployment-report.) This is also the definition adopted by the state of Maryland.

residential wired broadband service in the County's denser neighborhoods, neither provides service that meets the definition of broadband in sparsely populated areas.

Because of the challenging economics of broadband deployment in rural areas, private ISPs likely will not invest in ubiquitous broadband infrastructure in currently unserved parts of the County absent some sort of financial support. State and federal funding programs may present the County and its potential partners with opportunities to fill some broadband gaps.

1.1.1 The County has unserved residents and businesses in contiguous areas and scattered locations

Unserved areas are those where no infrastructure capable of delivering services that meets the federal and state definitions of broadband "passes" homes and businesses—meaning there is no infrastructure (such as optical fiber or coaxial cable) running along the road where the property can be accessed.[2]

Based on our review of a range of data sets and our own high-level surveys, we estimate that the number of unserved locations in the County is in the range of 3,000 to 3,500.[3] These fall into two categories: first, contiguous unserved areas (referred to herein as "Category 1") and, second, pockets of unserved locations on isolated unserved roads within otherwise-served areas ("Category 2").

There exists a third category of locations within the County where homeowners struggle to get service, despite the presence of broadband infrastructure passing the home: premises set so far back from the road that the ISP has no obligation, under County franchise requirements, to build the service drop from the road to the user's premises (i.e., along the driveway) at no cost to the customer (referred to herein as "Category 3"). Although these approximately 1,500 homes are effectively unserved because many homeowners find the drop construction cost unaffordable, the homes are not considered "unserved" under federal and state definitions or with respect to eligibility for federal or state broadband grant funding.

Table 1 lists the estimated number of addresses in each unserved category. We note that the category numbers do not indicate prioritization or emphasis in terms of the County's approach to filling its broadband gaps; the numbers are merely a convenient way to refer to the categories.

[2] A "passing" is the infrastructure that literally "passes" a home or business along the road but it does not include the "service drop"—the portion of the network that connects from the road to the home or business itself. The availability of a passing to a home or business is the universally understood definition of what is served, both within the industry and among the state and federal government entities that fund broadband expansion and regulate communications services.

[3] The range indicates the estimated uncertainty in the numbers due to the sampling methodology, described in the report. Greater precision can be obtained through a physical survey of all streets in the entire County, which would be part of a later-stage detailed design process.

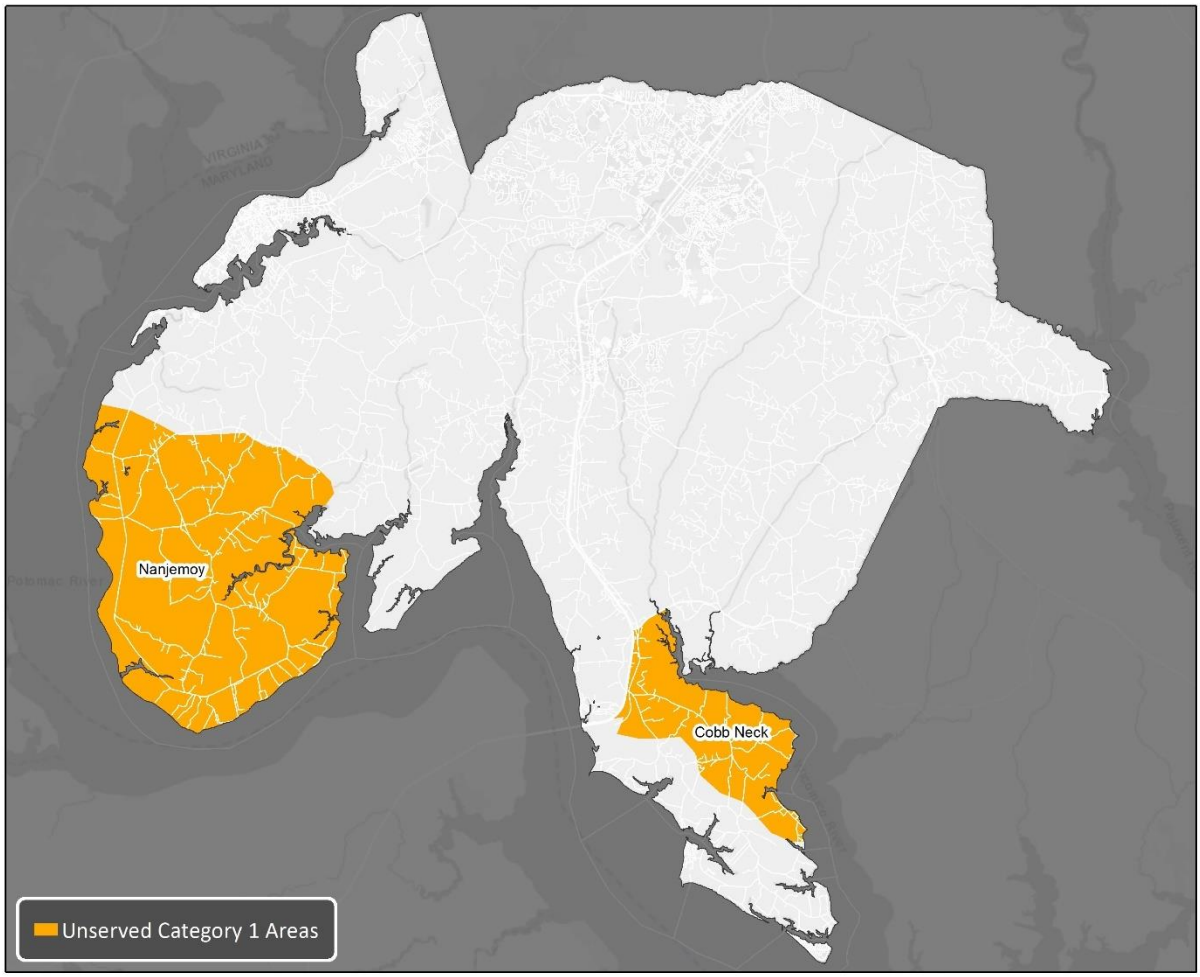
Table 1: Estimated Number of Unserved Premises

Category	Description	Estimated Unserved Homes and Businesses
1	Contiguous geographic areas	Approximately 2,300
2	Addresses on isolated roads	Approximately 1,000
3	Addresses with long driveways	Approximately 1,500

1.1.1.1 Unserved Category 1: Contiguous geographic areas

Category 1 comprises contiguous geographic areas where there exists no broadband infrastructure capable of delivering broadband speeds. Based on existing data sets, supplemented by desk and field surveys conducted by a CTC outside plant engineer, we identified two of these areas in Charles County—one in Nanjemoy and the other in Cobb Neck, on the County's southern peninsula (Figure 1). Within these two areas, there are approximately 2,300 unserved locations.

Figure 1: Category 1 Unserved Areas (Nanjemoy and Cobb Neck)



1.1.1.2 Unserved Category 2: Pockets of unserved locations within otherwise served areas

Category 2 comprises pockets of unserved premises located on isolated, low-density roads that fall within areas that are otherwise served. In other words, while the larger areas around these homes are generally served, these locations are on roads that do not have broadband infrastructure, usually because the density of homes is so low that the incumbent providers are not obligated to pass those locations with their infrastructure.

CTC's geographic information systems (GIS) team manually compared maps and datasets, as well as Google Earth imagery and other satellite imagery, to determine how many locations fit into this category. Our estimate, based on this range of datasets, is that there are approximately 1,000 Category 2 isolated unserved residential premises along an estimated 80 to 100 miles of roads in the County. These locations are dispersed throughout the County, other than in the densely populated towns.

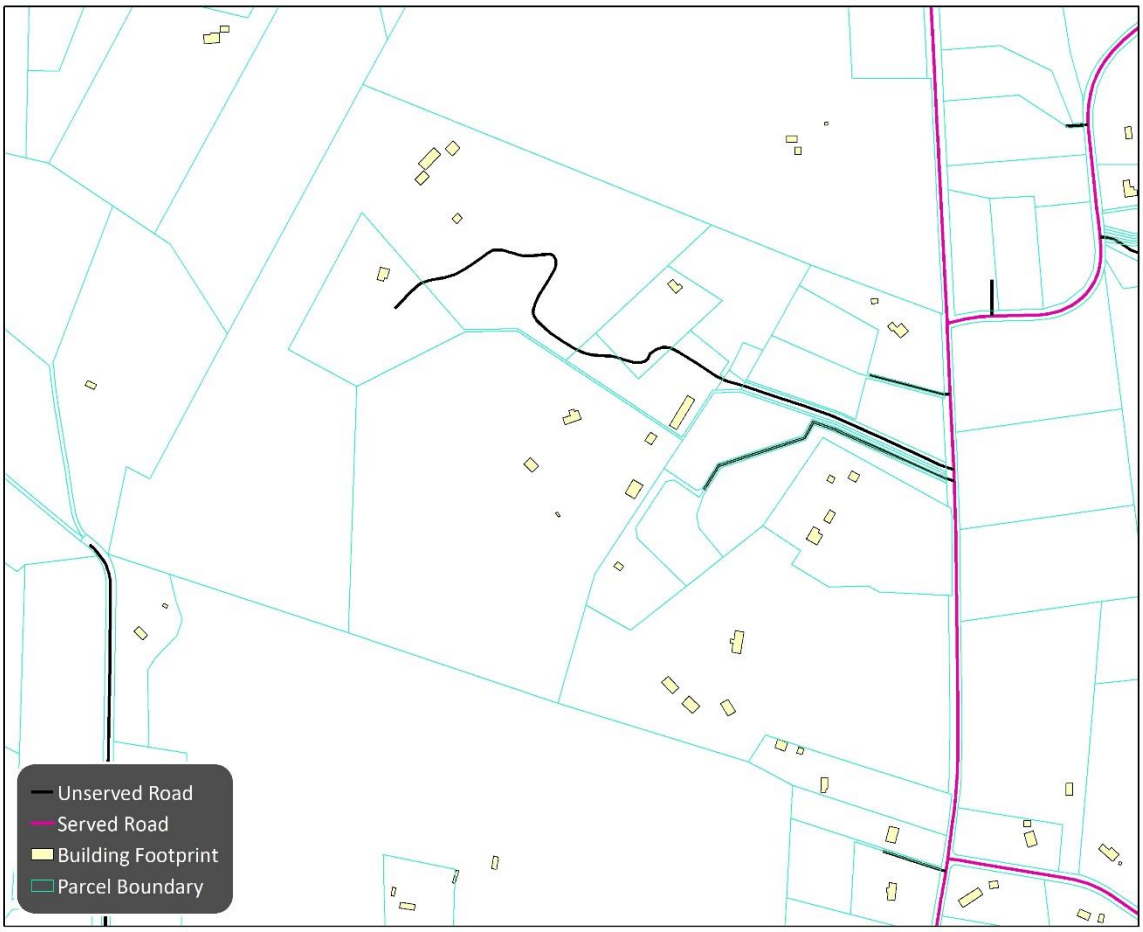
The Category 2 unserved locations typically are on roads that are long relative to the total number of potential broadband customers on the road. In the sample in Figure 2, the roads illustrated with black lines do not have broadband infrastructure, so the single homes at the end of each road are unserved.

Figure 2: Sample Category 2 Unserved Locations – Single Homes on Long Roads

Neither Verizon nor Comcast has business reasons to build infrastructure on those roads; their potential return on investment is not great enough to prompt an investment in reaching the potential customers who live there. Given the low density of houses, too, neither Verizon nor Comcast is obligated to build infrastructure on those roads under the terms of their cable franchise agreements with the County.

Other Category 2 locations include pockets of multiple unserved homes surrounded by served areas, as in the example in Figure 3.

Figure 3: Sample Category 2 Unserved Locations – Pockets of Unserved Homes



For the residents on these roads, which exist in locations in many parts of the County (as opposed to being clustered in contiguous geographic areas like the unserved homes in Nanjemoy and Cobb Neck), this situation is particularly challenging; the cost of Verizon or Comcast's line extension down their road—which the residents would be required to pay in order to get service from those companies—can be high.

1.1.1.3 Unserved Category 3: Locations that are served with a passing, but long driveways make actual service cost-prohibitive

Category 3 comprises premises for which the cost of installation of the service drop—the connection from the road to the user's premises—is so high as to make service infeasible. In Charles County, this generally refers to locations where the home or business is more than 300 feet away from the road—that distance being the typical limit for cable franchisees' obligations to install a service drop at no cost to the customer.[4] We estimate there are approximately 1,500 such premises in the County. Figure 4 illustrates a sample residence in this category; see Section 3 for more details.

Figure 4: Sample Category 3 Residence with Long Driveway

This is a situation that is extremely frustrating for Charles County residents who seek service but cannot afford to cover the cost of service drop installation, even if broadband infrastructure passes their property (and thus they are considered to be "served with broadband" by the state and federal governments). Service to these homes or businesses is a matter of the affordability of drop construction, not availability of infrastructure—because the ISP will serve the premises if the customer pays for the drop connection, but many consumers find the quoted cost of connection to be very high.

[4] Under the County's franchise agreement, for example, Comcast is obligated to build a drop to a customer at no cost if the setback is 300 feet or less. (*See:* "Cable Franchise Agreement Between the County Commissioners of Charles County, Maryland and Comcast of Maryland, LLC," July 18, 2019.) This 300-foot standard is consistent with what we see in other areas of Maryland.

1.1.2 The economics of rural broadband limit ISPs' interest in deploying broadband to unserved areas

Unserved portions of Charles County face the same challenges as other rural communities in attracting broadband infrastructure investment. Nationwide, even in the most affluent rural and semi-rural areas—from the horse farms around Lexington, Kentucky, to the ski communities outside of Aspen and Telluride, Colorado, to the resort areas on the Chesapeake Bay—the economics simply do not exist for rural broadband deployment absent substantial government funding. The private sector will not build costly infrastructure to reach all homes and businesses in low-density areas simply because the potential return on investment is insufficient to justify the investment.

The same dynamics apply to virtually all areas of rural infrastructure development. In the case of broadband, the issues are starker because broadband is traditionally thought of as an area of private investment, rather than public investment. The challenging economics result from the lack of density of homes—and, in many cases, the fact that homes are located on large parcels of land; long driveways or setbacks from the road greatly increase the cost to deploy wired infrastructure to those homes.

1.1.3 Building fiber-to-the-premises in the County's contiguous unserved areas would require an estimated $18 million capital investment but relatively low operating costs

Constructing fiber infrastructure to Category 1 unserved portions of the County would require a total capital investment of approximately $18 million. Considering only the outside plant infrastructure costs—not the service drops to the premises—the network would cost approximately $7,000 per passing. These estimates are based on conceptual-level engineering for serving 100 percent of Category 1 unserved premises; this planning-level design considers a range of factors that affect deployment costs, from the availability of utility poles to the number of fiber route miles necessary to pass all unserved homes and businesses. (Actual costs will also vary from this estimate due to factors that cannot be precisely known until the detailed design is completed, or until construction commences.) Section 3 describes this cost estimate in more detail.

1.1.3.1 An added benefit of constructing the fiber-to-the-premises backbone would be the ability to augment the County's wide-area network

In order to build fiber-to-the-premises in the Category 1 areas of the County, some construction of backbone fiber will also be necessary. That backbone would likely traverse long routes within the County. In a scenario in which the County partners with a private entity to deploy this network, the County could, even if it does not own the network, secure use of some fibers on the backbone that could add redundancy to or replace portions of the County's existing wide-area network (WAN). In our design, approximately 8 miles of additional lateral construction would be

required to connect 34 County WAN sites to the fiber-to-the-premises backbone. At an estimated cost of $125,000 per mile, constructing laterals from the fiber-to-the-premises backbone could thus augment the existing County WAN for approximately $1 million—while saving considerable cost relative to connecting these sites absent the new backbone. This is an additional benefit that can be considered in coming years as the County works to address the needs of unserved residents and businesses.

1.1.3.2 Fixed wireless could serve almost 90 percent of the contiguous unserved areas at lower capital cost than fiber—but with higher ongoing operating costs

As an alternative to deploying fiber-to-the-premises, the County could consider a fixed-wireless network to deliver broadband services to unserved Category 1 areas. CTC's engineers developed a candidate model to assess the viability of serving unserved Category 1 addresses with a fixed wireless network using existing government and commercial towers within the County.

Our analysis found that a fixed wireless network could be used to serve a portion of the County's unserved Category 1 homes and businesses—but it would have clear technical limitations relative to a fiber optic network, would not reach all unserved premises, and would be significantly more expensive *to operate* than a fiber network.

1.1.3.3 Fiber offers a better return than wireless, given total cost of ownership and technical benefits

Based on engineering and cost-estimation for the fiber-to-the-premises and fixed wireless solutions for Category 1 unserved portions of Charles County, we conclude that overall, fiber-to-the-premises represents a better broadband solution than fixed wireless for most unserved areas.

Taking into account the ongoing maintenance costs for each type of network—including tower lease fees and regular equipment replacement for the fixed wireless solution—the total long-term cost of ownership for a fiber-to-the-premises network would be lower than for a fixed wireless solution. Assuming a 35 percent take-rate,[5] fiber-to-the-premises has a lower 10-year total cost of ownership per customer ($26,650) than does a fixed wireless solution ($41,550). With a 60 percent take-rate, too, fiber-to-the-premises has a lower 10-year total cost of ownership per customer ($16,100) than does a fixed wireless solution ($26,500).[6]

[5] Take-rate is an important element of estimating capital and operating costs because each additional customer represents additional construction costs, to build the service drop and install service at the premises, as well as operating costs.

[6] These estimates are based on a range of assumptions, which are described in Section 3 and Section 3.

1.1.3.4 The potential exists for public-private partnerships, including some that are lower risk

Based on our discussion with the private sector, we believe there is opportunity for the County to address some of these challenges while sharing risk with the private sector—and indeed, ideally substantially transferring most of the risk to the private sector. We make recommendations below about potential partnerships, but note that the County could also seek additional partnership opportunities through an RFI or RFQ process. As you will see in the discussion of potential partnerships below, we recommend that the County partner with entities that have some or all of the following attributes:

- First, capability and experience in cost-effectively building communications infrastructure. These capabilities can range from demonstrated experience to ownership of the poles (which conveys structural benefits and enables lower-cost construction) to existing communications infrastructure in the area, such as fiber optic or coaxial plant.
- Second, a partner with demonstrated experience as an internet service provider. Our experience is that USDA in particular requires a showing of such experience for funding grants—and it certainly conveys additional benefits for any state or federal grant application.
- Third, a strong and experienced management team.
- Fourth, a track record in successfully applying for state or federal grants or both. This is a demonstration of the fact that grant makers have already vetted the company and approved its capabilities.
- Fifth, experience partnering with local governments and a clear willingness to work collaboratively with a local government on grant applications and toward shared goals.

1.1.4 Serving Category 2 addresses on isolated streets (extending Comcast or Verizon's networks on unserved streets within served areas) would cost an estimated $6 million

Because both state and federal grant programs are applicable to Category 2 unserved locations, the most logical potential solution for these unserved residents is for Verizon, Comcast, or both to seek public funds for line extensions—thus making it economically desirable for them to provide this service. Based on our estimate of 1,000 premises that fit in this category, our engineers estimate the cost to "pass" these isolated locations would be approximately $6 million, assuming approximately 80 road miles of fiber construction. (This estimated cost does not address the additional cost of the service drop from the road to the home, which could add additional cost for a homeowner located far from the road, as in Category 3.)

Unfortunately, we believe it would be far more challenging for an alternative or new competitive provider to build in these areas because the unserved pockets are not economically attractive on their own (given their low density) and the area is already generally served by either Comcast or Verizon—thus reducing the economic attractiveness of building the area. In addition, no state or federal funding is available to new providers to build communications infrastructure in areas that are already served—other than on the isolated roads, which would be a limited amount of funding relative to the total cost of building the area. As a result, Comcast or Verizon, plus a combination of state or federal funding, represent the most viable path forward—as our recommendation in Section 1.2.3 reflects.

1.1.5 Constructing drops to Category 3 addresses would cost an estimated $2.5 million

With respect to the locations in Category 3, locations that are "served" but for which the cost of the service drop from the road to the home is unaffordable, the options for funding are more limited. The County could choose to subsidize the cost of drop construction for the homes and businesses with long setbacks, but this is unfortunately an area in which the County will not have a state or federal partner to solve that problem—because neither state nor federal grant funding apply to building service drops to these locations.

1.1.6 Federal and state funding programs are an opportunity for the County and its private partners to fill some broadband gaps

Federal and state funding sources represent an important element of large-scale broadband deployments for unserved areas. While these programs tend to have restrictions that affect their potential breadth of impact, our analysis is that a number of programs—including Maryland's recently announced rural broadband grant program and the federal ReConnect and Rural Digital Opportunity Fund programs—could assist the County's efforts to reduce the number of unserved homes and businesses.

First, USDA's ReConnect program represents the most significant congressional appropriation of broadband funding since the Recovery Act in 2009—with $550 million available in 2020 and likely annual future appropriations. The program awards loans, grants, or a combination of the two for last-mile connections in rural areas; it favors applicants that demonstrate both experience in network operations and strong support from the local government in the area to be served. The current round of grant applications closes March 16, 2020.[7]

[7] "USDA to Make $550 Million in Funding Available in 2020 to Deploy High-Speed Broadband Internet Infrastructure in Rural America," U.S. Department of Agriculture, News Release, Dec. 12, 2019, https://www.usda.gov/media/press-releases/2019/12/12/usda-make-550-million-funding-available-2020-deploy-high-speed (accessed December 13, 2019).

Second, the FCC's Rural Digital Opportunity Fund is an auction process, likely to take place in mid- to late-2020, that will award $20.4 billion over the next decade to support the buildout of high-speed broadband networks in unserved areas of the country.

Third, Maryland's Office of Rural Broadband recently released the application for a broadband grant initiative that explicitly seeks to complement federal and local funding sources—an approach that could enable an entity partnering with the County to use the state's funding as a match for a federal ReConnect grant application, or to enable a lower bid in the Rural Digital Opportunity Fund reverse auction (in which the lowest bidder wins). The state will award grants of $1 million to $3 million from a total funding budget of at least $9 million. Applications are due by February 21, 2020.

1.2 The County Can Undertake a Multi-Year Effort to Leverage State and Federal Funding Programs with Potential Partners

Our primary recommendation is that the County collaborate with private sector partners to apply for state and federal broadband grants, with the understanding that this effort may require multiple years and is unlikely to be resolved in the short-term. For example, we believe the Category 1 (contiguous unserved) areas present a potential opportunity for a partnership between the County and a private entity in which the private entity, with the County's support, will seek state and federal grant funds to build broadband across one or both of the unserved areas. Our recommendations lay out a strategy and timeline for this approach beginning in 2020, with the understanding that there likely will be state and federal broadband funding in 2021 and beyond—and it may take years to access sufficient grant funds to address the entirety of the two unserved areas. (We note, however, that the Rural Digital Opportunity Fund does represent a unique opportunity for which time is of the essence, as we expect the reverse auction will be held in 2020 for a decade's worth of ongoing funding.)

While we cannot predict what partnerships and funding opportunities might come to fruition, we note that many different scenarios could play out—ranging from one entity building infrastructure to all of the County's unserved areas, to multiple entities each building in smaller parts of the unserved areas.

The following are our recommendations for immediate, intermediate, and long-term steps the County can take in light of what we have learned in conducting this study, to begin to remedy the broadband challenges identified.

1.2.1 Continue to engage with SMECO on these issues

Based on the County's recent communications with Southern Maryland Electric Cooperative (SMECO), we understand SMECO is not likely to make a decision about its broadband path forward in the near future—and may not determine that path until next year or later. As we

advised the County in an interim version of the document in December, SMECO was an obvious choice for a partner in the County's broadband deployment efforts; [8] for this reason, the County was prudent in waiting to take action until it had a clear indication from SMECO of its plans. However, given that SMECO has now indicated that it does not intend to bid on the FCC funds and is delaying a decision regarding broadband, we recommend the County move on to other options.

1.2.2 Partner with ThinkBig on a state broadband grant application and support federal funding applications for Category 1 unserved areas

CTC and the County engaged with a range of potential private partners for this effort during preparation of this report. Of those entities, the one that appears to be the most promising partner for the County is ThinkBig Networks, a Maryland company that is operating fiber-to-the-premises in Kent County and parts of Baltimore. ThinkBig appears willing and engaged in preliminary discussions with the County—and could be a viable partner for state and federal grant applications to construct fiber to serve the County's unserved areas.

We recommend that the County proceed with a partnership with ThinkBig Networks to address the Category 1 unserved areas. Fully addressing these challenges is likely to be a multiyear effort, but first steps can certainly be taken in 2020. ThinkBig has indicated an interest in working with the County to apply for state and potentially federal grants, and we believe it is feasible, as of this writing in late January 2020, that ThinkBig could apply within the next month for a state of Maryland broadband grant, and potentially even for federal grants in March.

The County's role would be to provide strong letters and other indications of support, as well as to facilitate and support the development of the grant applications. The 2020 grant applications for Maryland, due on February 21, and for USDA, due on March 16, would then be a starting point for grant applications in 2021 and beyond. ThinkBig could also consider bidding in the FCC's Rural Digital Opportunities Fund auction later this year. As is discussed above, we fully anticipate that both the state of Maryland and the federal government will continue current rural broadband grant programs in coming years.

All of these programs are highly competitive. Many very deserving grant applications will not be funded simply because there are insufficient funds appropriated to meet the demand. So ThinkBig's applications may not succeed in 2020 (or may not be possible to prepare in the limited

[8] Because it is member-owned, for example, SMECO presumably would not cherry-pick only certain areas; it is responsible to all its members, not just to business opportunity in the way a for-profit ISP would be. SMECO also owns utility poles—the core structural asset needed for broadband deployment—throughout the County's unserved areas; those poles would be able to support fiber attachments and would lower SMECO's fiber construction costs. In addition, SMECO has the technical capability to construct aerial fiber and a proven ability to manage customer relationships. Further, we expect electric cooperatives such as SMECO to benefit from the FCC's Rural Digital Opportunity Fund.

time before the grant deadlines), but this is one of the reasons we recommend a multiyear strategy and a persistence in applying to these grant programs over time. Even if the initial set of applications is successful, the funding is unlikely to be sufficient to address all of the Category 1 unserved areas—further reinforcing the need for a multiyear effort and an expectation that that broadband solution will take time.

1.2.2.1 ThinkBig has many attributes of a strong partner

We recommend ThinkBig as the County's partner for a number of reasons. First, ThinkBig's multiyear track record in fiber-to-the-premises deployment and operations, including on the Eastern Shore, means the company represents an able partner for the county. The company reports having constructed more than 40 miles of fiber in Maryland in the last couple of years. Based in Chestertown, ThinkBig offers fiber-to-the-premises gigabit connectivity in southern portions of Baltimore City (with plans to expand into the central city) as a competitive alternative to Comcast. In addition, ThinkBig has been working with Kent County to expand access to unserved rural areas supported by state grants.

Just as importantly, that track record is a critical element of experience, and based on our conversations with the funding authorities, only experienced entities are likely to succeed in applying for broadband grant funds. While ThinkBig is not a large company, its management team is experienced, it appears well-capitalized, and it holds a number of years of operating experience as a rural and urban ISP. These elements will be critical, non-negotiable components of a successful federal grant application.

Second, we recommend ThinkBig because it has a track record of successfully applying for rural broadband grants from the state of Maryland. That success record suggests that the state's grant-makers have vetted the company and are comfortable with funding it. This factor appears to us to be a strong consideration in favor of the County selecting ThinkBig as its partner with an eye toward supporting the most viable and fundable potential partner.

Finally, we recommend ThinkBig because, while we and the County engaged with a wide range of different potential private partners for this initiative, none of the others appear as viable for funding or as low-risk for the County. Whatever the amount the County invests in this initiative, either in the form of capital support or efforts to support its private partner's grant applications, we believe this selection is the most prudent for the County, and that ThinkBig's stability and track record, despite its modest size, would make the County's investment lower risk than would be the case with a company with less experience or capacity.

1.2.2.2 The County should negotiate with ThinkBig to mitigate the County's partnership risk

At the same time, we recommend additional elements in the partnership between the County and ThinkBig that will serve to further mitigate the County's risk. First, we recommend that ThinkBig be the grant applicant and the owner of the infrastructure built with grant funds. Private ownership and grant obligations remove those areas of risk, including construction risk and market risk, from the County—placing the risk squarely with the private partner. Second, we recommend a negotiation between the County and ThinkBig that will, in consideration of the County's efforts and potential financial contribution, give the County options in the event of failure of execution by ThinkBig, even if that represents an unlikely scenario. These options would allow the County to select another partner and proceed with the initiative without having to return to square one.

There are a number of ways this could be accomplished. For example, the County could negotiate for a perpetual right of use or ownership of some of the fiber or even an additional cable placed by ThinkBig during construction, with the limitation that the County could only use that fiber for commercial purposes in the event of ThinkBig's default. This would enable the County to itself provide services or to identify an alternative private partner to utilize its partner in the event that ThinkBig did not follow through on its obligations

In our experience, there are a number of other models, including partial County ownership of the asset, that have been pursued by other communities—but some of these are more challenging in the event of state or federal grant funding that require ownership only by the applicant. The model and details should be negotiated between the County and ThinkBig, but the core strategy is to ensure that the County has options in the event that the company does not meet the County's expectations as expressed in a contractual arrangement between the two entities.

At the same time, we note that the County's risk is further reduced by the strategy of leveraging state and federal funding. One significant benefit of state and federal grants is that those expert agencies bear the cost and the effort of evaluating the grant application—and will not only vet the applicant, but also administer and enforce the funding program requirements. This state and federal effort will reduce the County's risk and ongoing burden when it comes to the partner's performance.

Given all these considerations, and with the caveat that a robust contract between the two parties is a critical piece of protecting the County's interests, we recommend ThinkBig as a partner for the County for the Category 1 unserved areas, and state and federal grant applications, over all other entities of which we are aware that have expressed interest.

1.2.2.3 The County and ThinkBig should act quickly on grant opportunities

ThinkBig will not have the low cost to build that SMECO or Verizon would have, because it does not own the utility poles. But it would potentially be competitive for state grant funding or federal ReConnect funding. The Rural Digital Opportunity Fund also offers an opportunity for ThinkBig; if ThinkBig can successfully secure a state grant or support from the County, it could bid lower for Rural Digital Opportunity Fund funding and potentially position itself to win.

ThinkBig's initial, high-level capital cost estimate for building fiber to serve most of the unserved residents in Nanjemoy is a minimum of $2.6 million.

Given the pending deadlines for both state applications and ReConnect (the application window closes March 16, 2020),[9] we recommend the County and ThinkBig develop their plans as soon as possible or consider developing the partnership with an eye toward 2021 grant opportunities. If ThinkBig were awarded state broadband funding, it could use those funds (and any County contribution to that program's match requirements) as its match for the federal application.

1.2.3 Encourage Comcast and Verizon to apply for state funds for Category 2 isolated unserved pockets

Our next recommendation is that the County pursue potential partnership with Comcast and Verizon to address Category 2 unserved locations. As is discussed in this report, these isolated, low-density roads within areas that are otherwise served by either Comcast or Verizon (or both) do not present a compelling business case or opportunity for a new provider. In addition, the full areas are not eligible for state or federal funding because much of these areas are already served—further reducing the interest of new entrants to build in those areas.

Comcast and Verizon, however, are positioned to cost-effectively expand their infrastructure to those unserved pockets within their served areas, and both state and federal funding sources are available to them for this purpose if they choose to apply. For example, the state of Maryland late last year opened a grant opportunity for these "line extensions" by incumbents such as Comcast and Verizon (see Section 8.5). That particular grant opportunity has already closed, but we fully expect that the state will create new opportunities of that sort annually and potentially even more frequently, particularly if the companies show interest.

Further, the state's currently open grant opportunity, as well as the federal ReConnect opportunity, allow companies like Comcast and Verizon to apply for funds to build on multiple isolated roads within a larger geographic area. Indeed, other Maryland companies such as

[9] "USDA to Make $550 Million in Funding Available in 2020 to Deploy High-Speed Broadband Internet Infrastructure in Rural America," U.S. Department of Agriculture, News Release, Dec. 12, 2019, https://www.usda.gov/media/press-releases/2019/12/12/usda-make-550-million-funding-available-2020-deploy-high-speed (accessed December 13, 2019).

Armstrong Cable in Harford County plan to do exactly this—filing on an aggregated basis for a single grant to build on unserved roads within their existing served footprints.

We have unfortunately not been able to secure concrete indications from Comcast or Verizon about their intentions in this respect. This is not uncommon, as large incumbents are frequently reluctant to share deployment or expansion plans based on their concerns about proprietary and confidential data. That said, we believe there is an attractive opportunity for both companies to secure public funding to serve these areas. Verizon last year bid through another federal process for some isolated areas of Charles County, suggesting to us that it is willing, if subsidized by a public entity, to expand into these Category 2 unserved roads.

For these reasons, we recommend the County further pursue these options with both companies for upcoming opportunities, including the Rural Digital Opportunity Fund and state grant funding, and that the County potentially escalate within both companies if it is unable to secure information from local representatives of the companies.

1.2.4 In the event other strategies do not succeed, explore opportunities to support fixed wireless providers

Given our analysis of capital and operating costs (see Section 5), fixed wireless deployment would not be our first recommendation for filling the County's service gaps. That said, the technology is feasible and, if the County were to identify a suitable partner, using fixed wireless might be a suitable option for serving some homes and businesses. In the course of preparing this report, CTC reached out to a number of fixed wireless companies that indicated interest but did not provide any concrete information regarding areas in which they would be interested or terms of a partnership with the County. Given the lack of an immediate partner and the preferability of fiber for this effort, we recommend that the County consider fixed wireless as a fallback option or last resort in the event other strategies proposed herein do not materialize.

2 The County Has Unserved Homes and Businesses in Contiguous Areas and Scattered Locations

Unserved areas are those where no infrastructure capable of delivering services that meets the federal and state definitions of broadband passes[10] homes and businesses—meaning there is no cable or fiber plant in the right-of-way adjacent to the property.

Reflecting the commitment of its elected leaders and staff to ensuring equitable access to broadband, Charles County and its Rural Broadband Task Force have completed significant data collection and mapping to identify where residential broadband services[11] are and are not available. At the County's direction, we used those data as a foundation for our analysis of unserved locations.

2.1 Our methodology included an analysis of County-provided data, followed by extensive desk and field surveys

The County's service availability data, which were delivered to us as GIS layers, included improved parcels (i.e., properties with buildings—which might or might not be a habitable address) and are based on survey results,[12] citizen-reported service gaps,[13] and frequently updated property research. The County's mapping included the approximate areas currently served with broadband, as well as DSL and satellite internet access.[14]

To verify and fine-tune the County's service availability data (including the presence of Comcast and Verizon)—and to identify likely routes for fiber deployment to fill the service gaps—a CTC outside plant engineer conducted extensive desk and field surveys of representative portions of the County.

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[10] A "passing" is the infrastructure that "passes" a home or business along the public rights-of-way, but it does not include the "service drop"—the portion of the network that connects from the road to the home or business itself. The availability of a passing to a home or business is the universally understood definition of what is served, both within the industry and among the state and federal government entities that fund broadband expansion[10] and regulate communications services.

[11] The County is concerned about lack of service that meets the federal definition of broadband (i.e., 25 Mbps download/3 Mbps upload), while also recognizing that 10/1 service is a disqualifying threshold for some federal funding, such as the USDA's ReConnect program.

[12] "Internet Access Questionnaire," Online Survey Instrument, Charles County Government, https://www.charlescountymd.gov/internetaccess (accessed November 2019).

[13] CTC discussion with Mary Goddard, Charles County Government, 2019.

[14] The County's data also included key details that enabled us to develop a candidate fiber-to-the-premises solution for filling the identified service gaps (see Section 3); these include:

1. Locations of existing broadband-enabling infrastructure (e.g., I-Net fiber, Maryland Broadband Cooperative fiber)
2. Locations of County-owned properties
3. Locations of parks and other uninhabited land
4. Rights-of-way boundaries
5. Street center lines

The engineer prepared for the analysis by dividing the County into survey areas based on major roads and natural boundaries. He then determined the availability of highly detailed Google Earth Street View imagery for each section and planned driving routes for the portions of the County with limited or no available imagery.

During his desk survey, the engineer analyzed the Google Earth Street View maps where available—searching images of miles of County roadways for the presence (or lack thereof) of broadband infrastructure such as cable attachments on poles (for aerial construction) and handholes and pedestals (for underground construction). Following the completion of the desk survey, the engineer conducted an on-site field survey—driving a sampling of representative roadways in the County over the course of two days.

2.2 We found three categories of unserved residents and businesses in the County

Our mapping and analysis identified approximately 3,000 to 3,500 unserved homes and businesses in the County in two categories—contiguous unserved areas (Category 1) and addresses on isolated unserved roads (Category 2). There is an additional category of locations within the County (Category 3) where homeowners struggle to get service, despite the presence of broadband infrastructure passing the home: premises set so far back from the road that the ISP has no obligation to build the service drop from the road to the user's premises at no cost to the customer. Although these approximately 1,500 homes are effectively unserved because many homeowners find the drop construction cost unaffordable, the homes do not fit into the category of unserved for purposes of federal or state grant funding.

Table 2 lists the three categories of unserved premises in the County. We note that the category numbers do not indicate prioritization or emphasis in terms of the County's approach to filling its broadband gaps; the numbers are merely a convenient way to refer to the categories.

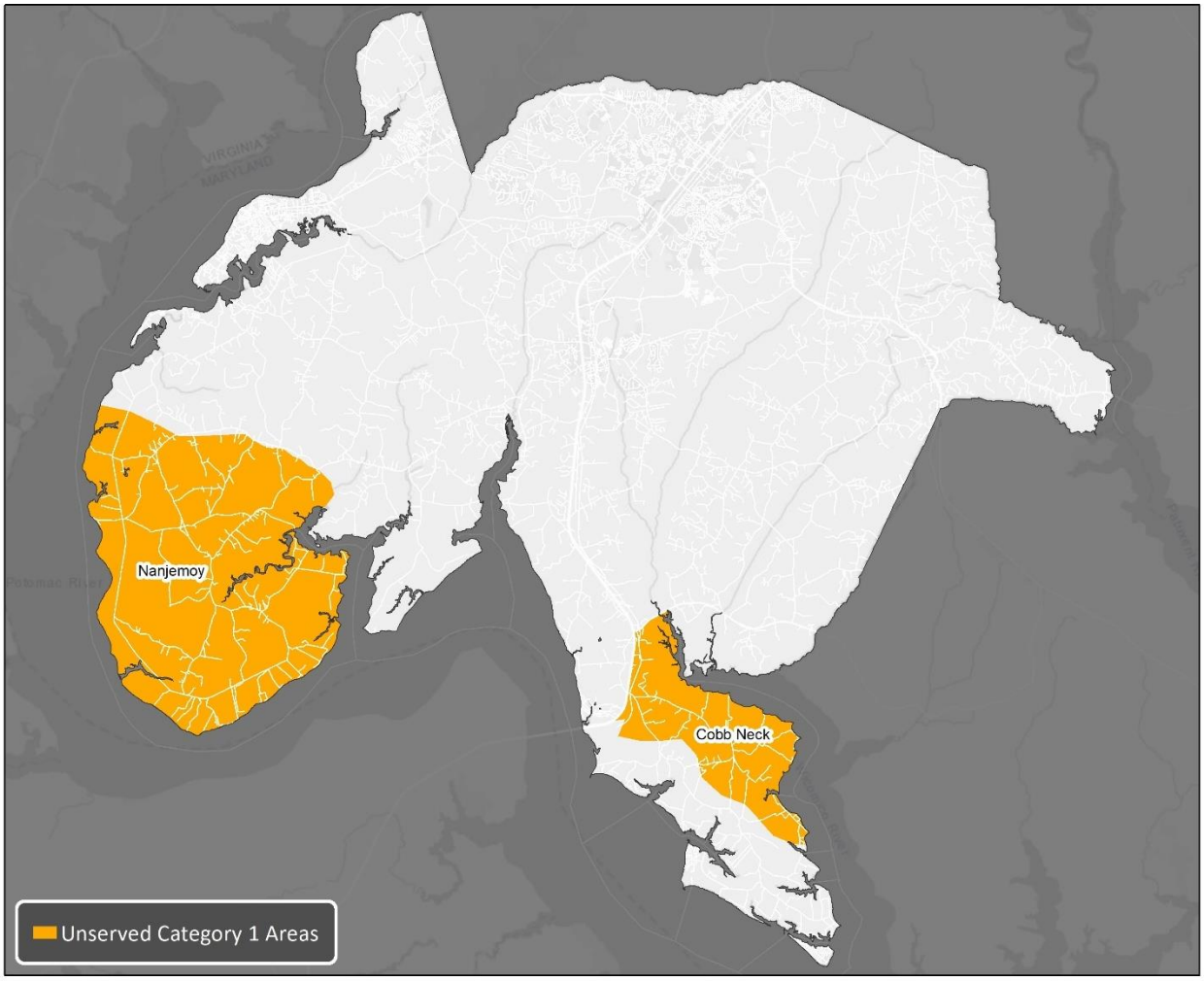
Table 2: Estimated Number of Unserved Premises

Category	Description	Estimated Unserved Homes and Businesses
1	Contiguous geographic areas	Approximately 2,300
2	Addresses on isolated roads	Approximately 1,000
3	Premises with long driveways (not considered "unserved" by state and federal definition)	Approximately 1,500

2.2.1 Unserved Category 1: Contiguous geographic areas

Category 1 comprises contiguous geographic areas where there exists no broadband infrastructure capable of delivering broadband speeds. Based on CTC's desk and field surveys, we determined that the County has two unserved areas in this category—one in Nanjemoy and the other in Cobb Neck, on the County's southern peninsula (Figure 5). Between the two areas, there are approximately 2,300 unserved locations.

Figure 5: Category 1 Contiguous Unserved Areas (Nanjemoy and Cobb Neck)



2.2.2 Unserved Category 2: Addresses on isolated roads

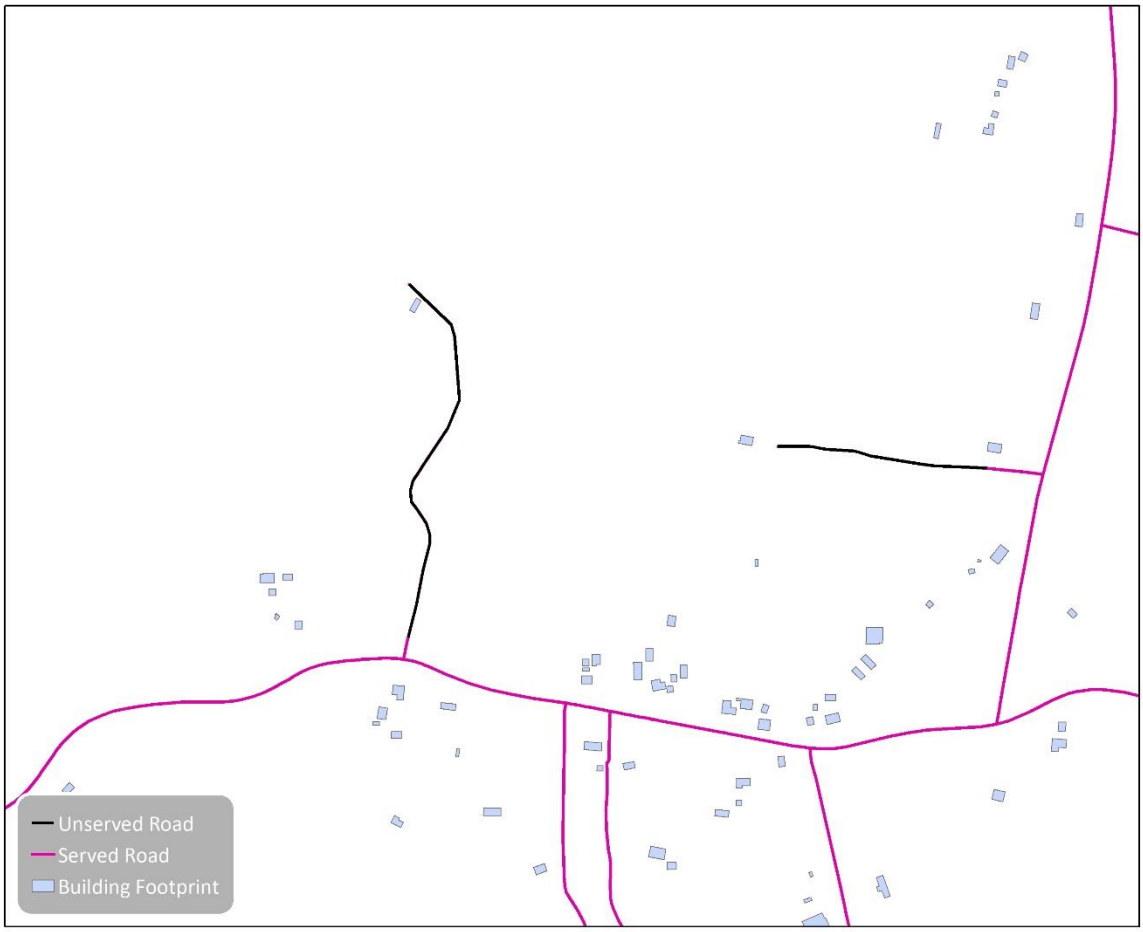
Category 2 comprises the unserved premises located on isolated, low-density roads that fall within areas that are otherwise served. In other words, while the larger areas around these homes are generally served, the homes are on roads that do not have infrastructure.

CTC's GIS team manually compared maps and datasets, as well as Google Earth imagery and other satellite imagery, to determine how many locations fit into this category. Our estimate, based on

this full range of datasets—many of which are imperfect—is that there are approximately 1,000 Category 2 isolated unserved residential premises along an estimated 80 to 100 miles of roads in the County.

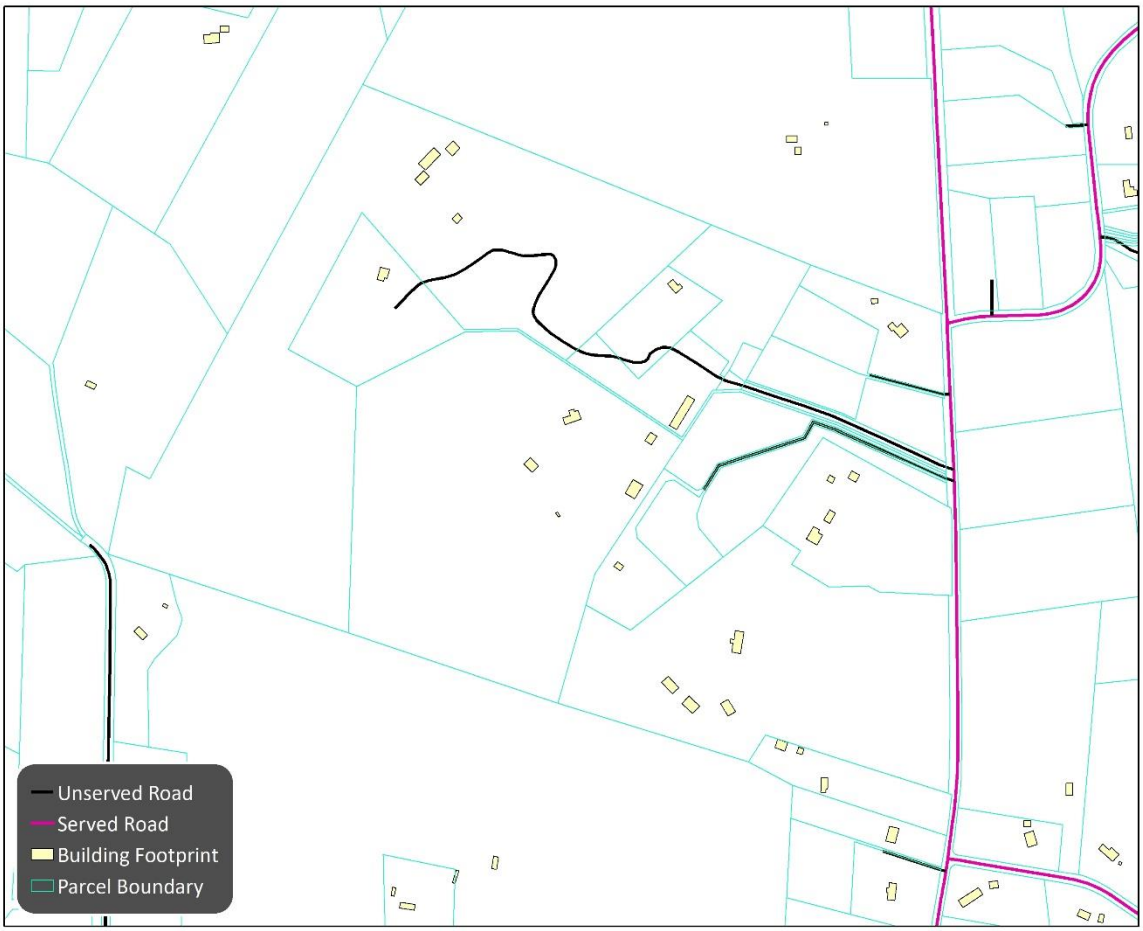
As the sample in Figure 6 illustrates, the isolated unserved premises are typically on roads that are particularly long relative to the number of potential broadband customers on the road; in that map, the black roads do not have broadband infrastructure, so the single homes at the end of each road are unserved. Neither Verizon nor Comcast has had business reasons to build infrastructure on those roads because their potential return on investment is not great enough to prompt an investment in reaching the potential customers who live there. Given the low density of houses, too, neither Verizon nor Comcast is obligated to build infrastructure on those roads under the terms of their cable franchise agreements with the County.

Figure 6: Sample Category 2 Unserved Locations – Single Homes on Long Roads



Other Category 2 locations include pockets of multiple unserved homes surrounded by served areas, as in the example in Figure 7.

Figure 7: Sample Category 2 Unserved Locations – Pockets of Unserved Homes



For the residents on roads like these, which exist in locations in many parts of the County, this situation is particularly challenging; the cost of Verizon or Comcast's line extension down their road—which the residents would be required to pay in order to get service from those companies—can be high.

2.2.3 Unserved Category 3: Addresses with long driveways

In addition to the two categories of unserved residents, we also identified a third category of premises that do not have broadband service. These are customers for whom the cost of installation of the service drop—the connection from the right-of-way to the user's premises—is so high as to make service infeasible. In Charles County, this generally refers to locations where the home or business is more than 300 feet away from the road—that distance being the typical limit for cable franchisees' obligations to install a service drop at no cost to the customer.[15] We

[15] Under the County's franchise agreement, for example, Comcast is obligated to build a drop to a customer at no cost if the setback is 300 feet or less. (*See:* "Cable Franchise Agreement Between the County Commissioners of

estimate there are approximately 1,500 such premises in the County. (See Section 7 for more details.) Figure 8 illustrates a home on a road with broadband infrastructure that is unserved because of the length of its driveway.

Figure 8: Sample Category 3 Residence with Long Driveway

This is a situation that is extremely frustrating for those Charles County residents who seek service but cannot afford to cover the cost of service drop installation, even if fiber passes their property (and thus they are considered to be "served with broadband" by the state and federal governments). Service to these homes or businesses is a matter of the affordability of drop construction, not availability of infrastructure. The County could choose to subsidize the cost of drop construction, but this is unfortunately an area in which the County will not have a state or federal partner to solve that problem—because neither state nor federal grant funding applies to building service drops to these locations.

2.3 Unserved Category 1 and Category 2 portions of the County are eligible for state and federal funding

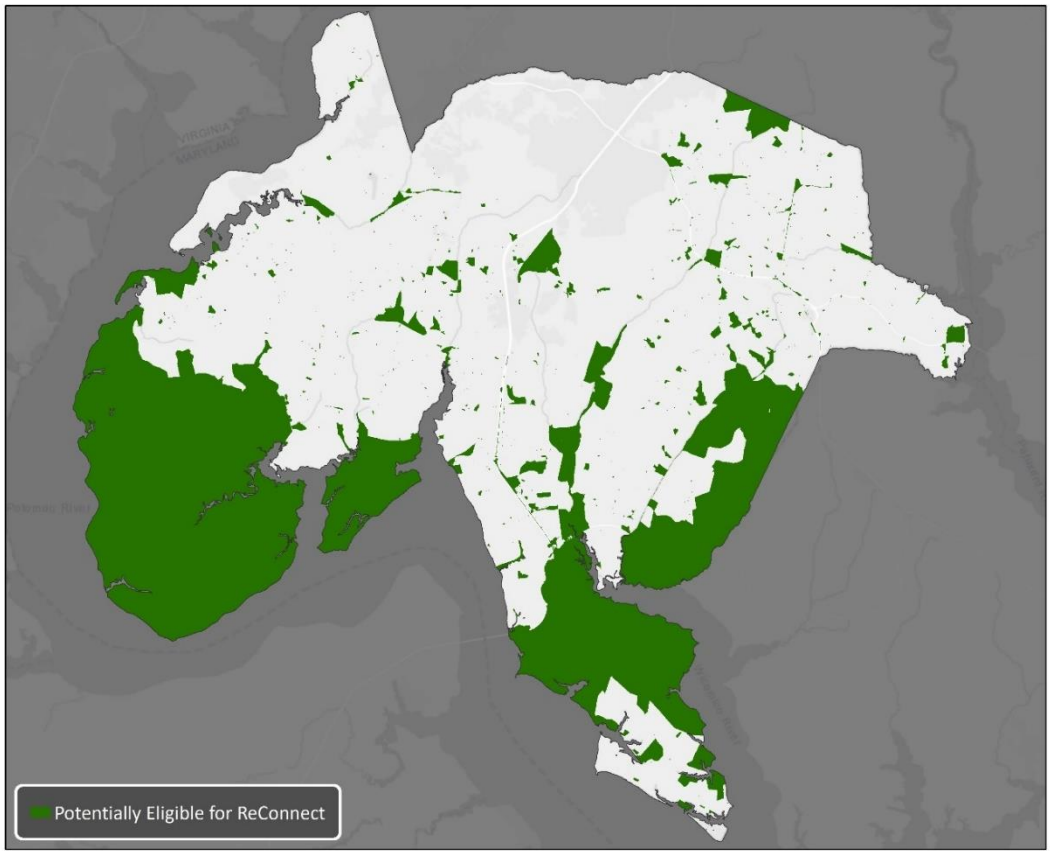
With an understanding that state and federal funding may represent a viable opportunity for enabling the County's efforts to fill broadband gaps in Category 1 and Category 2 (see Section 8), we also evaluated FCC Form 477 data about broadband services available in the County—both at

Charles County, Maryland and Comcast of Maryland, LLC," July 18, 2019.) This 300-foot standard is consistent with what we see in other areas of Maryland.

the 25/3 and 10/1 levels. We note that while the County is concerned about lack of service that meets the FCC's definition of broadband (25/3)—and that 25/3 is the threshold for the State of Maryland's broadband funding—the USDA's ReConnect grant and loan program uses 10/1 service availability as its minimum definition.

For purposes of identifying ReConnect-eligible areas at a high level, the following map illustrates the areas lacking 10/1 service as reported on Form 477 (Figure 9). Under current ReConnect rules, an applicant's proposed funded service area (PFSA) is eligible if 90 percent of the area lacks access to 10/1 service.

Figure 9: Areas Potentially Eligible for ReConnect Funding Because They Lack 10/1 Service According to Form 477 Data



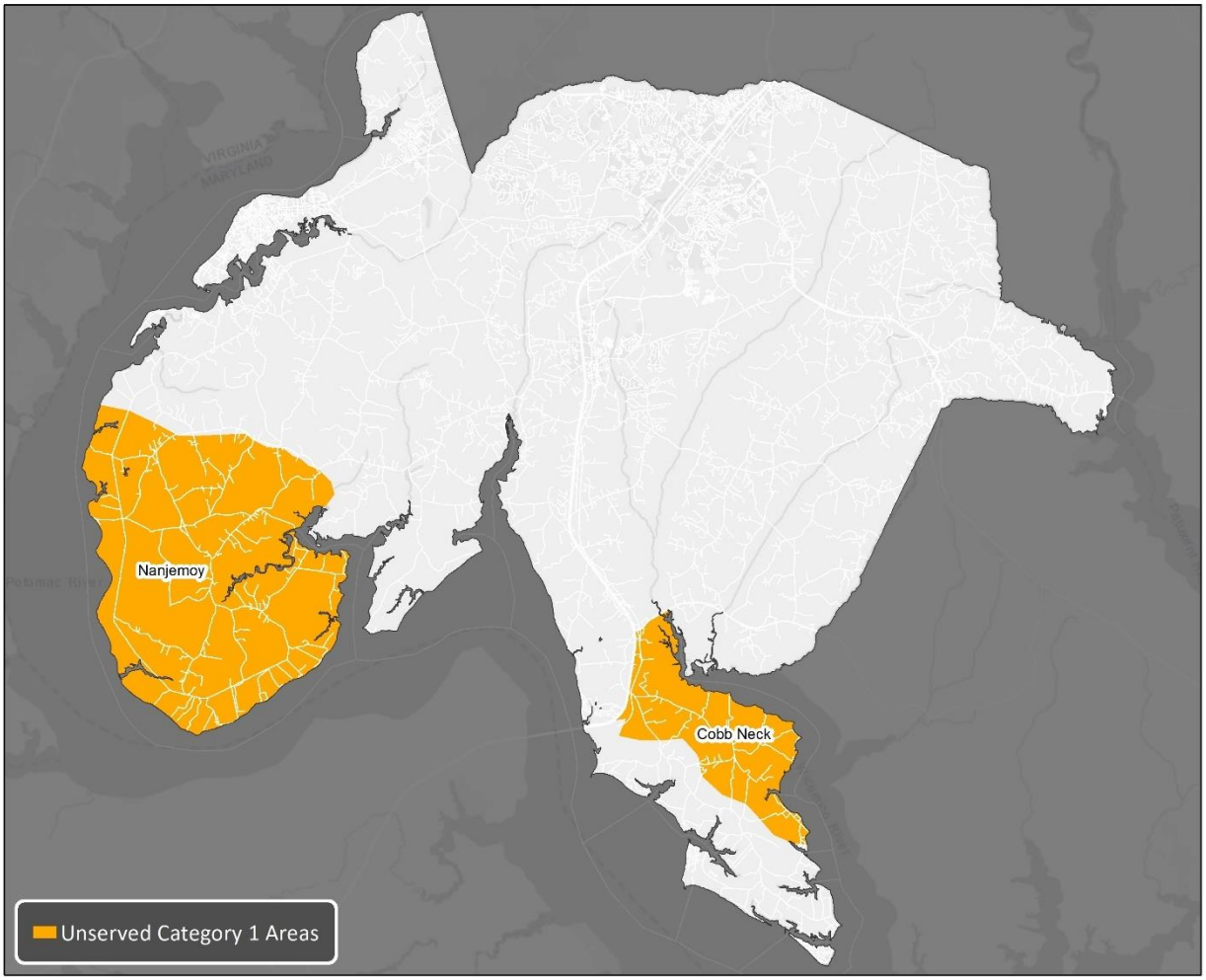
The shaded areas are not necessarily eligible for state funding, because the state's service threshold is 25/3. Importantly, too, the Form 477 data are insufficient to prove that an area is unserved for purposes of being eligible for ReConnect funding. Under the ReConnect rules, an applicant is required to demonstrate that its PSFA is indeed unserved—and the USDA will conduct field verification of projects before approving them for funding.

Given the distribution of the County's Category 2 unserved premises, it is also important to note that ReConnect applications can aggregate isolated unserved addresses in rural areas—meaning an application to serve the County could include non-contiguous eligible unserved areas.

3 Fiber-to-the-Premises Infrastructure to Fill Gaps in Category 1 Unserved Areas Would Have High Capital Cost but Relatively Low Ongoing Operating Costs

As documented in Section 2, CTC's analysis of County-provided data and our extensive desk and field surveys identified an estimated 2,300 Category 1 unserved homes and businesses (Figure 10) that could be served by a new ISP or by the incumbent providers.

Figure 10: Category 1 Unserved Areas (Nanjemoy and Cobb Neck)



As a candidate solution, CTC's engineers prepared a high-level network design for the deployment of a gigabit-capable fiber-to-the-premises network to Category 1 homes and businesses. We then estimated the cost for deploying that network, including a network backbone, assuming the construction was performed by the County or a partner entity that is not the incumbent telephone, power, or cable company.

The total estimated capital cost for the County or a partner to construct a fiber-to-the-premises network to serve the two Category 1 areas is $18 million; details are shown in Table 3.[16]

Table 3: Estimated Total Fiber Deployment Cost for Category 1 Unserved Areas

Cost Component	Estimated Cost
Outside Plant	$16,100,000
Central Network Electronics	$600,000
Fiber Service Drop Installations	$1,100,000
Customer Premises Equipment	$700,000
Total Estimated Cost:	*$18,400,000*

We estimated a cost per passing by dividing the outside plant cost by the number of passings. This is the cost of constructing fiber alongside the roads in front of homes and businesses, divided by the number of homes and businesses—essentially the cost of building a network independent of connections to any specific homes and businesses. We estimate the average outside plant cost per passing will be approximately $7,000 (Table 4).

Table 4: Estimated Outside Plant Cost per Passing for Category 1 Unserved Areas[17]

Cost Component	Estimated Cost
Outside Plant	$16,100,000
Passings	2,280
Outside Plant Cost per Passing[18]	*$7,050*

Because the two Category 1 unserved areas have different population densities, it is also instructive to consider the outside plant costs per passing within each area (Table 5).

Table 5: Estimated Outside Plant Cost and Cost per Passing by Category 1 Unserved Area

Category 1 Unserved Area	Street Miles	Outside Plant Cost per Mile[19]	Total Outside Plant Cost	Passings	Outside Plant Cost per Passing
Nanjemoy	150	$77,000	$11,550,000	1,870	$6,170
Cobb Neck	58	$77,000	$4,466,000	410	$10,890

[16] These numbers have been rounded.
[17] Unrounded numbers are used in the engineering calculations; these are then rounded in the discussion.
[18] This is the average cost to construct the outside plant portion of the fiber-to-the-premises network for each home and businesses in the unserved areas.
[19] This is the average cost per mile to construct outside plant to build out the fiber-to-the-premises network and backbone to the unserved areas.

These cost estimates—and the estimated operating costs described below (Section 3.5)—provide data relevant to assessing the financial viability of network deployment; they enable financial modeling to determine the approximate revenue levels necessary for the County or a partner to service any debt incurred in building the network. They also provide a baseline against which to evaluate the cost of incremental and non-fiber optic approaches, as compared to the cost of full coverage of the County's unserved areas with the highest-bandwidth technology.

In addition, because the fiber-to-the-premises backbone would traverse large portions of the County—and could thus be used to provide redundancy to or replace the existing County WAN—we also estimated the cost of constructing laterals to the 34 WAN sites that are within 1 mile of the theoretical fiber-to-the-premises backbone (see Section 3.6).

3.1 Capital cost estimates are derived from a customized outside plant network design

To develop and refine the range of assumptions that will have an impact on the network design and construction costs, a CTC engineer performed a desk survey of the County using Google Earth Street View, then conducted a two-day, on-site survey of targeted areas. The engineer reviewed available green space, estimated the modifications that would be necessary to existing infrastructure on utility poles, and estimated the percentage of utility poles that would need to be replaced to accommodate the new network infrastructure. Based on this analysis, we developed customized estimates of per-mile costs for construction on utility poles and for underground construction where poles are not available.

Table 6 summarizes the conditions determined through our desk and field surveys.

Table 6: Cost Factors Developed in Desk and Field Surveys

Cost Factor	Finding in Unserved Areas
Aerial Construction	95%
Poles per Mile	40
Average Moves Required per Pole[20]	1.5
Poles Requiring Make-Ready	8%
Cost Per Move	$350
Poles Requiring Replacement	4%
Average Pole Replacement Cost	$7,000
Intermediate Rock Underground	1%
Hard Rock Underground	0%

Make-ready is the work required to create space on an existing utility pole for an additional attachment. Existing attachments often have to be moved or adjusted to create the minimum clearance required by code to add an additional attachment. Each move on the pole has an associated cost (i.e., for contractors going out to perform the move). When a utility pole is not tall enough to support another attachment or the pole is not structurally capable of supporting the attachment, a pole replacement is required. The pole replacement cost is then charged to the new attacher.

Where utility poles do not exist, underground construction is required. One of the challenging variables with underground construction is the prevalence of rock. Softer stones and boulders (intermediate rock) require the use of a specialized boring missile that is more expensive than traditional boring. Where hard rock, such a granite is present, specialized rock boring machinery is required to directional bore new conduit. The cost of boring through rock is added to the cost of traditional boring.

CTC's outside plant engineer noted that the quality of the poles and pole attachments in the County varied, as they do in many cities and counties—but that overall, most of the poles have space for an additional attachment.

In many parts of the County's Category 1 unserved areas, the telecommunications cables (i.e., Verizon telephone lines) are on separate poles on the opposite side of the street from the SMECO electrical distribution cables. The telecommunications poles typically do not have space or capacity for an additional attachment, so we recommend the SMECO electrical poles be used for

[20] The average moves per pole is the average number of existing attachments on the utility pole that need to be moved to create space and clearance in the communications space to support a new attachment for the fiber-to-the-premises network.

new fiber attachments. The cost estimate assumes that the County could attach to the SMECO poles in the communications space below the electrical cables. Based on our experience, the SMECO pole lines are more favorable for new pole attachment than the average utility pole—which will correspond to a lower-than-average construction cost on the aerial poles.

The figures below show samples of poles in various conditions that we identified during our field survey of the County's Category 1 unserved areas. In Figure 11, for example, make-ready is required on the pole because there are multiple cables in the communications space. This utility pole appears tall enough that—with make-ready—another could attach to the pole.

Figure 11: Utility Pole Requiring Make-Ready

Tree trimming is required to attach an additional attachment on the utility poles in the following picture (Figure 12). Tree trimming is also an important maintenance function necessary to keep the pole line clear of tree limbs that could break and damage the wires on a utility pole.

Figure 12: Pole Line Where Tree Trimming Will Be Required

Figure 13 shows a low (favorable) make-ready pole line that has only one existing attachment in the communications space on the SMECO power poles (left); there is a separate pole line containing telecommunications cables on the opposite side of the street (right). Where make-ready is low, the cost of aerial construction is cheaper than in high make-ready areas.

Figure 13: Low-Make-Ready Pole Line in Unserved Area with Communications on a Separate Pole

3.2 The network architecture can support multiple subscriber models and classes of service

We developed a conceptual, high-level fiber-to-the-premises outside plant network design that is aligned with best practices in the industry and is open to a variety of electronic architecture options.[21]

Figure 14, below, shows a logical representation of the fiber-to-the-premises network architecture we recommend based on the conceptual outside plant design. The drawing illustrates the primary functional components in the fiber-to-the-premises network, their relative position to one another, and the flexibility of the architecture to support multiple subscriber models and classes of service.

The recommended architecture is a hierarchical data network that provides scalability and flexibility, both in terms of initial network deployment and its ability to accommodate the increased demands of future applications and technologies without requiring expensive new construction. The characteristics of this hierarchical fiber-to-the-premises data network are:

- **Capacity** – ability to provide efficient transport for subscriber data, even at peak levels
- **Availability** – high levels of redundancy, reliability, and resiliency; ability to quickly detect faults and re-route traffic
- **Failsafe operation** – physical path diversity in the network backbone to minimize operational impact resulting from fiber or equipment failure
- **Efficiency** – no traffic bottlenecks; efficient use of resources
- **Scalability** – ability to grow in terms of physical service area and increased data capacity, and to integrate newer technologies without new construction
- **Manageability** – simplified provisioning and management of subscribers and services
- **Flexibility** – ability to provide different levels and classes of service to different customer environments; can support an open access network or a single-provider network; can provide separation between service providers on the physical layer (separate fibers) or logical layer (separate Virtual Local Area Network (VLAN) or Virtual Private Network (VPN) providing networks within the network)

[21] The network's outside plant is both the most expensive and the longest-lasting portion. The architecture of the physical plant determines the network's scalability for future uses and how the plant will need to be operated and maintained; the architecture is also the main determinant of the total cost of the deployment.

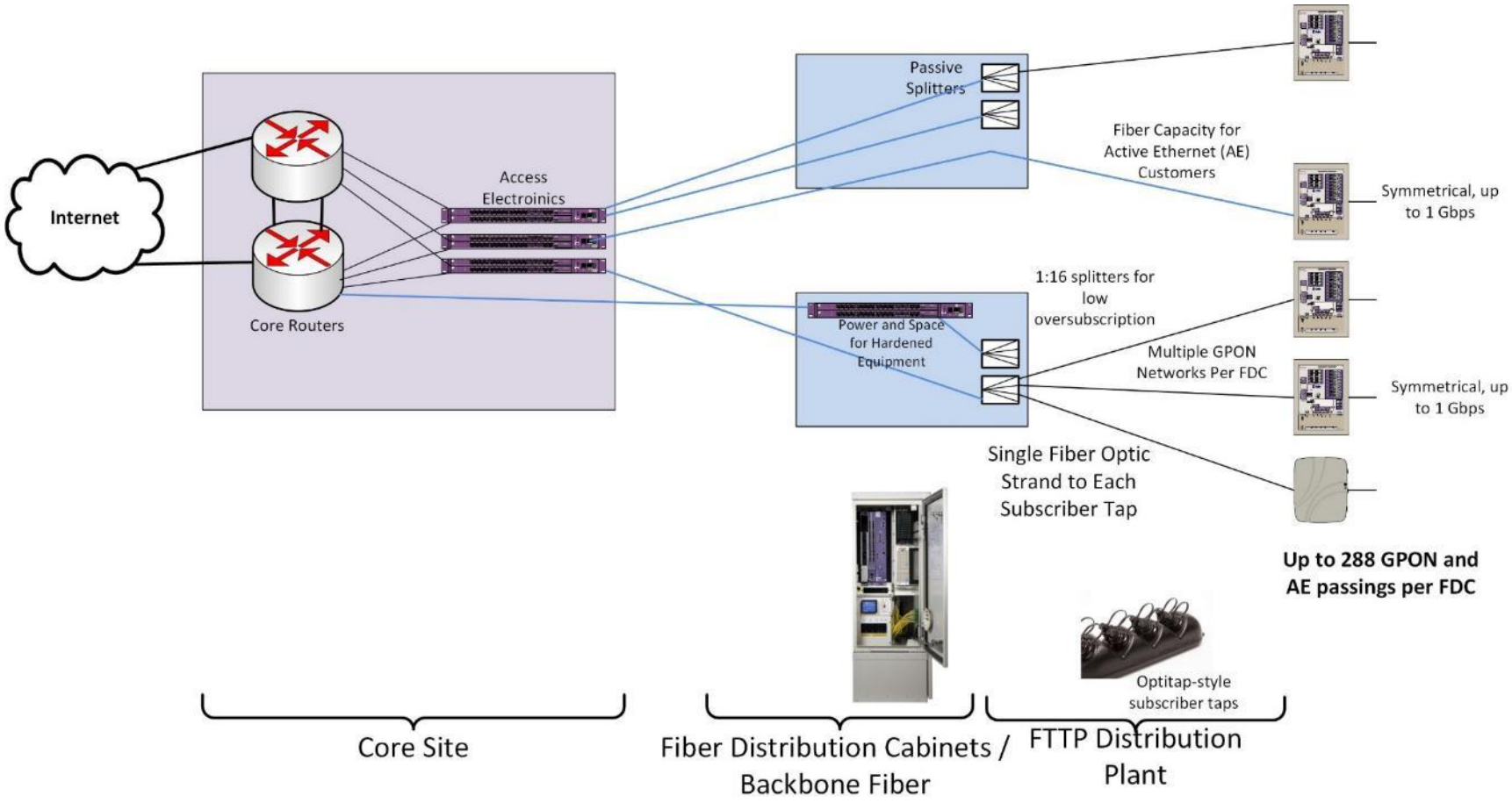
- **Security** – controlled physical access to all equipment and facilities, plus network access control to devices

This architecture offers scalability to meet long-term needs. It is consistent with best practices for either a standard or an open-access network model to provide customers with the option of multiple network service providers. This design would support the current industry standard gigabit passive optical network technology. It could also provide the option of direct Active Ethernet services.[22]

The design assumes placement of manufacturer-terminated fiber tap enclosures within the public right-of-way or easements, providing watertight fiber connectors for customer service drop cables, and eliminating the need for service installers to perform splices in the field. This is an industry-standard approach to reducing both customer activation times and the potential for damage to distribution cables and splices. The model also assumes that the County or a partner obtains easements or access rights to the gated communities and private drives within the communities to access the homes in those neighborhoods.

[22] The architecture enables the network to provide direct unshared Ethernet connections to 5 percent of customers, which is appropriate for a select group of high-security or high capacity commercial users (banks, wireless small cell connections). In extreme cases, the network can provide more customers with Active Ethernet with the addition of electronics at the fiber distribution cabinets on an as-needed basis.

Figure 14: High-Level Fiber-to-the-Premises Architecture



3.3 Network design assumptions include constructing more than 60 miles of fiber backbone

The network design and cost estimates assume the County or a partner will:

- Use existing County land to locate a core facility. The cost estimate includes the facility costs with adequate environmental and backup power generators to house network electronics, and provide backhaul to the internet.
- Construct approximately 50 miles of backbone network[23] to connect the unserved communities to the core via five fiber distribution cabinets. The fiber distribution cabinets will be located in the public right-of-way or on County-owned land that provides adequate space for the hosting and maintenance of the cabinet.
- Construct approximately 200 miles of fiber optics from the fiber distribution cabinets to approximately 2,300 homes and businesses (i.e., from termination panels in the fiber distribution cabinet to tap locations in the public right-of-way or on easements near the home or business).
- Obtain easements or access rights to private roads where public rights-of-way do not exist.

The fiber-to-the-premises network design was developed with the following criteria based on the above assumptions and required characteristics of the hierarchical fiber-to-the-premises network:

- Fiber will be installed in the communications space of the electrical utility poles where poles are present, and in newly constructed underground conduit in other areas.
- Fiber will vary between 12- and 288-count based on the projected need in the area.
- Fiber will be installed in the public right-of-way or in an easement on the side of the road.
- The network will target up to 288 passings per fiber distribution cabinet.
- Fiber distribution cabinets will support hardened network electronics and provide backup power and an active heat exchange.[24]

[23] The backbone construction costs are included in the cost of the fiber-to-the-premises network. The County or a partner may be able to leverage the Maryland Broadband Cooperative fiber in Nanjemoy to eliminate the need to build a fiber backbone to that unserved area.

[24] These hardened fiber distribution cabinets reflect an assumption that the network's operational and business model will require the installation of provider electronics in the fiber distribution cabinets that are capable of

- The network routes will avoid the need for distribution plant to cross major roadways and railways.

3.4 Total capital costs include outside plant construction, electronics, and service drop installation

3.4.1 Outside plant cost estimation methodology

We used the following unit cost assumptions when developing our estimated fiber construction costs (Table 7). Cost estimates are based on other fiber-to-the-premises projects and numbers provided by the County's fiber construction contractor.

Table 7: Unit Cost Estimate Assumptions

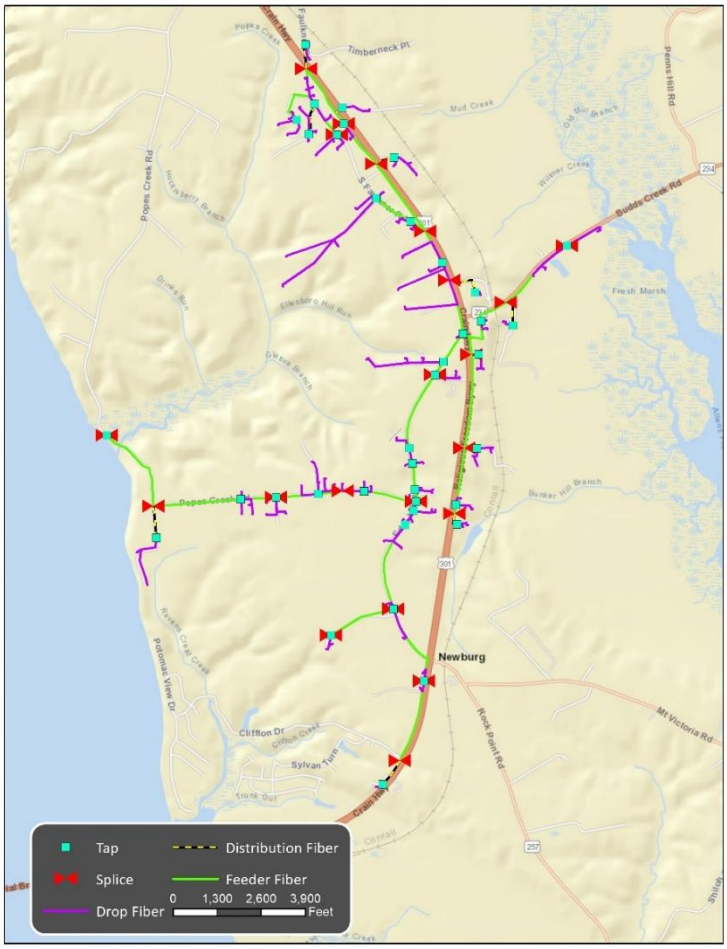
Description	Unit	Assumption
Placement of 2-inch conduit using directional boring	$/foot	$12.50
Pull-box placement, 24"x36"x36" Tier 22	each	$1,050
Aerial cable installation per foot	$/foot	$1.50
Traffic control and work area protection per foot	$/foot	$1.00
Tree trimming	$/foot	$1.00
Make-ready per foot	$/foot	$4.30
288-count cable	$/foot	$2.05
Aerial fiber installation materials	$/foot	$1.30

As with any utility, the design and associated costs for construction vary with the unique physical layout of the service area—no two streets are likely to have the exact same configuration of fiber optic cables, communications conduit, underground vaults, and utility pole attachments. Costs are further varied by soil conditions, such as the prevalence of subsurface hard rock; the condition of utility poles and feasibility of aerial construction involving the attachment of fiber infrastructure to utility poles; and crossings of bridges, railways, and highways.

supporting open access among multiple providers. We note that the overall fiber-to-the-premises cost estimate would decrease if the hardened fiber distribution cabinets were replaced with passive fiber distribution cabinets (which would house only optical splitters) and the providers' electronics were housed only at the hub facility.

To estimate costs, we extrapolated the costs for strategically selected sample designs based on street mileage and passings; Figure 15 is an example of a sample design.

Figure 15: Map of a Category 1 Unserved Area Sample Design



Our observations determined that the utilities are primarily aerial in unserved areas of the County, while most of the newly developed areas are all underground. There are also roads of use in the unserved areas where the County or a private provider will either need to acquire their own easements or use the easement granted to SMECO for its utility poles.

3.4.1.1 Aerial and underground construction approach

Aerial construction entails the attachment of fiber infrastructure to existing utility poles, which could offer significant savings compared to all-underground construction but increases uncertainty around cost and timeline. Under some circumstances, costs related to pole remediation and make-ready construction can make aerial construction cost-prohibitive in comparison to underground construction. However, as discussed in Section 3.1, our survey finds that the majority of poles likely have sufficient space and capacity, and that the amount of needed make ready is mostly average.

We assume that the fiber will be strand-mounted in the communications space on the existing utility poles. Splice cases, subscriber taps, and drops will also be attached to the strand, which facilitates maintenance and customer installation.

While generally allowing for greater control over timelines and more predictable costs, underground construction is subject to uncertainty related to congestion of utilities in the PROW and the prevalence of subsurface hard rock—neither of which can be fully mitigated without physical excavation and/or testing.

While anomalies and unique challenges will arise regardless of the design or construction methodology, the relatively large scale of this project is likely to provide ample opportunity for variations in construction difficulty to yield relatively predictable results on average.

We assume underground construction will be done using an industry-standard approach for this type of environment, which consists primarily of horizontal, directional drilling to minimize public right-of-way impact and to provide greater flexibility to navigate around other utilities. The design model assumes a single 2-inch, flexible, High-Density Polyethylene (HDPE) conduit over underground distribution paths, and dual 2-inch conduits over underground backbone paths to provide scalability for future network growth.

Costs for aerial and underground placement were estimated using available unit cost data for materials and estimates on the labor costs for placing, pulling, and boring fiber based on construction in comparable markets. The material costs were known, with the exception of unknown economies of scale and inflation rates and barring any shortages or supply disruptions restricting material availability and increasing costs. The labor costs associated with the placement of fiber were estimated based on comparable construction projects and data provided by the County.

3.4.1.2 Outside plant cost components

The cost components for outside plant construction include the following tasks:

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

- ***Quality Control / Quality Assurance*** – includes expert quality assurance field review of final construction for acceptance.

- ***General Outside Plant Construction*** – consists of all labor and materials related to "typical" underground or aerial outside plant construction, including conduit placement,

utility pole make-ready construction, aerial strand installation, fiber installation, and surface restoration; includes all work area protection and traffic control measures inherent to all roadway construction activities.

- ***Special Crossings*** – consists of specialized engineering, permitting, and incremental construction (material and labor) costs associated with crossings of railroads, bridges, and interstate / controlled access highways.
- ***Backbone and Distribution Plant Splicing*** – includes all labor related to fiber splicing of outdoor fiber optic cables.
- ***Backbone Hub, Termination, and Testing*** – consists of the material and labor costs of placing hub shelters and enclosures, terminating backbone fiber cables within the hubs, and testing backbone cables.
- ***Fiber-to-the-Premises Service Drop and Lateral Installations*** – consists of all costs related to fiber service drop installation, including outside plant construction on private property, building penetration, and inside plant construction to a typical backbone network service "demarcation" point; also includes all materials and labor related to the termination of fiber cables at the demarcation point. The model only includes drop costs for the estimated 60 percent of customers taking the service.

The assumptions, sample designs, and cost estimates were used to extrapolate a cost-per-mile for the outside plant infrastructure of $77,000.

The distribution plant covers approximately 200 miles, leading to a total outside plant cost of approximately $16 million. This leads to an average outside plant cost per passing of approximately $7,000. Table 8 provides a breakdown of the estimated outside plant costs.

Table 8: Estimated Outside Plant Costs[25]

Cost Per Plant Mile[26]	Distribution Plant Mileage	Total Cost	Estimated Passings	Cost per Passing[27]
$77,000	210	$16.1 million	2,280	$7,050

[25] Unrounded numbers are used in the engineering calculations; these are then rounded in the discussion.
[26] The cost per plant mile is the average cost of constructing a mile of outside plant for the fiber-to-the-premises network.
[27] The cost per passing is the average cost to construct the outside plant for the fiber-to-the-premises network to pass each premises within the unserved areas.

The actual cost to construct fiber-to-the-premises to every unserved Category 1 premises in the County could differ from the estimate due to changes in the assumptions underlying the model. For example, if make-ready and pole replacement costs are too high, the network would have to be constructed underground—which could significantly increase the cost of construction. A non-uniform take-rate (i.e., the percentage of passed customers that choose to purchase a service) across different areas could also influence costs. Further and more extensive analysis would be required to develop a more accurate cost estimate across the entire County.

Actual costs will also vary from this estimate due to factors that cannot be precisely known until the detailed design is completed, or until construction commences. These factors include:

- Costs of private easements;
- Utility pole replacement and make-ready costs;
- Variations in labor and material costs;
- Subsurface hard rock; and
- The County or its partner's operational and business model.

We have incorporated suitable assumptions to address these items based on our experience in similar markets.

3.4.2 Central network electronics costs

Central network electronics equipment to serve the unserved area will cost an estimated $600,000, assuming a 60 percent take-rate.[28] (These costs may increase or decrease depending on take-rate, and the costs may be phased in as subscribers are added to the network.) The network electronics consist of the core and distribution electronics to connect subscribers to the fiber-to-the-premises network at the core and the fiber-to-the-premises access electronics located at the fiber distribution cabinets. Table 9 lists the estimated costs for each segment.

Table 9: Estimated Central Network Electronics Costs

Network Segment	Subtotal
Core and Distribution Electronics	$400,000
Fiber-to-the-Premises Access Electronics	$200,000
Total	*$600,000*

[28] The take-rate affects the electronics and drop costs, but also may affect other parts of the network, as the County or its partner may make different design choices based on the expected take-rate. A 60 percent take-rate is possible in environments where a new provider delivers service in a previously unserved area. Market research would be required to estimate a more accurate take-rate at assumed service costs.

The electronics are subject to a seven- to 10-year replacement cycle, as compared to the 20- to 30-year lifespan of a fiber investment.

3.4.2.1 Core and distribution electronics

The core electronics connect the network to the internet. The core electronics consist of high-performance routers, which handle all the routing on both the network and to the internet. The core routers have modular chassis to provide high availability in terms of redundant components and the ability to "hot swap" line cards in the event of an outage.[29] Modular routers also provide the ability to expand the routers as demand for additional bandwidth increases.

The cost estimate design envisions running networking protocols, such as hot standby routing protocol (HSRP), to ensure redundancy in the event of a router failure. Additional connections can be added as network bandwidth on the network increases. The core sites would also tie to the distribution electronics using 10 Gbps links. The links to the distribution electronics can also be increased with additional 10 Gbps and 40 Gbps line cards and optics as demand grows on the network. The core networks will also have 10 Gbps to ISPs that connect the network to the internet.

The cost of the incremental core routing equipment is approximately $400,000. In addition, the network requires operations support systems, such as provisioning platforms, fault and performance management systems, remote access, and other operational support systems for operations. For a network of this scale, an operations support system costs approximately $100,000 to acquire and configure, if not provided by the network provider.

3.4.2.2 Fiber-to-the-premises access electronics

The access network electronics at the fiber distribution cabinets connect the subscribers to the network by connecting the backbone to the fiber that goes to each premises. We recommend deploying access network electronics that can support both gigabit passive optical network and Active Ethernet subscribers to provide flexibility within the fiber distribution cabinet service area. These electronics are commonly referred to as optical line terminals. We also recommend deploying modular access network electronics for reliability and the ability to add line cards as more subscribers join in the service area. Modularity also helps reduce initial capital costs while the network is under construction or during the roll-out of the network.

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

The cost of the access network electronics for the network is estimated at approximately $200,000. These costs are based on a take-rate of 60 percent and include optical splitters at the fiber distribution cabinets aligned to that take-rate.

An alternative design places the optical line terminals at the core location, with the fiber distribution cabinets containing only splitters. As the County or its partner examines more closely the specific electronics architecture, this alternative may be a suitable approach, which would reduce size of the fiber distribution cabinets and provide a small cost savings.

3.4.3 Service drop installation and customer premises equipment (per-subscriber costs)

Each activated subscriber would also require a fiber drop cable installation and related customer premises equipment, which would cost on average roughly $1,320 per subscriber, or $1.8 million total—again, assuming a 60 percent take-rate.

Customer premises equipment is the subscriber's interface to the network; for gigabit passive optical networks, these electronics are referred to as an optical node terminal. For this cost estimate, we selected customer premises equipment that both terminates the fiber from the network and provides only Ethernet data services at the premises (however, there are a wide variety of additional customer premises equipment offering other data, voice, and video services). The customer premises equipment can also be provisioned with wireless capabilities to connect devices within the customer's premises. Using the assumed take-rate of 60 percent, we estimated the cost for subscriber customer premises equipment and installation to be $500 per subscriber, or approximately $700,000 systemwide.

The drop installation cost is the biggest variable in the total cost of adding a subscriber. A short aerial drop can cost as little as $250 to install, whereas a long underground drop installation can cost upward of $5,000. Based on the prevalence of aerial and underground utilities, and sample designs, we estimate an average of approximately $820 per drop installation. The drop installation follows the existing utilities, so that if the existing utilities in the public right-of-way are aerial, the drop would be installed aerially and vice versa for underground. Average drop distances are extrapolated from the sample designs. Actual drop costs will vary for each premises.

The other per-subscriber expenses include the labor to install and configure the electronics, and the incidental materials needed to perform the installation. The numbers provided in Table 10, below, are averages and will vary depending on the type of premises and the internal wiring available at each premises.

Table 10: Per-Subscriber Cost Estimates

Construction and Electronics Required to Activate a Subscriber	Estimated Average Cost
Drop Installation and Materials	$820
Subscriber Electronics (Optical Node Terminal)	$200
Electronics Installation	$200
Installation	$100
Total	*$1,320*

3.5 Annual fiber-to-the-premises technical operating costs would total approximately $430,000

Some of the ongoing costs of operating a fiber-to-the-premises network include fiber maintenance, fiber locating, pole attachment fees, and equipment replacement. These estimates include costs directly related to the maintenance and operations of the physical and network electronics layers of the network, but does not include costs associated with higher layer services and other fixed administrative expenses that would otherwise be incurred regardless of the technical approach to network transport.

Regular fiber maintenance includes any add, moves, and changes required of the network. For example, if a roadway is widened a pole line may be moved or undergrounded, requiring the County to relocate this fiber. We estimate that 1 percent of the total capital costs is required annually for fiber maintenance, or $160,000.

Fiber locating includes the marking of underground utilities as part of the state's Miss Utility process. Each underground utility is responsible for locating and marking their utilities in the right-of-way. We estimate the cost at $1,800 per mile of underground construction annually for utility locates, or $35,000 annually for the estimated 20 miles of underground plant.

For every pole that the fiber network attaches to, the County or its partner must pay the pole owner an attachment fee for using the pole. Pole attachment fees go toward the maintenance of the utility pole line. We estimate a pole attachment fee of $20 per pole per year or a total of $150,000 annually for approximately 190 miles of aerial plant. Pole attachment fees are estimated and would be negotiated with the pole owners as part of the pole attachment process.

We also recommend establishing an equipment replacement fund where the County or its partner puts a portion of the necessary funds to replace the network electronics. We recommend planning on replacing the network electronics every seven years, requiring the County or its partner to place approximately $85,000 into the equipment fund annually.

Table 11 summarizes the fiber-to-the-premises technical operating costs.

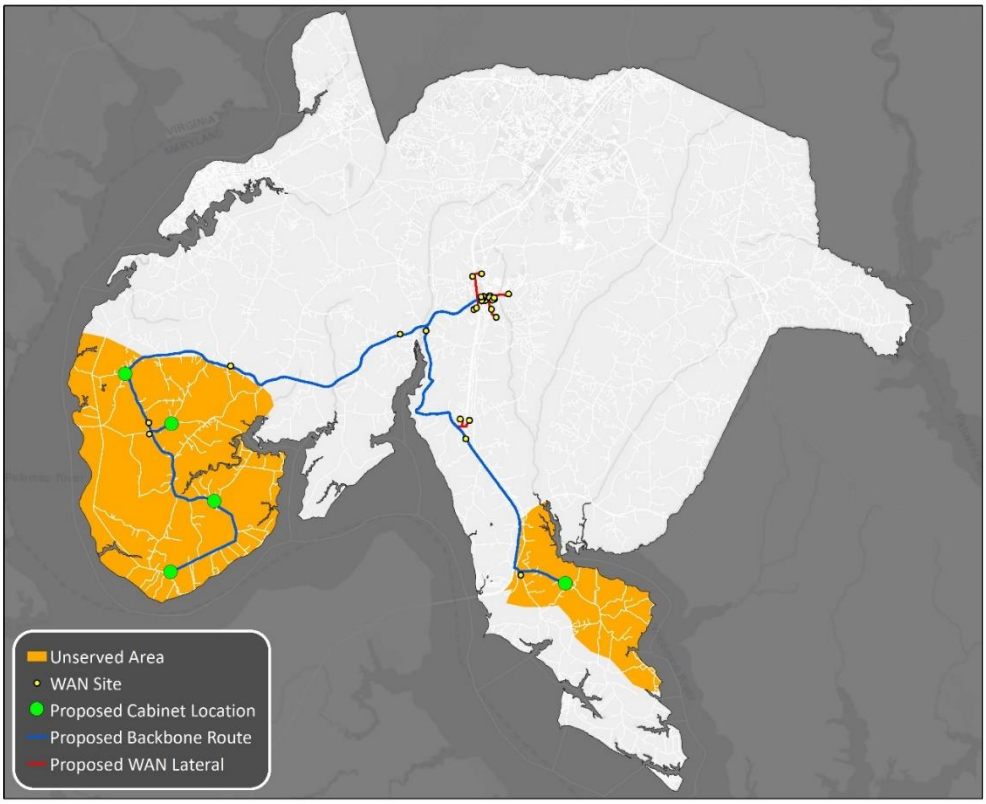
Table 11: Estimated Annual Fiber-to-the-Premises Technical Operating Costs

Description	Annual Cost
Fiber Maintenance	$160,000
Fiber Locating	$35,000
Pole Attachment Fees	$150,000
Equipment Replacement Fund	$85,000
Total	*$430,000*

3.6 Constructing laterals from the fiber-to-the-premises backbone to augment the County WAN would cost approximately $1 million

The backbone designed for the candidate fiber-to-the-premises network would traverse large portions of the County to serve the unserved homes and businesses. One of the benefits of the backbone is that it could be used to provide redundancy to or replace the County's existing wide-area network (WAN). Figure 16 shows the 34 WAN sites that are within 1 mile of the theoretical fiber-to-the-premises backbone.[30]

Figure 16: Theoretical Fiber-to-the-Premises Backbone Comparison to County WAN Sites



[30] The County provided CTC with a GIS layer of existing WAN sites.

It would take approximately 8 miles of lateral construction to connect 34 WAN sites to the fiber-to-the-premises backbone. At an estimated cost of $125,000 per mile, laterals constructed off the fiber-to-the-premises backbone could augment the existing County WAN for approximately $1 million. (We estimated a higher per mile cost than for the fiber-to-the-premises network as a whole to reflect the higher percentage of underground construction in the areas along the backbone.) The fiber-to-the-premises backbone may also provide opportunities to connect new sites to the County WAN that were previously cost-prohibitive.

Table 12 lists the WAN sites, their lateral distances from the backbone, and the estimated cost to connect each site.

Table 12: Lateral Costs for WAN Sites Near the Fiber-to-the-Premises Backbone[31]

Site ID	Name	Address	Site Dependence	Shared Location	Lateral Mileage	Lateral Cost
Site 1	Dept. of Social Services	200 Kent Ave La Plata 20646	16		0.1	$12,500
Site 2	CCSO Old Detention Center	6845 Crain Hwy La Plata 20646	5, 6, 7	2, 3, 4	0.3	$37,500
Site 3	Judicial Services Bldg. (old detention center)	6845 Crain Hwy La Plata 20646	2, 5, 6, 7	2, 3, 4	NA	$ –
Site 4	CCSO New Detention Center	6905 Crain Hwy (New Bldg.)	2, 5, 6, 7	2, 3, 4	NA	$ –
Site 5	CCSO/NEW HQ	6855 Crain Hwy La Plata 20646	0	5, 6, 7	0.4	$50,000
Site 6	CCSO District one (old CCSO HQ)	6855 Crain Hwy La Plata 20646	5	5, 6, 7	NA	$ –
Site 7	CCSO Tower	6855 Crain Hwy La Plata 20646	5	5, 6, 7	NA	$ –
Site 8	Town of LaPlata Police Department	5 Garret Ave 20646	0		0.1	$12,500
Site 9	Clark Senior Center	1210 Charles St La Plata 20646	16, 102, 80, 81		0.7	$87,500
Site 10	CCFD Company 1 LaPlata VFD	911 Washington Ave La Plata 20646	74		0.5	$62,500
Site 11	Charles Co. Courthouse/ Circuit Court	200 East Charles St La Plata 20646	0	11, 12	0.1	$12,500
Site 12	Dare Building SAO Child Support	200 East Charles St La Plata 20646	11	11, 12	NA	$ –
Site 13	Walter J. Mitchell Elem. School	400 Willow Ln 20646	16, 102		0.5	$62,500
Site 15	Charles Co. Courthouse/Bldg. 2	11 Washington Ave La Plata 20646	11, 12		0.1	$12,500
Site 16	CCSO/ Crime Lab	100 Kent Ave La Plata 20646	0		0.2	$25,000
Site 17	Election Board	201 East Charles Street La Plata 20646	0		0.1	$12,500
Site 18	CCFD Company 10 Bel Alton VFD	B9765 Bel-Alton Rd 20611	24		0.5	$62,500
Site 22	CC EMS Company 51 La Plata EMS	CC VRS2 Calvert St 20646	0		0.1	$12,500
Site 23	Dept. of Human Services Partnership	6 Garret Ave La Plata 20646	16, 102, 80, 81		0.1	$12,500

[31] The Site ID is a unique number for each County WAN site in GIS. The site dependence column lists the Site IDs of the laterals that must be constructed prior to the site as the site's lateral is constructed off of the dependent lateral. Shared locations are sites that site on the same property and therefore need only one lateral.

Site ID	Name	Address	Site Dependence	Shared Location	Lateral Mileage	Lateral Cost
Site 24	Bel Alton WWTP	9225 Twinberry Drive, Bel Alton	0		0.6	$75,000
Site 26	CC EMS Company 58 Ironsides Vol Rescue Squad	6120 Port Tobacco Rd 20646	0		0.2	$25,000
Site 29	CC EMS Company 14 Newburg VRS	12265 Rock Point Rd 20664	0		0.2	$25,000
Site 74	Emergency Services-Chesapeake St	9375 Chesapeake St	0		1.1	$137,500
Site 76	Stagg Hall (Port Tobacco Courthouse)	8450 Commerce Street, Port Tobacco	0		0.1	$12,500
Site 78	Dept. of Community Services	8190 Port Tobacco Rd La Plata 20646	0		0.1	$12,500
Site 80	University of MD – Charles Regional Medical Center	701 E. Charles St 20646	16, 102		0.2	$25,000
Site 81	Charles County Public Library-La Plata	2 Garret Ave La Plata 20646	16, 102, 80		0.2	$25,000
Site 102	Middle School-Milton M. Somers	300 Willow Ln 20646	16		0.5	$62,500
Site 106	Charles Co. Govt.	200 Baltimore St La Plata 20646	11, 12, 15		0.1	$12,500
Site 117	Bel Alton High School	9501 Crain Highway / Bel Alton High School Fiber Install Proposal	0		0.1	$12,500
Site 119	CC FD Company 4 Nanjemoy Vol FD & EMS	4260 Port Tobacco Rd. 20662	0		0.1	$12,500
Site 120	Nanjemoy Community Center	4375 Port Tobacco RD Nanjemoy MD, 20662	0	120, 121, 122	0.1	$12,500
Site 121	Welcome Center	12480 Crain Highway Newburg	120	120, 121, 122	NA	$ –
Site 122	Nanjemoy EMS Tower	4375 Port Tobacco Rd	120	120, 121, 122	NA	$ –

4 A Fixed-Wireless Solution to Partially Fill the Category 1 Broadband Gaps Would Have Lower Capital Costs Than Fiber but High Ongoing Operating Costs

As an alternative to deploying fiber-to-the-premises, the County could consider a fixed-wireless network to deliver broadband services to unserved members of the community. To that end, CTC's engineers developed a fixed wireless network model to assess the viability of serving Charles County's approximately 2,300 unserved Category 1 addresses using existing government and commercial towers within the County.

Our analysis found that, although it would have clear technical limitations relative to a fiber optic network, a fixed wireless network could be used to serve a portion of the County's unserved homes and businesses. Equipment mounted on two government-owned towers could enable coverage of approximately 37 percent of the Category 1 unserved premises (while also reducing the cost of constructing the network). Mounting equipment on 25 existing towers (government and commercial), as well, would enable the network to serve up to approximately 86 percent of the Category 1 unserved premises (but would require the ongoing payment of lease fees).

Table 13 summarizes the cost and scope of coverage using existing County-owned and commercial towers.

Table 13: Cost and Scope of Category 1 Coverage Using Fixed Wireless[32]

Number of Towers	25
Passings Served	1,982
Percent of Unserved Passings Served	86.9
Average Distribution Network Cost per Passing	$1,900
Incremental Installation and Electronics per Customer	$1,800
Capital Cost with 35% Take-Rate[33]	$5,000,000
Capital Cost with 60% Take-Rate	$6,000,000
Capital Cost per Customer with 35% Take-Rate	$7,200
Capital Cost per Customer with 60% Take-Rate	$5,000

The following sections:

- Provide a high-level introduction to fixed wireless connectivity (including technologies, basic architecture, spectrum, and elements of costs)

[32] Unrounded numbers are used in the engineering calculations; these are then rounded in the discussion.
[33] Includes subscriber equipment and installation for 35 percent of addresses.

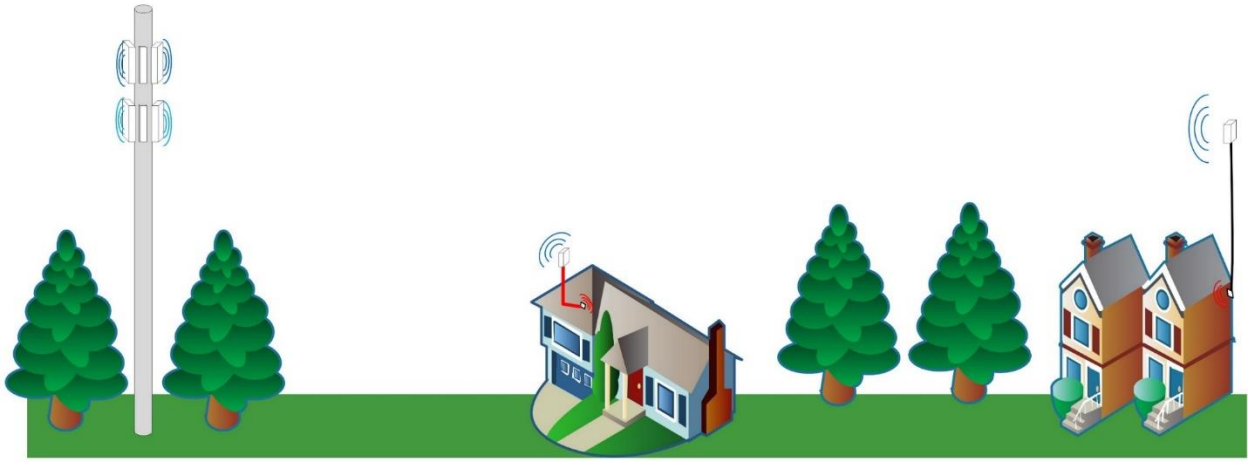
- Describe the use of the existing structures within the County in a fixed wireless solution for Category 1 unserved homes and businesses
- Analyze the potential for adding sites that would enhance the fixed wireless network's coverage

4.1 Fixed wireless networks can deliver broadband speeds

Broadband speeds in compliance with the FCC's definition (i.e., 25 Mbps download, 3 Mbps upload) are more readily available from fixed wireless networks than in the past, owing to the recent introduction of the Citizens Broadband Radio Service (CBRS) spectrum into the market and new wireless technologies. While wireless ISPs (WISP) typically are not able to offer connection speeds on a market-wide basis comparable to cable or fiber networks built to each premises, a fixed wireless connection may be a desirable solution if cable or fiber is not cost-effective. This is especially true in low-density rural areas where there are few homes and businesses per mile, and therefore the cost of building wired networks is often high.

As opposed to an underground or aerial cable, wireless broadband is provided from access point antennas on towers, monopoles, or rooftops. The customer antenna may be on the home or business or on a mast on the customer premises (Figure 17).

Figure 17: Example Fixed Wireless Network with Various Customer Antenna Configurations



4.1.1 Fixed wireless networks can use various technologies and spectrum bands

The fixed wireless networks in our model use the following spectrum:

- TV White Space (TVWS) 500 MHz
- Unlicensed 900 MHz, 2.4 GHz, 5 GHz
- Citizens Broadband Radio Service (CBRS) 3.5 GHz

Of these bands, only CBRS and 5 GHz technology have channel widths capable of consistently delivering 25 Mbps downstream and 3 Mbps upstream. For unlicensed spectrum, there exists the potential for others to be operating on the same, adjacent, or other interfering frequencies. Precautionary measures should be taken to mitigate different types of interference; such efforts include checking for a clean frequency in the area of interest and appropriate antenna and antenna pattern choice.

TVWS delivers service over unused television frequencies (known as white space). TVWS bands have much better non-line-of-sight transmission qualities than the other bands; however, due to its narrower bandwidth, TVWS is not capable of delivering 25 Mbps down, and therefore should only be considered in cases where other connectivity is not available or feasible. Also, because white space technology is still in an early phase of development, compatible equipment is far more expensive than other off-the-shelf wireless equipment. Finally, because Charles County has a metropolitan area and many existing broadcast television channels, the potential TVWS spectrum is significantly more limited than in more remote areas.

Most fixed wireless network solutions require the antenna at the subscriber location to be in or near the line of sight of the base station antenna. This can be especially challenging in highly wooded regions. It is also a problem in areas with dense vegetation or multiple tall buildings. WISPs often need to lease space at or near the tops of radio towers; even then, some customers may be unreachable without the use of additional repeaters. And because the signal is being sent through the air, climate conditions like rain and fog can impact the quality of service. In our model, we assumed that the top of any existing towers is already utilized, and that any new equipment would be placed at 80 percent of the current tower height.

In addition, there is a tradeoff in these bands between capacity and the ability to penetrate obstructions such as foliage and terrain. The higher frequencies have wider channels and therefore the capability to provide the highest capacity. However, the highest frequencies are those most easily blocked by obstructions. Wireless equipment vendors offer a variety of point-to-multipoint and point-to-point solutions. A medium-sized business location would be more likely to obtain a point-to-point solution with dedicated bandwidth from the service provider to obtain the needed bandwidth and quality. Small businesses and homes would obtain a point-to-

multipoint solution, which is more affordable to implement. Point-to-point networks may have limited network capacity, particularly in the upstream, making the service inadequate for applications that require high-bandwidth connections. The models in this document assume point-to-multipoint equipment, which is typical for a residential or small business connection.

A wireless analysis was conducted to determine how the unserved address in the County may be served via fixed wireless. The high-level model is for planning purposes only. The RF coverage analysis was modeled using CloudRF, which is an online service available for modelling the Radio frequency propagations. The software was chosen because of its ability to output coverage maps in a GIS layer than can be overlaid on the unserved address points, and therefore identify which of the address would be covered by the wireless model.

4.1.2 Fixed wireless network deployment costs depend on a range of factors

The following factors will determine the costs associated with a fixed wireless network:

- **Wireless equipment used:** Different wireless equipment has different aggregate bandwidth capacity and use a range of different spectrum bands, each with its own unique transmission capabilities.

- **Backhaul connection**: Although the bottleneck tends to be in the last-mile connection, if a WISP cannot get an adequate connection back to the internet from its tower, equipment upgrades will not be able to increase available speeds beyond a certain point.

- **Future capacity and lifespan of investment:** Wireless equipment generally requires replacement every five to 10 years, both because exposure to the elements causes deterioration, and because the technology continues to advance at a rapid pace, making decade-old equipment mostly obsolete. The cost of deploying a wireless network is generally much lower than deploying a wireline network, but the wireless network will require more regular investment.

- **Availability of unobstructed line of sight:** Most wireless networking equipment requires a clear, or nearly clear, line of sight between antennas for optimum performance. WISPs often lease space near the tops of radio towers, to cover the maximum number of premises with each base station.

- **Use of public safety infrastructure**: Public safety infrastructure must be built to public safety grade guidelines and is therefore more costly that commercial infrastructure. "'Public Safety Grade' is a conceptual term that refers to the expectation of emergency response providers and practitioners that their equipment and systems will remain operational during and immediately following a major natural or manmade disaster on

a local, regional, and nationwide basis. [The term] is used to refer to network hardening or network sustainability."[34]

4.2 Choosing the best-fit spectrum for a given tower location can improve coverage and reduce deployment costs

Our study examined three of the most suitable candidate frequency bands (and the associated technologies) for fixed wireless services: CBRS, unlicensed 5 GHz, and TVWS.

Because each band needs its own set of equipment, we sought to identify the most effective bands for each tower location with the understanding that if one or more bands can be eliminated from specific sites, then the overall cost of deployment and operations will be reduced.

The CBRS band is predicted to connect the most addresses—primarily due to its spectrum properties, and the fact that FCC licensing rules allow CBRS antennas to be mounted higher than TVWS antennas. It also has the greatest broadcast power of the three technologies. In addition, CBRS is the only band that can be licensed.

Of the frequencies examined, only CBRS and unlicensed technologies have channel widths (and therefore bandwidth) capable of delivering 25 Mbps down and 3 Mbps up. Because TVWS is not capable of delivering 25 Mbps down, we used that technology only in places where there is no 5 GHz or CBRS connectivity.

4.3 Cost-effective fixed wireless service depends on precise tower selection

To examine the potential for government and other towers to provide service to the County's Category 1 unserved addresses, we analyzed multiple commercial and government databases and identified approximately 52 existing tower locations in Charles County. Of these towers, we selected 25 that could potentially provide fixed wireless service to the unserved areas (based on the towers' locations, heights, and ownership).

CTC's engineers assessed the potential coverage that would be enabled by equipment mounted on each of the selected tower sites; using CloudRF software, we estimated how many of the Category 1 unserved address would be within the predicted coverage area of each of the three fixed wireless frequency band options (CBRS, 5 GHz, and TVWS). We based our analysis on the following assumptions:

[34] Definition of public safety grade from the National Public Safety Communications Council (NPSTC) report *Defining Public Safety Grade Systems and Facilities* which is under consideration to contribute to a future public safety grade standard.

- Antennas are placed at 80 percent of the tower height for 5 GHz and CBRS, and at the maximum allowable height of 30 meters for TVWS
- Broadcast power is at the FCC limit for all three bands
- Channel bandwidth is 20 MHz for 5 GHz, 10 MHz for CBRS, and 6 MHz for TVWS
- Subscriber equipment antennas would be placed at 4.57 meters (15 feet) above ground level
- Ground elevation and clutter resolution is 30 meters

4.4 Using existing towers, a fixed wireless network could cover about 90 percent of unserved Category 1 residents

Of the 25 optimal towers we identified, two are government-owned sites and the remainder are commercial sites. Figure 18 shows the government sites in blue and commercial towers in dark green.

Figure 18: Existing Towers in Relation to Category 1 Unserved Areas

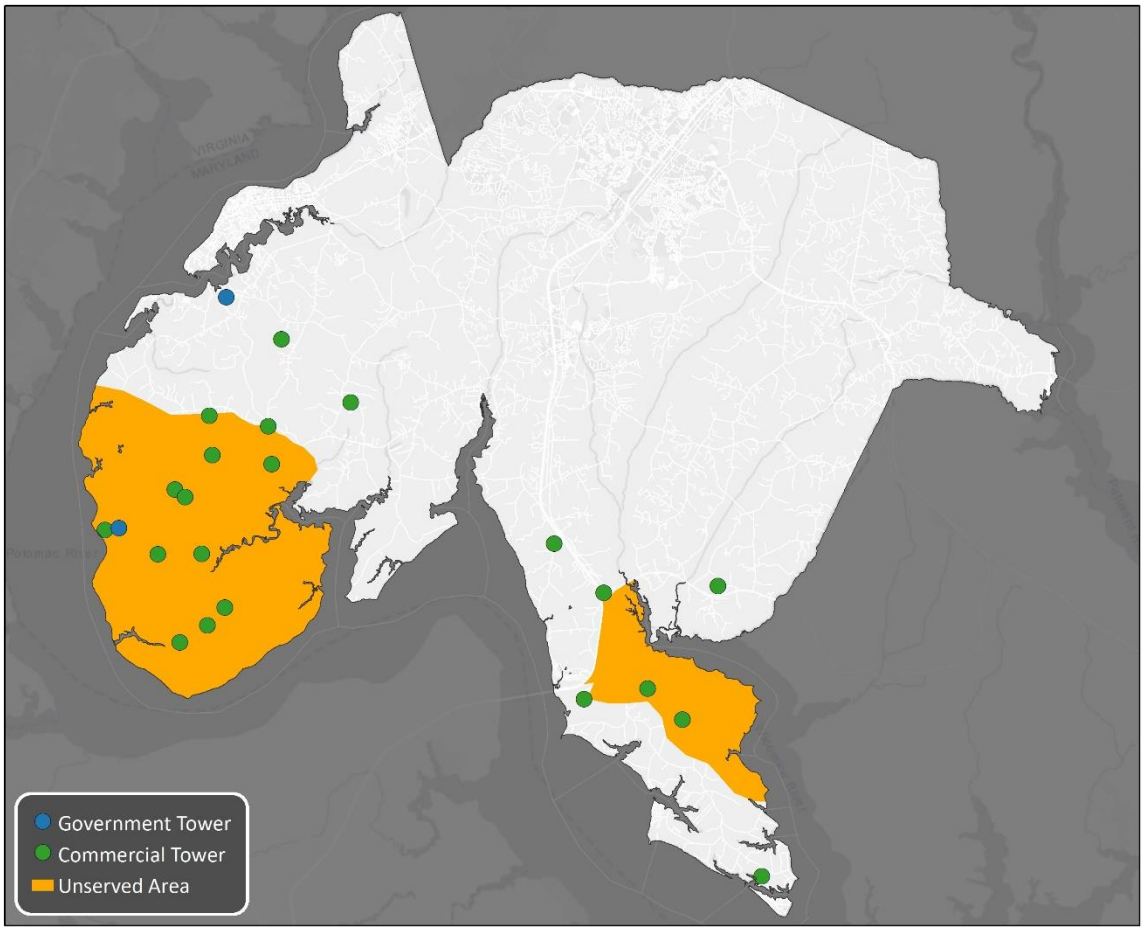


Table 14 (below) shows our cost breakdown for using existing towers for a Category 1 fixed wireless solution. Our assumptions are as follows:

- Towers will be configured with three sectors for each frequency used
- All selected towers will have CBRS deployed
- 25 percent of the towers will also have 5 GHz deployed
- 25 percent of the towers will also have TVWS deployed
- Towers will be connected to backhaul using microwave links; 10 percent of the sites will require an additional hop
- Engineering and design includes propagation studies, RF path analysis for point-to-point connections, structural analysis, construction plans, and permits
- Site acquisition costs include the costs of the preliminary equipment dimensioning, power needs, shelter requirements, RF suitability, escorts, and lease negotiations
- There is room within the shelter at the tower location for additional equipment
- To support a fixed wireless network, it is necessary to set up a core network to manage functions such as authentication, billing, security, and connection to the internet; CTC estimates $200,000 for equipment and setup of a core
- The costs outlined below are capital costs only and do not include operational costs

Table 14: Estimated Capital Cost for Fixed Wireless Network Using Existing Towers

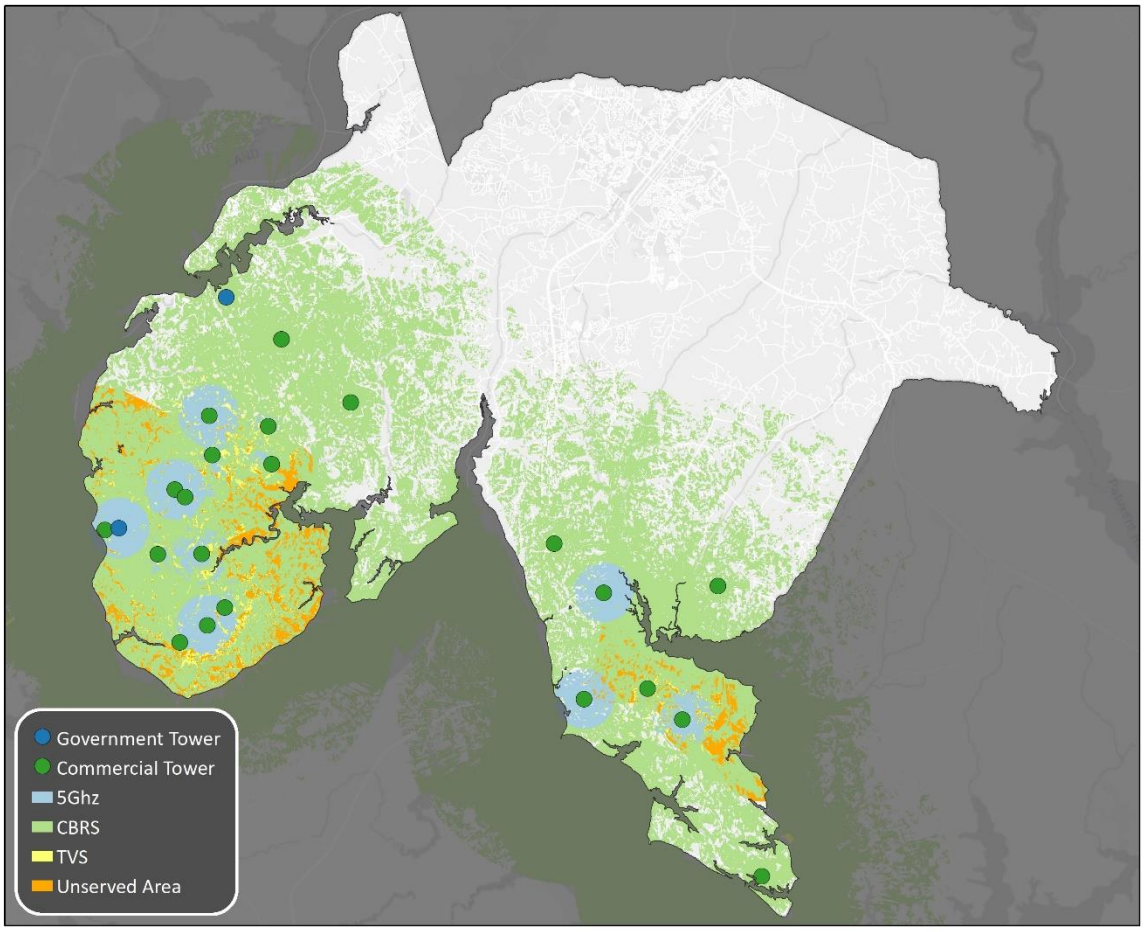
Item	Cost
Core Equipment	$200,000
Access Point Equipment	$425,000
Backhaul	$375,000
Installation, Engineering and Design	$1,750,000
Site Acquisition	$1,000,000
Estimated Total Distribution Network Cost	*$3,725,000*
Estimated Incremental Cost per Subscriber	*$1,800*

Table 15: Estimated Capital Cost for Fixed Wireless Network at Different Take-Rates

Item	Cost
Capital Cost (Distribution Only)	$3,750,000
Capital Cost (35% Take-Rate)	$5,000,000
Capital Cost (60% Take-Rate)	$6,000,000
Cost per Address (Distribution Only)	$1,900
Cost per Subscriber (35% Take-Rate)	$7,200
Cost per Subscriber (60% Take-Rate)	$5,000

Figure 19 shows the coverage areas for a fixed wireless solution using antennas mounted on the selected towers. The dark green and blue dots illustrate the tower locations, while the light green, blue, and yellow areas illustrate coverage with three types of wireless technologies. TVWS access points are included in the design as an alternative for serving addresses with exceptionally high obstruction due to foliage or terrain. Orange shading indicates the remaining Category 1 unserved areas.

Figure 19: Category 1 Fixed Wireless Coverage Using Existing Towers



Almost all Category 1 addresses that would have 5 GHz coverage would also have CBRS coverage. Although no more addresses are reached by adding 5 GHz than by simply deploying CBRS, there may be some cases where the CBRS capacity is at a maximum and 5 GHz could be deployed to offload some of the traffic.

Because CBRS covers the most addresses, and delivers 25 Mbps, we recommend it be deployed at all the towers; 5 GHz can be used selectively to add capacity at sites, and TVWS can be used selectively to pick up additional addresses at select locations.[35]

Our propagation analysis predicts approximately 300 addresses, or 13 percent of the Category 1 unserved premises, would not be covered by any frequency band from antennas mounted on the selected towers. Table 16 breaks down the results.

Table 16: Summary of Category 1 Coverage by Fixed Wireless Solution

Addresses	Estimated Number
Total addresses in Category 1 unserved area	2,280
Addresses served by CBRS band	1,393
Additional addresses served by TVWS band	145
Addresses served by one or more band	1,982
Addresses not served by any of the three bands	300
Percent of addresses served by one or more of the three bands	86.9%

[35] Determining which band would be deployed at each tower site is beyond the scope of this analysis.

5 Fiber-to-the-Premises Is a Clearly Preferable Technical Solution with Significantly Lower Operating Costs as Compared to a Fixed Wireless Solution for Serving Category 1 Areas

Overall, fiber-to-the-premises represents a better broadband solution than fixed wireless for most unserved areas of the County. Considering a 35 percent take-rate, fiber-to-the-premises has a lower 10-year total cost of ownership per customer ($26,650) than does a fixed wireless solution ($41,550). With a 60 percent take-rate, fiber-to-the-premises also has a lower 10-year total cost of ownership per customer ($16,100) than does a fixed wireless solution ($26,500). Total cost of ownership takes into account capital costs and maintenance costs—including tower lease fees and regular equipment replacement.

A comparison of the two technologies must also recognize that fiber and fixed wireless each have technical advantages and challenges.

Fiber optics, once constructed, is the highest-speed and most scalable technology. Current off-the-shelf technologies enable fiber-to-the-premises networks to provide capacity in excess of 1 Gbps to each subscriber, with new electronics making it possible to go to 10 Gbps or beyond in the coming years. Moreover, the fiber-to-the-premises network is not subject to interference from other signals or subject to line-of sight limitations.

Over time, maintenance and repair costs of fiber optic cables are low—approximately 1 percent of construction costs annually. Equipment replacement occurs every seven years, but new equipment costs are only a percentage of the capital cost of a fiber-to-the-premises network.

As discussed in Section 3, however, construction costs can be high and can vary based on the availability of space on utility poles and in the right-of-way. Construction can be delayed by utility pole owners, other utilities on the poles, and by the requirement for permitting in the right-of-way (including on bridges, water crossings, and expressway crossings).

By comparison, fixed wireless technology provides an aggregate capacity between 100 and 250 Mbps. Using unlicensed and CBRS spectrum and innovations like higher-order multiple input, multiple output (MIMO) antennas and spatial multiplexing, these capacities could increase to as fast as 750 Mbps.

It is important to note, however, that this is the aggregate capacity out of a single antenna or antenna array; in a point-to-multipoint architecture, this capacity will be shared among all users connected to a single base station. Even so, in most of the unserved environments in the County, download speeds in the tens or even low hundreds of Mbps per user may be possible. Additionally, wireless eliminates the need for new cable construction, significantly reducing the time to build and the complexity of construction.

Given the limitations of line of sight and of the available spectrum, however, the wireless solution is not as scalable as a wireline solution. The spectrum available for fixed wireless broadband is limited and provides much lower bandwidth than what is available in a fiber-to-the-premises network. Homes and businesses that have substantial tree cover and terrain will get poorer performance than others.

In addition, leasing space on a tower is costly. Leasing space for three sectors of antennas (as needed on each tower site) costs approximately $60,000 per year. This is a critical consideration, because the fixed wireless model uses 25 existing towers with an average 80 serviceable passings (potential customers) per tower, so ***the cost for tower leases alone exceeds $700 per year per passing***.

Upgrading a wireless network requires replacement of the radios at the antenna site and at the user premises. Electronics may need to be replaced at five- to 10-year intervals due both to technological obsolescence and wear and tear—and unlike a fiber network, the electronics comprise almost all of the capital cost of the network, thus significantly increasing the ongoing cost.

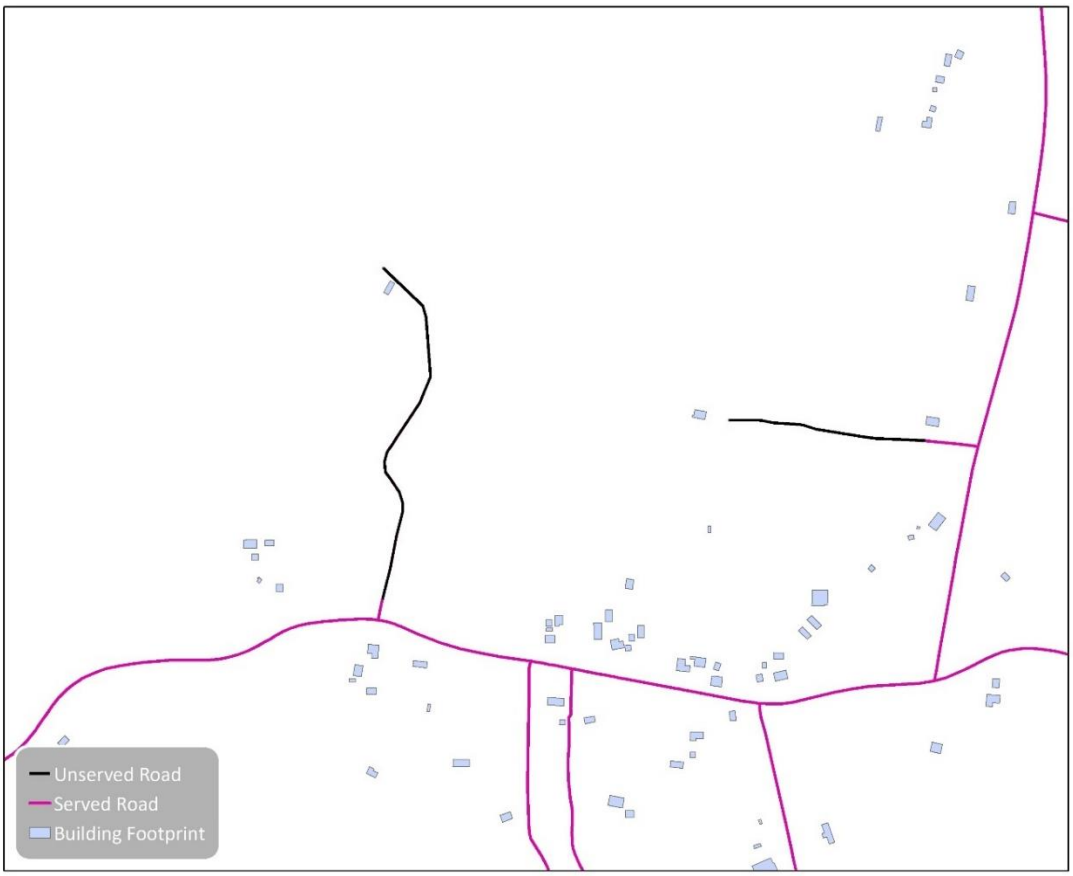
6 Serving Category 2 Addresses on Isolated Streets Would Require an Estimated $6 Million Investment to Build 80 Miles of Fiber Line Extensions

Isolated pockets of roads and small neighborhoods do not have service. Several common reasons why these Category 2 areas might not have service include:

1. The density is too low to justify the line extension under the terms of the franchise agreement;
2. The density is too low and the cost of construction is too high (e.g., all underground utilities) for the provider to justify the line extension; and
3. The roads are private roads, lacking public right-of-way, and the provider has not negotiated an easement for installing broadband services.

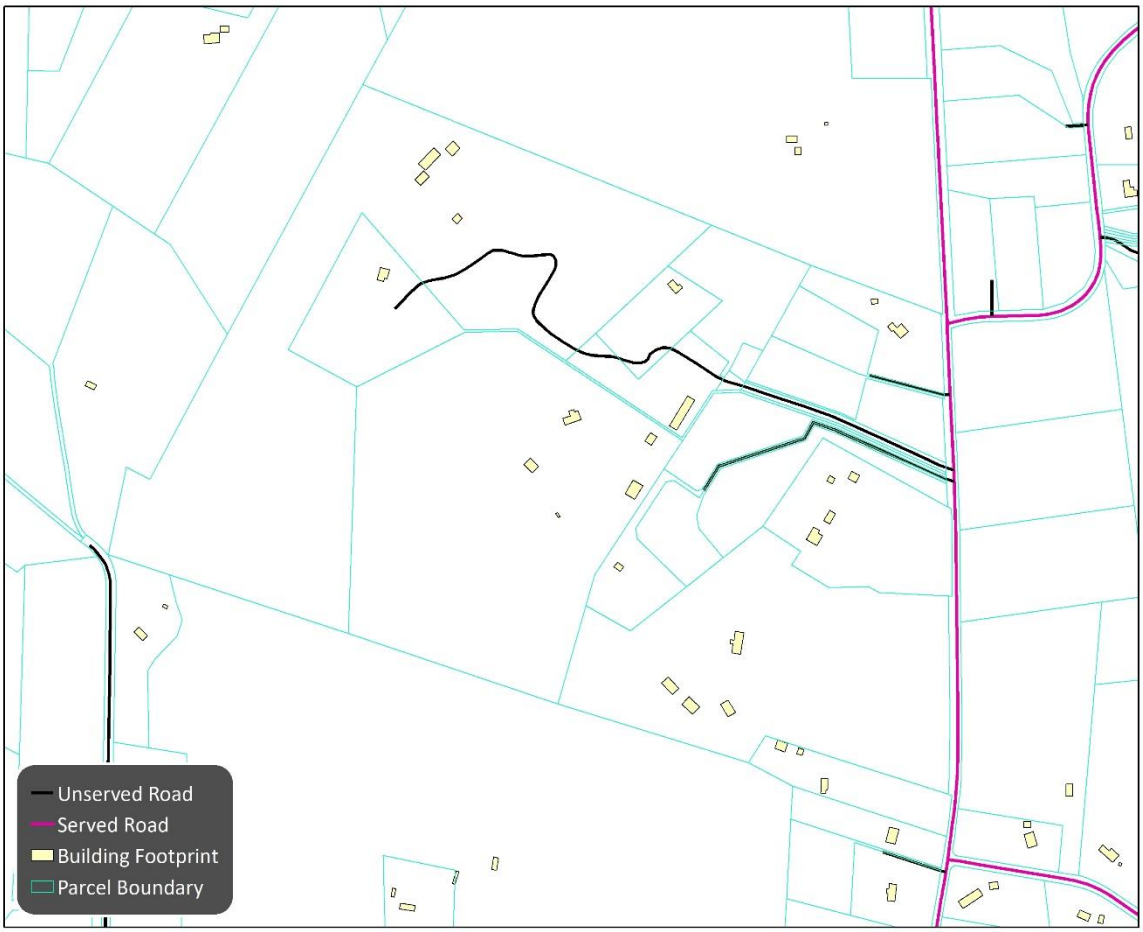
Figure 20 is an example of Category 2 isolated roads in an otherwise served area. (The pink roads were determined to be served, while the two black roads do not have service.) These are examples of a lack of density not justifying the cost of expanding service.

Figure 20: Sample Category 2 Unserved Locations – Single Homes on Long Roads



Other Category 2 locations include pockets of multiple unserved homes surrounded by served areas, as in the example in Figure 21.

Figure 21: Sample Category 2 Unserved Locations – Pockets of Unserved Homes



Using the County's GIS database, the County's data about unserved areas, and our field and desk surveys. CTC estimates that approximately 1,000 homes throughout the County that are located on 80 miles of isolated roads do not have service.[36]

The County may be able to work with Comcast and/or Verizon to seek grant funding to lower the cost to the providers for extending service to these isolated roads. A new broadband provider to the County would not be as interested in serving these isolated roads since they do not have existing plant adjacent to the isolated roads.

[36] Homes and businesses in CAF II auction areas were considered served for the purpose of this analysis.

Based on our estimated outside plant construction cost of $77,000 per mile, it would cost approximately $6 million to construct the roughly 80 miles of isolated road line extensions necessary to serve Category 2 addresses.

7 Constructing Fiber Drops to Category 3 Addresses Would Cost an Estimated $2.5 Million

For a small percentage of County premises, the homes and businesses are set so far back of the roads that a long network drop is required to provide service to the premises. Under the terms of the franchise agreements, the providers are responsible for the first 300 feet of network drop. Any additional costs beyond 300 feet are to be paid by the customer. This is standard practice throughout the industry as the broadband provider cannot outlay the cost of expensive network drops without a mechanism to ensure that it will recoup its costs.

To estimate the magnitude of the number of premises affected and the cost, we used the County's GIS data to analyze the number of parcels that may be require long network drops that the customer would have to pay for. First, we identified parcels with buildings located on them. We then focused only on parcels with one structure (87 percent of building parcels) on them to simplify the analysis and then extrapolate for the remaining parcels with more than one building.

To estimate the setback and driveway distance[37] we used GIS to calculate the distance from the building to the closest roadway centerline. We had to use this approximation as homes and businesses may not connect to the closest road and driveways may not always be straight, which may underestimate the drop length footages, but should only be off by a small percentage overall. Given the size of the County and number of parcels we still believe to be in the order of magnitude of the total distance to a roadway.

Upon eliminating the driveway distances less than 300 feet and the first 300 feet[38] for every home and business with longer driveways, we came up with approximately 50 miles of network drop distances to serve approximately 1,300 passings. Extrapolating for the multiple building parcels we estimated 60 miles of network drop extensions would be required to serve approximately 1,500 homes and businesses.

Homes and businesses with long driveways in Charles County tend to have underground utilities rather than pole lines running on private property to serve the buildings. To estimate the cost of the long driveway network drops we used $7 per foot as a construction cost, which assumes underground construction and a $200 per drop fee for the truck roll, network interface device, splicing, connectors, and provisioning. Using that cost we estimate the total long driveway network drop cost to County residents and businesses would be approximately $2.5 million.

[37] Network drops are often installed along driveways where existing pole lines do not go to the premises to minimize the surface damage to the customer's yard.

[38] The cost analysis assumes that the incumbent providers are responsible for the costs of the first 300 feet of every drop The cost estimate also assumes a tap is located adjacent to the driveway in the right-of-way.

Figure 22 is an example of a Category 3 long driveway in Charles County.

Figure 22: Sample Category 3 Residence with Long Driveway

Assuming the road in the photo above is served, this home's neighbors would be able to receive broadband service network drop installation for free as all of their homes are within 300 feet of the road and existing broadband plant. This particular home is set far back from the road and the homeowner would be responsible for the cost of the network drop installation that is greater than 300 feet from the broadband plant. If for some reason the road was not served, then a line extension as described in Section 6 would be required first to bring service up the street and then the customer would still need to pay for the network drop installation beyond 300 feet.

8 Federal and State Grants and Loans Offer Opportunities to Address the Needs of Unserved Charles County

Federal and state funding sources represent an important element of large-scale broadband deployments for unserved areas where no broadband is currently available. While these programs tend to have restrictions that affect their potential breadth of impact, our analysis is that the programs described below have the potential to assist the County's efforts to greatly reduce the number of unserved homes and businesses.

8.1 USDA's ReConnect program represents a unique rural funding opportunity

The ReConnect program represents the most significant congressional appropriation of broadband funding since the Recovery Act in 2009—with $550 million available in 2020. The program awards loans, grants, or a combination of the two for last-mile connections in rural areas. It is overseen by the Rural Utilities Service (RUS).

We recommend that the County plan for applications to ReConnect in partnership with a private partner, even if there is insufficient time to prepare for the current round of grant applications that closes March 16, 2020.[39] We expect continued appropriations for ReConnect and for other RUS broadband loan and grant programs, as these programs enjoy strong bipartisan support.

The program currently comprises three separate funding categories: 100 percent grants (covering up to 75 percent of eligible project costs, with a 25 percent match), 50 percent grants with a 50 percent loan or other form of match, and 100 percent loans. All categories require that funds go to rural areas where 90 percent or more of the households lack access to broadband (defined as speeds of at least 10 Mbps download and 1 Mbps upload).

Applicants must propose networks capable of providing access to every premises in the PFSA at minimum speeds of 25 Mbps downstream and 3 Mbps upstream.

Matching funds are another point of distinction. Applicants for 100 percent grant awards will need to provide matching funds equivalent to 25 percent of the project's cost—and that matching contribution must be expended first, followed by grant funds. For 50 percent grants with a 50 percent loan or other form of match, applicants can propose a cash alternative to the loan at the time of application. (For an awarded project in this scenario, all cash proposed must be expended first, followed by loan funds and then by grant funds.)

[39] "USDA to Make $550 Million in Funding Available in 2020 to Deploy High-Speed Broadband Internet Infrastructure in Rural America," U.S. Department of Agriculture, News Release, Dec. 12, 2019, https://www.usda.gov/media/press-releases/2019/12/12/usda-make-550-million-funding-available-2020-deploy-high-speed (accessed December 13, 2019).

Generally, we anticipate that USDA will prioritize applications from experienced internet service providers and public-private partnerships, so it will be important for the County to build a public-private partnership strategy. RUS will consider public networks that lack extensive experience to be startups and may disfavor their applications. Therefore, the County should consider partnering with an experienced public or private ISP to compete for these funds. And any experienced ISP, whether public or private, will require the strong collaboration and support of its local (and state) government to present a compelling case for funding.

We anticipate RUS will make grant/loan combinations in the $3 million to $10 million range. This is quite a bit more than RUS's Community Connect grants—and, because the program's funding is larger in total dollars, we anticipate ReConnect will make more awards. Further, ReConnect does not have the low-income requirements of Community Connect, making it more flexible.

Applications to this program will require a detailed business plan and pro forma. It will be critical to provide documentary evidence of the fact that the PFSA is unserved under the statutory definition (i.e., no 10/1 service available). As such, business planning and engineering will be essential. The PFSA must be defined with a count of the number of rural premises to be connected, including homes, farms, schools, libraries, healthcare facilities, and businesses (which are important because they confer additional points in the application). The engineering methodology used to demonstrate that the PFSA lacks service must also be documented.

Furthermore, applicants must verify that the PFSA contains no Connect America Fund II award census blocks and that the PFSA does not overlap an area of an existing RUS grantee or borrower.

RUS will grant application review points based on many factors. The rurality of the PFSA can earn almost 25 points alone. RUS will also award points to applications proposing to build networks capable of at least 100/100 Mbps. Additional points can be scored if the proposed area includes a healthcare center, education facility, or critical community facility. And points will be awarded for projects in states with an updated broadband plan in the past five years.

8.2 USDA's Community Connect program represents another, more modest opportunity

Community Connect is another program to which the County could apply with a partner. The USDA administers this modestly sized grant program for local and tribal governments; it targets broadband deployment to unserved (defined as speeds less than 10 Mbps download and 1 Mbps upload), low-income rural communities with fewer than 20,000 residents in a contiguous PFSA (*and* not adjacent to cities with more than 50,000 residents). To prepare the most competitive Community Connect grant application possible, we would recommend the County target the lowest-income portions of its unserved areas.

Grantees must ultimately offer service at the broadband grant speed (defined as 25 Mbps download plus 3 Mbps upload) to *all* households and community institutions in the PFSA, with free service for at least two years to a community center.

The application process is rigorous and competitive (i.e., only about 10 percent of applicants receive an award) and once awarded, program requirements can be demanding (e.g., requiring last-mile service be available for all households in the service area). The program has been funded consistently since it was introduced in 2002 and represents an important opportunity for qualifying communities.

Eligible applicants include local or state units of government, incorporated organizations, Indian tribes or tribal organizations, cooperatives, private corporations, and limited-liability companies organized on a for-profit or not-for-profit basis. Individuals or partnerships are not eligible. Any public or private applicant must have the legal capacity and authority to own and operate the proposed broadband facilities, to enter into contracts, and to otherwise comply with applicable federal statutes and regulations. Thus, awards cannot be granted to a local government entity that does not want to own or operate the broadband service.

Once awarded, projects must offer last-mile service at the broadband grant speeds (25 Mbps download and 3 Mbps upload) to *all* businesses, residents, and community facilities in the PFSA, with free service provided to all critical facilities,[40] and at least one community center (with weekend hours and two to 10 public computer access points) for at least two years from the grant award. Grants can be used to offset the cost of providing such service and to lease spectrum, towers, and buildings as part of the project design.[41] The lesser of 10 percent of the grant or $150,000 can be used to construct, acquire, or expand an existing community center.[42]

8.3 Department of Commerce economic development grants assist distressed communities

The Department of Commerce's Economic Development Administration (EDA) oversees the Economic Development Assistance program, which has provided economic assistance to distressed communities for many years. Public broadband projects in economically distressed communities are eligible for funding under the Public Works and Economic Adjustment Assistance (PWEAA) programs.

[40] Critical community facilities include public schools, public libraries, public medical clinics, public hospitals, community colleges, public universities, law enforcement, and fire and ambulance stations.
[41] Leasing costs can only be covered for three years.
[42] Note that additional funds can be used to provide the computer access points and their connection to the network. Applicants may use their own resources to cover costs exceeding this limit. The program historically required provision of at least 10 computer access points in a public community center; however, now requires only two such access points—with a *maximum* of 10 computers.

The EDA program coordinates with a $587 million grant program[43] also under the oversight of the Department of Commerce. This opportunity attempts to remedy disaster-stricken areas of the economic burdens that such disasters impose. Disasters are defined per the President's declaration. If the County were to qualify, this opportunity would provide a similar application process to the broader, non-disaster Economic Development Assistance grants.

EDA's materials on Public Works funding explicitly mention broadband,[44] but it does not appear that broadband funding has been a significant part of the portfolio. Over a period of a decade (2007–2017), the EDA's annual reports included only eight references to relevant projects.[45] While broadband funding to date through the EDA appears to be modest, both construction and technical assistance are clearly eligible. Moreover, applicants can apply existing federal funds toward the cost-share, which allows them to leverage available resources. Given this, we recommend the County consider this opportunity.

The PWEAA Notice of Funding Opportunity (NOFO) emphasizes the importance of consulting with the appropriate regional EDA contacts.[46] Regional staff is available to review project proposals, assess proposed cost shares, and preview all application materials. Though optional, we believe that such consultation would ultimately be beneficial if the County were to consider applying.[47]

8.4 The FCC's Rural Digital Opportunity Fund is an emerging opportunity

The Rural Digital Opportunity Fund represents the latest iteration of the FCC's Universal Service Fund's (USF) high cost program. Since 1996, the FCC has used the high cost program to subsidize telecommunications services in rural and remote areas, where the return on investment would otherwise be too low to prompt companies to invest in telecommunications infrastructure.

While the program initially provided subsidized telephone service on an ongoing basis, in 2011 the FCC began reorganizing the high cost program, creating the Connect America Fund (CAF) with the goal of accelerating the buildout of broadband-capable infrastructure to unserved areas. Instead of providing an ongoing subsidy in exchange for serving eligible areas, the CAF program provides an annual subsidy for a fixed period of time to help cover the initial cost of building out broadband-capable infrastructure in rural and remote areas.

The CAF program uses a cost model to estimate the appropriate subsidy for each eligible census block, and first made these funds available to incumbent price-cap carriers in exchange for a

[43] See https://www.grants.gov/view-opportunity.html?oppId=302953 (accessed November 2019).
[44] "Broadband Funding Guide," U.S. Department of Commerce EDA, December 12, 2018, https://broadbandusa.ntia.doc.gov/sites/default/files/funding_eda_01_0.pdf (accessed December 2019).
[45] EDA annual reports available online at: https://www.eda.gov/annual-reports/ (accessed November 2019).
[46] "Notice of Funding Opportunity – FY 2020 EDA Public Works and Economic Adjustment Assistance Programs," https://www.grants.gov/web/grants/view-opportunity.html?oppId=321695 (accessed December 2019).
[47] EDA regional contacts available online at: https://www.eda.gov/contact/ (accessed November 2019).

commitment to serve every household and business with service with speeds of at least 10 Mbps download and 1 Mbps upload. For those areas where the price-cap carrier declined CAF support, the FCC made funds available to any qualifying service provider through a multi-round, reverse, descending clock auction, with added weight given to those bids that committed to offering faster and lower latency broadband services.

The CAF Phase II auction took place in 2018 and was widely viewed as a success. The auction awarded just under $1.5 billion in support in exchange for a commitment to serve 713,176 homes and small businesses in 45 states, a total of 73 percent of eligible areas. Thanks to the weighting system that favored service providers willing to offer higher tiers of service, 99.75 percent of locations will have speeds of at least 25/3 Mbps, 53 percent will have at least 100/20 Mbps, and 19 percent will have 1 Gbps/500 Mbps. The 103 winning bidders will receive an annual sum each year for 10 years, provided they meet buildout requirements. Winners must offer service to 40 percent of homes and businesses by year 3 and continue to increase by 20 percent each year until year 6 when 100 percent of eligible homes and businesses must be served.[48] The total amount of support awarded was 70 percent less than the Connect America Cost Model (CAM) estimated would be needed.[49] Although the reverse auction process was complex, it secured higher-quality service for consumers at a significantly lower cost to the Universal Service Fund than previous methods of allocating subsidies.

The Rural Digital Opportunity Fund builds on the success of the CAF Phase II auction, with a proposal to allocate an additional $20.4 billion over the next decade in order to support the buildout of high-speed broadband networks in unserved areas of the country. While it is still in the rule-making phase (the draft order is on the agenda for the next open meeting, on January 30), the FCC has proposed using a reverse auction mechanism like the one used in the CAF Phase II auction, though this time incumbent price-cap carriers will not have the right of first refusal.

The FCC proposes awarding funds through two phases, the first focused on those areas wholly unserved by broadband at speeds of 25/3 Mbps, and the second on partially-served areas. As in the CAF Phase II auction, the FCC will use the CAM to establish the maximum subsidy available for each eligible area, and bidders compete for available subsidies with preference given to those bidders willing to commit to offering faster speeds and lower latency service. The bidder willing

[48] "Connect America Fund Auction to Expand Broadband to Over 700,000 Rural Homes and Businesses," *FCC*, August 28, 2018, https://docs.fcc.gov/public/attachments/DOC-353840A1.pdf (accessed November 2019).
[49] Joseph Gillan, "Lessons from the CAF II Auction and the Implications for Rural Broadband Deployment and the IP Transition," *National Regulatory Research Institute,* https://pubs.naruc.org/pub/9F958420-E885-F843-1AEC-4D290DC9A28E (accessed November 2019).

to commit to providing an area with the best quality service at the lowest subsidy amount wins the available support.[50]

The biggest change the FCC proposes is raising the service availability threshold to 25/3 Mbps, making even those areas where a provider received CAF funding for 10/1 Mbps service potentially eligible for support. The Commission is also considering a number of other minor adjustments, such as changing the minimum bidding areas from census blocks to census block tracts or counties, as well as adding a subscribership benchmark which would make some percentage of funds contingent on a winning bidder gaining sufficient market share.[51]

While the Republican commissioners appear ready to move forward with the Rural Digital Opportunity Fund, the Democratic commissioners argue that the FCC first needs to fix issues with its mapping data in order to more accurately identify which areas are unserved.[52] Although there are still many details to work out, some version of Rural Digital Opportunity Fund will become a reality in the near future thanks to the broad, bipartisan consensus in Washington that rural areas need better broadband. We note, too, that a Rural Digital Opportunity Fund application would not exclude applying to other federal and state programs. The County could have a partner applying for funding from multiple sources.

8.5 State of Maryland broadband grants are designed to address unserved areas and provide matching for federal funding applications

The Governor's Office of Rural Broadband focuses on efforts to extend broadband service to unserved rural parts of the state "through partnerships with local jurisdictions and the private sector."[53] The Office currently oversees both a small pilot program and a larger rural broadband grant initiative that explicitly seeks to complement federal and local funding sources—an approach that would enable the County or a partner, if it receives one of those larger grant awards, to use the state's funding as a match for a federal ReConnect grant application. For both opportunities, the unserved areas we documented in Section 2 would be eligible for funding.

The Office announced the details of its rural Broadband Infrastructure Network Buildout Program, with grants of $1 million to $3 million (up to a total of at least $9 million in available

[50] Federal Communication Commission, "Rural Digital Opportunity Fund, Connect America Fund," 84 FR 43543, August 21, 2019, https://www.federalregister.gov/documents/2019/08/21/2019-17783/rural-digital-opportunity-fund-connect-america-fund (accessed November 2019).
[51] Federal Communication Commission, "Rural Digital Opportunity Fund, Connect America Fund."
[52] Marguerite Reardon, "FCC Greenlights $20 billion rural broadband subsidy auction," *CNET*, August 1, 2019, https://www.cnet.com/news/fcc-greenlights-20-billion-rural-broadband-subsidy-auction/ (accessed November 2019).
[53] "Maryland Rural Broadband," Maryland Department of Housing and Community Development, https://dhcd.maryland.gov/RuralBroadband/Pages/default.aspx (accessed December 2019).

funding), in late November 2019.[54] The applicant has to be a local jurisdiction or the jurisdiction's recognized partner. The grant will cover up to 50 percent of construction costs—with the applicant committing a 100 percent match—for a project that delivers at least 25/3 service to an unserved area.[55] Our sense is that these requirements intentionally put larger companies in a better position because of their access to cash for the match and ability to file for larger grants. The proposed service area does not have to be contiguous and can cross county boundaries.

Any entity that plans to apply needed to submit a non-binding letter of intent by December 23, 2019. Applications are due by February 21, 2020. Awardees will not be eligible for future state grants in the awarded jurisdiction for the later of two years or completion of construction.

The Office earlier solicited statements of interest from local jurisdictions for "Assistance for Broadband Expansion Pilot Projects." The state will award relatively small grants of up to $200,000 to local jurisdictions, in partnership with an incumbent ISP, to cover as much as "50 percent of the construction costs related to an ISP extending service [from the ISP's existing network] to unserved households." Pilot project applications were due January 7, 2020 but we fully expect that the state will create new opportunities of this sort annually. The County and its partner would be required to commit a 100 percent match for this line-extension funding, and to delivering at least 25/3 service.

[54] "Maryland Broadband Infrastructure Grant Program: Grant Application Guide," Governor's Office of Rural Broadband, State of Maryland, November 27, 2019, https://dhcd.maryland.gov/RuralBroadband/Documents/FY2020-Broadband-Infrastructure-Program-Grant-Application-Guide.pdf (accessed December 2019).

[55] The match must be in cash, not in-kind, and must be shown to be available at the time the grant contracts are executed. There is an exception to level of match requirements for Sustainable Communities (DHCD) and Priority Funding Areas (MDP) which have some limited overlap with some of the unserved area of Charles County.