ctc technology & energy

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Broadband Feasibility Study

Prepared for Worcester County, Maryland

December 2019 | DRAFT

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1 Executive Summary

Commissioned in spring 2019 by the government of Worcester County, Maryland, this report reflects the County's ongoing efforts to ensure that all residents and businesses have access to high-speed, affordable broadband services.

As the County's consultant, CTC Technology & Energy (CTC) performed the following tasks at the County's direction:

- Conducted extensive desk and field surveys, and analyzed data and maps to identify served and unserved portions of the County
- Met with key public and private stakeholders to identify broadband needs
- Spoke with representatives of some 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
- 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

Residents of Worcester County have access to a mix of internet services, but the availability of robust broadband services for individual homes and businesses depends on location. For example, while Comcast and Mediacom provide residential wired service in the County's denser neighborhoods (e.g., Berlin, Pocomoke City, and Ocean City), neither provides service in other, sparsely populated areas that meets the definition of broadband adopted by the FCC and the

State of Maryland's Office of Rural Broadband (25 Mbps download and 3 Mbps upload, or "25/3").[1]

Because of the challenging economics of broadband deployment in rural areas, commercial 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 "Unserved" homes and businesses are those not passed by broadband infrastructure

Unserved areas are those where no infrastructure capable of delivering services that meets the federal definition of broadband "passes" along the public right-of-way adjacent to homes and businesses.[2] In practice, an unserved location is one where there is no cable or fiber plant in the right-of-way.

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[3] and regulate communications services. It is important to note, however, that a "passing" does not include the "service drop"—the portion of the network that connects the infrastructure at the curb to the home or business itself.

As a result, there is another category of locations within the County where homeowners may struggle to get broadband service—but those homes do not fit into the category of unserved (and thus are not included in the count of unserved premises). These are areas where broadband infrastructure passes homes or businesses (and thus the premises are considered served), but because the premises are set back far from the road, the cost to build the service drops to the users' premises is prohibitive.

Service to these homes or businesses is thus not a matter of the availability of infrastructure, but rather a matter of the affordability of drop construction—because many consumers, particularly those with very long driveways, will find the ISP's quoted cost of connection to be very high.[4] The County could choose to subsidize the cost of drop construction, but this is unfortunately an area

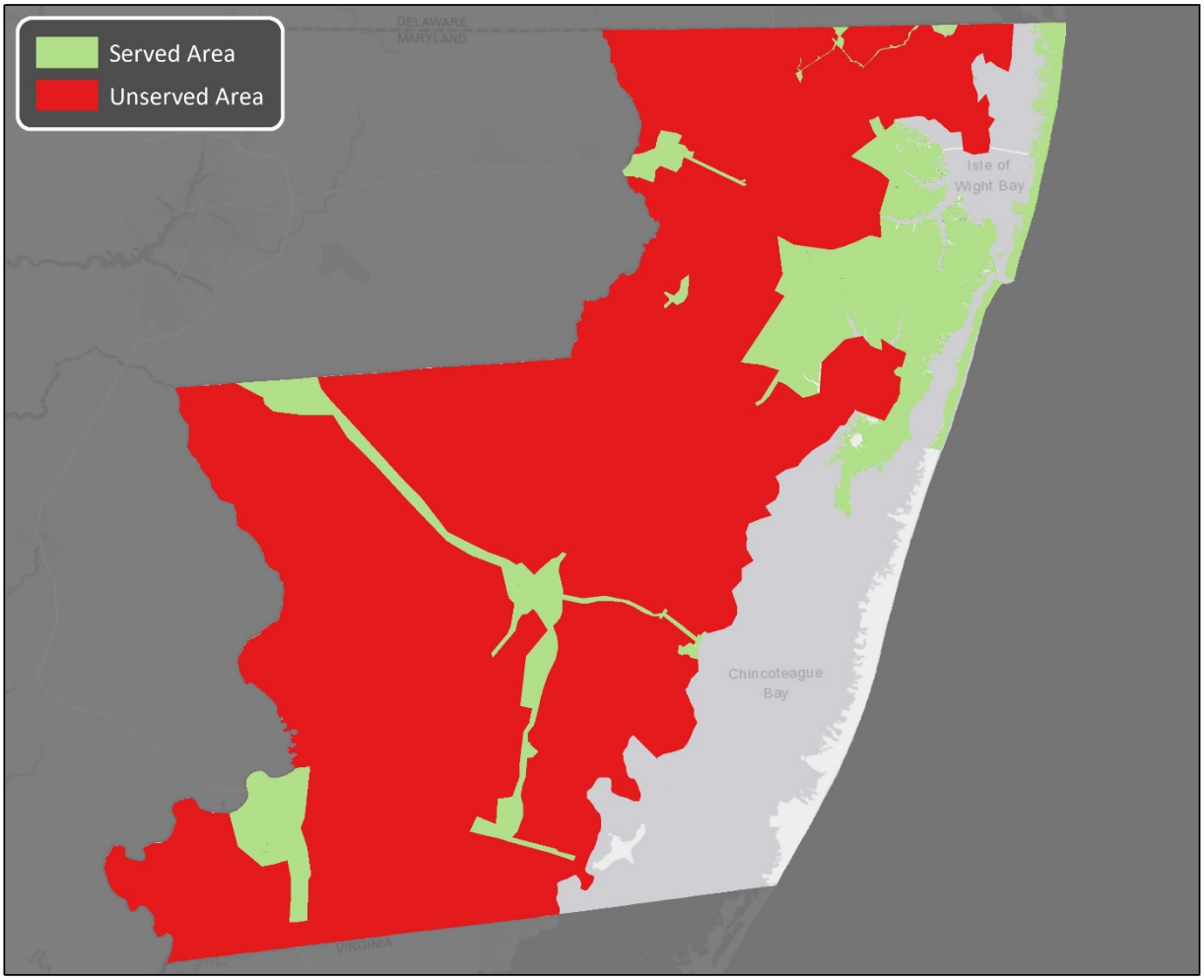
[1] "2018 Broadband Deployment Report," FCC, Feb. 2, 2018, https://www.fcc.gov/reports-research/reports/broadband-progress-reports/2018-broadband-deployment-report (accessed December 2019).
[2] The current federal and state benchmark is 25/3, although some federal grants consider 10/1 speed as being served.
[3] Such as through the state and federal programs discussed in Section 6, below.
[4] Some local franchise agreements include language that require the cable company to build drops of up to a certain length (say, 300 feet) at no cost to the customer; drops longer than that threshold may be priced at the ISP's discretion.

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 this challenging issue.

1.1.2 Broadband is not available to about 6,400 homes and businesses throughout the County

CTC's analysis indicates that about 6,400 homes and businesses in the County do not have access to internet service that meets the federal definition of broadband. Based on desk and field surveys of wireline infrastructure conducted by a CTC outside plant engineer, we determined that the County's unserved areas are the red highlighted portions of the map below (Figure 1). We did not include the southern portion of Assateague Island in our analysis; that land is shaded white in the map below.

Figure 1: Unserved Portions of Worcester County



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

Unserved portions of Worcester County face the same challenges as other rural communities in terms of 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 in the United States 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.

1.1.4 If the County invests in new infrastructure, fiber offers a better return than fixed wireless, given total cost of ownership and technical benefits

Based on engineering and cost-estimation for both a fiber-to-the-premises and a fixed wireless solution for unserved portions of Worcester County, we conclude that overall, fiber-to-the-premises represents a better broadband solution than fixed wireless for most unserved areas. Fiber-to-the-premises and fixed wireless have comparable 10-year costs per customer.[5] But over a longer period, the total cost of ownership for a fiber-to-the-premises network would be lower than for a fixed wireless solution.

1.1.4.1 Fiber-to-the-premises in the County's unserved areas would require a large capital investment but relatively low operating costs

Constructing fiber infrastructure to unserved portions of the County would require a capital investment of approximately $46.7 million to $49.7 million, or $6,500 per passing (outside plant infrastructure cost only). This estimate is based on conceptual-level engineering that considers a range of factors that affect deployment costs, from availability of utility poles to number of fiber route miles necessary to pass all unserved homes and businesses. Section 3 describes this cost estimate in more detail.

[5] These estimates are based on a range of assumptions, which are described in Section 3 and Section 4.

1.1.4.2 A best-case fixed wireless solution could serve 50 to 85 percent of the County's unserved homes and businesses—but would require high capital and operating costs, and would not be as capable as a fiber network

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. CTC's engineers developed a model to assess the viability of that approach.

Our analysis found that a fixed wireless network could be used to serve a portion of the County's unserved homes and businesses—but it would have clear technical limitations relative to a fiber optic network and would not reach all unserved premises. In the best-case scenario, equipment mounted on 40 existing towers in the County could enable coverage of approximately 85 percent of the unserved premises; a more conservative coverage model indicates that about 50 percent of unserved premises could be served.

1.1.5 State and federal broadband funding programs represent an important opportunity for the County

State and federal 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 the state'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.

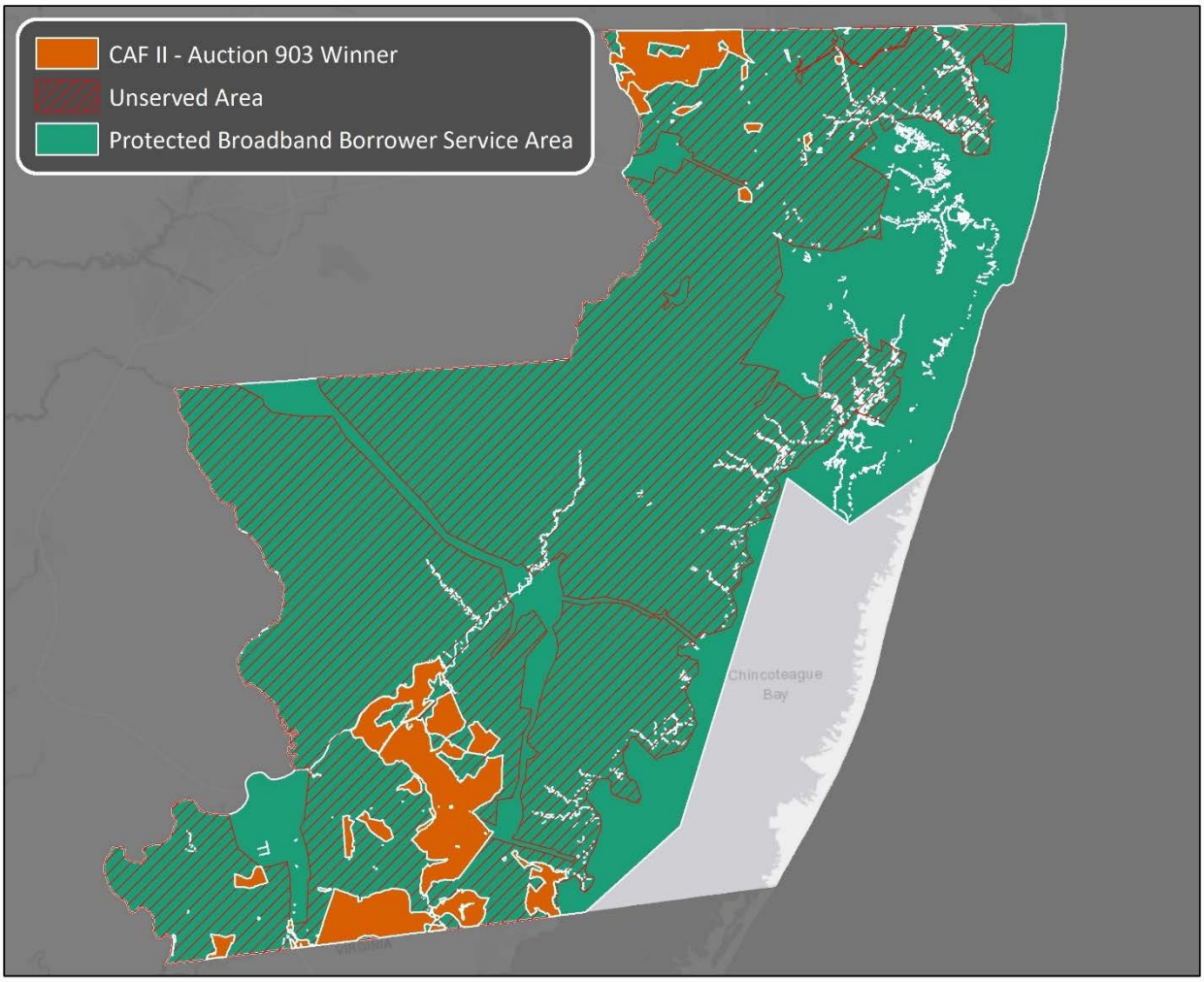
The federal ReConnect program represents the most significant congressional appropriation of broadband funding since the Recovery Act in 2009—with $600 million allocated in 2019 and $550 million available in 2020. The program awards loans, grants, or a combination of the two for last-mile connections in rural areas; it favors private sector applicants that demonstrate, experience in network operations, solid financials, and strong support from the local government in the area to be served. The second round of grant applications opens on January 31, 2020, and closes March 16, 2020.[6] A third round of funding for this program is anticipated in the next year.

However, Congress created a significant barrier to ReConnect funding for the County when it wrote the legislation: It made ineligible any areas for which another grantee or loan recipient has received a previous broadband award. A wireless ISP, Bloosurf, was awarded $3.2 million in USDA Broadband Initiatives Program (BIP) grant and loan funding in 2010 for service across the

[6] "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).

County,[7] and won the Connect America Fund II (CAF II) auction for additional portions of the County; those areas (shaded in green or orange, respectively, in the map below) are technically ineligible for ReConnect funding; we expect the protected status to expire in 2021, but the CAF II exclusion will continue.[8]

Figure 2: Grant-Eligible and Ineligible Areas in Worcester County



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 and underserved areas of the country. The Rural Digital Opportunity Fund will exclude CAF-II funded areas, but current indications are that no other areas are "protected." Instead the focus is on unserved areas in terms of the 25/3

[7] "Advancing Broadband," USDA BIP Awards Report, January 2011, https://www.rd.usda.gov/files/reports/RBBreportV5ForWeb.pdf (accessed December 2019).
[8] See Section 6 for more details regarding how the County might challenge Bloosurf's protected status in a ReConnect application.

benchmark. That leaves the green and cross-hatched areas in the map above potentially eligible for these grants. The Rural Digital Opportunity Fund represents 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 funding.

The EDA opportunity does not exclude or protect any areas, and does not have any requirement for minimum speeds; it only focuses on broadband as an economic development tool—and therefore represents another good opportunity for the County with no protected or excluded areas.

The Governor'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).

In contrast to the ReConnect protected areas, the state's grant program focuses exclusively on the broadband benchmark of 25/3, which leaves the entire cross-hatched area indicated as unserved in the map above as potentially eligible.

The Broadband Infrastructure Network Buildout Program will award grants of $1 million to $3 million from a total funding budget of at least $9 million. While applicants needed to submit a non-binding letter of intent by December 23, 2019 (for applications due by February 21, 2020), we anticipate there will be state broadband funding again in 2021. Applicants for this opportunity would be the owners and deployers of the proposed broadband infrastructure.

1.1.6 The fixed wireless provider Bloosurf's status as an RUS borrower represents a significant obstacle to some current federal funding opportunities, but not to state funding

Bloosurf has received funding from federal grant and loan programs that effectively protects it from alternative provider applications in its claimed service areas under several federal grant programs. Bloosurf's service area covers the entire County. Once this protected status expires, however, these areas will open back up to applicants, presumably at the 25/3 benchmark.

This obstacle does not apply to the state programs, and does not present itself equally for all future federal grant programs; for example, the Rural Digital Opportunity Fund does not exclude the areas that are excluded under the ReConnect rules.

1.2 Recommendation: Develop a multi-year strategy to collaborate with partners to apply for state and federal broadband grants

Our primary recommendation is that the County collaborate with private sector partners to apply for state and federal broadband grants. The state program is particularly promising because it does not place restrictions on geographic areas, other than being unserved by 25/3. We recommend pursuing state funding immediately—encouraging Comcast, ThinkBig, and any other well-qualified entities to apply.

Federal funding program also looks promising, particularly the Rural Digital Opportunity Fund. We believe this could be a good option and we encourage the County to work with Choptank and also potentially ThinkBig (as well as alternative bidders) if Choptank does not bid.

The ReConnect opportunity will be more difficult, given the protect status of much of the County's unserved areas. The County could undertake an effort in this round of ReConnect funding to contest the protected areas status, because anecdotal and other data, including the County's own experience, suggest that there is not anything resembling adequate service in these areas. We think that such a challenge will be difficult, because USDA will be conservative in its evaluation of competing data and claims—but it may be worth the County's effort to perform the necessary mapping, planning, and engineering. The County is left in limbo of not having a performing private entity, but not being able to find another solution with federal funds. A ReConnect challenge will bring attention to the fact that the federal government has given money to an entity that does not appear to be delivering on its promised broadband service—and the federal government is simultaneously saying that the County is not eligible for new funding.

Based on the dialogue CTC and the County have established with some service providers, we recommend the following approaches.

1.2.1 Engage with Choptank Electric Cooperative on these issues

Choptank is an obvious choice for a partner in the County's broadband deployment efforts. Indeed, Choptank and electric cooperatives throughout the state have positioned themselves for this opportunity by asking the Maryland legislature to give them the authority to enter the broadband market.[9]

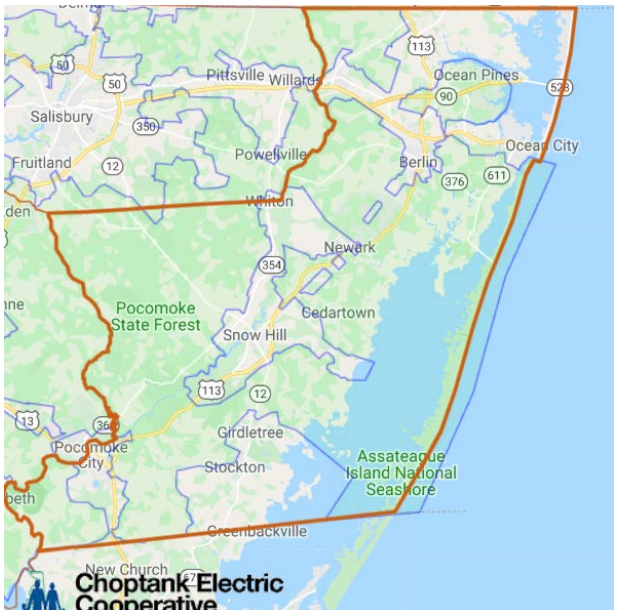
Because it is member-owned, Choptank presumably would not cherry-pick only certain unserved areas; it is responsible to all members within its service footprint in the County, not just to business opportunity in the way a for-profit ISP would be. Choptank also owns utility poles—the core structural asset needed for broadband deployment—throughout the County's unserved areas; those poles would be able to support fiber attachments and would dramatically lower

[9] See, for example: "Support Choptank Fiber," https://supportchoptankfiber.com/ (accessed December 2019).

Choptank's fiber construction costs. In addition, Choptank has the technical capability to construct aerial fiber and a proven ability to manage customer relationships.

While Choptank's current publicly published service area does not encompass all unserved areas of the County, there is substantial overlap that would enable Choptank to reach many of the unserved areas. The figures below show Choptank's self-reported electric coverage map, side by side with the County's unserved broadband areas.

Figure 3: Choptank's Self-Reported Electric Service Area Compared to Unserved Portions of the County[10]



We expect electric cooperatives such as Choptank to benefit from the FCC's Rural Digital Opportunity Fund, in particular, because of its ownership of poles in unserved areas. Choptank would have the lowest cost to build of any entity other than Verizon, which would be a competitive advantage if it were to bid on the FCC's planned reverse auction for the Rural Digital Opportunity Fund (in which the lowest bidder wins).

What's more, Choptank could also apply for state and ReConnect grants, in addition to Rural Digital Opportunity Fund funding. If Choptank were to miss the Rural Digital Opportunity Fund application window, it would still be eligible to apply for later rounds of ReConnect and state funding—but optimally, Choptank would secure funding from all of those sources.

[10] Areas shaded darker are service areas for Choptank. Source: https://choptank.maps.sienatech.com/ accessed 12/15/2019.

1.2.2 Partner with ThinkBig on a state broadband grant application and potentially support a ReConnect grant application

ThinkBig Networks could also be a strong partner for state and federal grant applications to construct fiber to serve the County's unserved areas. The company has indicated preliminary but not concrete interest.

ThinkBig will have a higher cost to build than Choptank would have, because it does not own the utility poles. But it would potentially be competitive for state grant funding (in partnership with the County) or federal ReConnect funding (See Section 2.3 and Section 6 regarding potential barriers to a ReConnect application.) And if Choptank does not bid on the Rural Digital Opportunity Fund, ThinkBig might be a competitor in the reverse auction; if ThinkBig can successfully secure a state grant, ReConnect funding, or support from the County, it could bid lower for Rural Digital Opportunity Fund funding and potentially position itself to win.

We recommend that the County explore a partnership with ThinkBig on a state broadband grant application, with the condition that if it receives funding, the company will seek to apply for a federal ReConnect grant using the state funds as part of its required matching contribution. Unless ThinkBig already submitted letters of intent for the current state grants, this strategy should be oriented toward expected future cycles of state grants. 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 to apply for a state broadband grant

As a cable provider with a presence in the denser areas of the County (and current plans to expand in Ocean Pines),[11] Comcast has infrastructure in the County that could enable it to expand into unserved areas with relatively lower costs per passings than other wireline providers. (See Section 3.6 for our sample cost estimate.)

Like ThinkBig, Comcast does not own utility poles so it would not be the most competitive Rural Digital Opportunity Fund bidder—but if Choptank does not bid, Comcast could be competitive. That said, we are unable to analyze the Comcast opportunity in much detail because the company has not given us any concrete sense of their plans with regard to the Rural Digital Opportunity Fund. Representatives have told us that the company does not plan to submit applications for ReConnect anywhere in the country; this may also be the case for the Rural Digital Opportunity Fund, but the company's intent is unclear.

CTC and the County approached Comcast to explore the potential to build to unserved areas under the terms of the state's grant program. As of this writing, we have not received concrete

[11] Greg Ellison, "Comcast brings service competition to Ocean Pines," Bayside Gazette, Sept. 12, 2019, https://baysideoc.com/comcast-brings-service-competition-to-ocean-pines/ (accessed December 2019).

feedback from Comcast that would enable us to determine what areas it is interested in or what grant levels would provide sufficient incentives for Comcast to work with the County and state.

1.2.4 Explore opportunities to support fixed wireless providers

Given our analysis of capital and operating costs (see Section 4 and Section 5), fixed wireless deployment would not be our first recommendation for filling the County's broadband 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.

2 The County Has About 6,400 Unserved Homes and Businesses

Based on our discussions with County staff, Worcester County government has a general understanding of where residential broadband services[12] are and are not available to members of the community. At the County's direction, we used those insights as a foundation for our analysis—then verified and fine-tuned the boundaries with our own surveys, as described below.

Unserved areas are those where no infrastructure capable of delivering services that meets the federal definition of broadband "passes" along the public right-of-way adjacent to homes and businesses. This is the universally understood definition of what is served, both within the industry and among the government entities that fund broadband expansion[13] and regulate communications services at the state and federal levels. In practice, an unserved location is one where there is no cable or fiber plant in the right-of-way.

It is important to note that a "passing" does not include the "service drop"—the portion of the network that connects the infrastructure at the curb to the home or business itself. As a result, there is another category of locations within the County where homeowners may struggle to get broadband service—but those homes do not fit into the category of unserved (and thus are not included in the 6,400 estimated unserved premises). These are areas where broadband infrastructure passes homes or businesses (and thus the premises are considered served), but because the premises are set back far from the road, the cost to build the service drops to the users' premises is prohibitive.

Service to these homes or businesses is thus not a matter of the availability of infrastructure, but rather a matter of the affordability of drop construction—because many consumers, particularly those with very long driveways, will find the ISP's quoted cost of connection to be very high.[14] 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 this challenging issue.

2.1 Desk and field surveys verified the County's extensive unserved areas

To identify the County's served and unserved areas—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 the County.

[12] This study is focused on 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.

[13] Such as through the state and federal funding programs discussed in Section 6, below.

[14] Some local franchise agreements include language that require the cable company to build drops of up to a certain length (say, 300 feet) at no cost to the customer; drops longer than that threshold may be priced at the ISP's discretion.

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, and that were identified as special areas of interest based on County data or density analyses.

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 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 confirmed the Street View results with an on-site field survey—driving along representative roadways throughout the County.

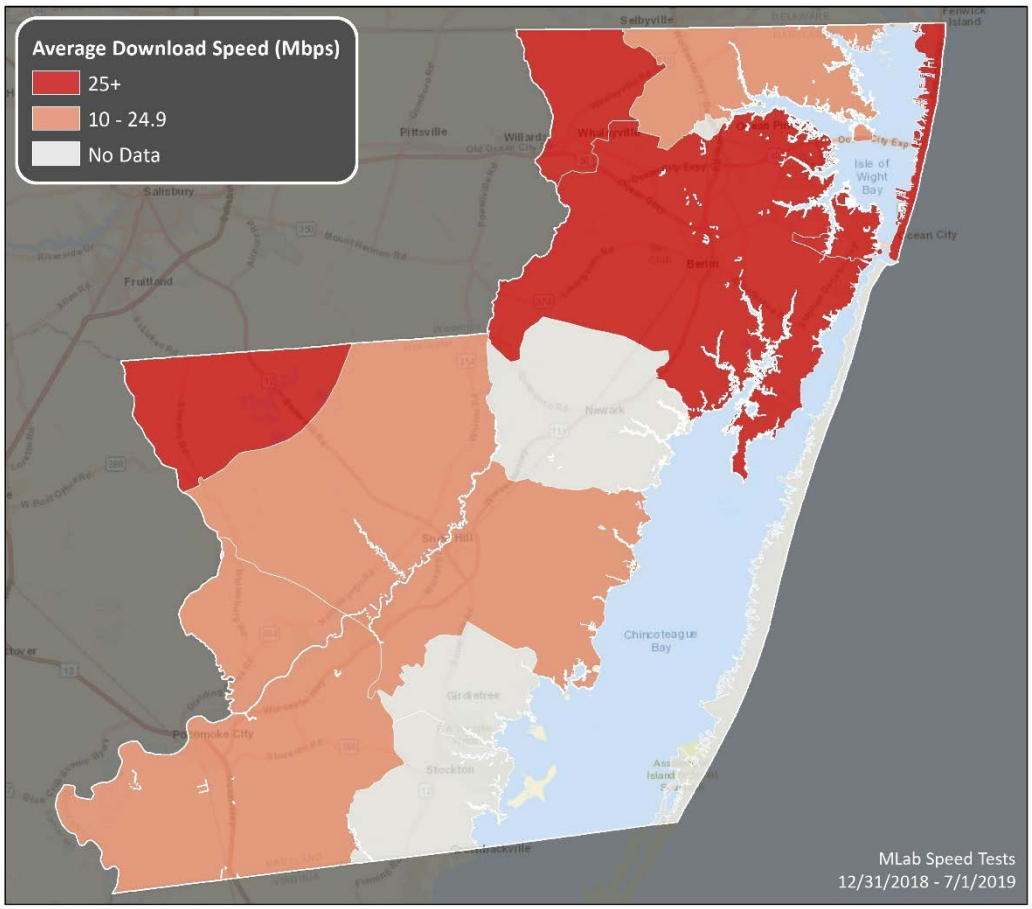
Through these desk and field surveys, the engineer found that 6,390 homes and businesses in the County do not have access to internet service that meets the federal definition of broadband (i.e., a minimum of 25 Mbps downstream and 3 Mbps upstream), as illustrated in red in Figure 4. We did not include the southern portion of Assateague Island in our analysis as this is home to Assateague State Park, the Assateague Island National Seashore, and a small part of the Chincoteague National Wildlife Refuge—all of which are uninhabited, environmentally protected lands. (Those areas are shaded white in the map.)

While these areas are unserved with wireline infrastructure based on our review, we note that a wireless ISP, Bloosurf, claims to have some level of service in these areas. We were unable to determine whether that is the case—but data provided by the County and other sources suggest that Bloosurf service does not under any circumstance achieve 25/3 speeds in these areas, and it is not clear that Bloosurf delivers even lower levels of speed to customers throughout much of the County—despite the fact that these areas purportedly are served by Bloosurf. As we discuss in Section 6 and Section 7, Bloosurf's service is a critical issue for the County's approach to federal grant funding opportunities.

Figure 4: Unserved Portions of Worcester County

As an additional validation of the unserved areas in the County, we also evaluated the speed test data gathered by M-Lab for the first six months of 2019 (Figure 5). M-Lab collects approximate locations based on users' IP addresses, which are then aggregated by ZIP code. While these data are not granular enough for detailed analysis, they do create a snapshot of the recorded download speeds greater or less than 25 Mbps for each ZIP code in the County. The M-Lab data generally agree with the field survey, indicating the County's central and southeastern areas are potentially unserved based on the lack of data from those ZIP codes.

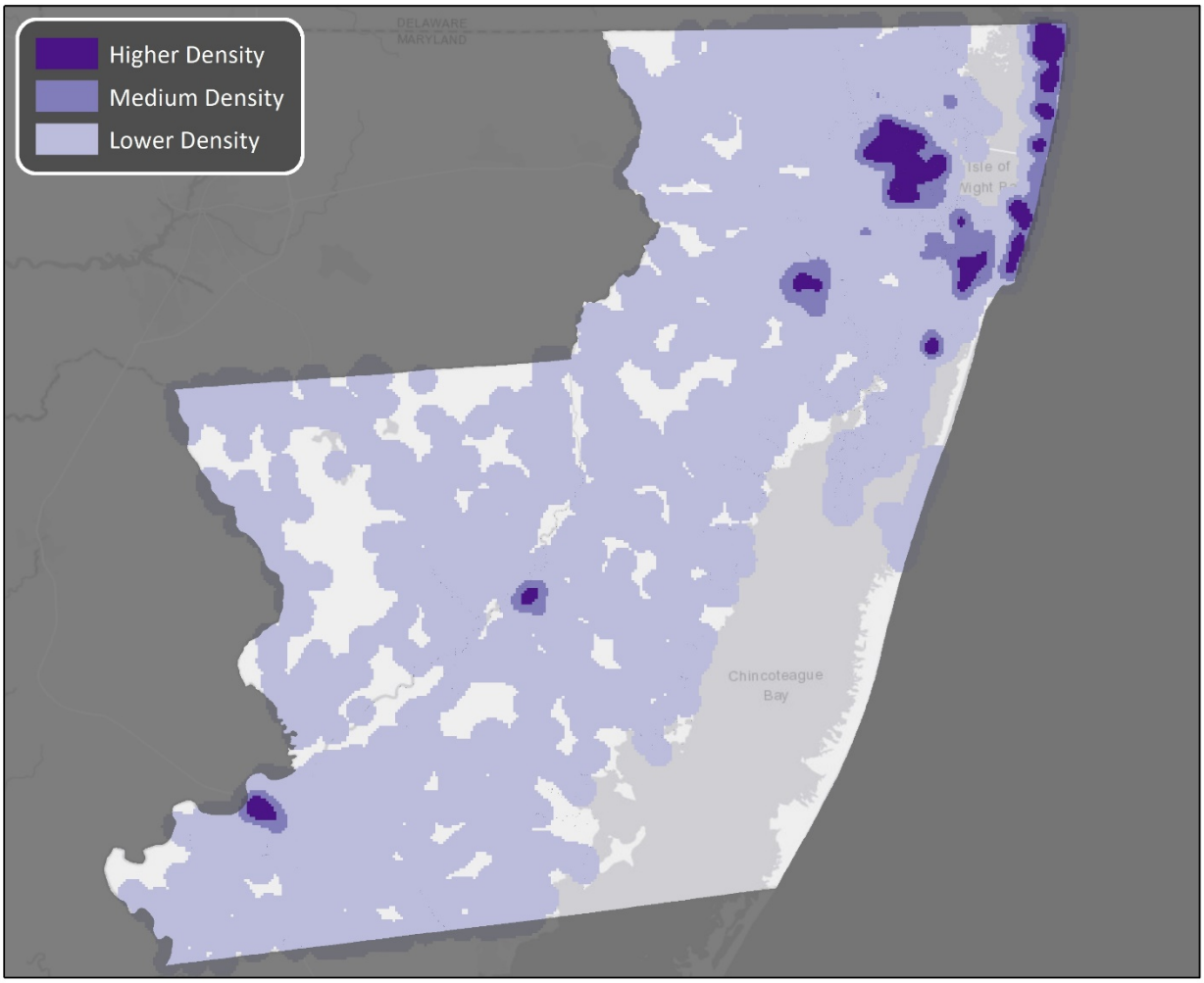
Figure 5: M-Lab Speed Test Results – Average Download



2.2 Broadband service in the County aligns with population density

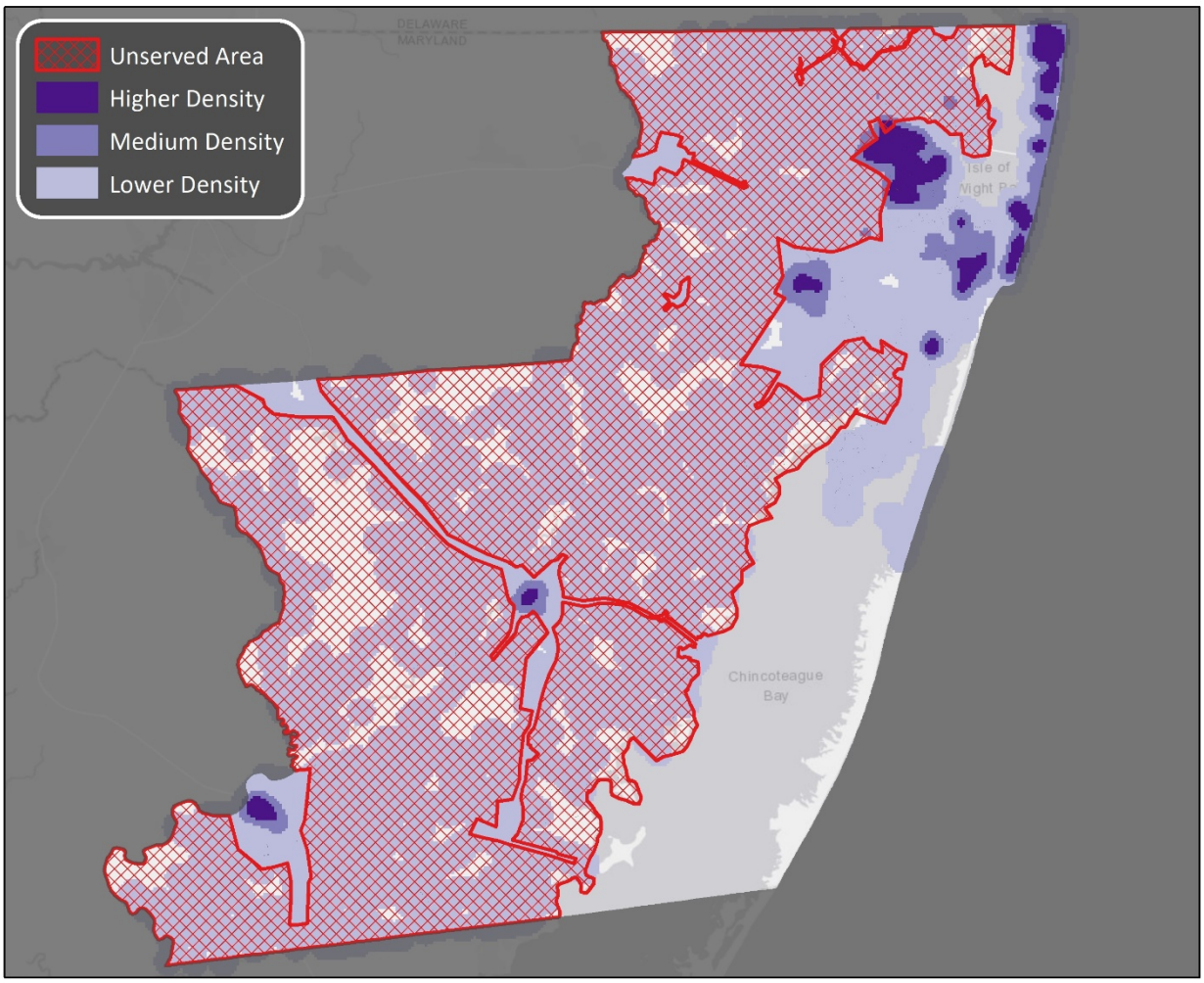
Using the County's address data, we developed a heat map of population density across the County (Figure 6). Most of the County has relatively low population density; very low density spaces are not included in the analysis, and thus are not shaded in the map.

Figure 6: Worcester County Population Density Heat Map



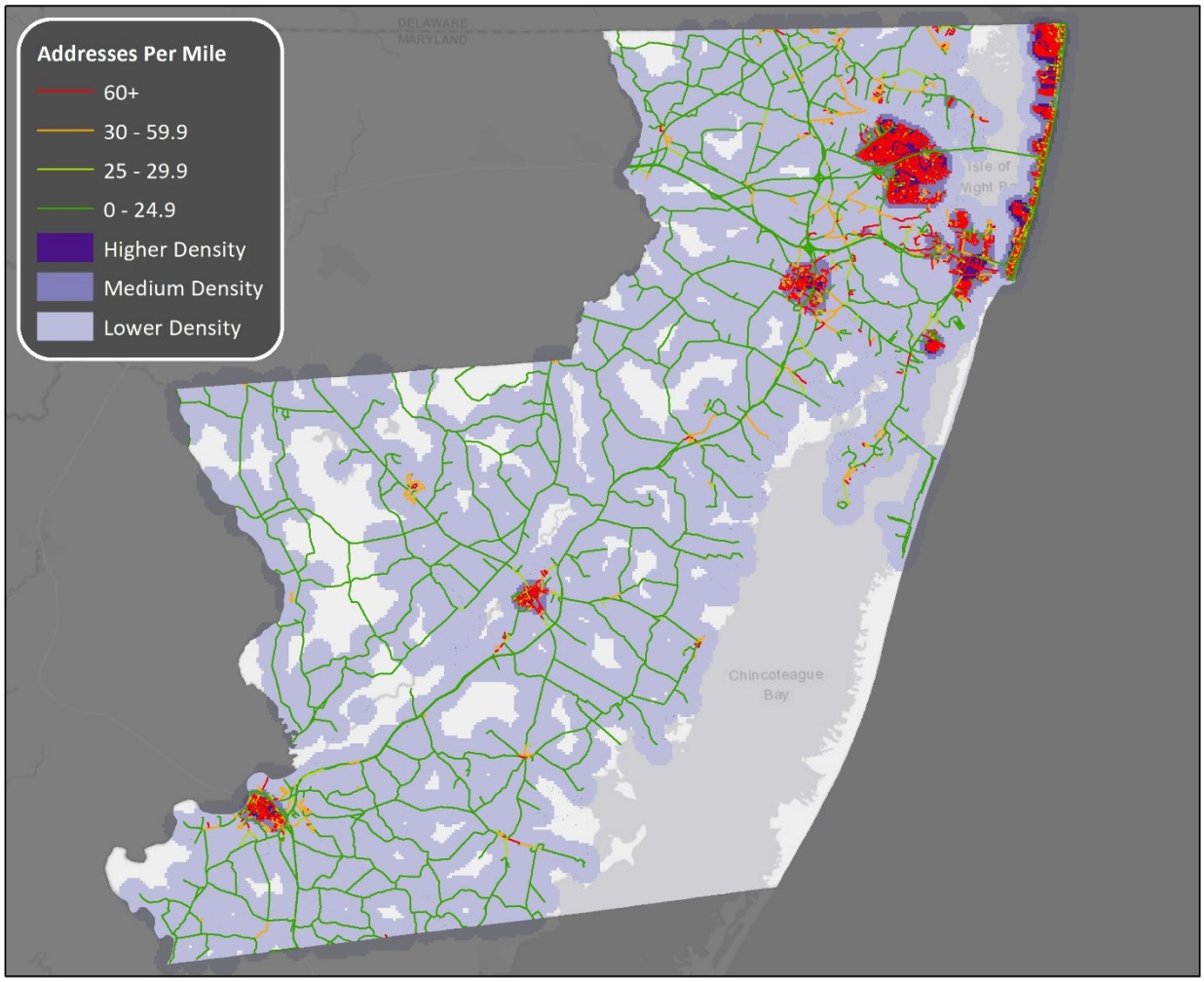
Not surprisingly, based on national broadband deployment patterns, the County's high-density areas align with the areas that our desk and field surveys indicate as being served with broadband (Figure 7). Similarly, we found that low population density is relatively homogeneous across the County's unserved areas. Very low density spaces are not included in the analysis, and thus are not shaded in the map.

Figure 7: Unserved and Served Portions of Worcester County



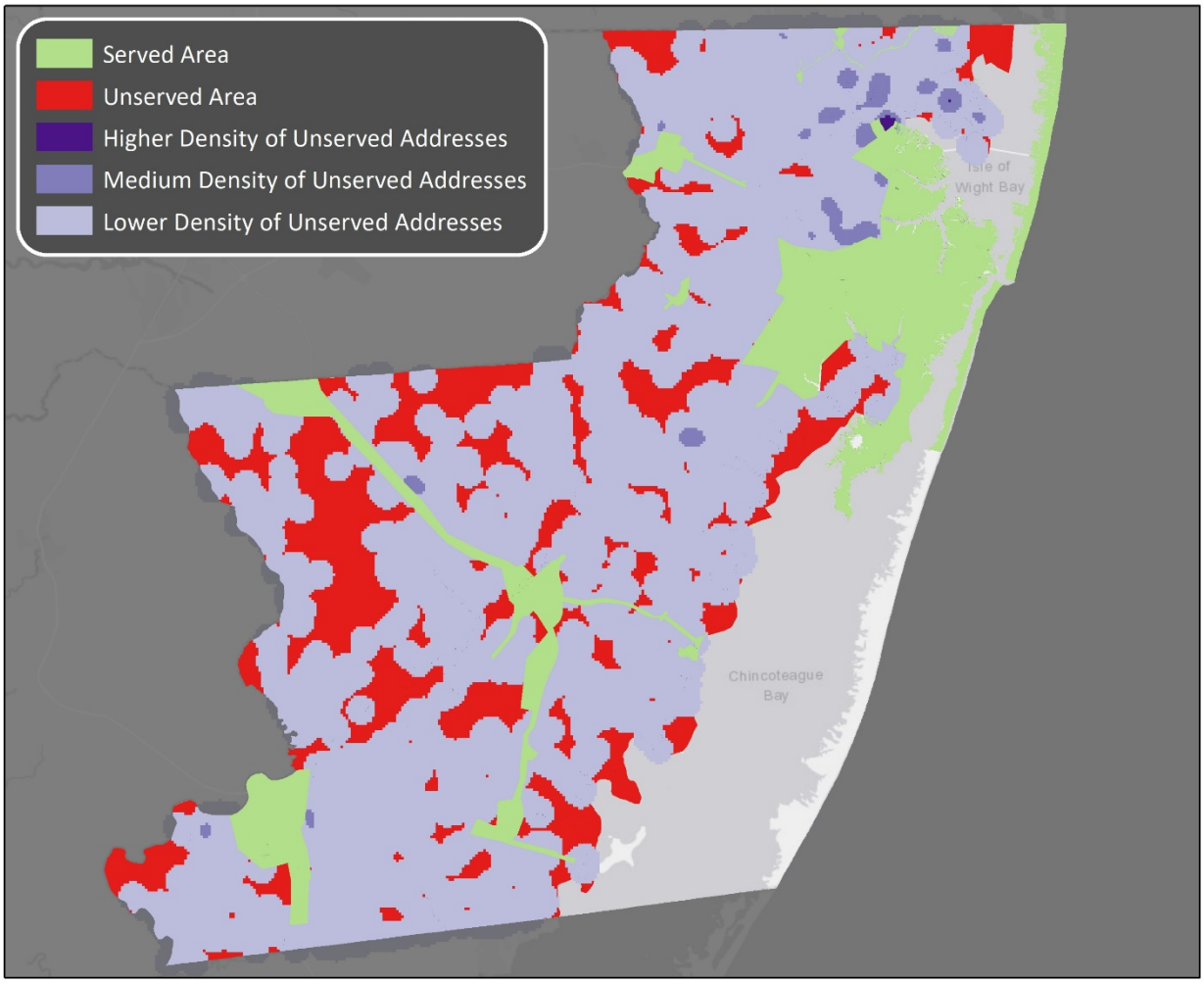
We calculated the passings per mile on each of the County's roads, which confirmed that the unserved areas are all low-density (Figure 8).

Figure 8: Passings per Mile, Density, and Service Availability



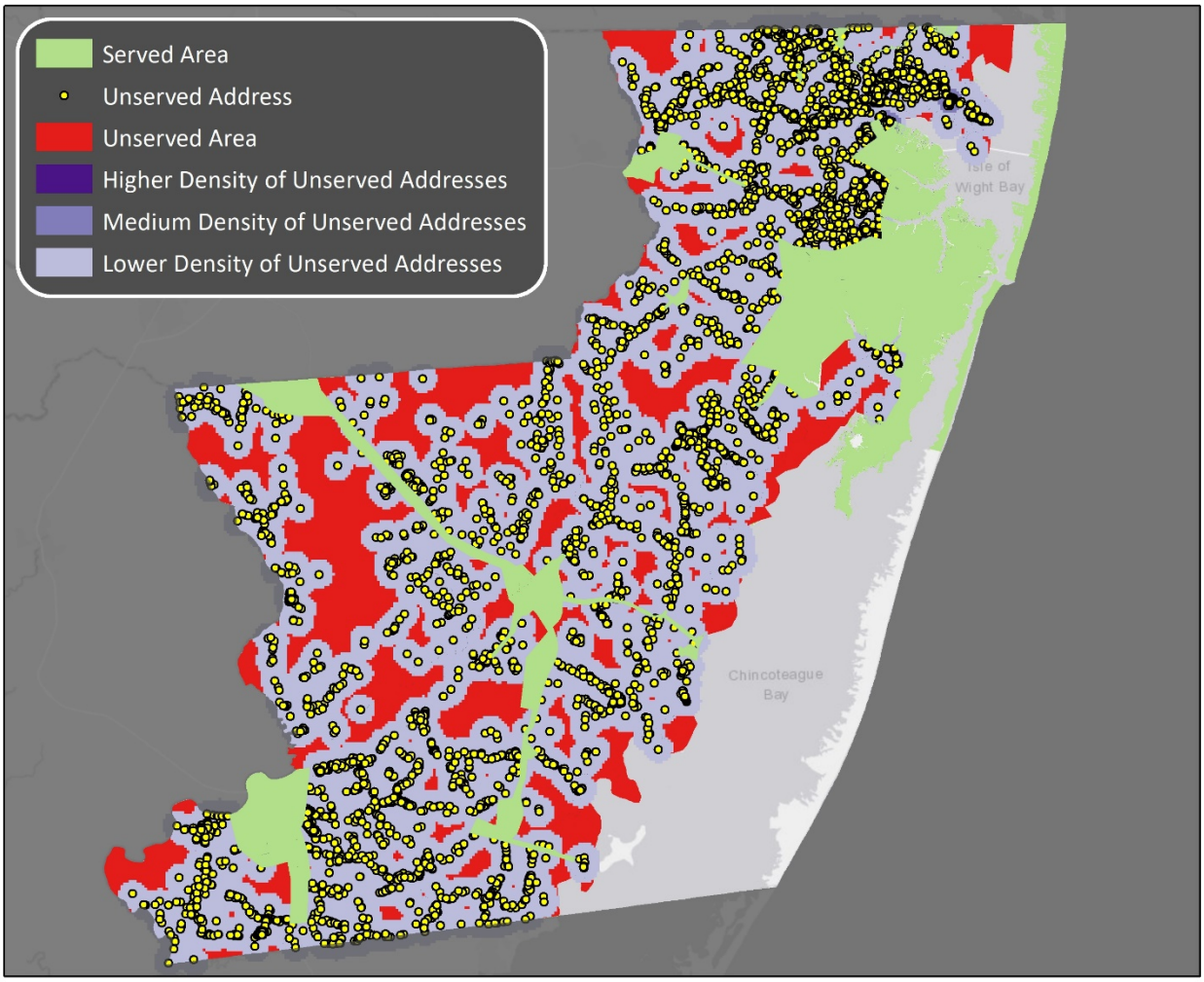
Removing all served areas from the map clearly shows the unserved areas of the County (Figure 9). Areas in red are unserved and uninhabited.

Figure 9: Unserved Portions of Worcester County by Population Density



The following map illustrates the same unserved areas, with County-provided address points added for emphasis (Figure 10).

Figure 10: Unserved Portions of Worcester County (with Addresses)



2.3 The County's unserved areas are eligible for state funding but applying for some federal funding would require challenging an existing federal grantee

With an understanding that state and federal funding may represent a viable opportunity for enabling the County's efforts to expand broadband availability, we also evaluated available FCC Form 477 data about broadband services available in the County—both at 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 expected broadband funding—the USDA's ReConnect grant and loan program uses 10/1 service availability as its minimum definition. (See Section 6 for a detailed discussion of funding opportunities.)

There is a tendency for Form 477 data to overstate service availability, given that an entire census block is reported as being served if even one location in the block meets the FCC's requirement. (The data are also self-reported by carriers.) In the case of Worcester County, the Form 477 data do overstate broadband availability—as illustrated by the following map of 25/3 service availability, overlaid with the boundaries of the unserved areas confirmed in our desk and field surveys (Figure 11). **The survey-defined unserved areas are eligible for state broadband funding.**

Figure 11: FCC Form 477 Data on 25/3 Availability as Compared to Desk and Field Survey Findings

While the Form 477 data are not the sole basis for determining federal funding eligibility, federal entities will evaluate those data as they relate to applications; if the County or a partner applies, it will need to document where the County's documented unserved boundaries diverge from those data—in other words, the portions of the unserved areas confirmed through our desk and field surveys that are incorrectly identified by Form 477 data as having service availability.

For purposes of identifying federal ReConnect-eligible areas, the following maps illustrate the Form 477-reported availability of 10/1 service (Figure 12) and the 10/1 service availability overlaid with the boundaries of the unserved areas confirmed in our desk and field surveys (Figure 13).

Figure 12: FCC Form 477 Data on 10/1 Availability

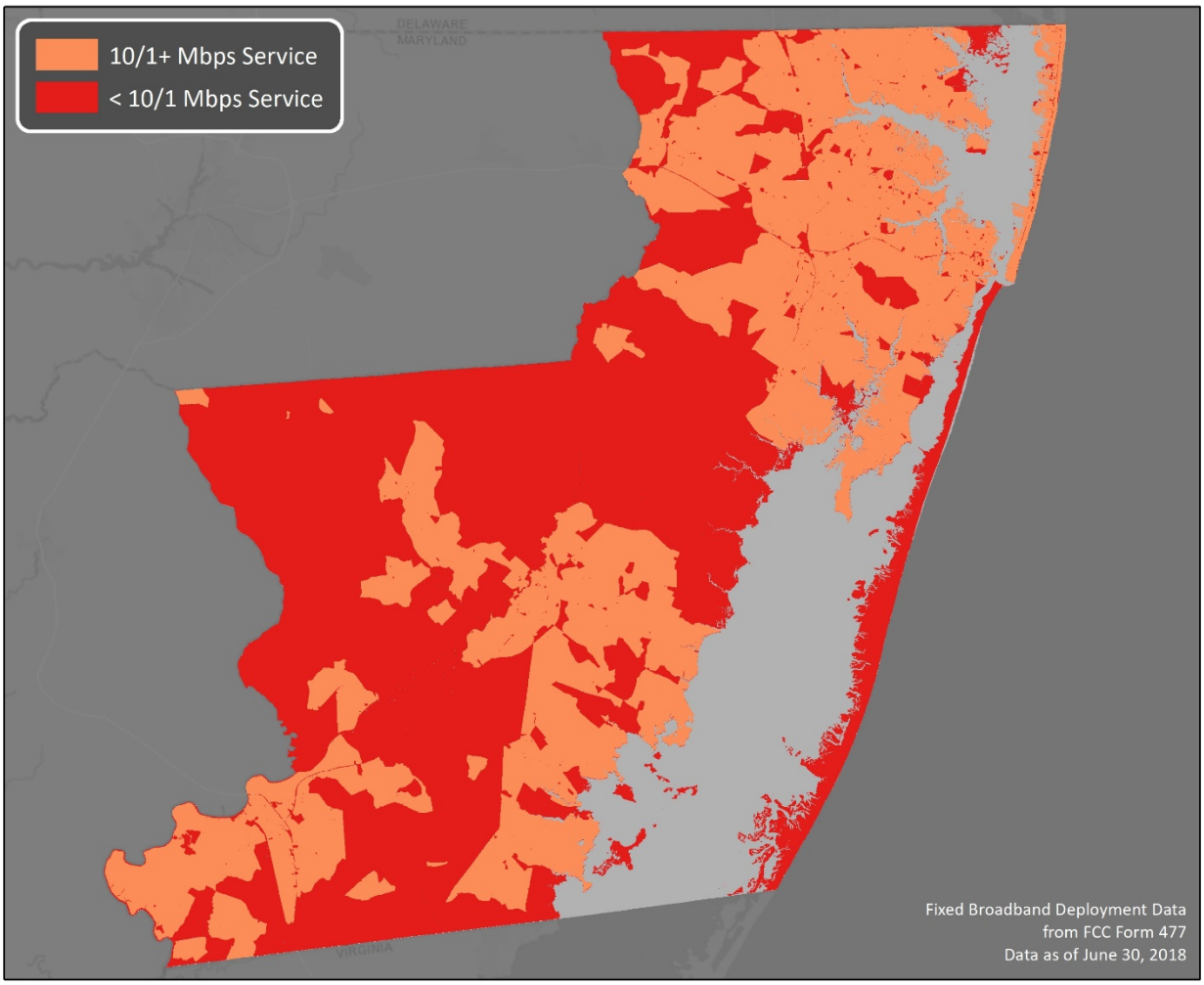
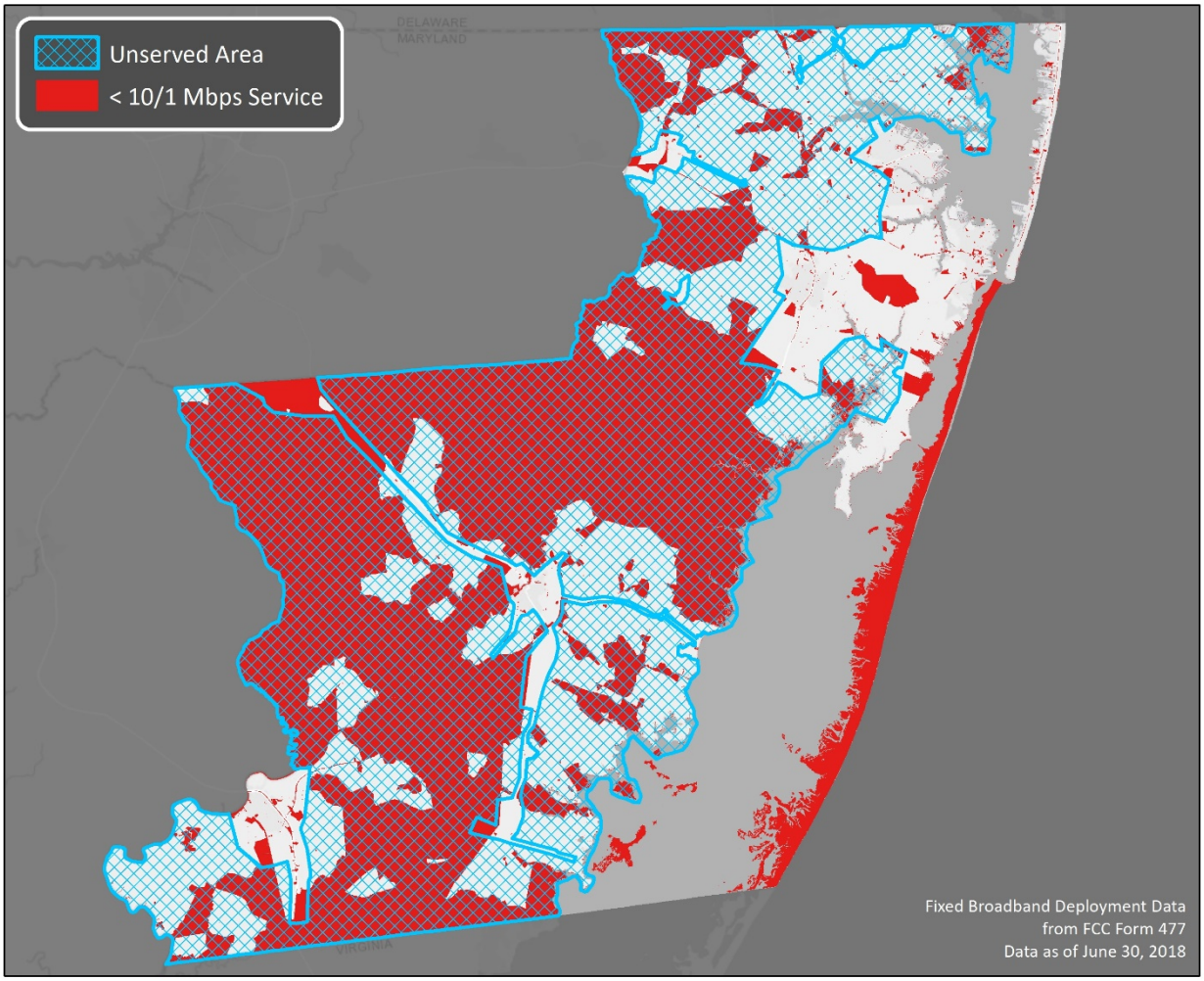


Figure 13: FCC Form 477 Data on 10/1 Availability as Compared to Desk and Field Survey Findings



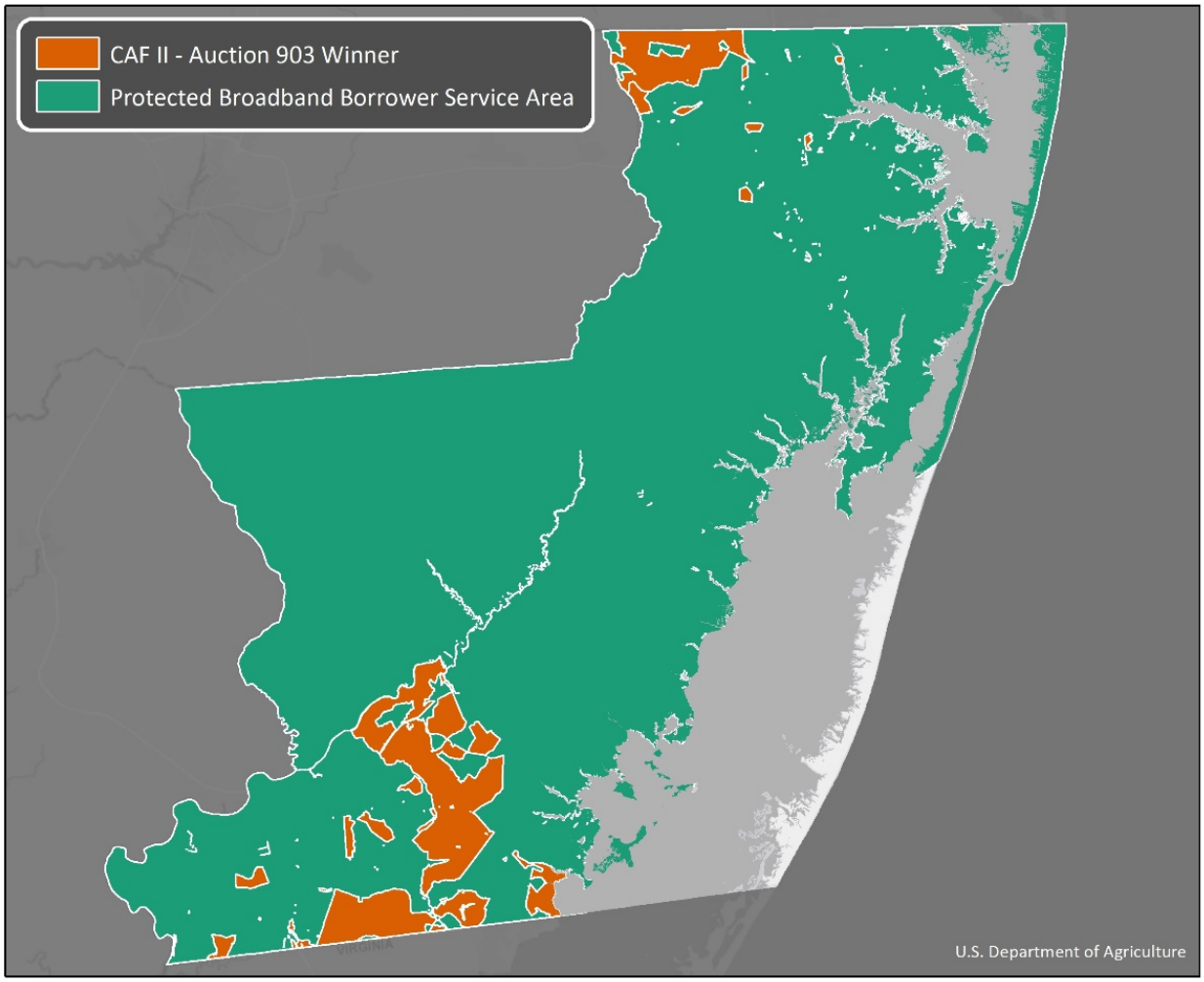
The ReConnect-eligible areas of the County would typically be those with less than 10/1 Mbps service, as documented by Form 477 data and our desk and field surveys. However, as Figure 14 (below) illustrates, most of the County is technically excluded from ReConnect eligibility because a wireless ISP, Bloosurf, has been awarded federal Connect America Fund II (CAF II) funding in certain areas (orange shading) and also previously received broadband grant and loan funding from the USDA's Rural Utilities Service (RUS); that funding makes the rest of the County a "protected broadband borrower service area" (green shading).[15]

As we describe in more detail in Section 6, if the County and a partner were to apply for ReConnect funding, they would need to challenge Bloosurf's protected broadband borrower service areas status as part of their application; the challenge would need to be based on

[15] "Eligible Service Area," ReConnect Loan and Grant Program, USDA RUS, https://www.usda.gov/reconnect/eligible-service-area (accessed November 2019).

documentation showing Bloosurf has not provisioned the services to which they committed delivering under their RUS award.

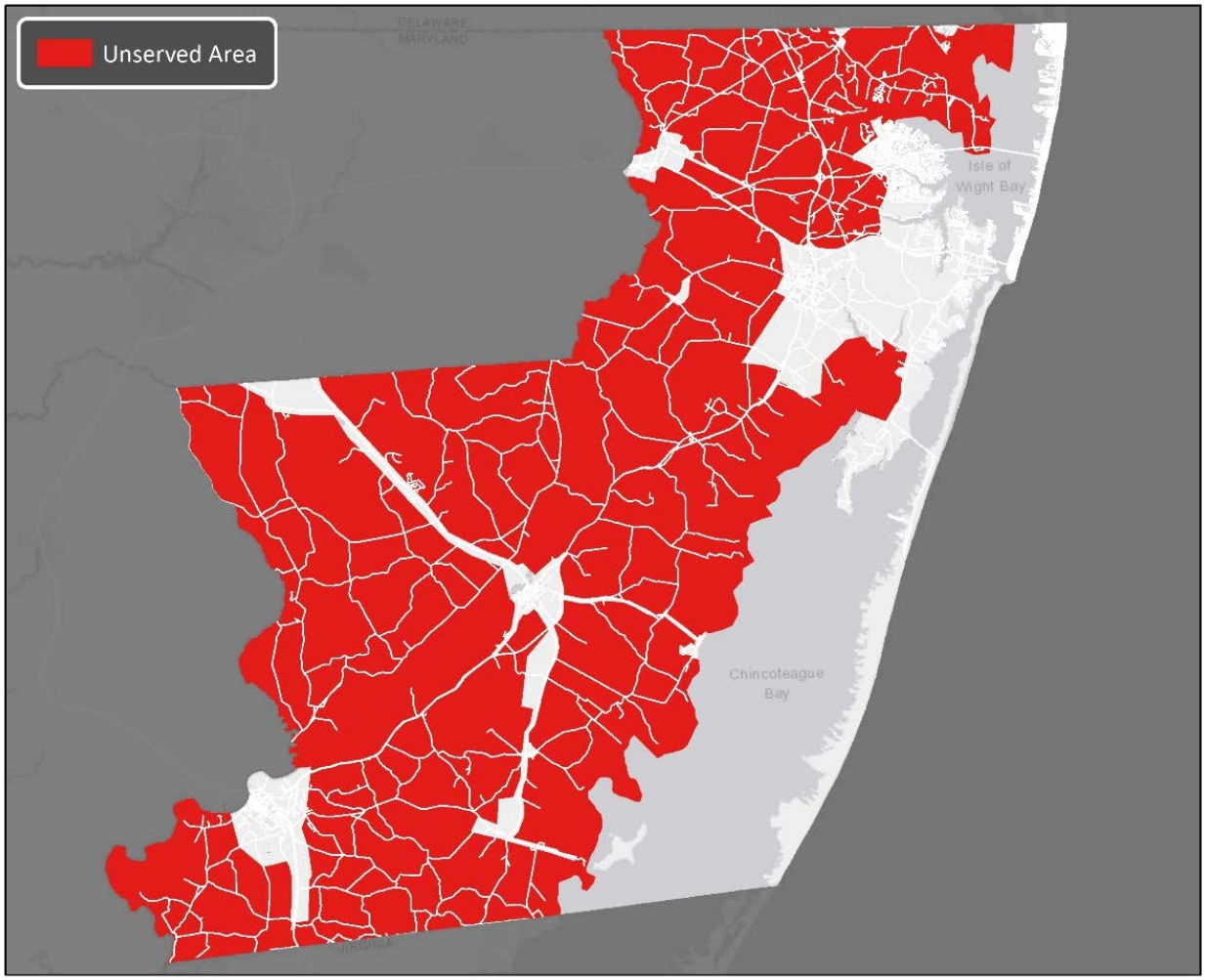
Figure 14: ReConnect-Ineligible Areas in Worcester County



3 Fiber-to-the-Premises Infrastructure to Fill Service Gaps 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 the location of the County's unserved residents and businesses.[16] For purposes of discussing a potential technical solution for serving those members of the community, we identified 6,390 unserved homes and businesses (also known as "passings") (Figure 15).

Figure 15: Unserved Portions of Worcester County as Confirmed by Desk and Field Surveys



[16] The County is concerned about lack of service that meets the federal definition of broadband (i.e., 25 Mbps download/3 Mbps upload).

As a candidate solution, CTC's engineers prepared a high-level network design for the deployment of a gigabit-capable fiber-to-the-premises (FTTP) network to homes and businesses. We then estimated the County's costs for deploying that network.

The total estimated capital cost for the County to construct an FTTP network to serve unserved areas is $46.7 million to $49.7 million; details are shown in Table 1.[17]

Table 1: Estimated Total FTTP Deployment Cost for Unserved Areas

Cost Component	Estimated Cost (35% Take Rate)	Estimated Cost (60% Take Rate)
Outside Plant	$41,500,000	$41,500,000
Central Network Electronics	$1,300,000	$1,500,000
FTTP Service Drop Installations	$2,800,000	$4,800,000
Customer Premises Equipment	$1,100,000	$1,900,000
Total Estimated Cost:	*$46,700,000*	*$49,700,000*

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. The average outside plant cost per passing will be approximately $6,500.

Table 2: Estimated OSP Cost per Passing for Unserved Areas

Cost Component	Estimated Cost
Outside Plant	$41,500,000
Passings	6,390
OSP Cost per Passing	*$6,500*

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 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.

[17] These numbers have been rounded.

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 County's network design and construction costs, a CTC engineer performed a desk survey of the County using Google Earth Street View (see Section 2.1 for more details). 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 3 summarizes the important factors for construction determined through our desk and field surveys.

Table 3: Cost Factors Developed in Desk and Field Surveys

Cost Factor	Finding in Unserved Areas
Aerial Construction	95%
Poles per Mile	35
Average Moves Required per Pole	1
Poles Requiring Make-Ready	7%
Cost Per Move	$350
Poles Requiring Replacement	3%
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 as 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 in the unserved areas have space for an additional attachment.

In some parts of the County's unserved areas, the telecommunications cables (i.e., Verizon telephone lines) are on separate poles on the opposite side of the street from the electrical distribution cables. The telecommunications poles typically do not have space or capacity for an additional attachment, so we recommend the electrical poles be used for new fiber attachments. The cost estimate assumes that the County could attach to the electrical poles in the communications space below the electrical cables. Based on our experience, the electric 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 desk and field surveys of the County's unserved areas. In the following figure, for example, make-ready is required to add a communications attachment. The extension arm would need to be replaced with a longer extension arm to gain horizontal clearance or a taller pole would be needed to provide vertical clearance.

Figure 16: Utility Pole Requiring Make-Ready

Tree trimming is required to attach an additional attachment on the utility poles in the following picture (Figure 17). 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 17: Pole Line Where Tree Trimming Will Be Required

Figure 18 shows a low (favorable) make-ready pole line that has only one existing attachment in the communications space on the utility poles and where no tree trimming is required. Where make-ready is low, the cost of aerial construction is less than in high make-ready areas.

Figure 18: Low-Make-Ready Pole Line in Unserved Area

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

We developed a conceptual, high-level FTTP outside plant network design that is aligned with best practices in the industry, reflects the County's goals, and is open to a variety of electronic architecture options.[18]

Figure 19, below, shows a logical representation of the FTTP network architecture we recommend based on the conceptual outside plant design. The drawing illustrates the primary functional components in the FTTP network, their relative position to one another, and the flexibility of the architecture to support multiple subscriber models and classes of service.

The recommended architecture is a hierarchical data network that provides 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 FTTP data network are:

- **Capacity** – ability to provide efficient transport for subscriber data, even at peak levels
- **Availability** – high levels of redundancy, reliability, and resiliency; ability to quickly detect faults and re-route traffic
- **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)

[18] 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.

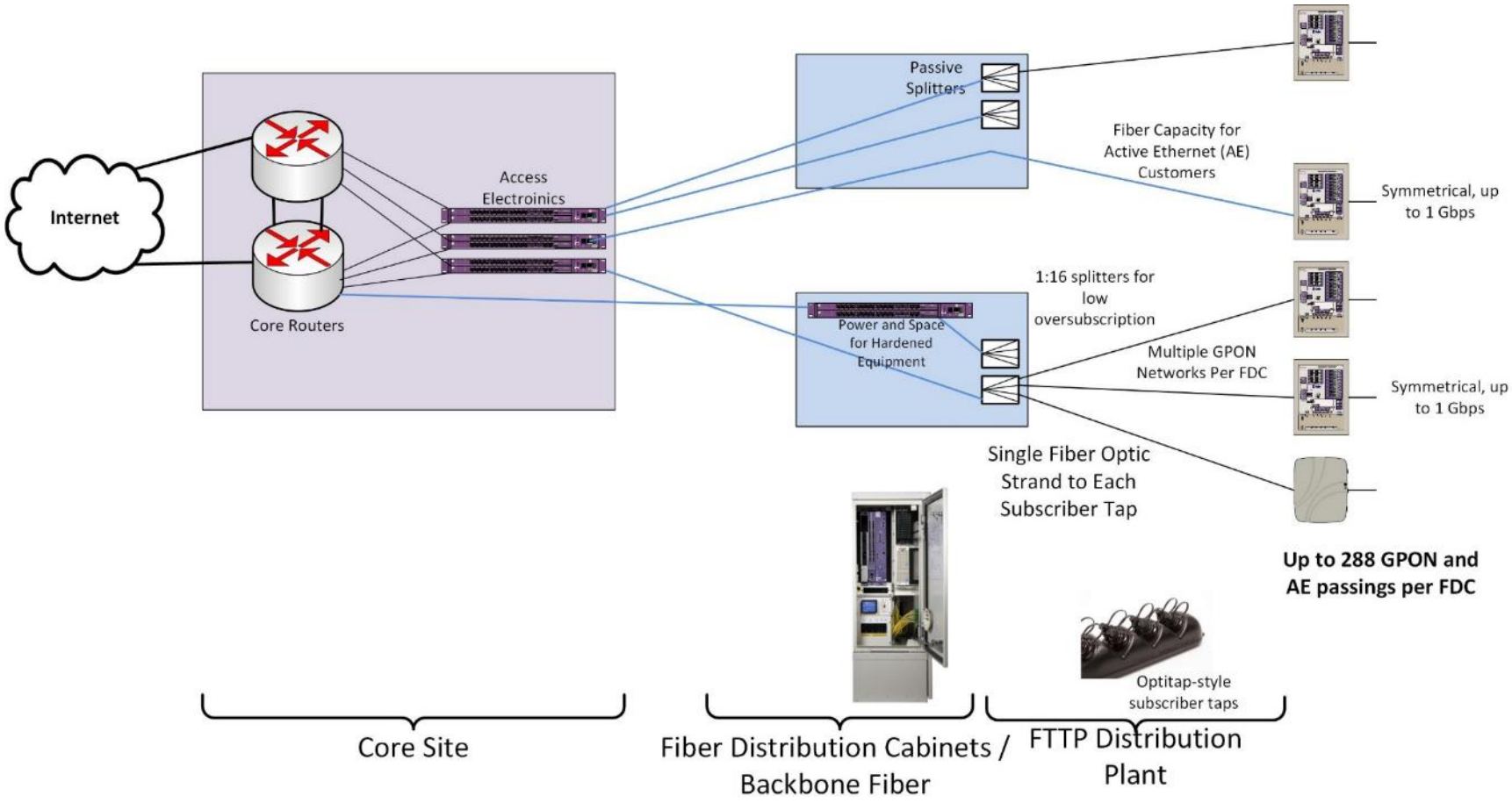
- **Security** – controlled physical access to all equipment and facilities, plus network access control to devices

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 (GPON) technology. It could also provide the option of direct Active Ethernet (AE) services.[19]

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 obtains easements or access rights to the gated communities and private drives within the communities to access the homes in those neighborhoods.

[19] 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 FDCs on an as-needed basis.

Figure 19: High-Level FTTP Architecture



3.3 Network design assumptions include constructing more than 70 miles of fiber backbone

The network design and cost estimates assume the County will:

- Use existing County land to locate a core facility with adequate environmental and backup power generators to house network electronics, and provide backhaul to the internet
- Construct approximately 70 miles of backbone network to connect the unserved communities to the core via 15 fiber distribution cabinets (FDC)
- Construct 560 miles of fiber optics from the FDCs to each of the 6,390 residences and businesses (i.e., from termination panels in the FDC to tap locations in the public right-of-way or on County easements near the residence or business)
- Obtain easements or access rights to private roads where public rights-of-way do not exist, which we estimate is less than 10 percent of roads in the unserved areas[20]

The FTTP network design was developed with the following criteria based on the above assumptions and required characteristics of the hierarchical FTTP 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 FDC
- FDCs will support hardened network electronics and provide backup power and an active heat exchange[21]
- The network routes will avoid the need for distribution plant to cross major roadways and railways

[20] The County reports that all roadways that are lanes are private roads that may need easements.

[21] These hardened FDCs reflect an assumption that the County's operational and business model will require the installation of provider electronics in the FDCs that are capable of supporting open access among multiple providers. We note that the overall FTTP cost estimate would decrease if the hardened FDCs were replaced with passive FDCs (which would house only optical splitters) and the providers' electronics were housed only at the hub facility.

- Internet bandwidth access will be purchased from existing ISPs in the County such as the Maryland Broadband Cooperative.

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. Cost estimates are based on comparable FTTP projects and numbers provided by local fiber construction contractors.

Table 4: Unit Cost Estimate Assumptions

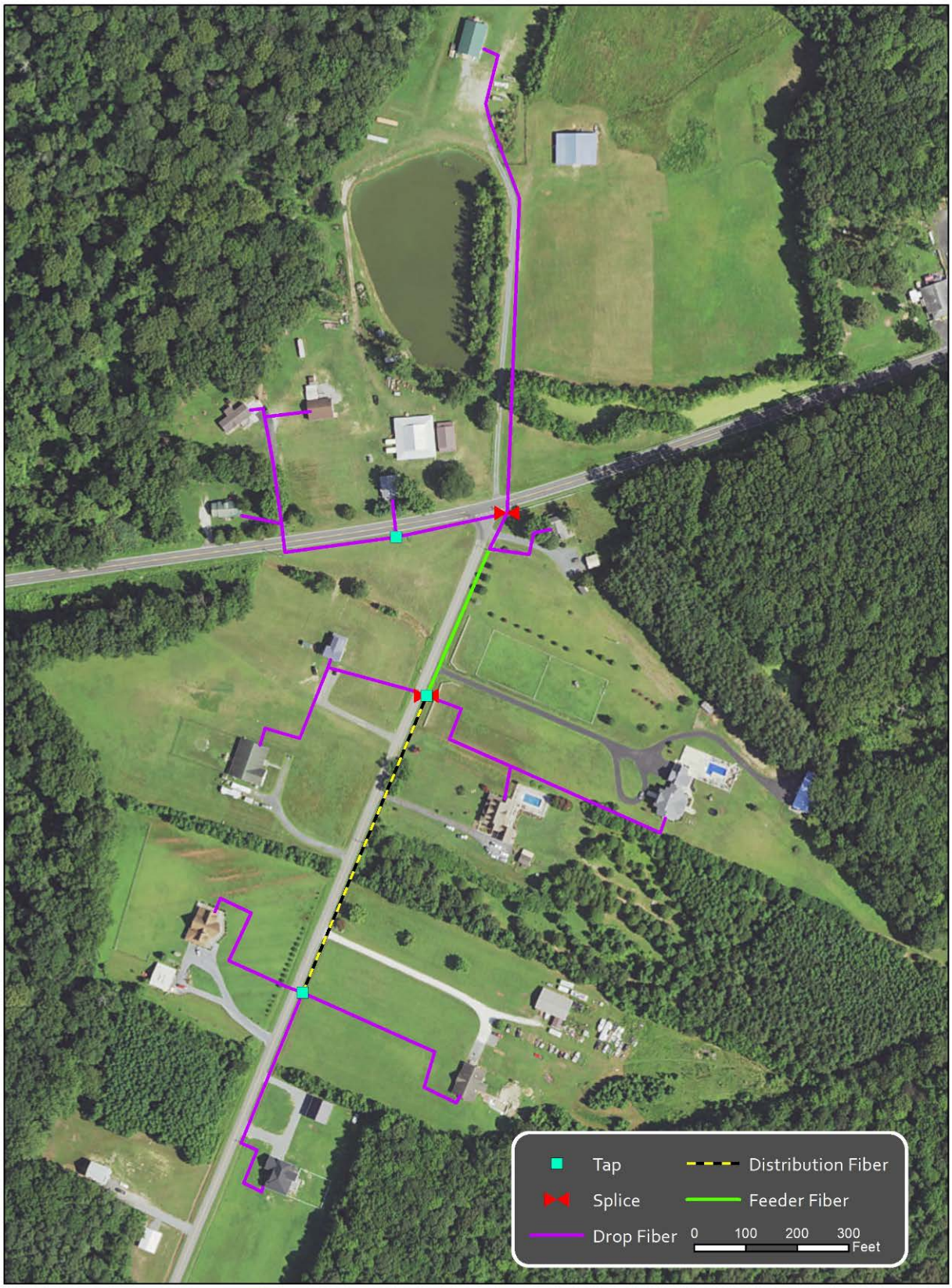
Description	Unit	Assumption
Placement of 2-inch conduit using directional boring	$/foot	$12.50
Pull-box placement, 24"x36"x36" Tier 22	each	$1,050
Aerial cable installation per foot	$/foot	$1.50
Traffic control and work area protection per foot	$/foot	$.50
Tree Trimming	$/foot	$.50
Make-ready per foot	$/foot	$3.80
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.

To estimate costs, we extrapolated the unit costs determined from strategically selected sample designs in portions of the County that closely match the average density for the unserved areas.

Figure 20 is an example of a sample design. The area was chosen because the average density in the area closely matches the average for the total unserved areas.

Figure 20: Map of an Unserved Area Sample Design



Our observations determined that the utilities are primarily aerial in unserved areas of the County. Most of the underground plant areas are in newly developed areas of the County, although these areas tend to be served. There are also private roads in the unserved areas where the County will either need to acquire their own easements or use the easement granted to Choptank Electric Cooperative or Delmarva Power, to place infrastructure on their 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 in Worcester County 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.

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.
- ***FTTP Service Drop and Lateral Installations –*** consists of all costs related to fiber service drop installation, including outside plant construction on private property, building penetration, and inside plant construction to a typical backbone network service "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 customers taking the service, an estimated 35 percent.

The assumptions, sample designs, and cost estimates were used to extrapolate a cost-per-mile for the outside plant infrastructure of $66,000.

The distribution plant covers 630 miles, leading to a total outside plant cost of $41,500,000. This leads to an average outside plant cost per passing of $6,500. Table 5 provides a breakdown of the estimated outside plant costs. (Note that the costs have been rounded.)

Table 5: Estimated Outside Plant Costs

Area	Cost Per Plant Mile	Distribution Plant Mileage	Total Cost	Passings	Cost per Passing
Unserved	$66,000	630	$41,500,000	6,390	$6,500

The actual cost to construct FTTP to every unserved 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 across different areas could also influence costs. Further and more extensive analysis would be required to develop a more accurate cost estimate.

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'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

Incremental network electronics equipment to serve the unserved area will cost an estimated $1.3 million, assuming a 35 percent take-rate, and $1.5 million assuming a 60 percent take-rate.[22] (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 FTTP network at the core and the FTTP access electronics located at the customer premises. Table 6, below, lists the estimated costs for each segment.

[22] The take-rate affects the electronics and drop costs, but also may affect other parts of the network, as the County may make different design choices based on the expected take-rate. A 35 percent take-rate is typical of environments where a new provider joins the telephone and cable provider in a County and thus is the most conservative estimate for take-rate in this area. A 60 percent take rate is more likely where no other providers are available.

Table 6: Estimated Central Network Electronics Costs

Network Segment	35% Take-Rate	60% Take-Rate
Core and Distribution Electronics	$1,000,000	$1,000,000
FTTP Access Electronics	$300,000	$500,000
Central Network Electronics Total	**$1,300,000**	**$1,500,000**

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

3.4.2.1 Core and distribution electronics

The core electronics connect the FTTP network to the internet. The core electronics consist of high-performance routers, which handle all the routing on both the FTTP 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.[23] 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, such as the Maryland Broadband Coop, that connect the FTTP network to the internet.

The cost of the incremental core routing equipment is approximately $1,000,000. In addition, the network requires operations support systems (OSS), such as provisioning platforms, fault and performance management systems, remote access, and other operational support systems for FTTP operations. For a network of this scale, an OSS costs approximately $100,000 to acquire and configure, if not provided by the network provider.

3.4.2.2 FTTP access electronics

The access network electronics at the FDCs connect the subscribers to the FTTP network by connecting the backbone to the fiber that goes to each premise. We recommend deploying access network electronics that can support both GPON and AE subscribers to provide flexibility within the FDC service area. These electronics are commonly referred to as optical line terminals

[23] 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.

(OLT). 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.

The cost of the access network electronics for the network is estimated at approximately $300,000 and $500,000, based on a take-rate of 35 percent and 60 percent, respectively; the costs include optical splitters at the FDCs aligned to those take-rates.

An alternative design places the OLTs at the core location, with the FDCs containing only splitters. As the County examines more closely the specific electronics architecture, this alternative may be a suitable approach, which would reduce size of the FDCs and provide a small cost savings.

3.4.3 FTTP 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 $1,750 per subscriber, or $3.9 million total, assuming a 35 percent take-rate; at a 60 percent take-rate the total cost would be $6.7 million.

Customer premises equipment is the subscriber's interface to the FTTP network; for GPON networks, these electronics are referred to as an optical node terminal (ONT). For this cost estimate, we selected customer premises equipment that both terminates the fiber from the FTTP network and provides only Ethernet data services at the premises (however, there is a wide variety of additional customer premises equipment offering other data, voice, and video services). The CPE can also be provisioned with wireless capabilities to connect devices within the customer's premises. We estimated the cost for subscriber customer premises equipment and installation to be $500 per subscriber, or approximately $1.1 million or $1.9 million systemwide, assuming 35 percent or 60 percent penetration.

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 $10,000. We estimate an average of approximately $1,250 per drop installation, which is based on the sample design and the average setbacks of the passings from the road.

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 7, below, are averages and will vary depending on the type of premises and the internal wiring available at each premises.

Table 7: Incremental Per-Subscriber Cost Estimates

Construction and Electronics Required to Activate a Subscriber	Estimated Average Cost
Drop Installation and Materials	$1,250
Subscriber Electronics (ONT)	200
Electronics Installation	200
Installation	100
Total	*$1,750*

Taking into account the subscriber penetration, the costs per customer are $22,460 for a 35 percent take-rate and $14,720 for a 60 percent take-rate.

Table 8: Estimated Total Capital Costs per Customer

	Network Cost	Customers	Fixed Customer Costs	Incremental Customer Cost	Total Customer Cost
35% Take-Rate	$46.7 million	2,236	$20,890	$1,750	$22,640
60% Take-Rate	$49.7 million	3,833	$12,970	$1,750	$14,720

3.4.4 Construction of the FTTP network to unserved areas could expand the County's fiber for internal purposes

The County has its own fiber optic routing that is often colocated with state fiber resources and is maintained by the state. Much of the fiber is in areas that are served; however, the fiber could be used to provide backhaul to the FTTP network or additional fiber might be overlashed or pulled through the same conduit.

The Maryland Broadband Cooperative also has fiber collocated with the state and County fiber. The Cooperative fiber could be used to provide internet access to the FTTP network.

The County's fiber resources will not dramatically change the cost or scope of fiber construction needed to build out to the unserved areas. If the fiber can be overlashed or pulled through the same conduit then the network construction costs can be reduced by $40,000 per mile. It is more likely that building the FTTP network would expand the County's fiber footprint so that the County could connect other facilities to the County's internal network, such as public safety radio locations.

3.5 Annual FTTP technical operating costs would total $1.1 million

Some of the ongoing costs of operating an FTTP 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 cost is required annually for fiber maintenance, or $400,000.

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 $120,000 annually for the estimated 65 miles of underground plant.

For every pole that the fiber network attaches to, the County 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 $400,000 annually for approximately 565 miles of aerial plant.

We recommend establishing an equipment replacement fund where the County 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 to place approximately $190,000 into the equipment fund annually.

Table 9 summarizes the FTTP technical operating costs.

Table 9: Annual FTTP Technical Operating Costs

Description	Annual Cost
Fiber Maintenance	$400,000
Fiber Locating	$120,000
Pole Attachment Fees	$400,000
Equipment Replacement Fund	$190,000
Total	*$1,110,000*

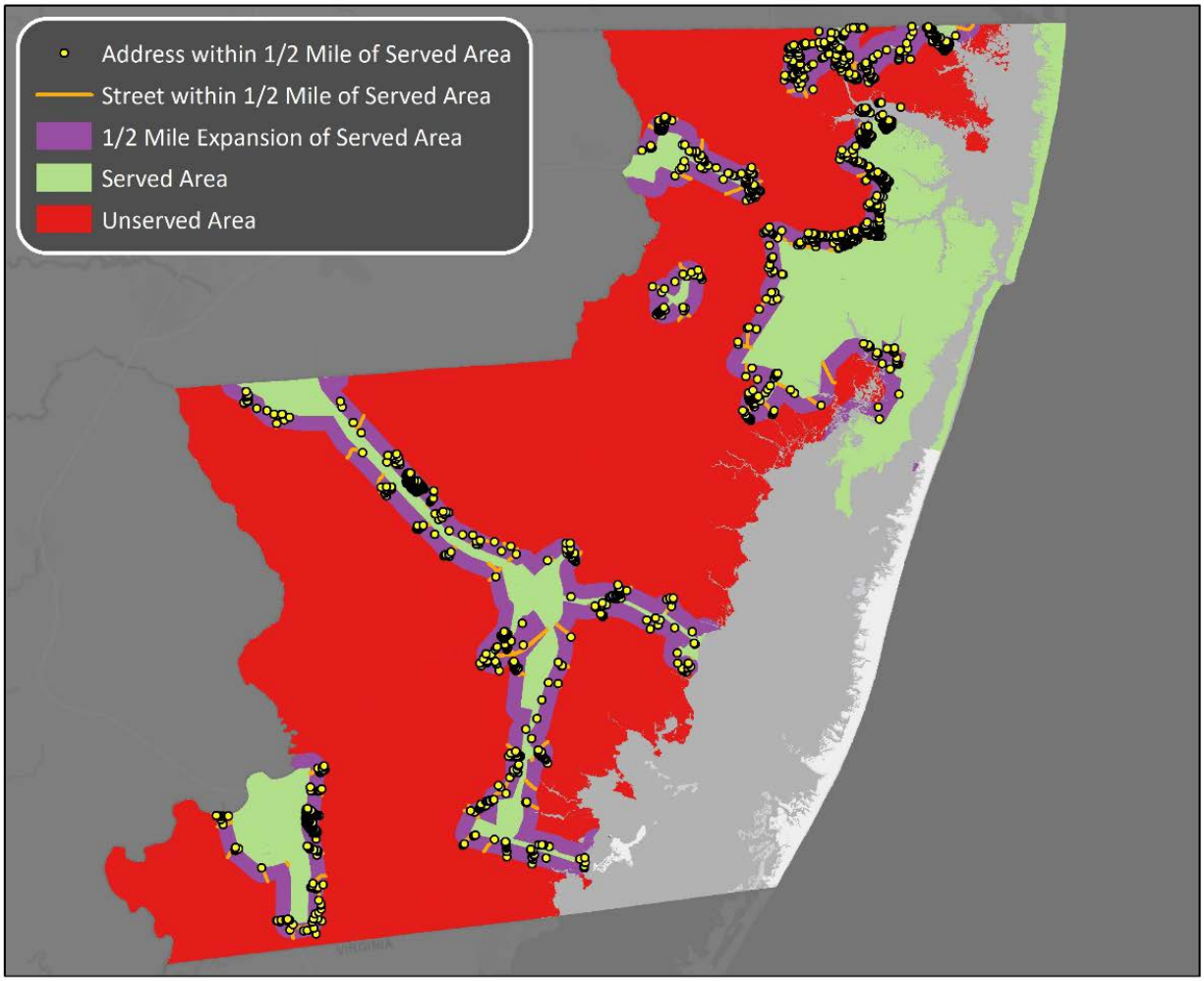
3.6 Comcast and Mediacom could pass 2,315 unserved homes and businesses with relatively small network extensions

As a point of comparison, we evaluated a scenario in which the cable companies expand their plant out from the edges of their existing footprints to pass currently unserved homes and businesses. This is not a comprehensive solution, but it indicates that there is a path forward for Comcast or Mediacom to address some of the County's unserved addresses with relatively modest network extensions.

We found that Comcast and Mediacom could serve approximately 2,315 unserved homes and businesses (36 percent of the County's unserved population) with a one-half mile network expansion from their existing plant for $3,140 per passing. We note, however, the remaining unserved homes and businesses would be the most expensive unserved passings; if the companies were to extend infrastructure to the entire unserved areas, their average costs would be comparable to the County's fiber-to-the-premises cost of $6,500 per passing.

The one-half mile network expansion from the cable companies' current service areas into the unserved areas (Figure 21) would require 110 miles of fiber construction. Comcast and Mediacom have no attachments in the unserved areas and would likely pay close to our estimate of $66,000 per mile. Based on these and other assumptions, the total cost of network expansion would be $7.3 million, not including network electronics or drop installation, which would be required for each new subscriber.

Figure 21: Unserved Addresses Within One-Half Mile of Existing Plant



The following table compares the outside plant costs between the existing network providers expanding the networks one-half mile and the outside plant costs for the County to build the entire unserved areas.

Table 10: Comparison of County-Built FTTP to Network Expansion Costs

	County-Owned FTTP Network	Cable Company Half-Mile Expansion
Passings	6,390	2,315
Plant Miles	630	110
Passings Per Mile	10	21
Cost Per Mile	$66,000	$66,000
Outside Plant Construction Costs	$41.5 million	$7.3 million
Outside Plant Cost Per Passing	$6,500	$3,140

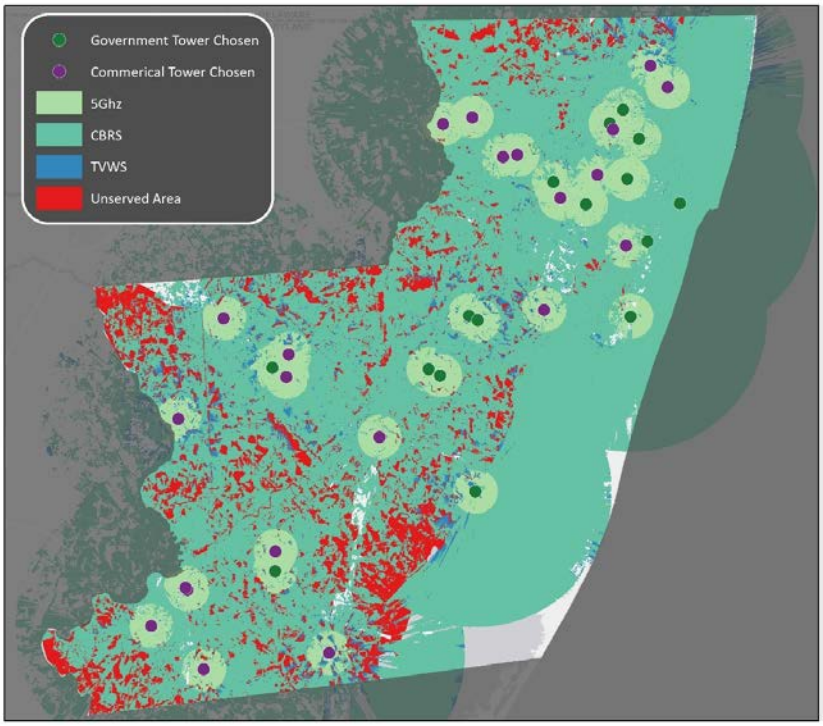
The network expansion area is more than twice as dense as the total unserved areas. This should be true given the areas closest to the existing providers are likely to be denser than the areas farther away from them. Using the same construction costs for both networks, the existing providers would see an approximately half the cost to construct their network per passing. This also implies that if the existing providers were to build these areas, the cost for the County to construct an FTTP network would double per passing as those denser portions of the unserved areas would now be served. In addition, there would be a smaller subscriber base of unserved residents—which would decrease the economies of scale for the operations of the County-built FTTP network.

4 A Fixed Wireless Solution to Partially Fill the County's Broadband Gaps Would Have Per Customer Capital Costs Comparable to Fiber, But Higher Ongoing Operating Costs, and Lower Performance

As an alternative to deploying fiber-to-the-premises, the County could consider a fixed wireless network—although it would have clear technical limitations relative to a fiber optic network. To that end, CTC's engineers developed a high-level candidate fixed wireless network model for serving the County's 6,390 unserved addresses using equipment mounted on existing towers; we then developed variations on that model (i.e., increasing the customers' received signal level required for service) to illustrate more conservative coverage estimates.

Our analysis found that a fixed wireless network could be used to serve a portion of the County's unserved homes and businesses. In an absolute best-case scenario for our candidate model, equipment mounted on 40 existing towers could deliver service to an estimated 86 percent of the County's unserved premises (Figure 22).[24]

Figure 22: Coverage From Candidate Fixed Wireless Network



[24] The green and violet dots illustrate the tower locations, while the light green, dark green, and blue areas illustrate coverage with three types of wireless technologies. The red indicates the remaining unserved areas, not covered by any of these three scenarios. It should be noted that most of the blue areas (i.e., locations covered by "TV White Spaces" spectrum) would not achieve the current federal benchmark for broadband speeds of 25 Mbps downstream and 3 Mbps upstream.

However, we believe that model is not realistic, so we added receiver thresholds to make it more realistic. When we increased the candidate network's receiver thresholds by 5 dB and 15 dB to illustrate the potential for foliage or other obstructions to limit signal propagation, we found that the network would cover, respectively, about 78 percent and 50 percent of the County's unserved premises. Table 11 summarizes the cost and scope of the three scenarios.

Table 11: Capital Cost and Coverage of Candidate Fixed Wireless Network Model

Option	Number of Towers	Percent of Unserved Premises Served	Premises Served	Capital Cost with 35% Penetration[25]	Capital Cost with 60% Penetration	Capital Cost Per Customer 35% Penetration	Capital Cost Per Customer 60% Penetration
Candidate Network with 5 dB Higher Receiver Threshold	39	78	4,999	$8,900,000	$11,100,000	$5,000	$3,700
Candidate Network with 15 dB Higher Receiver Threshold	37	50	3,191	$7,500,000	$8,900,000	$6,700	$47,000

The following sections:

- Provide a high-level introduction to fixed wireless connectivity (including technologies, basic architecture, spectrum, and elements of costs)
- Describe a candidate fixed wireless solution for the County's unserved homes and businesses
- Analyze the impact of foliage and other obstructions (i.e., increased signal thresholds) to estimate the likely range of network 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—which is also the definition of "served" used for this project) 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 internet service providers (WISP) typically are not able to offer connection speeds on a

[25] Includes subscriber equipment for 35 percent of addresses.

market-wide basis comparable to cable or fiber networks built to each premise in a given area, 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 relative to potential subscribers.

In contrast to an underground or aerial cable, wireless broadband is provided from access point antennas on towers or rooftops. The customer antenna may be on the home or business or on a mast on the customer premises (Figure 23).

Figure 23: Example Fixed Wireless Network with Access Point Antennas on a Monopole

4.1.1 Fixed wireless networks can use various technologies and spectrum bands

Fixed wireless networks typically 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 delivering broadband (i.e., 25 Mbps down and 3 Mbps up).

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, until recently, TVWS was not capable of delivering 25 Mbps down, and even now has significantly less capacity than other technologies. 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 Worcester County has a metropolitan area and many existing

broadcast television channels, the potential TVWS spectrum is significantly more limited than in more remote areas. Therefore, we only recommend TVWS use where other wireless connectivity is not available or feasible.

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 mountainous regions and in areas with dense vegetation or 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 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 manufacturers 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 residences 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 report assume point-to-multipoint equipment, which is typical for a residential or small business connection.

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:** Different wireless equipment has different aggregate bandwidth capacity and uses 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

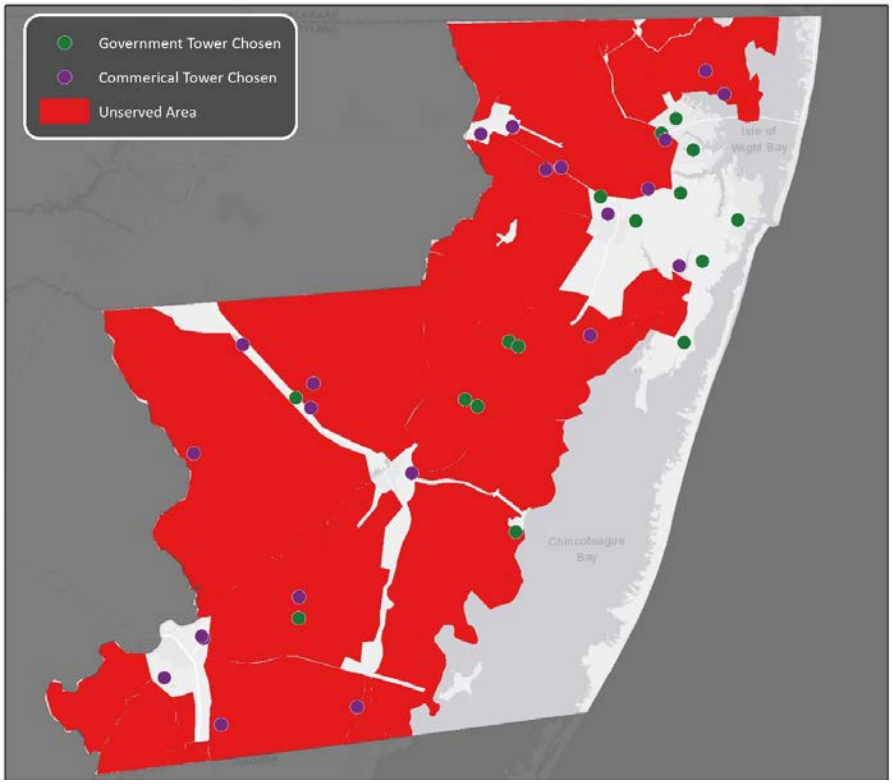
generally much lower than deploying a wireline network, but the wireless network will require more regular investment.

- **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.

4.2 A candidate fixed wireless network depends on precise tower selection

To examine the feasibility of deploying a fixed wireless network to connect the County's unserved addresses, we analyzed multiple commercial and government databases and identified 51 existing tower locations in Worcester County; we then examined their height and ownership relative to their potential use as part of a solution. Of these towers, we selected 40 (16 of which are government-owned) that could potentially provide fixed wireless service to the County's unserved addresses. Figure 24 shows the government towers (in green) and commercial towers (in purple) selected as part of our candidate design.

Figure 24: Existing Towers Suitable for Fixed Wireless Solution



CTC assessed the coverage that could be provided by each of the selected tower sites using the three fixed wireless frequency band options (CBRS, 5 GHz, and TVWS) to determine how many of the unserved addresses would be within each band's predicted coverage area. (Each band will

need its own set of equipment; if one or more bands could be eliminated from specific sites, then the overall cost of deployment and operations would be reduced.)

Among the three technology options, the CBRS band is predicted to connect the most addresses. In addition to the characteristics of the spectrum that enable better connectivity around line-of-sight obstacles, CBRS antennas can be mounted higher than TVWS antennas (per FCC licensing rules), and have the greatest broadcast power of the three technologies, thereby allowing for better coverage than the other bands.

We based our analysis on the following assumptions:

- Antennas are placed at 80 percent of the tower height for 5 GHz and CBRS (i.e., we assumed that the top space of any existing towers is already utilized), and at the maximum allowable height of 30 meters (98 feet) for TVWS
- Broadcast power is at the FCC maximum for all three bands
- Channel bandwidth is 20 MHz for 5 GHz, 10 MHz for CBRS, and 6 MHz for TVWS
- Subscriber equipment antenna is placed at 4.57 meters (15 feet) above the ground
- Ground elevation and clutter resolution is 30 meters

4.3 Using existing towers, a fixed wireless network could serve about 50 to 86 percent of unserved residents

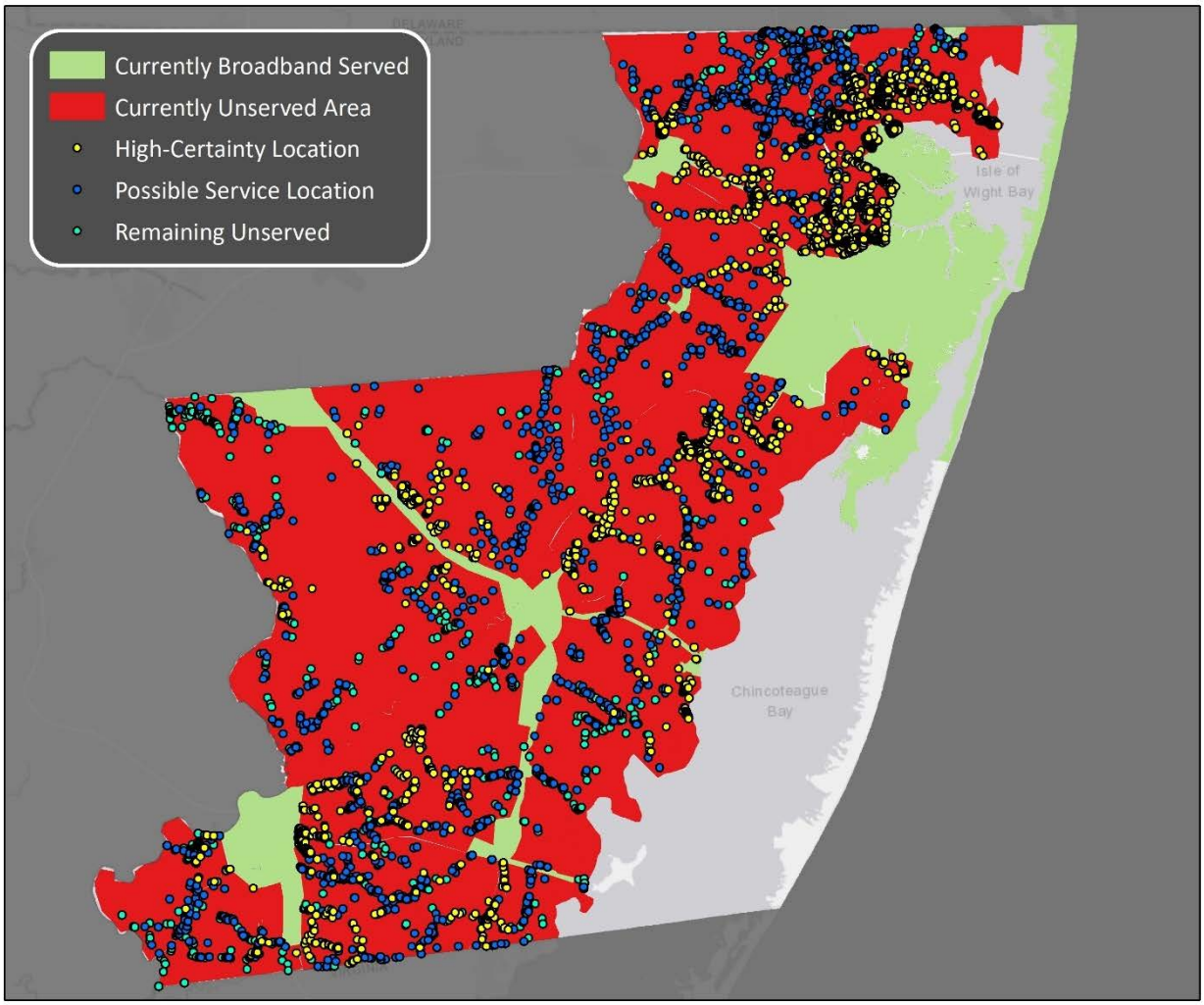
For the County's planning purposes, we conducted a high-level analysis to determine how many unserved premises could be served by a fixed wireless network. Combining the candidate coverage maps and our map of the County's unserved addresses in GIS, we identified the addresses that would be covered by the best-case wireless model.

One of the largest sources of uncertainty in wireless quality is the effect of trees. Our candidate model has characteristics that try to include the effect of trees based on the aerial imagery—however, this is often not finely enough tuned to take into account small variations in tree cover that can make very large difference in individual lines of sight (such as individual trees close to houses). To take that into account, we created two additional models—one with a light increase in tree cover (+5 dB receiver threshold) and one with a large increase in tree cover (+15 dB receiver threshold).

We believe the larger (15 dB) increase in signal attenuation represents a worst-case scenario—meaning that there is a high degree of certainty of coverage for the premises that appear to be served in that model. We believe the actual network coverage will be between the worst-case and the best-case scenarios—so in the potential coverage map (Figure 25), we depict the

locations that are not covered by the worst-case model but are covered by the best-case model as possible service locations.

Figure 25: Potential Fixed Wireless Coverage



4.3.1 A best-case fixed wireless network could cover about 86 percent of unserved residents

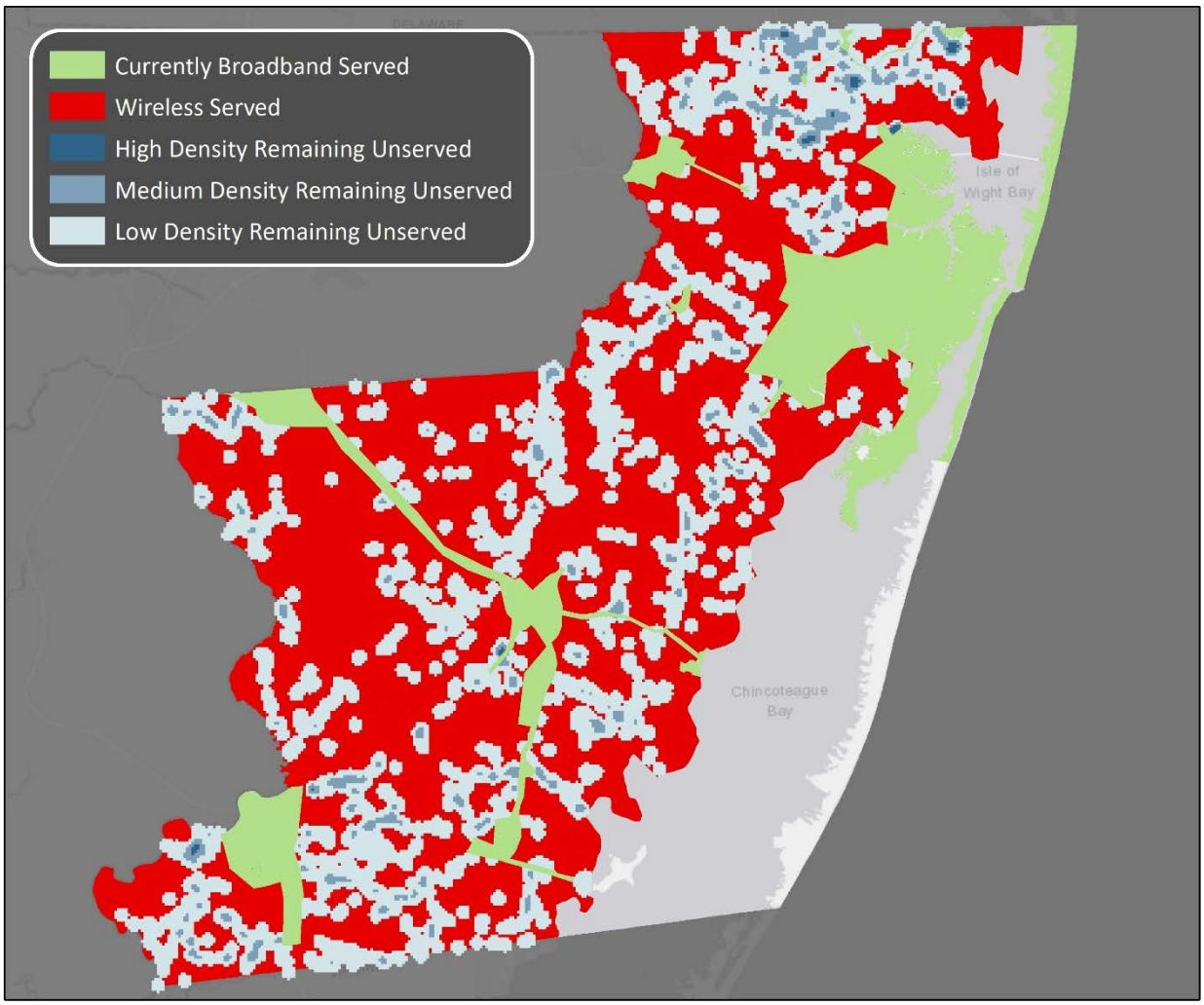
Our propagation analysis predicts that 5,501 addresses would be served by our candidate fixed wireless model—meaning that 887 addresses, or 14 percent of the County's unserved premises, would not be covered by any frequency band in this best-case scenario. The following table breaks down the results.

Table 12: Summary of Best-Case Fixed Wireless Network Coverage

Addresses	Number
Total addresses in unserved area	6,390
Addresses served by CBRS band	3,657
Additional addresses served by TVWS band	247
Addresses served by one or more band	5,501
Addresses not served by any of the three bands	887
Percent of addresses served by one or more of the three bands	86%

Figure 26 is a heat map of the remaining addresses by density.

Figure 26: Density of Remaining Addresses



We used the Longley-Rice radio frequency (RF) model (also called the irregular terrain model (ITM)) because it is the most conservative and takes into consideration atmospheric conditions,

ground elevation, obstacles between the base station and the mobile station, and ground clutter.[26]

We modeled the RF coverage using CloudRF software to generate propagation maps showing signal levels that would achieve a minimum throughput for each of the frequencies used. For the 5 GHz and CBRS frequencies, the maps indicate the areas where throughputs of 25 Mbps download and 3 Mbps upload (i.e., broadband speeds) can be achieved at the cell edge. Because TVWS will not achieve these throughputs, the coverage areas indicate the availability 10 Mbps download and 2 Mbps upload speeds (although 20 Mbps download and 4 Mbps upload may be attainable where bonding of two or more pairs of channels is possible).

Almost all addresses that have 5 GHz coverage 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. The 5 GHz equipment can be used selectively to add capacity at sites, and TVWS can be used selectively to pick up additional addresses at select locations.[27] TVWS access points are included in the design as an alternative for serving addresses with exceptionally high obstruction due to foliage or obstructing terrain.

Our assumptions are as follows:

- Towers will be configured with three cell 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.

[26] Other propagation models used for RF analysis include line of sight (LOS), Cost 231, Okumura Hata.
[27] Determining which band would be deployed at each tower site is beyond the scope of this analysis.

- There is room within the shelter at the tower location for necessary additional equipment
- A core network to manage functions such as authentication, billing, security, and connection to the internet will be set up at a cost of $200,000

4.3.2 Assuming a low level of signal obstruction, the candidate network could cover 78 percent of unserved residents

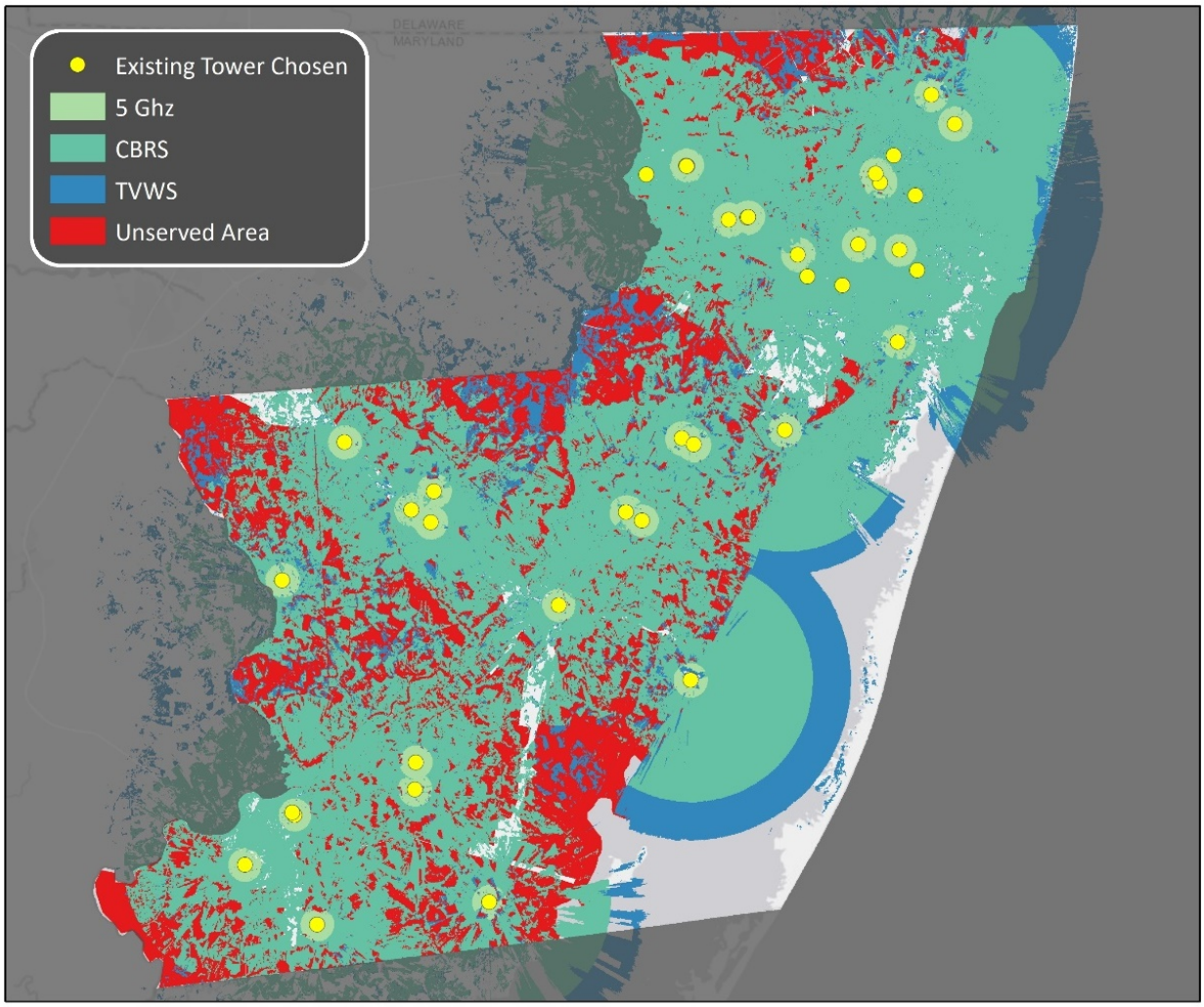
The model then increases the receiver thresholds by 5 dB. Our propagation analysis predicts that about 5,000 premises would be served by 39 of the original 40 towers—meaning that 1,389 addresses, or 22 percent of the County's unserved premises, would not be covered by any frequency band. The following table summarizes the results.

Table 13: Summary of Fixed Wireless Coverage with 5 dB Higher Receiver Threshold

Addresses	Number
Total addresses in unserved area	6,390
Addresses served by CBRS band	3,907
Additional addresses served by TVWS band	306
Addresses served by one or more band	4,999
Addresses not served by any of the three bands	1,389
Percent of addresses served by one or more of the three bands	78%

Figure 27 shows the coverage in this model.

Figure 27: Fixed Wireless Coverage with 5dB Higher Receiver Threshold



The following table shows the costs for this model.

Table 14: Capital Cost Estimate for Fixed Wireless Network with 5 dB Higher Receiver Threshold

Item	Cost
Core Equipment	$200,000
Access Point Equipment	$663,750
Backhaul	$585,000
Installation, Engineering and Design	$2,730,000
Site Acquisition	$1,560,000
Total Distribution Network Cost	*$5,738,750*

Table 15: Capital Cost Estimate at Different Penetration Rates

Item	Cost
Capital Cost (Distribution Only)	$5,738,750
Capital Cost (35% Penetration)	$8,888,120
Capital Cost (60% Penetration)	$11,137,670
Cost per Subscriber (35% Penetration)	$5,000
Cost per Subscriber (60% Penetration)	$3,700

4.3.3 Assuming a worst-case level of signal obstruction, the candidate network could cover 50 percent of unserved residents

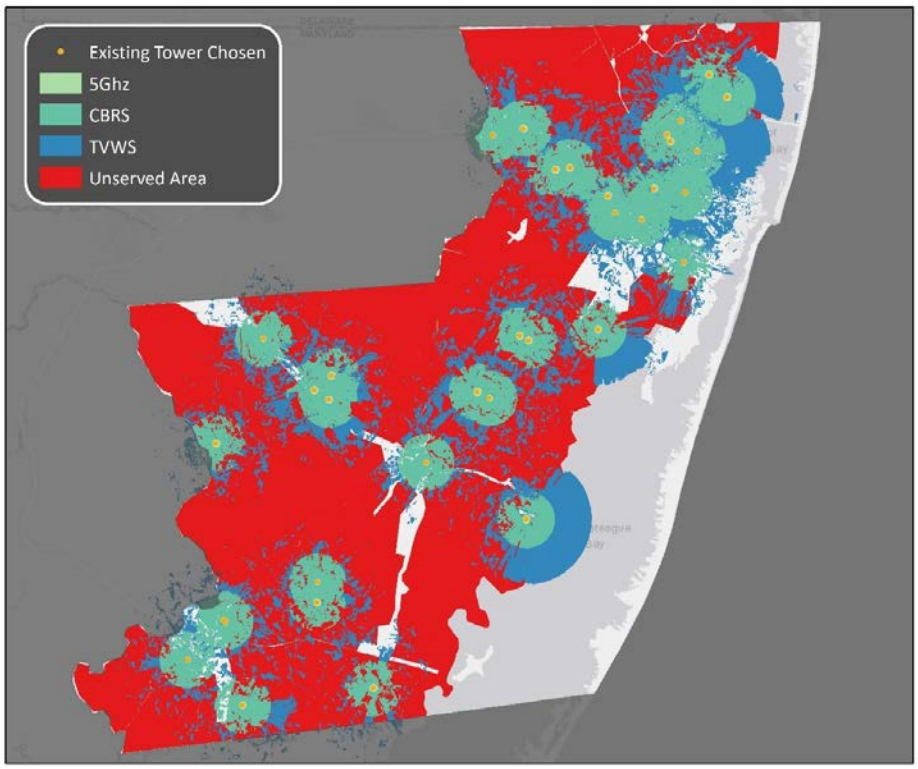
This model increases the receiver thresholds by 15 dB. Our propagation analysis predicts that in this worst-case, which requires 37 of the 40 original towers, 3,191 addresses would be served—meaning that 3,197 addresses, or 50 percent of the County's unserved premises, would not be covered by any frequency band. The following table summarizes the results.

Table 16: Summary of Worst-Case Fixed Wireless Coverage (15 dB Higher Receiver Threshold)

Addresses	Number
Total addresses in unserved area	6,390
Addresses served by CBRS band	1,823
Additional addresses served by TVWS band	1,198
Addresses served by one or more band	3,191
Addresses not served by any of the three bands	3,197
Percent of addresses served by one or more of the three bands	50%

Figure 28 shows the coverage in this model.

Figure 28: Worst-Case Fixed Wireless Coverage (15 dB Higher Receiver Threshold)



The following table shows the costs for this model.

Table 17: Capital Cost Estimate for Worst-Case Fixed Wireless Network (15 dB Higher Threshold)

Item	Cost
Core Equipment	$200,000
Access Point Equipment	$626,250
Backhaul	$555,000
Installation, Engineering and Design	$2,590,000
Site Acquisition	$1,480,000
Total Distribution Network Cost	$5,451,250

Table 18: Capital Cost Estimate at Different Penetration Rates

Item	Cost
Capital Cost (Distribution Only)	$5,451,250
Capital Cost (35% Penetration)	$7,461,580
Capital Cost (60% Penetration)	$8,897,530
Cost per Subscriber (35% Penetration)	$6,700
Cost per Subscriber (60% Penetration)	$4,700

5 Fiber-to-the-Premises Is Clearly a Preferable Technical Solution with Lower Long-Term Operating Costs Than a Fixed Wireless Solution

Overall, FTTP represents a better long-term broadband solution than fixed wireless for most unserved areas of the County—both because it is a superior technical solution and because it would have a lower long-term cost of ownership. Considering a likely 35 percent take-rate, the total 10-year cost per customer is comparable for FTTP ($27,550) and fixed wireless ($23,000 for the best-case model). Considering a 60 percent take-rate, the 10-year cost per customer is also comparable for FTTP ($17,590) and fixed wireless ($15,700 for best-case). (See Table 19 and Table 20.) However, over a longer period of time, an FTTP network would have a lower total cost than a fixed wireless network because the latter has higher operating costs.

Table 19: Fixed Wireless 10-Year Total Cost of Ownership Comparison

Option	Capital Cost Per Subscriber	Subscribers	10-Year Operating Costs Per Subscriber	Total 10-Year Capital and Operating Costs Per Subscriber*
Best Case (35% Take-Rate)	$5,000	1750	$18,000	$23,000
Worst Case (35% Take-Rate)	$6,700	1116	$25,000	$31,700
Best Case (60% Take-Rate)	$3,700	3000	$12,000	$15,700
Worst Case (60% Take-Rate)	$4,700	1914	$16,000	$20,700

Table 20: FTTP 10-Year Total Cost of Ownership Comparison

Option	Distribution Network per Subscriber	Incremental Cost per Subscriber	Subscribers	10-Year Operating Cost Per Subscriber	Total 10-Year Capital and Operating Costs Per Subscriber
FTTP (35% Take-Rate)	$20,890	$1,750	2,236	$4,910	$27,550
FTTP (60% Take-Rate)	$12,970	$1,750	3,833	$2,870	$17,590

This estimate is a simplified operations cost model focusing on required operating costs such as maintenance, fiber locating, pole attachments, equipment replacement, and towering leasing. Costs such as staffing, marketing, and legal resources are not included as these would vary depending on the business model chosen.

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 FTTP 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 FTTP 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. The FTTP network also has maintenance costs for fiber locating and pole attachments. Fiber locating is the cost of marking underground utilities when there is a Miss Utility locate request. We estimate locating costs at $1,800 per mile of underground plant. The network will also have to pay pole attachment fees to rent their space on the utility poles at an estimated cost of $20 per pole per year. Equipment replacement occurs every seven years, but new equipment costs are only a percentage of the capital cost of an FTTP network.[28]

As discussed in Section 4, 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 the use of 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. Note that

[28] FTTP electronics could realistically last more than 10 years. We used seven years as a more conservative replacement estimate.

these are theoretical speeds for the network where in reality users may get less than the State's 25 Mbps down and 3 Mbps up definition of broadband. 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 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 an FTTP 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 37 to 40 existing towers, of which 16 are government (with potentially lower or eliminated lease costs), but the remainder are commercial. We find that tower lease costs, assuming free access to the government towers, are $275 to $400 per passing.

Additionally, securing continuing space on a tower is not as predictable as with fiber. Occasional fiber relocations as part of road projects typically are built into maintenance costs. In addition, pole leases are fairly secure over the long-term as there is a well-regulated governance around pole attachments and fees, and poles are rarely removed, but rather replaced when needed. In contrast, tower may need to relocate or be decommissioned, and tower owners may decide to let other clients receive space or mandate relocation of radios to a less than optimal location on the tower. Such relocations require heavy capital and operational expenses and risks at a systemic level.

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.

Permitting for new tower locations may require a public hearing process and a lengthy approval process that stretches into many months, and may be difficult to achieve if there is local opposition to the tower.

6 State and Federal Grants and Loans Offer Opportunities to Address the Needs of Unserved Worcester 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 discussed below have the potential to assist the County's efforts to greatly reduce the number of unserved homes and businesses.

As we describe below, the County is in a challenging situation in terms of some federal funding opportunities. The presence of a protected borrower grantee and CAF II awardee in the County (Bloosurf) makes Worcester's unserved areas ineligible for ReConnect funding (see the orange and green shaded areas in the map below). But Bloosurf does not appear to be delivering anything like broadband speeds—and in fact it is not even clear how extensively they have any level of service in these protected areas. The County has indicated to us that they have little data suggesting Bloosurf has many customers, and they believe that large parts of the protected areas are entirely unserved by Bloosurf.

Fortunately, the County is eligible for state funding (because the state's program considers only unserved status, not the presence of another federal grantee); further, there is another federal program—the Rural Digital Opportunity Fund—that may open as soon as late 2020, and that will not exclude any protected areas (i.e., the green shaded areas in the map). Additionally, circumstances around the eligibility of the Bloosurf protected area for ReConnect will hopefully be resolved in 2021 when it is expected that Bloosurf's RUS loan/grant protection expires—and, along with it, the protected borrower status that currently blankets the County; at that point, we anticipate the County and a partner might apply for ReConnect.[29]

6.1 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 (the Office), which is housed in the Department of Housing and Community Development, focuses on efforts to extend broadband service to unserved rural parts of the state "through partnerships with local jurisdictions and the private sector."[30] 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

[29] Bloosurf's CAFII funding cannot be contested because it is on 10-year timeline and recipients do not have to show performance yet. However, the FCC gave funding to an entity that was already failing to adequately deliver on funding provided for service in the same County. Then the ReConnect statute compounded the problem by prohibiting the County or another entity from applying for that funding to remedy the situation.

[30] "Maryland Rural Broadband," Maryland Department of Housing and Community Development, https://dhcd.maryland.gov/RuralBroadband/Pages/default.aspx (accessed December 2019).

awards, to use the state's funding as a match for a potential federal ReConnect grant application (if the County determines that such an application would be feasible). The unserved areas we documented in Section 2 would be eligible for state funding (Figure 30).

Figure 29: Unserved Portions of Worcester County

The Office announced the details of its rural Broadband Infrastructure Network Buildout Program, with grants of $1 million to $3 million (with a total of at least $9 million in available funding program-wide), in late November 2019.[31] 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 cash match—for a project that delivers at least 25/3

[31] "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).

service to an unserved area.[32] Our sense is that these requirements intentionally put larger companies in a better position to apply because of their access to cash for the required 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 in this first offering was required to submit a non-binding letter of intent by December 23, 2019; those applications are due by February 21, 2020. (We expect multiple rounds of funding, however, so this will not be the only opportunity to apply.) Awardees will not be eligible for future grants from the program in the awarded jurisdiction for two years or until construction is complete, whichever is later.

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 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." The County and its partner would be required to commit a 100 percent match for the funding, and to delivering at least 25/3 service. Pilot project applications are due January 7, 2020.

6.2 USDA's ReConnect program represents a new, unique rural funding opportunity

The ReConnect program represents the most significant congressional appropriation of broadband funding since the Recovery Act in 2009—with $600 million allocated in 2019 and $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). The upcoming round of grant applications opens on January 31, 2020, and closes March 16, 2020.

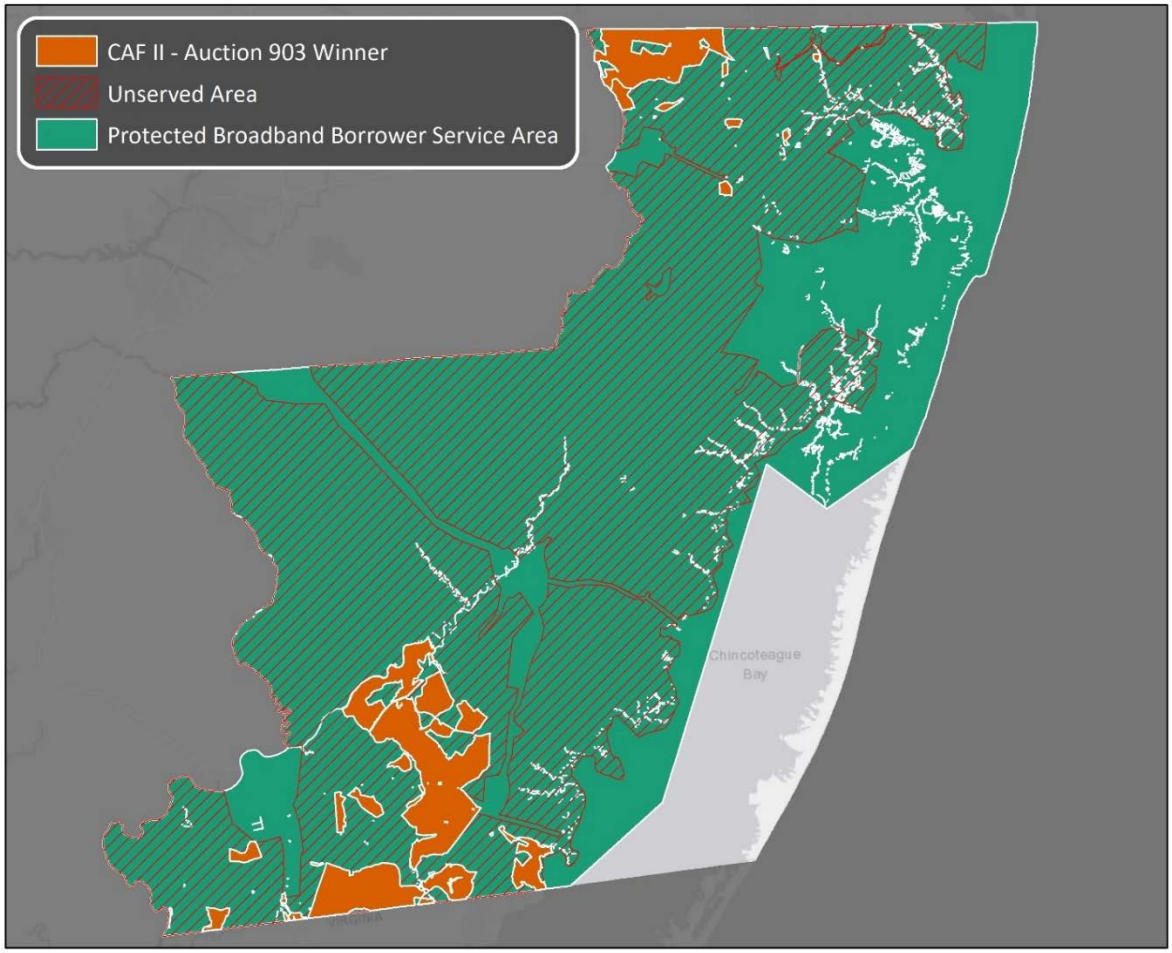
However, Congress created a significant barrier to ReConnect funding for the County when it wrote the legislation: It made ineligible any areas for which another grantee or loan recipient has received a previous broadband award. Bloosurf was awarded $3.2 million in USDA Broadband Initiatives Program (BIP) grant and loan funding in 2010 for service across the County,[33] and won the Connect America Fund II (CAF II) auction for additional portions of the County; those areas—encompassing all of the County's documented unserved areas—are technically ineligible for ReConnect funding (Figure 31).

[32] 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 (Maryland Department of Housing and Community Development) and Priority Funding Areas (Maryland Department of Planning).

[33] "Advancing Broadband," USDA BIP Awards Report, January 2011, https://www.rd.usda.gov/files/reports/RBBreportV5ForWeb.pdf (accessed December 2019).

In the sections below, we offer details on the ReConnect program—and the steps the County would need to take to challenge Bloosurf's protected status, if it determines that it wants to take that path.

Figure 30: Grant-Eligible and Ineligible Areas in Worcester County for certain federal grants



6.2.1 USDA will prioritize private-sector applications and public-private partnerships

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. For Round 2 funding, the categories have the same requirements in terms of existing services allowed in the proposed funded service area (PFSA): Funds will go to rural areas where 90 percent or more of the households lack access to broadband speeds of at least 10 Mbps download and 1 Mbps upload. (In Round 1, 100 percent of the households in the PFSA had to lack access to 10/1 Mbps broadband for 100 percent grant awards.)

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 a point of distinction. Applicants for 100 percent grant awards will need to provide matching funds equivalent to 25 percent of the project's total 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.)

Generally, we anticipate that USDA will prioritize private-sector applications and public-private partnerships, so it will be important for local governments to build a public-private partnership strategy for this program. RUS will consider public networks that lack extensive experience to be startups and may disfavor their applications. Therefore, public entities without extensive experience as an ISP 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.

Applications to this program will require a detailed business plan and pro forma. RUS will grant application review points based on those plans, as well as many other 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. Furthermore, points will be awarded for projects in states with an updated broadband plan in the past five years.

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 considerably larger in total dollars, we anticipate that ReConnect will make more awards. Further, ReConnect does not have the low-income requirements of Community Connect, making it a more flexible program.

6.2.2 In Worcester, a ReConnect application will require challenging an existing USDA borrower

As we note above, most of the County is technically excluded from ReConnect eligibility because a wireless ISP, Bloosurf, has been awarded federal Connect America Fund II (CAF II) funding in certain areas and also previously received RUS broadband grant and loan funding; that funding

makes the rest of the County a "protected broadband borrower service area"—and thus ineligible for ReConnect funding. However, the County could challenge Bloosurf's protected status.[34]

Any potential challenge to the protected borrower area should start with a consultation with the USDA's Rural Development representative for Maryland, Richard Jenkins, and include the Director of Maryland's Governor's Office of Rural Broadband, Kenrick Gordon, who can advise on the best path forward. Additionally, Richard Jenkins advised that a challenge process should include a consultation with USDA Deputy Assistant Administrator Ken Kuchno, because each protected broadband borrower service area will likely have unique background to review. [35]

In other words, a challenge should not be rushed. Most importantly, the applicant will need to document that its PFSA, as defined, lacks 10/1 Mbps services (or whatever speed was to be provided per the original borrower documents). If the County or its partner can show that Bloosurf does not deliver the service it promised in the part of the protected area where the County's PFSA is drawn, the new application may be eligible for consideration.

Under the program rules published in Round 1, a challenge can be made "if the applicant believes that at least 75% of the households in the part of the proposed funded service area in which they are seeking ReConnect funds are not receiving broadband service at the level for which an original RUS Broadband loan was made;" in order for the challenge to be viable, the RUS loan will need to have been "rescinded, defaulted on, or the terms and conditions of the original loan must not have been met."[36]

Round 2 rules did not explicitly include directions on potential challenges to protected borrower status. However, regulations for the overall program do allow for challenges[37]—and the Round 2 rules do allow an ISP to file a challenge to a ReConnect application if the ISP delivers services in a proposed applicant's PFSA[38] (i.e., the reverse of the scenario in which the applicant would challenge an existing borrower).

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[34] We do not have any public data about what RUS required of Bloosurf, but there is no evidence of service being available, or of service that meets the federal or state definitions of broadband, in the unserved portions of the County.

[35] Telephone discussion between Heather Mills, Lead, CTC Funding Strategies Team, and Richard Jenkins, USDA Rural Development General Field Representative for Maryland, December 30, 2019.

[36] "Broadband Pilot (ReConnect) Program," Federal Register, April 12, 2019, https://www.federalregister.gov/documents/2019/04/12/2019-07345/broadband-pilot-reconnect-program (accessed December 2019). We note these are the Round 1 rules; the Round 2 rules omit details on filing a challenge to protected broadband borrower service area status.

[37] Telephone discussion between Heather Mills, Lead, CTC Funding Strategies Team, and Richard Jenkins, USDA Rural Development General Field Representative for Maryland, December 30, 2019.

[38] "ReConnect Pilot Program," Federal Register, December 12, 2019, https://www.govinfo.gov/content/pkg/FR-2019-12-12/pdf/2019-26522.pdf (Accessed December 2019).

6.3 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,[39] 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

[39] Critical community facilities include public schools, public libraries, public medical clinics, public hospitals, community colleges, public universities, law enforcement, and fire and ambulance stations.

spectrum, towers, and buildings as part of the project design.[40] The lesser of 10 percent of the grant or $150,000 can be used to construct, acquire, or expand an existing community center.[41]

6.4 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 delivered funds 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—which do not require that an area is unserved, but do require that jobs be created or saved as a direct result of the proposed project.

The EDA program coordinates with a $587 million grant program[42] 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,[43] 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.[44]

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. Additionally, the program does not require proof of lack of service or poor service. Instead, a proposed project must demonstrate that it will positively affect the economic prospects of the area; generally, in the form of addition of or saving of jobs. A local community economic development plan that highlights a need for better broadband will be an essential first requirement.

[40] Leasing costs can only be covered for three years.
[41] 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.
[42] See https://www.grants.gov/view-opportunity.html?oppId=302953 (accessed November 2019).
[43] "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).
[44] EDA annual reports available online at: https://www.eda.gov/annual-reports/ (accessed November 2019).

The PWEAA Notice of Funding Opportunity (NOFO) emphasizes the importance of consulting with the appropriate regional EDA contacts.[45] 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.[46]

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

6.5.1 The Rural Digital Opportunity Fund is the latest iteration of a 20-year-old effort

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 and underserved 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 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

[45] "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).
[46] EDA regional contacts available online at: https://www.eda.gov/contact/ (accessed November 2019).

until year 6 when 100 percent of eligible homes and businesses must be served.[47] The total amount of support awarded was 70 percent less than the Connect America Cost Model (CAM) estimated would be needed.[48] 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.

6.5.2 Worcester County's unserved areas are eligible for Rural Digital Opportunity Fund 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 and underserved areas of the country. We anticipate, based on data released so far (which are only draft rules, and thus are preliminary), that the FCC will fund areas that lack 25/3 service—even those that have another subsidized competitor. Thus, with the exception of CAF II funded areas, the County's documented unserved areas will be eligible (Figure 32).

[47] "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).
[48] 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).

Figure 31: Rural Digital Opportunity Fund Eligibility Based on Survey Findings and Form 477 Data

While it is still in the rule-making phase, the FCC has proposed using a reverse auction mechanism almost identical to the one used in the CAF Phase II auction, though this time incumbent price-cap carriers will not have the right of first refusal. We anticipate the auction opening in late 2020.

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

to commit to providing an area with the best quality service at the lowest subsidy amount wins the available support.[49]

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.[50]

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 and underserved.[51] 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.

[49] 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).
[50] Federal Communication Commission, "Rural Digital Opportunity Fund, Connect America Fund."
[51] 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).

7 The County Should Consider Pursuing Strategies for Leveraging State and Federal Funding Programs with Potential Partners

Given the alignment of state and federal funding opportunities—and the County's multiple strong potential partners—we recommend the County take concrete steps to engage with and support partners in applying for grants. 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.

7.1 Develop a multi-year, strategic approach to the state and federal opportunities

As we described above, a number of extremely promising funding sources are available. The state program is particularly promising because it does not place restrictions on geographic areas, other than being unserved by 25/3. We recommend pursuing state funding immediately—encouraging Comcast, ThinkBig, and any other well-qualified entities to apply. (We were not able to identify other potential partners, but some may exist.) We anticipate multiple rounds of state funding.

Of the federal funding programs that look promising, the Rural Digital Opportunity Fund is the best starting point. We encourage the County to work with Choptank and also potentially ThinkBig (as well as alternative bidders) if Choptank does not bid.

The ReConnect opportunity will be more challenging. As we describe above, Congress excluded protected borrower areas such as Bloosurf's purported service area in Worcester from ReConnect eligibility. While there is limited public data available about the duration of the protected status, we believe it may expire in 2021—at which point those areas of the County would be eligible for subsequent rounds of ReConnect funding.[52]

Alternatively, the County could undertake an effort now to contest the protected areas status, because anecdotal and other data, including the County's own experience, suggest that there is not adequate service in these areas. While we think such a challenge may be difficult because the USDA will be conservative in its evaluation of competing data and claims, it may be worth the County's effort to perform the necessary mapping, planning, and engineering to enable strategic decisions to be made. Otherwise, the County could be left in the limbo of not having a performing private entity, and not being able to find another solution with federal funds. Additionally, a ReConnect challenge may bring attention to the fact that the federal government has given

[52] "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).

money to an entity that does not appear to be delivering on its promised broadband service—while the federal government is simultaneously saying that the County is not eligible for new funding. (We are hopeful that the significant flaws of the ReConnect program that were written into the legislation by Congress will not also present themselves in the Rural Digital Opportunity Fund once final rules are released.) The Department of Commerce economic development grant opportunities may be an attractive option to explore for portions of the County, if only because they do not require proof of lack of service in order to apply. However, the County must have in place an economic development plan that includes the need for broadband as a discussion point—and any proposed project must demonstrate eligibility around creating or saving jobs in the project area. Additionally, as noted above, the program has not historically approved grants for broadband projects and the proposal process is arduous step; so there should be good preparation and discussion of the possible project with the department's regional representative prior to submitting a proposal.

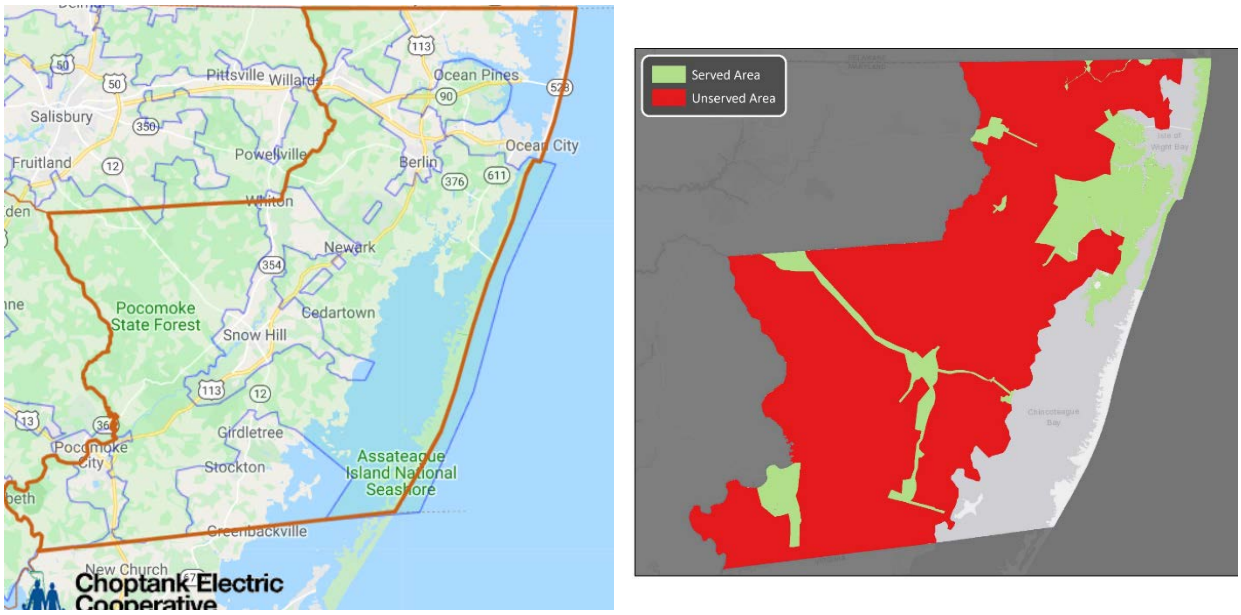
Within that framework, and based on the ongoing dialogue CTC and the County have established with some service providers, we recommend the following approaches. We note, too, that the County should not see the USDA or state grant applications as a one-time opportunity; we anticipate that there will be state and federal broadband funding in 2021 as well as 2020. In contrast, however, 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 funding.

7.2 Engage with Choptank Electric Cooperative on these issues

Choptank is an obvious choice for a partner in the County's broadband deployment efforts. Because it is member-owned, for example, Choptank presumably would not cherry-pick only certain unserved areas; it is responsible to all members within its service footprint in the County, not just to business opportunity in the way a for-profit ISP would be. Choptank 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 dramatically lower Choptank's fiber construction costs. In addition, Choptank has the technical capability to construct aerial fiber and a proven ability to manage customer relationships.

While Choptank's current publicly published service area does not encompass all unserved areas of the County, there is substantial overlap that would enable Choptank to reach many of the unserved areas. The figures below show Choptank's self-reported electric coverage map, side by side with the County's unserved broadband areas.

Figure 32: Choptank's Self-Reported Electric Service Area Compared to Unserved Portions of the County[53]



We expect electric cooperatives such as Choptank to benefit from the FCC's Rural Digital Opportunity Fund, in particular, because of its ownership of poles in unserved areas. Choptank would have the lowest cost to build of any entity other than Verizon, which would be a competitive advantage if it were to bid on the FCC's planned reverse auction (in which the lowest bidder wins). Indeed, Choptank and electric cooperatives throughout the state have positioned themselves for this opportunity by asking the Maryland legislature to give them the authority to enter the broadband market.

What's more, Choptank could also apply for state and ReConnect grants, in addition to Rural Digital Opportunity Fund funding. If Choptank were to miss the Rural Digital Opportunity Fund application window, it would still be eligible to apply for later rounds of ReConnect and state of Maryland funding—but the optimal situation would be for Choptank to secure funding from all of those sources.

7.3 Partner with ThinkBig on a state broadband grant application and potentially support a ReConnect grant application

ThinkBig is a network which has built extensively in Kent County and is currently building in areas of Baltimore. It reported strong interest in partnering with the County but did not offer specific

[53] Areas shaded darker are service areas for Choptank. Source: https://choptank.maps.sienatech.com/ accessed 12/15/2019.

details. It reported strong internal and investor support for expansions in rural areas of Maryland. ThinkBig Networks could be a strong partner for state and federal grant applications to construct fiber to serve the County's unserved areas.

ThinkBig will not have the low cost to build that Choptank would have, because it does not own the utility poles. But it would potentially be competitive for state grant funding (in partnership with the County) or federal ReConnect funding. And if Choptank does not bid on the Rural Digital Opportunity Fund, ThinkBig might be a competitor in the reverse auction; if ThinkBig can successfully secure a state grant, ReConnect funding, or support from the County, it could bid lower for Rural Digital Opportunity Fund funding and potentially position itself to win.

ThinkBig, based in Chestertown, 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 and underserved rural areas supported by state grants. The company continues to explore new opportunities to leverage future state and federal grant opportunities.

We recommend that the County partner with ThinkBig on a state broadband grant application, with the condition that if it receives funding, the company will apply for a federal ReConnect grant using the state funds as part of its required matching contribution.

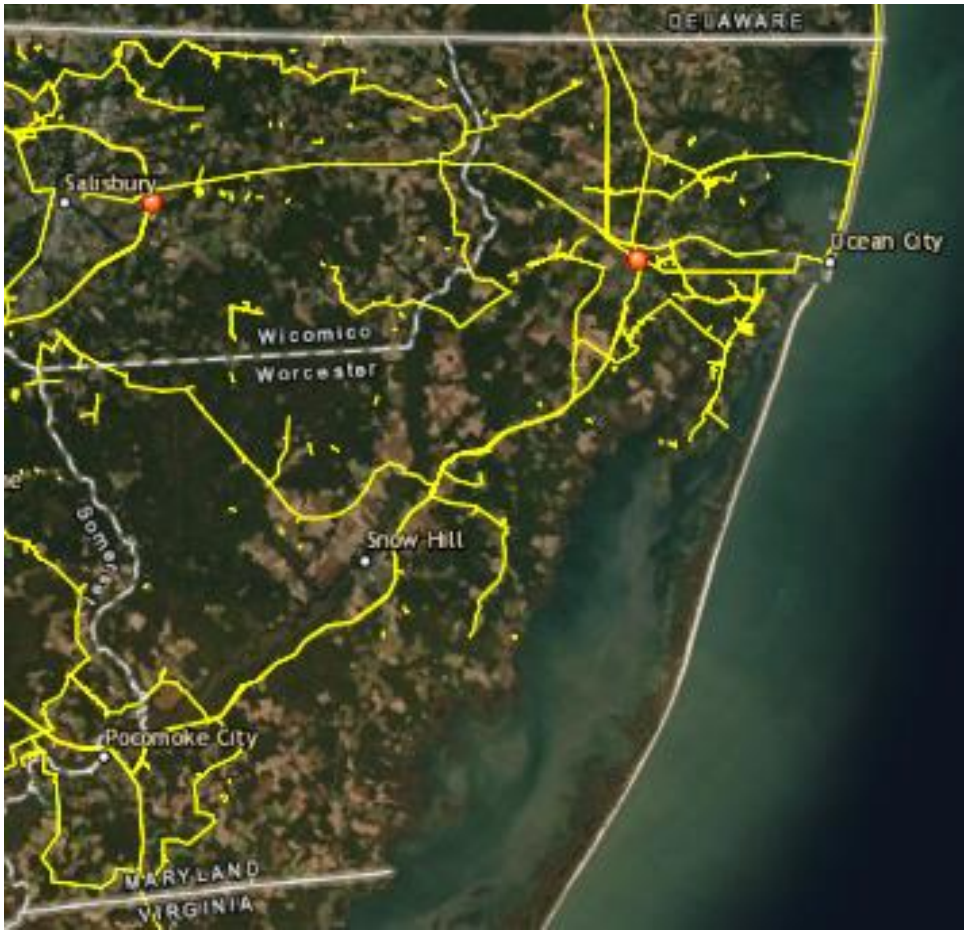
Given the pending deadlines for both state applications and ReConnect (the application window opens in January and closes March 16, 2020),[54] we recommend the County and ThinkBig develop their plans as soon as possible. If ThinkBig were awarded state broadband funding, it could use those funds (and any County contribution to that program's match requirements) as its match for the federal application.

In terms of its capabilities, ThinkBig reports having constructed more than 40 miles of fiber in Maryland in the last couple of years. The gigabit service uses high-grade GPON technology for the physical connection, but pairs it with their own software-defined network routing in a box. This allows them to pair high-quality, resilient physical infrastructure with off-the-shelf, unlicensed electronics for cost-effective operations. They describe their construction process as highly mobile, using smaller excavating equipment and their own experienced, dedicated construction staff. Working with backbone partners such as the Maryland Broadband Cooperative additionally allows them to keep costs manageable on the construction and

[54] "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).

operations side; given the presence of Maryland Broadband Cooperative fiber in many of Worcester's unserved areas (Figure 34), this presents a strong case for the partnership.

Figure 33: Maryland Broadband Coop Fiber Routes



ThinkBig's service offering is $85 to $99 per month for gigabit service, and $70 for symmetrical 200 Mbps service. In addition, they offer $20 unlimited long-distance telephone service, and work with individual customers to select television streaming packages, with a typical price point around $40.

7.4 Encourage Comcast to apply for a state broadband grant

As a cable provider with a presence in the denser areas of the County (and plans to expand in Ocean Pines),[55] Comcast has infrastructure in the County that could enable it to expand into unserved areas with relatively lower costs per passings than other wireline providers. (See Section 3.6 for our sample cost estimate.)

[55] Greg Ellison, "Comcast brings service competition to Ocean Pines," Bayside Gazette, Sept. 12, 2019, https://baysideoc.com/comcast-brings-service-competition-to-ocean-pines/ (accessed December 2019).

Like ThinkBig, Comcast does not own utility poles so it would not be the most competitive Rural Digital Opportunity Fund bidder—but if Choptank does not bid, Comcast could be competitive. That said, we are unable to analyze the Comcast opportunity in much detail because the company has not given us any concrete sense of their plans with regard to the Rural Digital Opportunity Fund. Representatives have told us that the company does not plan to submit applications for ReConnect anywhere in the country; this may also be the case for the Rural Digital Opportunity Fund, but the company's intent is unclear.

CTC and the County approached Comcast to explore the potential to build to unserved areas under the terms of the state's grant program. As of this writing, we have not received concrete feedback from Comcast that would enable us to determine what areas it is interested in or what grant levels would provide sufficient incentives for Comcast to work with the County and state.

7.5 Explore opportunities to support fixed wireless providers

Given our analysis of capital and operating costs (see Section 4 and 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 light of some of the operational and technical challenges with fixed wireless deployments, it would be in the County's interest to ensure there will be an ongoing process for validating service coverage, bandwidth, and customer support expectations. Writing such a process into the partnership agreement would enable both parties to independently test actual performance and work together on addressing service and coverage issues. It would also build-in documentation that could be used for challenging the provider's exclusivity on the service area with an alternative provider in future grant applications, if the fixed wireless provider is unable to address the coverage and bandwidth issues in accordance with the original terms for providing service in the unserved area.