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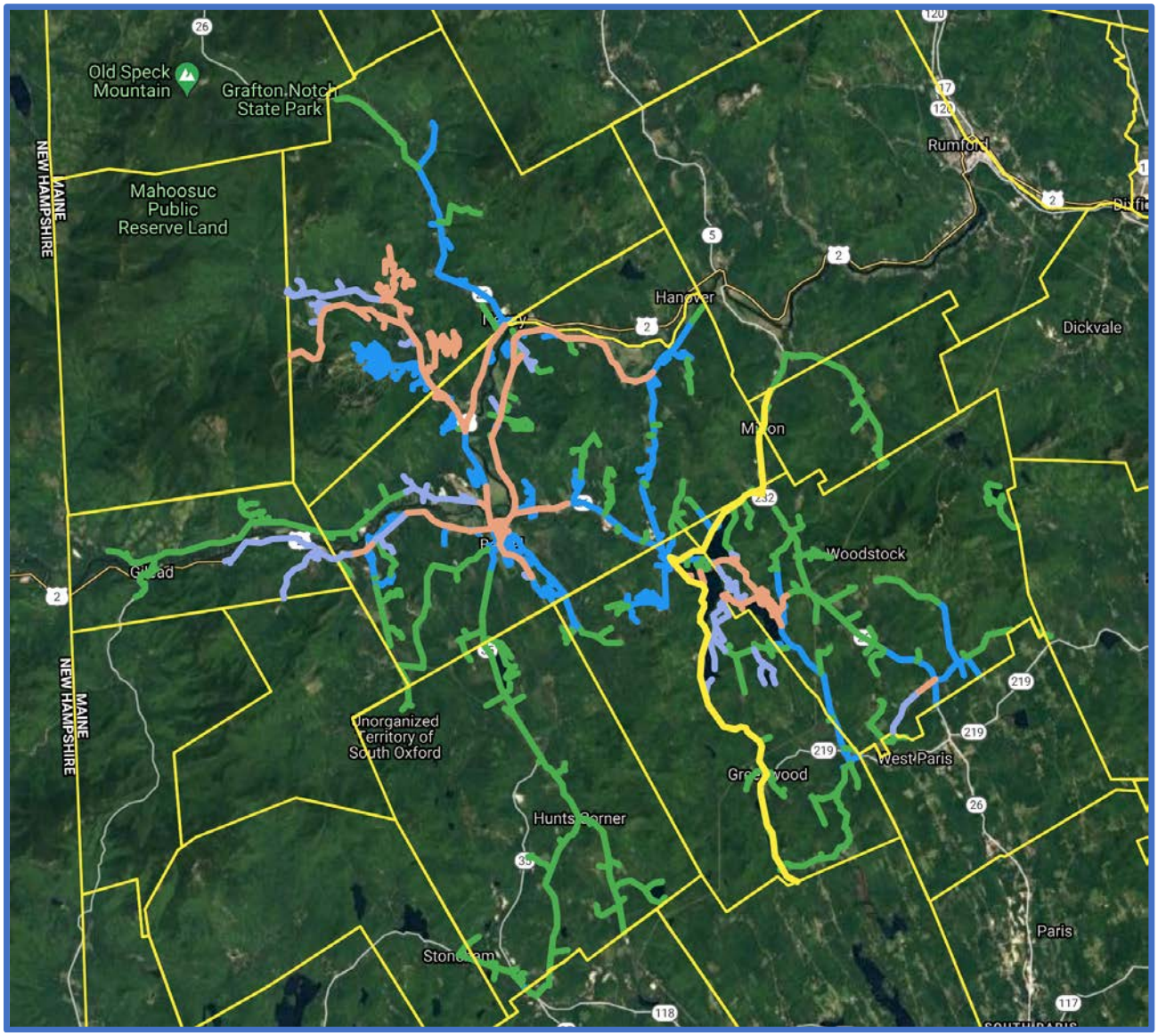
Mahoosuc
Broadband Planning Report



Casco Bay Advisors, LLC

August 2021

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Broadband/Telecom Consulting

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Cover Image

Map Key	
	FTTH & no CATV *(considered served)*
	FTTH & CATV *(considered served)*
	CATV *(considered served)*
	No CATV or FTTH *(assumed to be unserved at less than 50Mpbs/10Mbps)*
	Maine Fiber Company (FirstLight) 3-Ring-Binder Network *(middle-mile fiber)*

Disclaimer

It is important to understand this report contains high level costs and projections based on the information readily available and should not be interpreted as providing the level of detail required for investing purposes.

All costs contained in the report are estimates based upon high-level desk-top engineering designs, our estimates of construction costs for various providers, and our knowledge of costs for similar types of projects. In order to develop precise costs, a detailed engineering analysis will need to be performed and actual construction costs determined.

All service providers, with the exception of FirstLight declined to provide mapping or data to illustrate the location of their assets. In the absence of service provider data, we performed a detailed field audit during the first quarter of 2021 to visually capture and note the location of existing phone company fiber optic cables, remote terminals and central offices. At the same time, we visually captured and noted the location of the hybrid fiber/coax infrastructure of the cable TV company. We believe the process used to visually capture the presence of infrastructure is 98% accurate.

Finally, we utilized 911 location data and parcel boundary data (where available) filed with the State of Maine by the Towns/Twps. Not every potential subscriber location has been uploaded into the State of Maine 911 systems and many of those that have been uploaded are not spatially accurate. As such, we examined Google Earth imagery to discover potential subscriber locations present at the time the aerial imagery was captured on May 4, 2018. New construction since that date is not necessarily included in this analysis.

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1 Executive Summary

Casco Bay Advisors, LLC (Casco Bay) is pleased to present this Broadband Planning Report (Report) to Community Concepts Finance Corporation (CCFC) on behalf of the Mahoosuc Community Broadband Committee (Mahoosuc) and towns in the Mahoosuc Region, including Albany Township, Bethel, Gilead, Greenwood, Milton Township, Newry and Woodstock (Towns). The purpose of this Report was to identify the location of existing high-speed broadband infrastructure, the gaps in that infrastructure and the estimated costs and potential strategies to extend service to all potential subscriber locations across those 7 Towns/Twps.

How did we inventory the existing infrastructure? – We drove along every roadway *(public & private)* and every long driveway where we had access and manually noted the presence of cable TV (CATV) infrastructure and fiber optic cables used for either transmission purposes or Fiber-to-the-Home (FTTH) service delivery.

How did we document the findings from the field audit? – The maps manually notated in the field were entered into the VETRO Fibermap GIS system, identifying the type of infrastructure along each road segment. In addition, we utilized 911 addresses and manually examined aerial imagery to identify potential subscriber locations without 911 addresses assigned and incorporated that data in the VETRO system. Each potential subscriber location was then associated with the infrastructure type to determine the quantity of locations for each type of infrastructure and whether the location meets the State of Maine definition of served or unserved.

How did we determine the estimated costs? – The data created in VETRO was exported in tabular form to determine mileage by infrastructure type and quantity of potential subscriber locations per infrastructure type, and as either served or unserved. Using unit costs observed in past projects we were then able to determine estimated costs to either extend the CATV infrastructure or deploy FTTH service in each Town/Twp.

How can we develop Public-Private Partnerships to fill the gaps? - From the start, we have approached this analysis to support the development of Public-Private Partnerships to fill the gaps in coverage. With the completion of this Report, the intent is to share the Report and underlying data with all service providers currently operating in the state of Maine and facilitate discussions with those service providers to negotiate deployment and funding strategies, with a requirement to provide ubiquitous coverage in each Town/Twp.

How much will it cost to expand the availability of high-speed Internet? – We have estimated the cost to either extend CATV infrastructure or to deploy FTTH service in those areas of the County not currently served to be approximately $6,386,5850. Our model suggests local and county funding of $1,664,899 with the balance provided by state and federal grants and service provider investment.

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How can this project be funded? – The private sector has determined there is not a viable economic business case to deploy network into the unserved areas. As a result, public funding must be secured to turn these uneconomic business cases into economic business cases to assure the long-term viability of the networks. The State of Maine strategy calls for the private sector, federal, state and local government each contributing 25% of the costs on average. The hypothetical funding strategy provided in Section 7 of this Report analyzes the use of local and county American Recovery Plan Act (ARPA) funding, combined with state and federal funding administered by the ConnectMaine Authority (CMA) and the newly formed Maine Connectivity Authority (MCA) in an attempt to equitably distribute the funding burden. As mentioned in the title of this Section 7, this analysis is hypothetical, but the model forms the foundation for a reasonable approach that can be modified as necessary.

What are the next steps? – Build community, funding and service provider support:

- Share the report with the leadership of each Town, with elected officials, with the CMA and MCA staff and board members, and with the service providers.
- Facilitate committees for each Group of Towns with representation from each Town to assist with building the community support and funding development.
- Quickly reserve all available ARPA funding.
- Negotiate Public-Private Partnerships with service providers.

2 How to read this report

Section 3 – Incumbent Telephone Company Service Areas identifies the areas service by Consolidated Communications and FirstLight.

Section 5 – Town / Township Metrics provides a breakdown of the quantity and types of existing infrastructure and provides an estimate of the costs to either extend the CATV infrastructure or to deploy FTTH infrastructure.

Section 6 – Public-Private Partnership Strategies discusses various approaches to utilize the data produced in this Report to facilitate discussions with potential service provider partners.

Section 7 – Hypothetical Funding Strategy – Illustrates potential sources of funding and the private provider match. This analysis can be modified to reflect any number of different scenarios.

Section 8 – Next Step Recommendations reviews the recommended steps to quickly move into discussions with potential service provider partners and efforts to secure funding.

Sections 9 & 10 – provides various definitions and overviews of the differing technologies used to provide broadband Internet service.

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Section 11 – Maps Appendix – provides a map of each Town/Twp is more granular detail than the regional map provided in Section 5.

For those who chose to read only the first 8 sections of this Report (only 18 pages), there are three (3) definitions you should be familiar with.

- **FTTH** - Fiber-to-the-Home (FTTH) or Fiber-to-the-Premise (FTTP) is a network utilizing fiber optic cables directly to the home or business and is capable of offering virtually unlimited symmetrical bandwidth. Most FTTP networks can offer 1 Gbps of bandwidth in both download and upload directions, with some providers offering 2 Gbps and even 10 Gbps service capacity. The majority of new networks being deployed utilize this type of technology and most consider this type of network to be "future-proof".

- **CATV** - Cable modem Internet access is provided over a hybrid fiber coaxial (HFC) broadband network. It has been employed globally by cable television operators since the early 1990s and is the network architecture utilized by Spectrum. In an HFC cable system, service is provided over a fiber optic cable to a node where the signal is converted from light pulses to an electrical signal. The electrical signal is then transmitted to the subscriber over a coaxial cable. Currently, the maximum download speed of this type of architecture is 940Mbps in the downstream directly and 35Mbps in the upstream direction. A new cable industry standard – DOCSIS 4.0, is under development and reportedly will be capable of providing symmetrical gigabit speeds.

- **DSL** - Digital subscriber line (DSL) is a technology most frequently used by traditional telephone system operators such as Consolidated Communications, Inc. (CCI) and FirstLight to deliver advanced services *(high-speed data and potentially video)* over twisted pair copper telephone wires. This technology has lower data carrying capacity than the hybrid fiber coaxial network deployed by cable system operators like Charter Communications (Spectrum). Data speeds are range-limited by the length of the copper cable serving the premise, the wire gauge of the copper conductors and the condition of the copper.

Additional discussion of these and other technologies are included in Section 10 – Internet Access Technology Overview.

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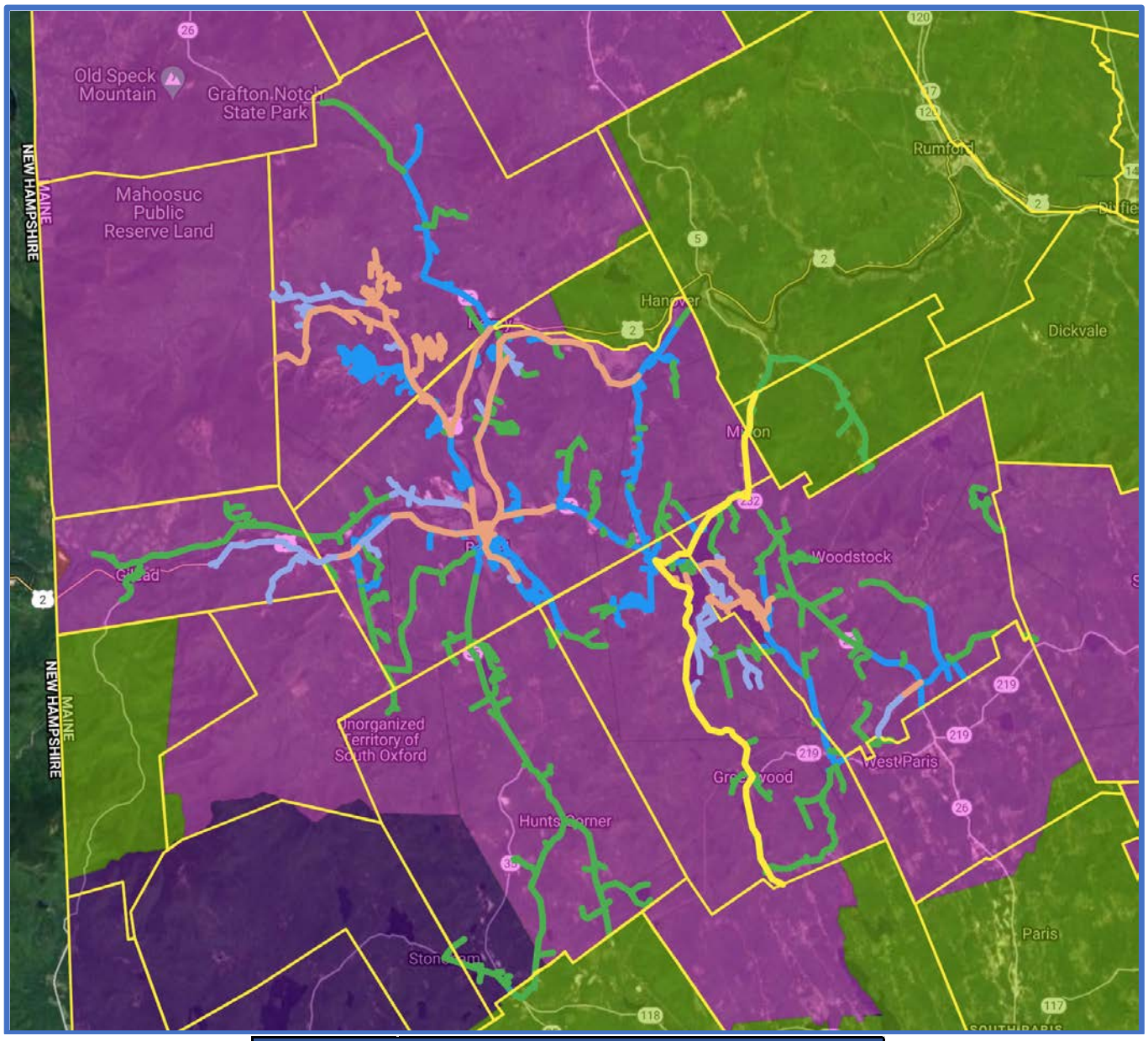
3 Incumbent Telephone Company Service Areas



Incumbent Telephone Company Service Areas	
	Consolidated Communications
	FirstLight
	Consolidated Communications

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4 Reserved

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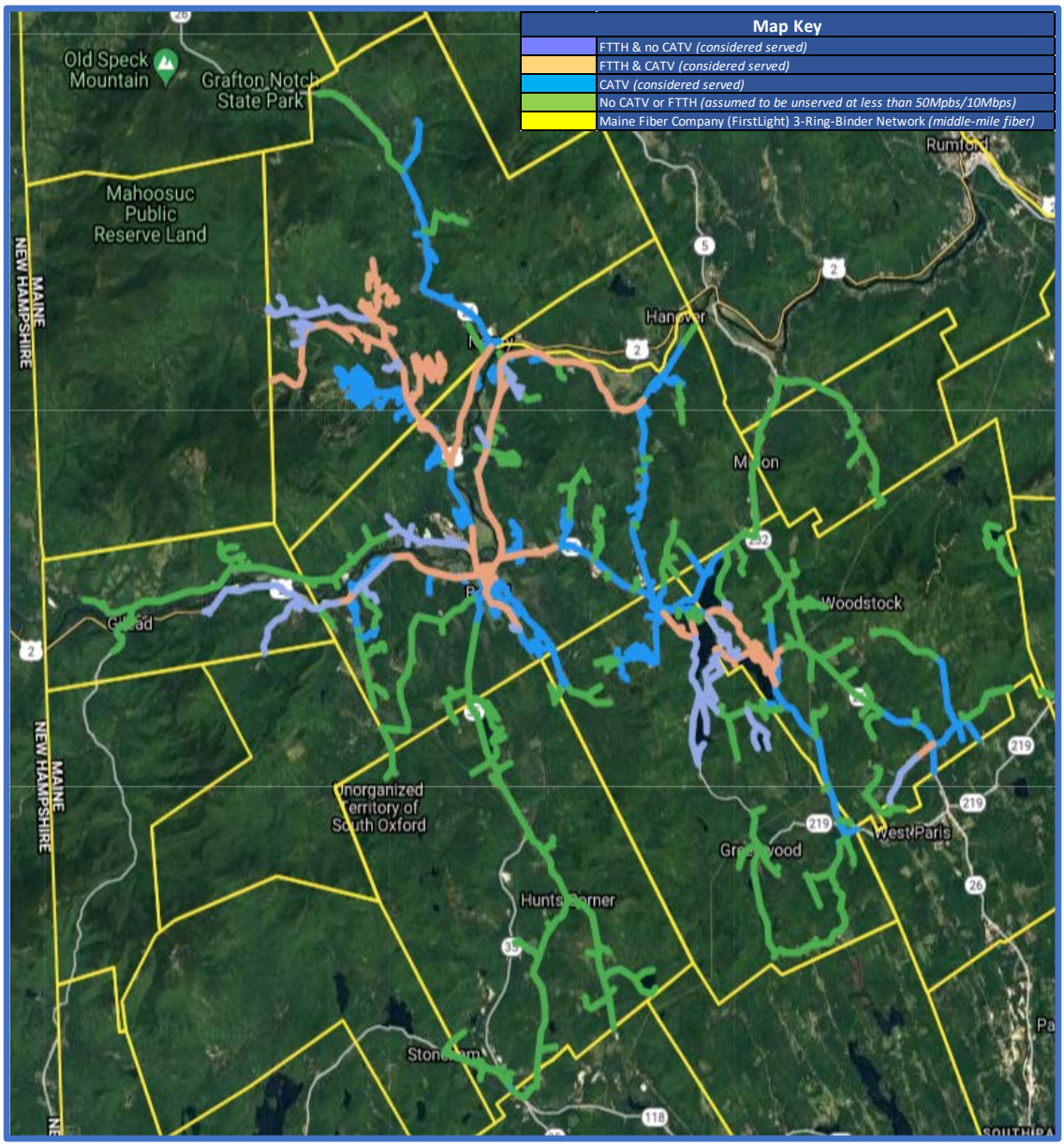
5 Town-by-Town Analysis

In the following subsections, we provide:

- A map of the overall Mahoosuc area illustrating existing service and gaps in service
- Itemization of potential subscriber locations and road mileage for each type of infrastructure
- Estimated costs to either extend the CATV infrastructure or deploy FTTH infrastructure
- Detailed mapping of each Town is provided in the Appendix



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5.1 Town Metrics

This table breaks down the estimated backbone mileage required to pass all potential subscribers in each Town/Twp except for those locations believed to be off-the-grid or too remote to serve economically.

Town/Twp	Mileage				
	Unserved Uncabled <50/10	Served (Cabled)	Served FTTH & Uncabled	Served FTTH & Cabled	Total
Albany Twp	32.4	0.2			32.6
Bethel	32.8	36.9	7.8	24.7	102.2
Gilead	10.2		5.6		15.8
Greenwood	20.2	12.3	9.8	1.8	44.0
Milton Twp	8.0				8.0
Newry	5.6	19.2	5.8	17.5	47.9
Woodstock	26.9	14.3	3.6	7.5	52.4
Totals	**136.1**	**82.8**	**32.6**	**51.4**	**302.9**
	45%	27%	11%	17%	

By road mileage, 45% of the group of Towns/Twps is considered unserved and is eligible for funding by ConnectMaine and 28% of road mileage is served by FTTH infrastructure.

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This table itemizes the quantity of potential subscriber locations for each Town/Twp.

Town/Twp	Potential Subscriber Locations						
	Unserved <25/3 per CMA	Unserved <50/10	Served (Cabled)	Served FTTH & Uncabled	Served FTTH & Cabled	Off Grid or Uneconomic	Total
Albany Twp	443	360	7			47	414
Bethel	167	470	1,020	85	530	19	2,124
Gilead	3	117		48		1	166
Greenwood	143	257	308	178	46	15	804
Milton Twp	73	86				1	87
Newry	143	64	540	47	259	18	928
Woodstock	84	382	341	37	176	72	1,008
Totals	**1,056**	**1,736**	**2,216**	**395**	**1,011**	**173**	**5,531**
		31%	40%	7%	18%	3%	

- The shaded column is based on data supplied by the ConnectMaine Authority where the service as reported by the existing service providers is less than 25Mbps/3Mbps, which was the definition of "unserved" in Maine until June 2021.
- The next column is the quantity of locations determined by this Report to have service of less than 50Mbps/10Mbps, which is the new "unserved" standard established in June 2021. This is the quantity of locations that are not served by CATV or FTTH infrastructure and does not include those locations determined to be off-the-grid or too remote to serve economically.
- The 1,736 unserved locations are eligible for funding by ConnectMaine.

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Town/Twp	Other Infrastructure Mileage			Per Mile Averages		
	LEC non-FTTH Fiber	MFC 3RB		Average Locations per Unserved Mile	Average Locations per Served Mile	Average Locations per Mile per Town
Albany Twp	14.3			11	39	13
Bethel	17.3	1.8		14	24	21
Gilead	7.7			11	9	10
Greenwood	21.6	11.8		13	22	18
Milton Twp	1.1	1.1		11		11
Newry	5.3			12	20	19
Woodstock	18.2	2.5		14	22	19
Totals	**85.5**	**17.1**		**13**	22	**18**

- **LEC non-FTTH Fiber** - Itemizes the amount of fiber optic cabling in each Town/Twp owned by the incumbent local telephone company (LEC) that is not designed for use as FTTH infrastructure. This fiber is typically utilized to provide a connection between central offices, service to cell towers, large businesses, schools and libraries. It is also utilized to provide a high-capacity connection between the central office and remote terminals used to provision DSL-based Internet service.

- **MFC 3RB Fiber** - The mileage of the former Maine Fiber Company 3-Ring-Binder (3RB) network, known as a "middle mile" network, now owned by FirstLight. The 3RB was constructed partially by federal grant dollars under the ARRA BTOP program and is available at below market rates to connect rural communities to Boston, New York and beyond.

- **Per Mile Averages** - The average quantity of potential subscriber locations for each Town/Twp for those locations that are unserved, those that are served, and the combined average.

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5.2 Cost Estimates

Town/Twp	Cable Extension Cost	Town/Twp-wide FTTH Construction Cost *(excluded existing FTTH areas)*									
		Total Estimated Poles	Estimated Pole Make-ready Cost	Estimated Fiber Construction	Unserved Market Share after 3 years	Served Market Share after 3 years	Total Subscribers after 3 years	Estimated Central Office / FDH Costs	Estimated Optical Electronics / Drop Cost	Project Manageent / Contingency Cost	Estimated Total Construction Cost
	$45,000	33	$400	$25,000	50%	30%		$100	$1,200	10%	
Albany Twp		1,076	$430,452	$815,250	180	2	182	$18,210	$218,520	$148,243	$1,630,675
Bethel	$1,474,200	2,298	$919,248	$1,741,000	235	306	541	$54,100	$649,200	$336,355	$3,699,903
Gilead		338	$135,168	$256,000	59	0	59	$5,850	$70,200	$46,722	$513,940
Greenwood	$909,450	1,071	$428,472	$811,500	129	92	221	$22,090	$265,080	$152,714	$1,679,856
Milton Twp		264	$105,732	$200,250	43	0	43	$4,300	$51,600	$36,188	$398,070
Newry	$250,200	816	$326,304	$618,000	32	162	194	$19,400	$232,800	$119,650	$1,316,154
Woodstock	$1,210,050	1,361	$544,236	$1,030,750	191	102	293	$29,330	$351,960	$195,628	$2,151,904
Totals	**$3,843,900**	**7,224**	**$2,889,612**	**$5,472,750**	**868**	**665**	**1,533**	**$153,280**	**$1,839,360**	**$1,035,500**	**$11,390,502**

Cable Extension Cost – For those Towns/Twps where there is existing CATV infrastructure, we have included an estimated cost to extend the service in that individual Town/Twp. This cost is the total estimated cost, and it is expected the CATV provider would share in this cost with the Town/Twp, should extending the CATV infrastructure be the solution of choice.

FTTH Construction Costs – This section itemizes the costs and the assumed market share attained for each Town. Where we have included the Cable Extension Cost for an individual Town/Twp, we have also provided the FTTH cost for all areas without FTTH infrastructure for comparison.

- **Total Estimated Poles** – We assume there are an average of 33 utility poles per mile based on records from similar past projects. The actual quantity of poles cannot be known for certainty until additional detailed field audits are performed to determine the GPS coordinates and pole IDs for each required pole. This is the first step performed after a solution is identified and funding is secured.

- **Estimated Pole Make-ready Cost** – We assume the average make-ready cost per pole is $400, which includes the field audit effort referenced above, submission of the pole applications and processing of those applications to determine the actual costs for make-ready, as well as the costs the pole owners will charge to make the poles ready for a new attachment or replacement of poles without sufficient space.

- **Estimated Fiber Construction** – We assume an average cost of $25,000 per mile to install the fiber optic backbone. This cost can vary depending upon the quantity of down guys and anchors required to be installed, the position of the attachment on the poles, any traffic control requirements for a particular area, and the density of potential subscribers along the route.

- **Unserved Market Share after 3 years** – For areas that are currently unserved, we are conservatively assuming 50% of the potential subscriber locations will subscribe to service within three (3) years. This is a conservative estimate and most of the projects previously

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observed attain 65% - 80% after three (3) years.

- **Served Market Share after 3 years** – For those areas where there is existing CATV infrastructure, or a viable competitive alternative, we assume 30% of the potential subscriber locations will subscribe to service within three (3) years. Again, this is a conservative estimate, and we routinely see market share in these over-built areas achieve 35% – 45% market share.

- **Estimated Central Office / FDH Costs** – We have assumed $100 per subscriber contracted after three (3) years to cover the costs for the central office and fiber distribution hubs to provide service.

- **Estimated Optical-Electronics / Drop Costs** – We have assumed an average of $1,200 per subscriber for the fiber optic drop cable from the backbone network to the subscriber location and for the optical-electronics in the central office and subscriber location for the total subscribers contracted after three (3) years.

- **Project Management / Contingency –** For planning purposes, we have included an additional 10% for project management of the construction project and as a contingency for unexpected costs or material/labor cost increases. This contingency amount may be reduced or modified once actual quotes from the pole owners for make-ready are received and bids are secured for construction.

The **Estimated Total Construction Cost** is the sum of the individual costs described above and represents the capital cost extend FTTH infrastructure to those areas without availability today. Creating a public-private partnership with the incumbent provider or an alternative provider, where the private provider shares in the overall cost will reduce this amount significantly.

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6 Public-private partnership strategies

There are a number of potential public-private partnership strategies to improve service at a lower cost than deploying a town-owned FTTH network. Below we provide a brief overview of those options and potential partners.

6.1 Incumbent Telephone & Cable Providers

The local telephone company and cable providers are the lowest cost options to upgrade service to FTTH or to extend the cable infrastructure, by virtue of their existing attachments to all or most of the utility poles. Sharing this report with each of these providers will generate interest and discussions which should be pursued.

FirstLight has expressed an interest in developing a Public-Private Partnership funding model with the Mahoosuc group and we believe Charter (Spectrum) will also be responsive.

6.2 Alternative service providers

There are a number of alternative service providers who are active across the state of Maine who are willing to partner with towns to deploy FTTH networks. Those providers include GWI, Pioneer Broadband, Axiom, Premium Choice Broadband, LCI, Matrix, FirstLight, and Outer Reach Broadband. Each service provider has a different model with variable ownership and funding options. Each is experienced in leveraging various government grant and/or loan programs with the USDA, ConnectMaine Authority, Northern Border Regional Commission and the EDA. Sharing this report with each of these providers, as with the incumbent telephone and cable providers as mentioned above, will generate interest and discussions which should be pursued.

Given the depth of coverage by both FirstLight with their existing FTTH infrastructure and their status as the incumbent phone provider, and by Charter (Spectrum) with a presence in 4 of the 6 Towns, we recognize there may be less interest in providing service on the part of the alternative providers.

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7 Hypothetical Funding & Ownership Strategy

Four (4) "Hypothetical" funding and ownership strategies are illustrated in the tables below. We believe these represent the most likely scenarios, but we readily recognize the ultimate solution may vary. These scenarios are included to provide a range of options to be considered. These models can easily be modified to examine other potential strategies.

7.1 Strategy "A" - Partner w/ FirstLight & Spectrum excluding existing FTTH & CATV areas

Hypothetical Funding Strategy - "A" *(Partner w/ FirstLight & Spectrum excluding existing FTTH & CATV areas)*							
Town/Twp	**CATV Extension / FTTH**	**Estimated Total Construction Cost**	**Local ARPA Funds Received**	**Local ARPA Funds Requested**	**Pro rata share of County ARPA Funds**	**State / Federal Funding**	**Private Funding**
							50%
Albany Twp	FTTH	$1,630,675	$0	$0	$111,326	$704,012	$815,338
Bethel	CATV	$1,474,200	$270,000	$227,931	$509,169	$0	$737,100
Gilead	FTTH	$513,940	$20,000	$20,000	$40,819	$196,151	$256,970
Greenwood	CATV	$909,450	$80,000	$80,000	$162,106	$212,619	$454,725
Milton Twp	FTTH	$398,070	$0	$0	$27,929	$171,106	$199,035
Newry	CATV	$250,200	$40,000	$40,000	$65,038	$20,062	$125,100
Woodstock	CATV	$1,210,050	$130,000	$130,000	$250,581	$224,444	$605,025
Totals		**$6,386,585**	**$540,000**	**$497,931**	**$1,166,968**	**$1,528,394**	**$3,193,293**
				8%	**18%**	**24%**	**50%**

The table above is a hypothetical view of the source of funds assuming the following:

- For Towns with existing CATV infrastructure, we have chosen the cost to extend the Charter (Spectrum) CATV system as it represents the lowest estimated cost. For Towns without CATV infrastructure, we have chosen the cost to extend the FirstLight FTTH service.
- Assumes FirstLight and Charter (Spectrum) would contribute 50% of the funding.
- The pro rata shares of County ARPA funds, based upon population are allocated to broadband.
- The entire amount of Local ARPA funds is allocated to broadband, except for Bethel who would not require the total amount of ARPA funds received at the local level.
- The balance of funding is assumed to be provided by State and federal funds.

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7.2 Strategy "B" - Partner w/ FirstLight excluding existing FTTH areas

Hypothetical Funding Strategy - "B" *(Partner w/ FirstLight excluding existing FTTH areas)*							
Town/Twp	**CATV Extension / FTTH**	**Estimated Total Construction Cost**	**Local ARPA Funds Received**	**Local ARPA Funds Requested**	**Pro rata share of County ARPA Funds**	**State / Federal Funding**	**Private Funding**
							50%
Albany Twp	FTTH	$1,630,675	$0	$0	$111,326	$704,012	$815,338
Bethel	FTTH	$3,699,903	$270,000	$270,000	$509,169	$1,070,782	$1,849,951
Gilead	FTTH	$513,940	$20,000	$20,000	$40,819	$196,151	$256,970
Greenwood	FTTH	$1,679,856	$80,000	$80,000	$162,106	$597,822	$839,928
Milton Twp	FTTH	$398,070	$0	$0	$27,929	$171,106	$199,035
Newry	FTTH	$1,316,154	$40,000	$40,000	$65,038	$553,039	$658,077
Woodstock	FTTH	$2,151,904	$130,000	$130,000	$250,581	$695,371	$1,075,952
Totals		**$11,390,502**	**$540,000**	**$540,000**	**$1,166,968**	**$3,988,283**	**$5,695,251**
				5%	**10%**	**35%**	**50%**

The table above is a hypothetical view of the source of funds assuming the following:

- FirstLight would extend their FTTH network to all areas, including those areas served by the Charter (Spectrum) CATV system.
- Assumes FirstLight would contribute 50% of the funding.
- The pro rata shares of County ARPA funds, based upon population are allocated to broadband.
- The entire amount of Local ARPA funds is allocated to broadband.
- The balance of funding is assumed to be provided by State and federal funds.

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7.3 Strategy "C" - Town-owned excluding existing FTTH areas

Hypothetical Funding Strategy - "C" *(Town-owned excluding existing FTTH areas)*							
Town/Twp	**CATV Extension / FTTH**	**Estimated Total Construction Cost**	**Local ARPA Funds Received**	**Local ARPA Funds Requested**	**Pro rata share of County ARPA Funds**	**State / Federal Funding**	**Additional Local Funding**
		State/Federal Grant amount per unserved location				***$2,500***	
Albany Twp	FTTH	$1,630,675	$0	$0	$111,326	$900,000	$619,349
Bethel	FTTH	$3,699,903	$270,000	$270,000	$509,169	$1,175,000	$1,745,734
Gilead	FTTH	$513,940	$20,000	$20,000	$40,819	$292,500	$160,621
Greenwood	FTTH	$1,679,856	$80,000	$80,000	$162,106	$642,500	$795,250
Milton Twp	FTTH	$398,070	$0	$0	$27,929	$215,000	$155,141
Newry	FTTH	$1,316,154	$40,000	$40,000	$65,038	$160,000	$1,051,116
Woodstock	FTTH	$2,151,904	$130,000	$130,000	$250,581	$955,000	$816,323
	Subtotal	**$11,390,502**	**$540,000**	**$540,000**	**$1,166,968**	**$4,340,000**	**$5,343,534**
		$801,664	*overbuild of existing FTTH in order to reach non-FTTH areas*				**$801,664**
Totals		**$12,192,166**	**$540,000**	**$540,000**	**$1,166,968**	**$4,340,000**	**$6,145,198**
				4%	**10%**	**36%**	**50%**

The table above is a hypothetical view of the source of funds assuming the following:

- The Towns would own and contract with a provider to operate and maintain the network.
- Assumes the network would require overbuilding some areas of the existing FirstLight FTTH network but would not compete with the existing FirstLight FTTH service areas.
- Assumes State and federal dollars of up to $2,500 per current “unserved” potential subscriber location would be available under future grant programs.
- Assumes the Towns would contribute the balance of funding required, above and beyond ARPA funding.
- The pro rata shares of County ARPA funds, based upon population are allocated to broadband.
- The entire amount of Local ARPA funds is allocated to broadband.

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7.4 Strategy "D" - All new Town-wide / Town-owned FTTH

Hypothetical Funding Strategy - "D" *(all new Town-wide / Town-owned FTTH)*							
Town/Twp	**CATV Extension / FTTH**	**Estimated Total Construction Cost**	**Local ARPA Funds Received**	**Local ARPA Funds Requested**	**Pro rata share of County ARPA Funds**	**State / Federal Funding**	**Additional Local Funding**
		State/Federal Grant amount per unserved location				***$2,500***	
Albany Twp	FTTH	$1,690,768	$0	$0	$111,326	$900,000	$679,442
Bethel	FTTH	$5,569,223	$270,000	$270,000	$509,169	$1,175,000	$3,615,054
Gilead	FTTH	$792,640	$20,000	$20,000	$40,819	$292,500	$439,321
Greenwood	FTTH	$2,356,356	$80,000	$80,000	$162,106	$642,500	$1,471,750
Milton Twp	FTTH	$412,260	$0	$0	$27,929	$215,000	$169,331
Newry	FTTH	$2,517,447	$40,000	$40,000	$65,038	$160,000	$2,252,409
Woodstock	FTTH	$2,828,839	$130,000	$130,000	$250,581	$955,000	$1,493,258
Totals		**$16,167,534**	**$540,000**	**$540,000**	**$1,166,968**	**$4,340,000**	**$10,120,566**
				3%	**7%**	**27%**	**63%**

The table above is a hypothetical view of the source of funds assuming the following:

- The Towns would own and contract with a provider to operate and maintain the network.
- Assumes 100% overbuild of existing Charter (Spectrum) CATV and FirstLight FTTH infrastructure.
- Assumes State and federal dollars of up to $2,500 per current “unserved” potential subscriber location would be available under future grant programs.
- Assumes the Towns would contribute the balance of funding required, above and beyond ARPA funding.
- The pro rata shares of County ARPA funds, based upon population are allocated to broadband.
- The entire amount of Local ARPA funds is allocated to broadband.

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8 Next step recommendations

With the publication of this report, we recommend the Towns pursue the following steps in parallel to ensure your Town is well positioned with ongoing service provider expansion plans, current funding programs and to take the necessary steps to educate and inform your constituents.

8.1 Revisit and confirm goals and vision

Now that the costs and options for various solutions have been identified in this Report, the Towns should revisit their goals and vision. This effort should be completed at the earliest opportunity in order to inform the next steps.

8.2 Public-private partnership negotiations

We recommend exploring potential partnerships with all service providers concurrently in a fully transparent and inclusive manner. This is important from a due diligence perspective to generate confidence by your constituents that all avenues have been explored and the differences given the appropriate weight.

8.3 Secure funding to support negotiations

While the efforts of Mahoosuc, Town staffs, select board members and committee member volunteers should be celebrated and continue, any public-private partnership negotiations will benefit from the guidance and facilitation of a consultant with deep telecom/broadband engineering and operating experience and relationships with the service providers. Mahoosuc should secure additional funding to continue to support these efforts.

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9 Internet Access and Broadband Definition

The terms “Internet access” and “broadband” are often used interchangeably. There is frequently confusion between the two, especially as the definitions evolve with technology changes.

Internet access connects individual computer terminals, computers, mobile devices, and computer networks to the Internet, enabling users to access Internet services such as email, applications and information delivered via the World Wide Web. Internet service providers (ISPs) offer Internet access through various technologies that offer a wide range of data signaling rates (speeds).

Consumer use of the Internet first became popular through dial-up Internet access in the 1990s. By the first decade of the 21st century, many consumers in developed nations used faster, broadband Internet access technologies.

Broadband is a generic term representing any wide-bandwidth data transmission method with the ability to transport multiple signals and traffic types simultaneously. This data can be transmitted using coaxial cable, optical fiber, radio or twisted pair copper. In the context of Internet access, broadband is used much more loosely to mean any high-speed Internet access that is always on and faster than traditional dial-up access. Different governing authorities have developed inconsistent definitions of what constitutes broadband service based on access speed.

In January 2015, the Federal Communications Commission (FCC) voted to define broadband as Internet service with at least 25 Mbps (megabits per second) download and 3 Mbps upload. Their definition affects policy decisions and the FCC's annual assessment of whether broadband is being deployed to all Americans quickly enough. In Maine, the ConnectMaine Authority Board[1] currently defines effective broadband network capacity as speeds equal to or greater than 50Mbps/10Mbps, and anything less as “unserved.”

[1] In recognition of the critical importance of modern technology for education, health care, and business success in Maine, the Legislature created the ConnectME Authority (Authority) in 2006 as an independent state agency to develop and implement broadband strategy for Maine. The Authority is governed by a board which is comprised of members appointed by the Governor or specifically identified and designated by statute.

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10 Internet Access Technology Overview

In this section, we present an overview of different Internet access technology, including digital subscriber line, cable modem, fixed wireless, 4G/LTE Advanced, 5G, satellite, and Fiber-to-the-Premise.

10.1 DSL

Digital subscriber line (DSL) is a technology most frequently used by traditional telephone system operators such as Consolidated Communications, Inc. (CCI) and FirstLight to deliver advanced services *(high-speed data and potentially video)* over twisted pair copper telephone wires. This technology has lower data carrying capacity than the hybrid fiber coaxial network deployed by cable system operators like Charter Communications (Spectrum). Data speeds are range-limited by the length of the copper cable serving the premise, the wire gauge of the copper conductors and the condition of the copper.

DSL service can be delivered simultaneously with wired telephone service on the same telephone line. This is possible because DSL uses higher frequency bands for data transmission than are required for the voice service transmission. On the customer premises, a DSL filter on each non-DSL outlet blocks any high-frequency interference to enable simultaneous use of the voice and DSL services.

The bit rate of consumer DSL services can range from 256 Kbps *(kilobits per second)* to over 100 Mbps in the direction of the service provider to the customer (downstream), depending on the DSL technology, line conditions, and the length of the copper loop. Until recently, the most commonly installed DSL technology for Internet access has been asymmetric digital subscriber line (ADSL). With ADSL, the data throughput in the upstream direction *(the direction from the consumer to the service provider)* is lower, hence the designation of asymmetric service.

At the central office, a digital subscriber line access multiplexer (DSLAM) terminates the DSL circuits and aggregates them, where they are handed off to other networking transport equipment. The DSLAM terminates all connections and recovers the original digital information. For locations beyond the maximum distance from the central office for the particular type of DSL technology deployed (7,000 – 12,000 feet), DSLAMs can be deployed in the field in outside plant cabinets *(remote terminals)* and connected to the central office by fiber optic cables. A shorter distance from the subscriber premise to the DSLAM results in greater bandwidth *(speed and/or capacity)* for the connected users.

The customer end of the connection consists of a terminal adaptor or "DSL modem." This converts data between the digital signals used by computers and the voltage signal of a suitable frequency range which is then applied to the phone line.

There are additional formats of DSL technologies that can enhance the capacity of the network. ADSL2+ extends the capability of basic ADSL by doubling the number of downstream channels, increasing the frequency from 1.1 Mhz to 2.2 Mhz. The data rates can be as high as 24 Mbps

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downstream and up to 1.4 Mbps upstream, depending on the distance from the DSLAM to the subscriber's premises. Like the previous standards, ADSL2+ will degrade from its peak bit rate after a certain distance.

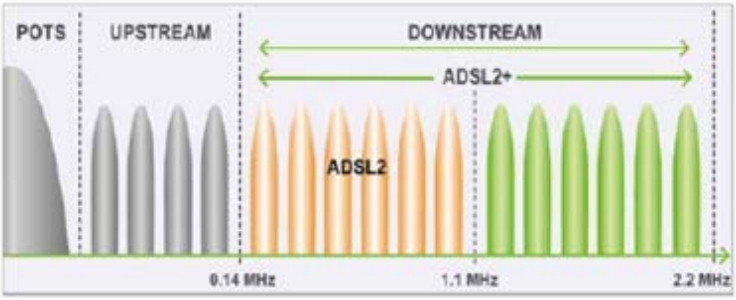

Figure 1: ADSL2+ Frequency Utilization

ADSL2+ allows port bonding, where multiple ports are physically provisioned to the end user and the total bandwidth is equal to the sum of all provisioned ports. When two lines capable of 24 Mbps are bonded, the end result is a connection capable of 48 Mbps download and twice the original upload speed.

Very-high-bit-rate digital subscriber line 2 (VDSL2+) permits the transmission of asymmetric and symmetric aggregate data rates up to 200 Mbps downstream and upstream on twisted pairs using a bandwidth up to 30 Mhz. It deteriorates quickly from a theoretical maximum of 250 Mbps at the source to 100 Mbps at 1,600 feet and 50 Mbps at 3,300 feet but degrades at a much slower rate from there. Starting from one mile, its performance is similar to ADSL2+. Bonding may be used to combine multiple wire pairs to increase available capacity or extend the copper network's reach.

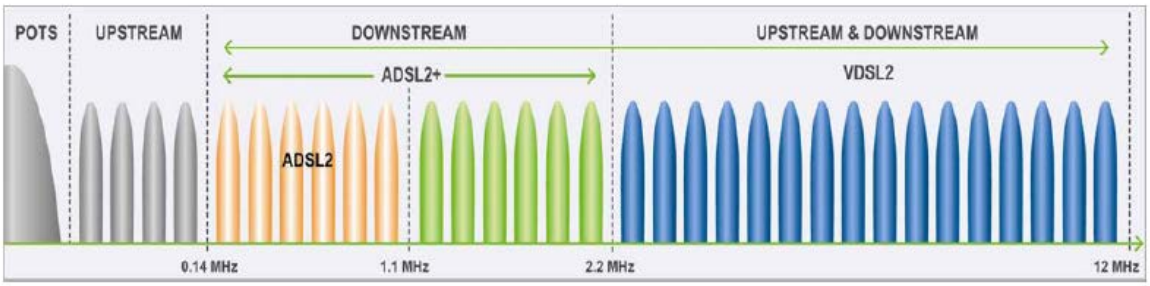

Figure 2: VDSL2+ Frequency Utilization

All new DSL deployments for CCI and FirstLight utilize VDSL2+ equipment.

10.2 Cable Modem

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Cable modem Internet access is provided over a hybrid fiber coaxial (HFC) broadband network. It has been employed globally by cable television operators since the early 1990s and is the network architecture utilized by Spectrum. In an HFC cable system, the television channels are sent from the cable system's distribution facility, the headend, to local communities through optical fiber trunk lines. The fiber-optic trunk lines provide adequate bandwidth to allow future expansion for bandwidth-intensive services. At the local community, an optical node translates the signal from a light beam to an electrical signal and sends it over coaxial cable lines for distribution to potential subscribers.

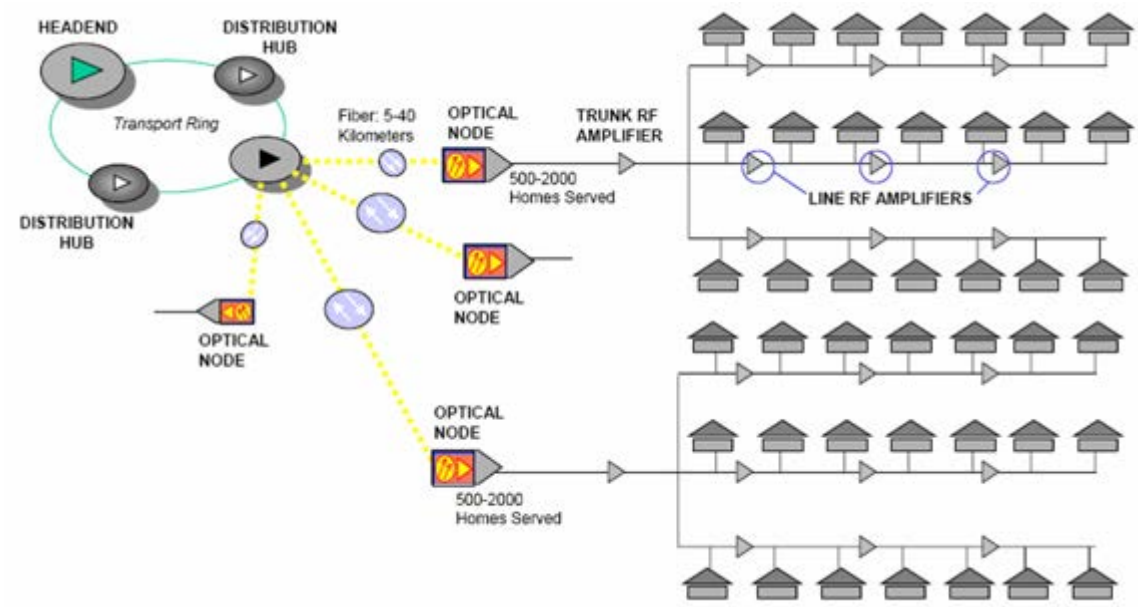

Figure 3: Hybrid Fiber/Coax Network Architecture Diagram

The coaxial portion of the network connects 25–2,000 homes in a tree-and-branch configuration off the node. RF amplifiers are used at intervals to overcome cable attenuation and passive losses of the electrical signals caused by splitting or "tapping" the coaxial cable.

The HFC broadband network is typically operated bi-directionally, meaning that signals are carried in both directions on the same network from the headend/hub office to the home, and from the home to the headend/hub office. The forward-path or downstream signals carry information such as video content, voice and data. The return-path or upstream signals carry information such as video control signals to order a movie or Internet data to send an email. The forward-path and the return-path are carried over the same coaxial cable in both directions between the optical node and the home.

Data Over Cable Service Interface Specification (DOCSIS) is an international telecommunications standard that permits the addition of high-bandwidth data transfer to an existing cable TV (CATV) system. DOCSIS 3.1 has been deployed by Spectrum to provide Internet access over their existing HFC infrastructure. The DOCSIS 3.1 standard is capable of supporting Internet speeds of up to 10 Gbps

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(gigabits per second), but most providers are currently offering speeds of 1 Gbps or less service for residential users.

10.3 Fixed Wireless

Fixed wireless broadband is the operation of wireless devices or systems used to connect two fixed locations *(e.g., building to building or tower to building*) with a radio or other wireless link. Fixed wireless data (FWD) links are often a cost-effective alternative to leasing fiber or installing cables between the buildings. The point-to-point signal transmissions occur through the air over a terrestrial microwave platform. The advantages of fixed wireless include the ability to connect with users in remote areas without the need for laying new cables and the capacity for broad bandwidth that is not impeded by fiber or cable capacities. Fixed wireless services typically use a directional radio antenna on each end of the signal. These antennas are generally larger than those seen in Wi-Fi setups and are designed for outdoor use. They are typically designed to be used in the unlicensed Industrial, Scientific, and Medical (ISM) radio frequency bands (900 MHz, 1.8 GHz, 2.4 GHz and 5 GHz). However, in many commercial installations licensed frequencies may be used to ensure quality of service (QoS) or to provide higher connection speeds.

To receive this type of Internet connection, consumers mount a small dish to the roof of their home or office and point it to the transmitter. Line-of-sight is usually necessary for Wireless Internet Service Providers (WISPs) operating in the 2.4 and 5 GHz bands. The 900 MHz band offers better non-line-of-sight (NLOS) performance. Providers of unlicensed fixed wireless broadband services typically provide equipment to customers and install a small antenna or dish somewhere on the roof. This equipment is usually deployed and maintained by the company providing that service.

10.4 4G/LTE Advanced Broadband

4G/LTE Advanced is wireless technology being deployed by cellular telephone providers such as AT&T, Verizon Wireless, US Cellular, Sprint and T-Mobile for traditional mobile phone and data services. The latest standard incorporates two new technologies - Carrier Aggregation, and Multiple Input Multiple Output (MIMO), in order to provide speeds in excess of 100 Mbps, and eventually up to 1 Gbps and beyond. While standard data connections use one antenna and one signal at any given time, 4G LTE Advanced has the capability of utilizing multiple signals and multiple antennas.

Mobile LTE wireless service uses MIMO technology to combine multiple antennas on both the transmitter and the receiver. A 2×2 MIMO configuration has two antennas on the transmitter and two on the receiver, but the technology is not limited to 2x2. More antennas could theoretically operate at faster speeds as the data streams can travel more efficiently. The signal is then combined with “carrier aggregation,” which allows a device to receive multiple 4G signals at once. The received signals don’t have to be on the same frequency; one could receive an 1800 MHz and an 800 MHz signal at the same

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time, which is not possible with standard 4G. Up to five different 20 MHz signals can be combined to create a data pipe of up to 100 MHz of bandwidth.

10.5 5G Wireless[2]

Fifth-generation wireless (5G) is the latest iteration of cellular technology, engineered to greatly increase the speed and responsiveness of wireless networks. With 5G, data transmitted over wireless broadband connections could travel at rates as high as 20 Gbps by some estimates -- exceeding wireline network speeds -- as well as offer latency of 1 millisecond or lower for uses that require real-time feedback. 5G will also enable a sharp increase in the amount of data transmitted over wireless systems due to more available bandwidth and advanced antenna technology.

In addition to improvements in speed, capacity and latency, 5G offers network management features, among them network slicing, which allows mobile operators to create multiple virtual networks within a single physical 5G network. This capability will enable wireless network connections to support specific uses or business cases and could be sold on an as-a-service basis. A self-driving car, for example, would require a network slice that offers extremely fast, low-latency connections so a vehicle could navigate in real time. A home appliance, however, could be connected via a lower-power, slower connection because high performance isn't crucial.

5G networks and services will be deployed in stages over the next several years to accommodate the increasing reliance on mobile and internet-enabled devices. Overall, 5G is expected to generate a variety of new applications, uses and business cases as the technology is rolled out.

How 5G works - Wireless networks are composed of cell sites divided into sectors that send data through radio waves. Fourth generation (4G) Long-Term Evolution (LTE) wireless technology provides the foundation for 5G. Unlike 4G, which requires large, high-power cell towers to radiate signals over longer distances, 5G wireless signals will be transmitted via large numbers of small cell stations located in places like light poles or building roofs. The use of multiple small cells is necessary because the millimeter wave spectrum -- the band of spectrum between 30 GHz and 300 GHz that most 5G implementations rely on to generate high speeds -- can only travel over short distances (500 - 1,000 feet) and is subject to interference from weather and physical obstacles, like buildings[3].

Previous generations of wireless technology have used lower-frequency bands of spectrum. To offset millimeter wave challenges relating to distance and interference, the wireless industry is also considering the use of lower-frequency spectrum for 5G networks so network operators could use

[2] https://searchnetworking.techtarget.com/definition/5G

[3] T-Moble is reportedly deploying 5G in the 600Mhz spectrum that can travel over much longer distances (3 - 5 miles) and will not require line-of-sight, but the bandwidth available will be much less than that provided in the higher spectrum ranges.

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spectrum they already own to build out their new networks. Lower-frequency spectrum reaches greater distances but has lower speed and capacity than millimeter wave.

10.6 Satellite

Satellite Internet is available to virtually the entire lower 48 states, with some coverage in Alaska, Hawaii and Puerto Rico. The satellites are positioned more than 22,000 miles above the equator. These satellites are geostationary, which means they are always above a specific point on the earth as it rotates. The first Internet satellites successfully brought the Internet to a larger audience, but the rates were incredibly slow. Modern satellites use more advanced technology to transmit information which provides faster Internet access, but this is still much slower than landline-based Internet and terrestrial wireless Internet services.

When a consumer subscribes to satellite Internet, the company installs household equipment, which consists of an antenna dish and a modem. The antenna is located outside of the house and is generally two or three feet in diameter. The antenna must have an unobstructed view of the sky, called the line-of-sight, in order to communicate with the satellite. The antenna is connected to a modem, which connects to a computer with an Ethernet cable.

To manage bandwidth quality for all users, each plan comes with a cap on the data you can transmit or consume per month. The amount of data allotted depends on the subscriber's plan. Plans typically range from 5 GB to 50 GB of data transmission per month with use limits prescribed. If you exceed the allotted data amount, Internet speeds will be throttled back until the next month. However, some companies allow subscribers to pay for more data capacity once the threshold is met, resetting normal operation levels.

Looking forward, at least a dozen companies, including Boeing, Amazon, SpaceX, OneWEb and Telesat are deploying, or planning to deploy thousands of Low Earth Orbit (LEO) satellites in massive constellations to provide Internet service to unserved and underserved regions of the world. The benefit of LEO satellites includes greater bandwidth and less latency, with the reported potential of displacing traditional land-line based Internet service. SpaceX and others have begun deploying LEO satellites and are in the process of testing the service to demonstrate their viability.

Satellite industry proponents say that now, unlike decades ago when Teledesic and the earlier iteration of Iridium failed to develop successful businesses, technology advancements are enabling satellite service to be offered more affordably and efficiently.

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10.7 Fiber-to-the-Home (FTTH)

Fiber-to-the-Home (FTTH) or Fiber-to-the-Premise (FTTP) is a network utilizing fiber optic cables directly to the home or business and is capable of offering virtually unlimited symmetrical bandwidth. Most FTTP networks can offer 1 Gbps of bandwidth in both download and upload directions, with some providers offering 2 Gbps and even 10 Gbps service capacity. The majority of new networks being deployed utilize this type of technology.

FTTH networks can be configured and operated in a number of different ways. These include:

- As a single service provider in a closed network environment.
- As an open access dark fiber[4] configuration where, competing providers can lease the fiber and place their own optical/electronics to complete the service.
- As an open access dark fiber configuration where the network owner provides the optical/electronics and leases the service to competing providers.
- As a Software Defined Network, where competing providers interconnect with the network and users select their provider in a virtual manner.

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[4] Dark fiber is fiber optic strands that have no optical/electronic equipment connected at both ends to "light" the fiber for use by a consumer. In this example, the network owner would provide the "dark fiber" leased by a service provider who would place their own optical electronics on the fiber to provide a finished service.

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11 Maps Appendix

The following pages contain maps of the 7 Towns/Twps in alphabetical order.

Map Key	
	FTTH & no CATV *(considered served)*
	FTTH & CATV *(considered served)*
	CATV *(considered served)*
	No CATV or FTTH *(assumed to be unserved at less than 50Mpbs/10Mbps)*
	Maine Fiber Company (FirstLight) 3-Ring-Binder Network *(middle-mile fiber)*

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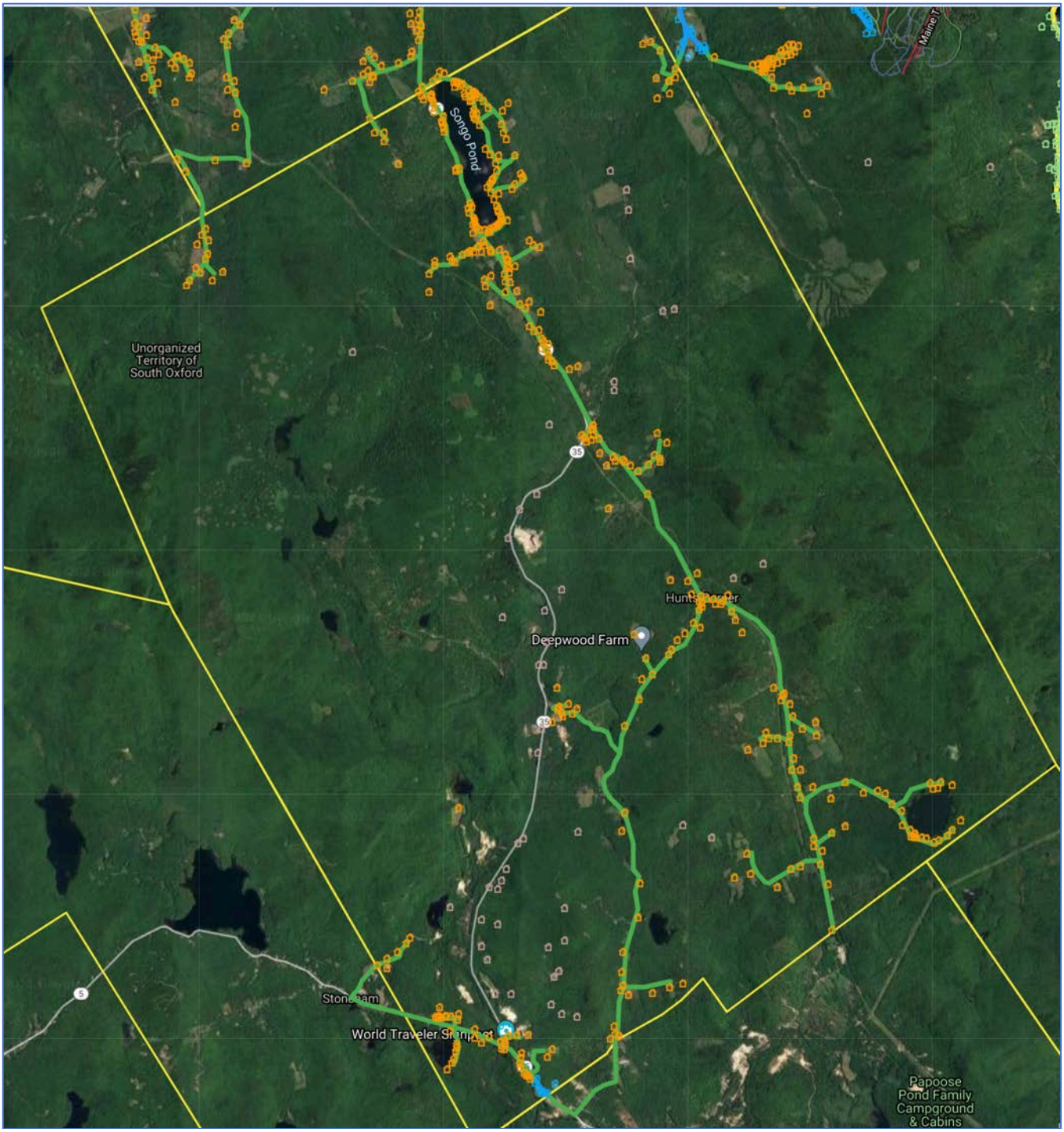
Albany Township



Map Key	
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	CATV *(considered served)*
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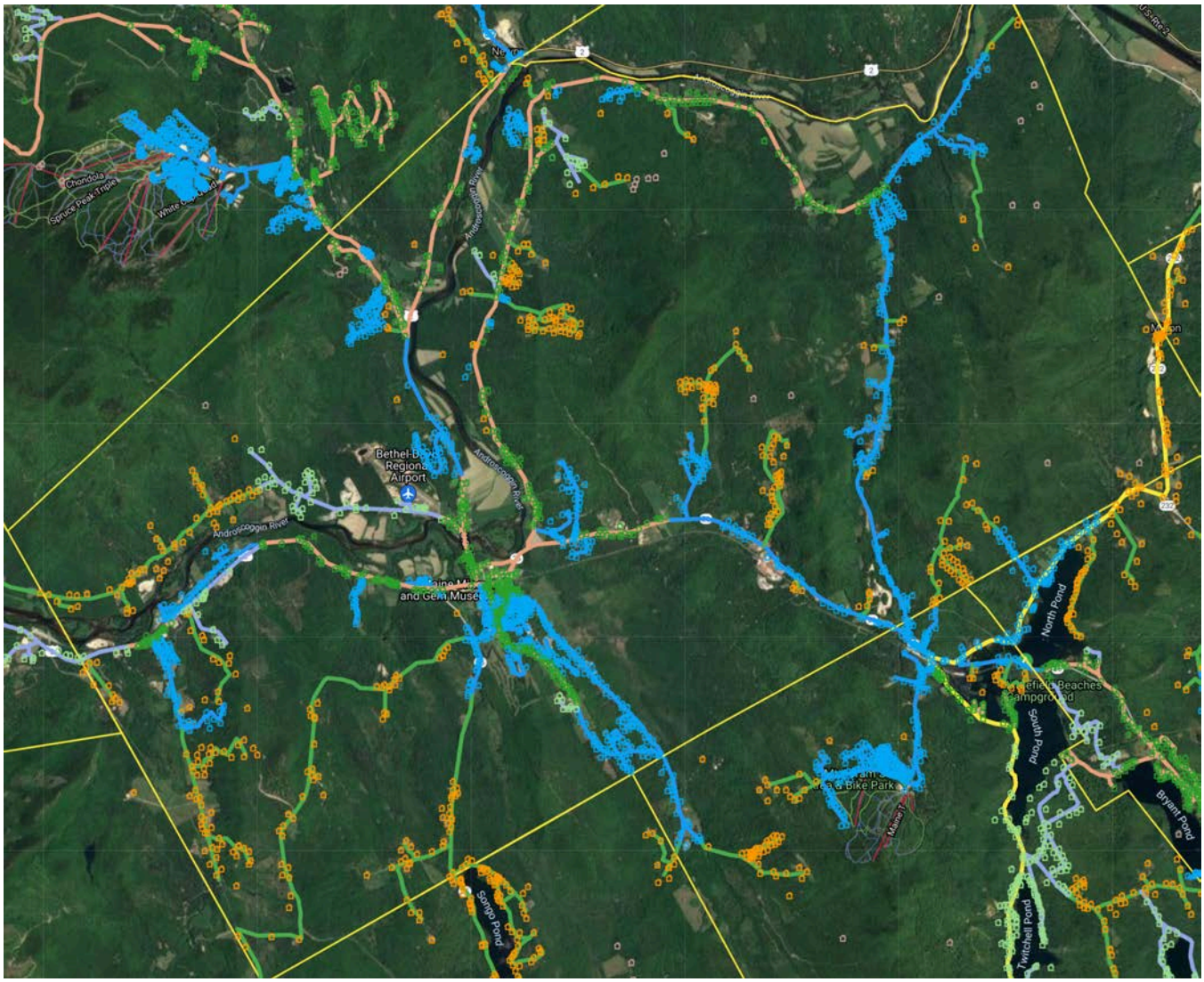
	Maine Fiber Company (FirstLight) 3-Ring-Binder Network *(middle-mile fiber)*

Casco Bay Advisors, LLC
Broadband/Telecom Consulting

Bethel



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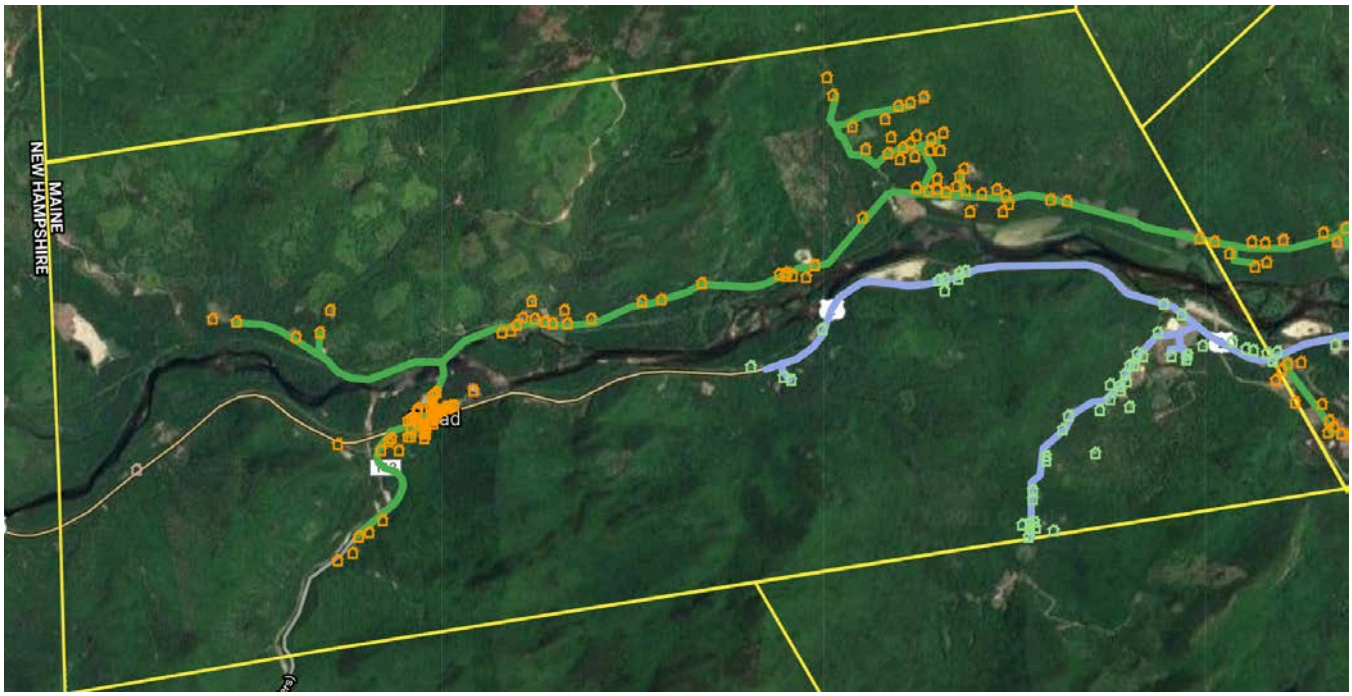
Gilead



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	Maine Fiber Company (FirstLight) 3-Ring-Binder Network *(middle-mile fiber)*

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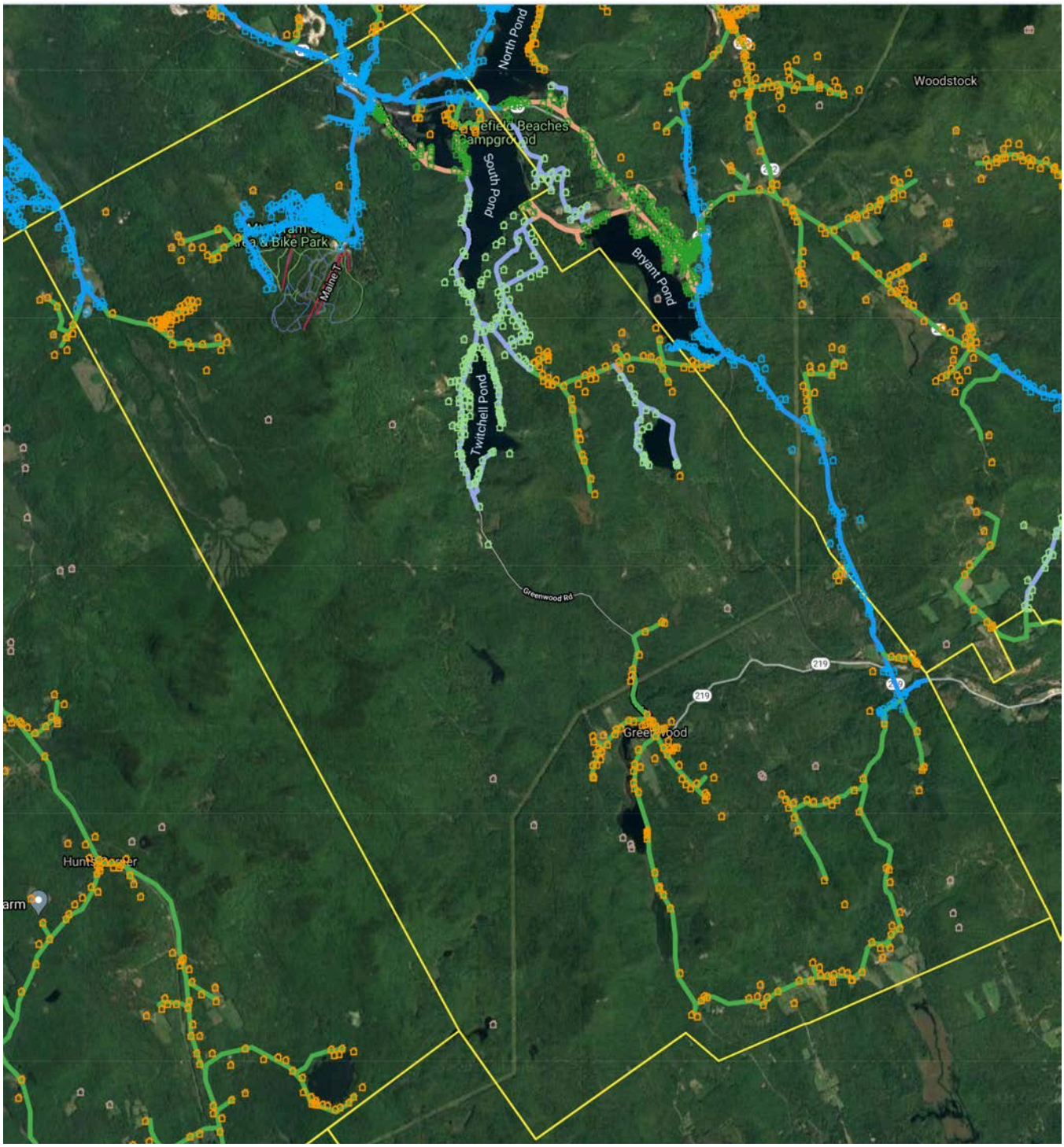
Broadband/Telecom Consulting

Greenwood



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	CATV *(considered served)*
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	Maine Fiber Company (FirstLight) 3-Ring-Binder Network *(middle-mile fiber)*

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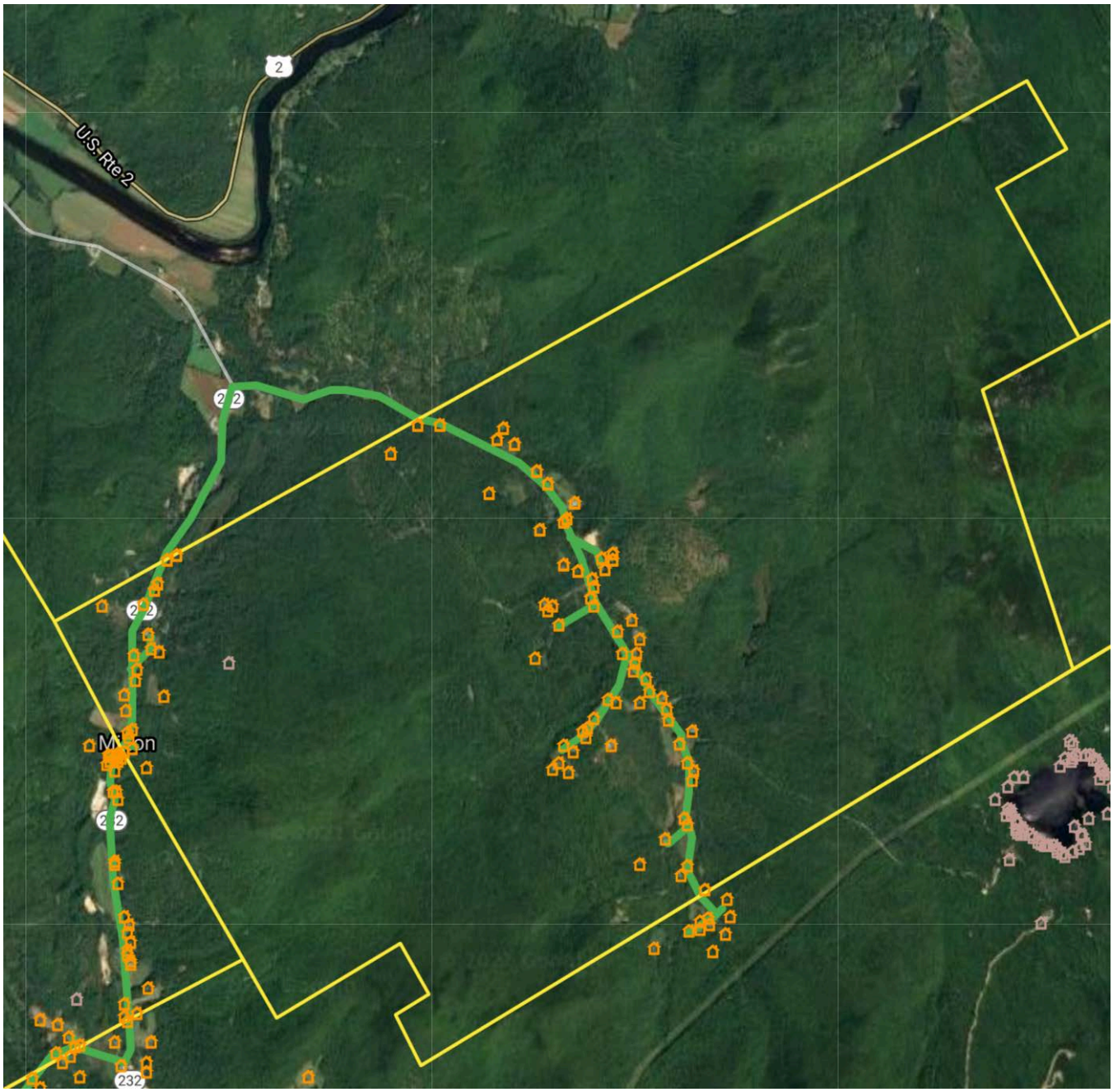
Milton Township



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	Maine Fiber Company (FirstLight) 3-Ring-Binder Network *(middle-mile fiber)*

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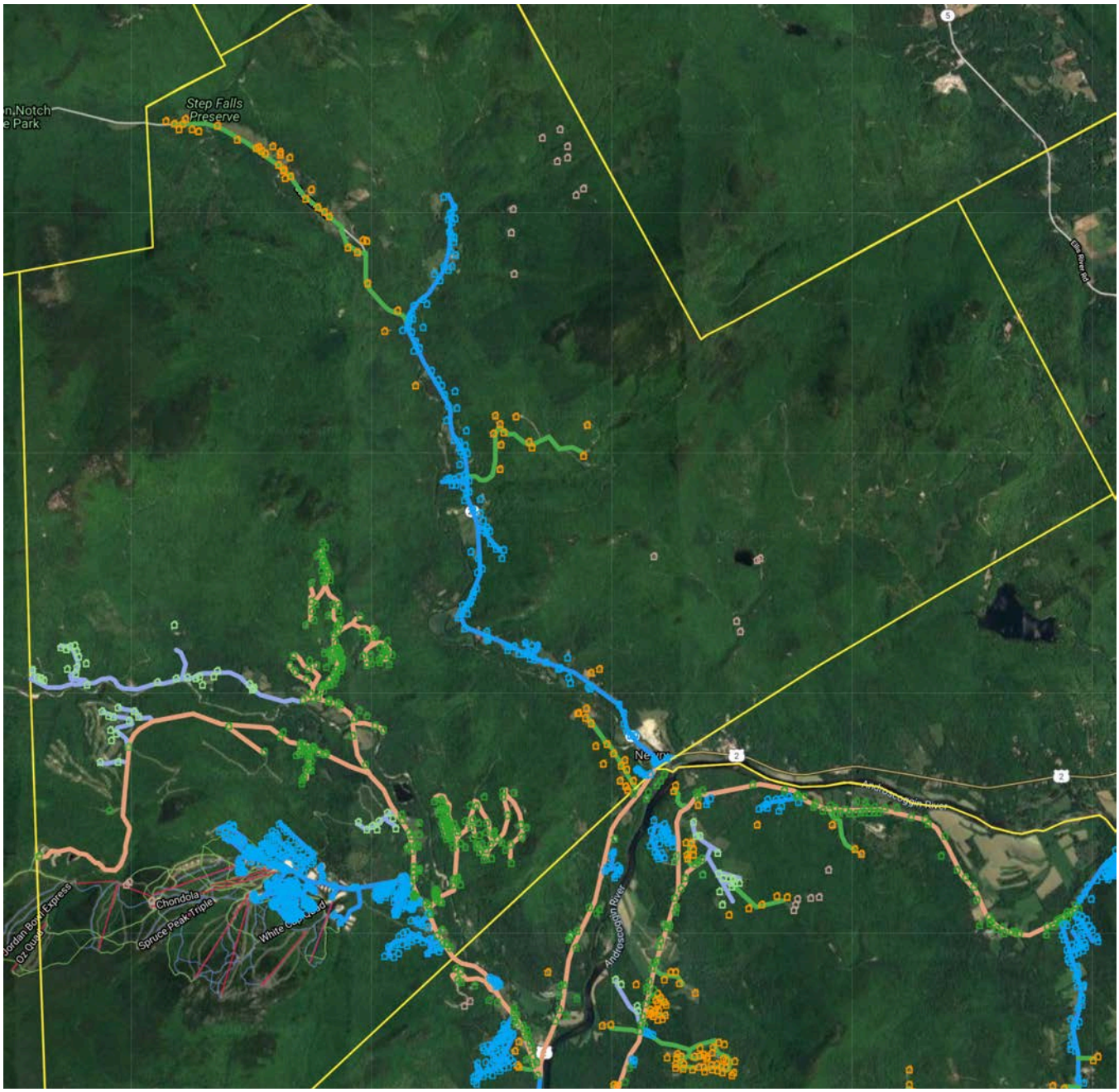
Broadband/Telecom Consulting

Newry



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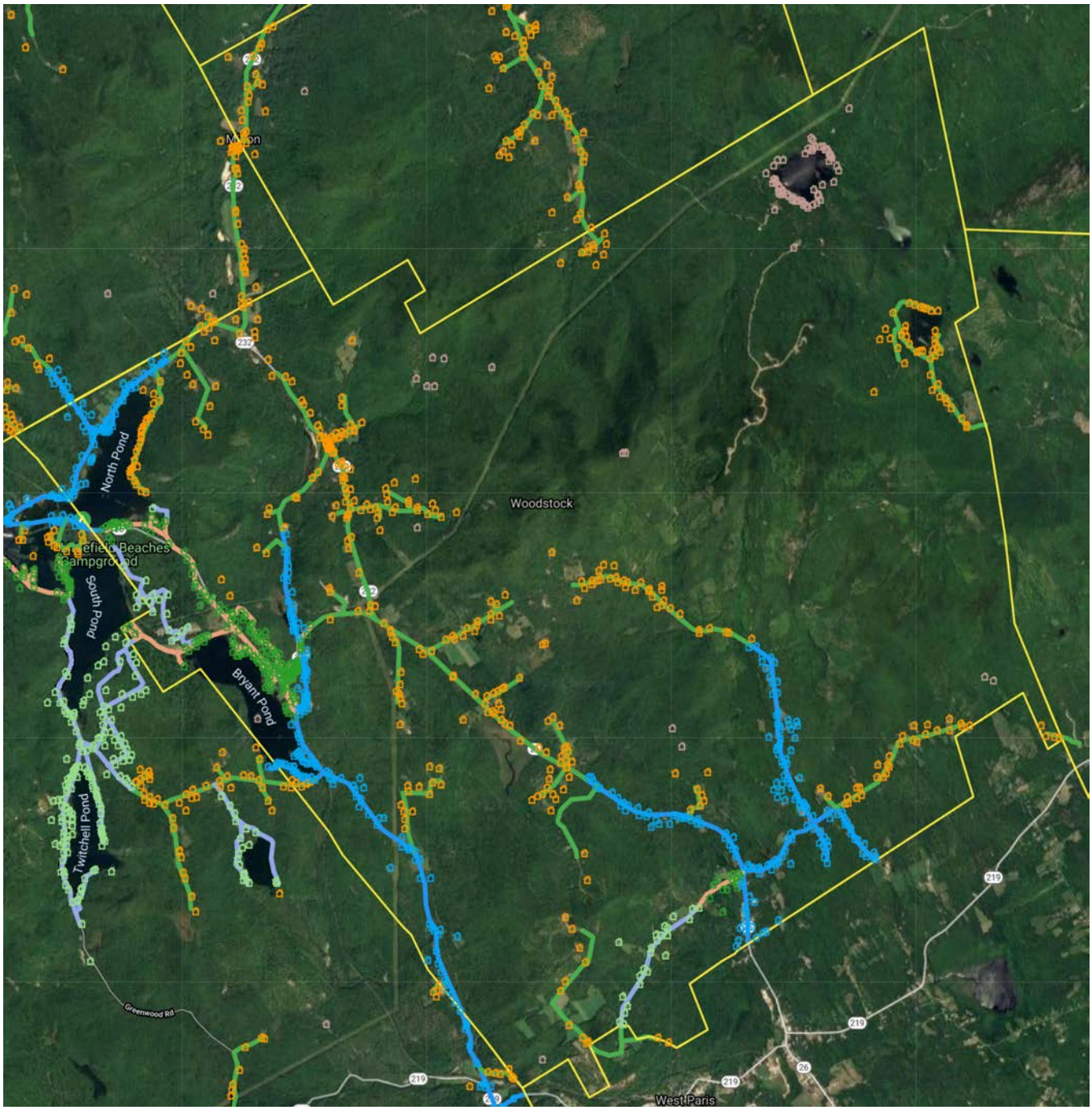
Casco Bay Advisors, LLC
Broadband/Telecom Consulting

Woodstock



Map Key	
	FTTH & no CATV *(considered served)*
	FTTH & CATV *(considered served)*
	CATV *(considered served)*
	No CATV or FTTH *(assumed to be unserved at less than 50Mpbs/10Mbps)*
	Maine Fiber Company (FirstLight) 3-Ring-Binder Network *(middle-mile fiber)*