TILSON

Islesboro Broadband Study

Submitted to:
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Note

Cost information included in the following report is an estimate based on recent quotes, historical data, certain assumptions about the project scope and approach, the regulatory environment and market conditions at a fixed point in time. Given these variables, we recommend updating the estimate as time passes, and allocating sufficient contingency to allow for inevitable but unpredictable changes in the cost environment if the project moves forward.

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Executive Summary

The Town of Islesboro engaged Tilson to evaluate current broadband availability on the island for homes and businesses. The Town Selectmen have expressed concern that existing internet access may be insufficient, and poses a critical challenge for sustaining the island's year round community. The Selectmen believe that it will be difficult to retain and attract young residents, families, and businesses if high-speed, reliable internet connectivity is not universally available on Islesboro.

As part of the engagement, Tilson focused on three topics:

1. Analysis of the current state of broadband availability on Islesboro.
2. Strategies for improving broadband availability on Islesboro.
3. Investment required for improving broadband infrastructure on Islesboro.

By measuring current service access and consumer satisfaction on the island through a survey, reaching out to commercial internet service providers to gauge interest in pursuing a project on the island, and conducting sufficient engineering and cost estimation to understand the capital expenditure needed to improve broadband facilities on the island, Tilson has developed the following report to help the Town explore possible options for improving broadband Islesboro.

The key findings of the report are as follows:

- Based on a comparison of local broadband availability to state and national levels, a survey of Islesboro residents and businesses, and an evaluation of potential economic impact of improved broadband on the island, Tilson agrees that improved broadband infrastructure on Islesboro would benefit the Town.

- Tilson does not believe there is a viable market-based business case for an existing commercial internet service provider to invest the full amount required to improve broadband facilities on the island. In other words, the incumbent service provider, FairPoint Communications, or a new service provider would need some external investment to be enticed to pursue a project on Islesboro. This investment could come from a number of different public and private sources.

- There are six potential strategies for the Town to improve broadband availability on Islesboro:

1. The Town partners with the incumbent service provider, FairPoint, to upgrade existing facilities on Islesboro to serve all premises on the island at faster speeds. FairPoint would construct, maintain, operate, and provide service on the network and would cover all ongoing operating costs. Based on our initial conversations, FairPoint would need some additional external investment of an as yet undetermined amount to do so.

2. The Town partners with Time Warner Cable to build a new DOCSIS 3.0 cable network on Islesboro, which would be the same technology that Vinalhaven and North Haven have, and provide internet, voice, and video service to all premises on the island. Time Warner Cable would construct, maintain, operate, and provide service on the network and would cover all ongoing operating costs. Based on our initial conversations, Time Warner Cable would need some additional external investment of an as yet undetermined amount to do so.

3. The Town partners with another existing commercial internet service provider, such as Axiom, GWI, OTT or Tidewater Telecom, to build a fiber-to-the-home network on Islesboro serving all premises on the island. The service provider would construct, maintain, operate, and provide service on the network and would cover all ongoing operating costs. Based on our initial conversations, these carriers would need some additional external investment of an as yet undetermined amount to do so.

4. A private community-oriented entity builds a fiber-to-the-home network to all premises on the island.[1] The entity would construct, maintain, and operate the network. The entity could partner with a private internet service provider to provide service to customers. The entity would own the network and be responsible for all ongoing operating costs, which would be paid using network revenues from customer subscriptions.

5. The Town pursues a joint venture with a private community-oriented entity to build a fiber-to-the-home network to all premises on the island. The venture would construct, maintain, and operate the network. The venture could partner with a private internet service provider to provide service to customers. The venture would own the network and be responsible for all ongoing operating costs, which would be paid using network revenues from customer subscriptions.

[1] By "community-oriented entity", we mean an entity consisting of individuals with personal or business connections to Islesboro.

6. The Town builds a fiber-to-the-home network serving all premises on the island. The Town could partner with a private internet service provider to provide retail service to customers.[2] The Town would own the network and be responsible for all ongoing operating costs, which would be paid using network revenues from customer subscriptions.

- For Options 1-3, Tilson estimates an investment of $1.24 million to $2.48 million will be required, which would be paid directly to the commercial internet service provider with which the Town partners.

- For Options 4-6, Tilson estimates a total investment of $2.48 million will be required, with a fixed cost of $1.6 million and the rest being deployed over a number of years on a success basis. In each of these options the network owner would also be responsible for covering annual operating costs, which Tilson estimates would be approximately $206,000 per year.

- For Options 4-6, a fixed and total investment amount are identified because network construction costs would contain two components: a fixed capital expenditure needed to construct facilities that pass each premise on the island and a variable cost for connecting homes and businesses with service from the street curb. An investment covering the fixed amount would be required upfront, whereas the variable cost of customer connections could be phased over time based on customer uptake. As properties across the island have varying driveway lengths, individual household connections will cost different amounts.

- For next steps, the Town needs additional information from the commercial internet service provider community to effectively evaluate the value of all possibilities. Tilson recommends that the Town proceeds into a formal request for information (RFI) process to get specific information from service providers about the required amount of investment needed to pursue a commercial initiative. With this information in hand, the Town will be able to better understand the needs for network construction, maintenance, network operation, and service provision moving forward.

[2] By “retail service”, we mean internet, voice, and potentially video content delivery.

Current State of Broadband on Islesboro

Over the last twenty years, the internet and communications technologies have fundamentally transformed Americans' lives. Between 2000 and 2010, the number of Americans with broadband access at home grew from eight million to nearly 200 million. Today, it is hard to imagine life without these technologies, as they have reshaped the ways in which we interact and do business.

Recognizing this tectonic shift, the U.S. Congress directed the Federal Communications Commission (FCC) in 2009 to develop a National Broadband Plan with the goal of ensuring that every American gains access to broadband capability. In the report's opening lines, the FCC recognizes the economic importance of broadband in today's hyper-connected world:[3]

> Like electricity a century ago, broadband is a foundation for economic growth, job creation, global competitiveness and a better way of life. It is enabling entire new industries and unlocking vast new possibilities for existing ones. It is changing how we educate children, deliver health care, manage energy, ensure public safety, engage government, and access, organize and disseminate knowledge. (xi)

However, the FCC recognizes that broadband remains inaccessible to many Americans, especially when compared to availability in other developed countries:

> Approximately 100 million Americans do not have broadband at home. Broadband-enabled health information technology can improve care and lower costs by hundreds of billions of dollars in the coming decades, yet the United States is behind many advanced countries in the adoption of such technology. Broadband can provide teachers with tools that allow students to learn the same course material in half the time, but there is a dearth of easily accessible digital educational content required for such opportunities. A broadband-enabled Smart Grid could increase energy independence and efficiency, but much of the data required to capture these benefits are inaccessible to consumers, businesses and entrepreneurs. And nearly a decade after 9/11, our first responders still lack a nationwide public safety mobile broadband communications network, even though such a network could improve emergency response and homeland security. (xi)

In light of these findings and the Town's concerns that existing broadband availability on Islesboro is insufficient, Tilson evaluated the current state of broadband on the island in three ways:

[3] Federal Communications Commission. 2009. *Connecting America: National Broadband Plan.* Available at http://www.broadband.gov/plan/.

1. Comparison of broadband availability on Islesboro to local, state, and national averages using publically-available data.
2. Survey of Islesboro residents and businesses to measure current access and consumer satisfaction.
3. Evaluation of potential economic impact of improved broadband availability on Islesboro using existing academic literature.

Overall, Tilson agrees that improved broadband infrastructure would benefit the Town. At present, broadband availability on Islesboro lags behind national averages and goals for future access. In the survey, residential and business respondents expressed strong interest in improved internet service. Lastly, based on academic studies of other broadband initiatives in the U.S. and internationally, Tilson believes improved broadband availability would have a positive economic impact on Islesboro.

Comparing Local, State and National Averages

To benchmark current broadband availability on Islesboro, Tilson examined local, state, and national broadband data. Overall, access to broadband in any form on the island is on par with other communities in mid coast Maine, but average delivered speeds on Islesboro lag behind other towns in Maine, and Maine lags behind the national average. However, with the recent installation of the Three Ring Binder dark fiber network along Lincolnville's and Northport's Route 1, the island is in proximity to relatively inexpensive access to internet backhaul among others options (FairPoint, Time Warner Cable, Tidewater, other Competitive Local Exchange Carriers) that can be leveraged to improve service.

Local Broadband Data

In Maine, the ConnectME Authority has developed the most comprehensive database of municipal broadband availability to date. As part of its recent Broadband Mapping and Inventory Project, the agency mapped broadband penetration throughout the state using data reported by internet service providers. The findings were published in the Authority's *Developing Broadband in Maine: Needs Assessment*, which details download speeds on Islesboro and in surrounding communities:[4]

[4] Report is available at http://www.sewall.com/files/connectme_na_v2.pdf. Broadband availability is measured by road mileage, as communications facilities are located on roadside poles to be able to pass households.

Figure 1: Community Broadband Access by FCC Speed Tier

	Broadband Tier								
Town	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**<null>**
Belfast				24.4%	13.3%	50.9%	11.4%		
Camden				2.6%	1.9%	0.3%	46.5%	48.7%	
Islesboro	0.6%	0.2%			0.5%		98.7%		
Lincolnville		5.3%	2.1%	0.0%	0.4%		92.1%		
North Haven				1.8%	2.3%		95.9%		
Northport	0.1%	4.9%	3.5%		22.0%	3.6%	65.6%		0.2%
Vinalhaven	0.2%	14.2%		35.4%			45.4%		4.9%
Road Footprint	**0.1%**	**3.6%**	**0.8%**	**10.9%**	**5.9%**	**11.3%**	**59.8%**	**6.7%**	**0.7%**

While the Authority's data enables comparison of broadband availability throughout mid coast Maine, Tilson believes the underlying methodology for data collection produces an overstatement of broadband availability on the island. More specifically, the primary source of data the Authority uses in determining broadband levels is advertised connection speeds that are self-reported by internet service providers. In this method, maximum advertised connection speeds in a census block are applied to the entire block, even if only some individuals in a service area are actually able to obtain such speeds.

On Islesboro, the Authority's data suggests 99 percent of the island has access to Tier 6 download speeds (between 25 Mbps and 100 Mbps). Broadband "tiers" are defined and explained on page 36. As detailed in the next section, Tilson surveyed island residents and businesses and asked respondents located on the island to use an online tool that measures connection speed. Of the 58 responses (46 residential and 12 business), which represent 7.5 percent of occupied properties on the island, no respondent registered a Tier 6 download speed. In fact, only one respondent measured a download speed above 8 Mbps. The average download and upload speeds reported on the island were 3.74 Mbps and 0.62 Mbps respectively. This average translates to a Tier 3 download speed and an upload speed less than Tier 1. While reported speeds depend on two factors, availability of service and customers' willingness to subscribe to higher speeds, these low reported averages seem to suggest that access to faster speed tiers is an obstacle to broadband adoption on Islesboro.

As a number of Tilson's field technicians have worked on telecommunications infrastructure in mid coast Maine, they were asked to provide an overview of local broadband availability based on their experience in the area:

Figure 2: Community Broadband Access Summary – Tilson

Town	Local Service Provider(s)	Cumulative Coverage Footprint	Technologies Utilized	Average Connection Speed in Town
Camden	FairPoint/Lincolnville Telco/Midcoast-GWI/Time Warner Cable	90%+	Cable/DSL/Wireless/Fiber	10Mbps+
Belfast	FairPoint/Lincolnville Telco/Midcoast-GWI/Time Warner Cable	80%+	Cable/DSL/Wireless	4Mbps+
Lincolnville	Midcoast-GWI/Tidewater	95%+	Wireless/DSL	3Mbps+
Northport	FairPoint/Midcoast-GWI	60%+	Wireless/DSL	3Mbps+
Vinalhaven	FairPoint/Midcoast-GWI/Time Warner Cable	85%+	Wireless, DSL, Cable	6 Mbps+
Northaven	FairPoint/Midcoast-GWI/Time Warner Cable	85%+	Wireless/DSL/Fiber	10 Mbps+

The table identifies which service providers are present in each town and how much of each town has at least one service option. The average connection speed represents the average level available to the town as a whole.

Historically, a primary obstacle preventing faster connection speeds from competitive internet service providers in mid coast Maine has been a lack of inexpensive internet backhaul. A broadband network has two primary components: middle mile service and last mile service. Middle mile service is the backhaul bandwidth that enables customers to connect to the internet. Last mile service includes the facilities that connect end user premises to the middle mile facilities via an aggregation point at the town level commonly known as a central office (CO).

With prohibitively expensive backhaul bandwidth costs due to a lack of competitive fiber-based middle mile facilities, last mile service in mid coast Maine has not been able to be economically advanced. However, with the completion of Maine Fiber Company's Three Ring Binder network in 2012, improvements to FairPoint's interoffice fiber facilities, and local network investments by Time Warner Cable and Lincolnville/Tidewater telecom, the region now has several competitive options for internet backhaul.

The Three Ring Binder was publically funded as part of the 2010 American Recovery and Reinvestment Act (ARRA), and has a requirement that network capacity is available to users on a non-discriminatory, open-access basis. In other words, customers cannot be prohibited access if there is unused fiber and all are charged the same amount for access. The Three Ring Binder is a middle mile network and runs along Route 1 in Lincolnville and Northport, and, in conjunction with Central Maine Power's proposed subsea fiber cable to be installed between

Northport to Islesboro, offers a relatively inexpensive alternative option for middle mile backhaul that has previously not existed for Islesboro. The middle mile fiber can be leased by any party, and requires a service provider to light the fiber to provide a backhaul service.

State Broadband Data

In addition to surveying municipal broadband availability, the ConnectME Authority's *Needs Assessment* aims to measure overall broadband availability in Maine. The average statewide download speed in Maine is 4.8 Mbps, compared to 6.4 Mbps nationally. Maine ranks 49th nationally in speeds greater than 10 Mbps, with Tier 5 download and upload speeds only available at roughly one-fifth of street locations across the state:

- 93 percent of street locations in Maine have access to Tier 1 download and upload speeds from at least one service provider.
- 85 percent of street locations in Maine have access to Tier 3 download and upload speeds from at least one service provider.
- 21 percent of street locations in Maine have access to Tier 5 download and upload speeds from at least one service provider.

For adoption, 90 percent of Maine households have some form of internet connection, with 75 percent of households subscribing at broadband levels. 94 percent of Maine businesses have some form of internet connection, with 93 percent of businesses subscribing at broadband levels.

Considering Islesboro in the context of statewide broadband availability, Islesboro's average download and upload speeds appear to lag behind the statewide average, which in turn lag behind the national average. Tilson's surveyed town average of 3.74 Mbps downstream is less than the statewide average of 4.8 Mbps, and the town average of 0.62 Mbps upstream is less than Tier 1.

National Broadband Data

At the national level, the FCC has conducted several initiatives focused on measuring broadband access nationwide and targeting future goals for availability and adoption. In its *National Broadband Plan,* the FCC sets two primary goals for future broadband access in the U.S.:[5]

1. The United States must lead the world in the number of homes and people with access to affordable, world-class broadband connections. As such, 100 million U.S. homes should have affordable access to actual download speeds of at least 100 Mbps and actual upload speeds of at least 50 Mbps by 2020.

[5] Pg. 9. *Connecting America: National Broadband Plan.* Federal Communications Commission. Available at http://www.broadband.gov/plan/.

2. As a milestone, by 2015, 100 million U.S. homes should have affordable access to actual download speeds of 50 Mbps and actual upload speeds of 20 Mbps.

At present, current service options on Islesboro do not meet these goals.

In addition to the FCC's work, the White House Office of Science and Technology Policy and the National Economic Council have worked to measure current broadband availability in the U.S. In their 2013 report *Four Years of Broadband Growth,* the portion of the American population with access to advertised download speeds is higher than the averages for Maine and Islesboro:[6]

Figure 3: Percentage of U.S. Population with Access to Various Advertised Broadband Download Speeds (Mbps)

	>3Mbps	>6Mbps	>10Mbps	>25Mbps	>50Mbps	>100Mbps	>1Gbps
All Broadband	98.18%	96.17%	94.39%	78.51%	75.15%	47.09%	3.17%
Wireline	93.41%	92.81%	90.91%	78.11%	74.85%	46.87%	3.17%
Wireless	94.37%	84.17%	80.66%	4.94%	3.03%	1.80%	0.00%

As with the ConnectME Authority's data, one must be cautious when drawing conclusions based on advertised speeds reported by service providers. That being said, the disparity between national and state data seems to support Maine's low national ranking in availability of Tier 5 and higher connection speeds.

On Islesboro, the primary type of communications technology utilized in homes and businesses is DSL. The following table shows how technology selection relates to delivered connection speeds nationally, based on the portion of the U.S. population with access to advertised download speeds:[7]

Figure 4: Percentage of U.S. Population with Access to Broadband Speeds by Technology Type

	>3Mbps	>6Mbps	>10Mbps	>25Mbps	>50Mbps	>100Mbps	>1Gbps
Cable	86.92%	86.95%	86.15%	76.42%	72.63%	44.20%	0.00%
DSL	73.51%	64.60%	47.39%	7.21%	0.11%	0.01%	0.00%
Fiber	20.20%	20.00%	19.86%	18.72%	18.25%	6.79%	3.16%
Fixed	34.33%	25.81%	10.89%	4.88%	2.99%	1.78%	0.00%
Mobile	91.81%	80.58%	78.67%	0.00%	0.00%	0.00%	0.00%
Copper	43.25%	15.37%	14.59%	1.46%	0.27%	0.12%	0.01%

[6] Pg. 5. *Four Years of Broadband Growth*, 2013. The White House Office of Science and Technology Policy & The National Economic Council.

[7] Pg. 6, *Four Years of Broadband Growth*, June 2013. The White House Office of Science and Technology Policy & The National Economic Council.

Lastly, it is interesting to compare broadband availability and adoption in urban and rural regions of the U.S. Nationally, urban areas have a 72 percent broadband adoption rate compared to only 58 percent in rural areas. The following table shows the availability of broadband access by street location:[8]

Figure 5: Broadband Availability by Urban and Rural U.S. Populations

	>3Mbps	>6Mbps	>10Mbps	>25Mbps	>50Mbps	>100Mbps	>1Gbps
Rural	91.1%	81.8%	74.3%	40.8%	37.6%	22.8%	1.2%
Urban	99.9%	99.6%	99.1%	87.5%	84.0%	52.9%	3.6%

As noted in the following sections, this is an important factor to consider when contemplating customer uptake and long term financial sustainability of the network.

Community Broadband Census

In order to better understand the current state of broadband availability on Islesboro, Tilson surveyed island residents, businesses, and schoolchildren to gather the following information:

1. Services that residents are currently using and how much they are paying.
2. An assessment of the adequacy of current service.
3. Service options residents would like to have to meet their current and projected needs.

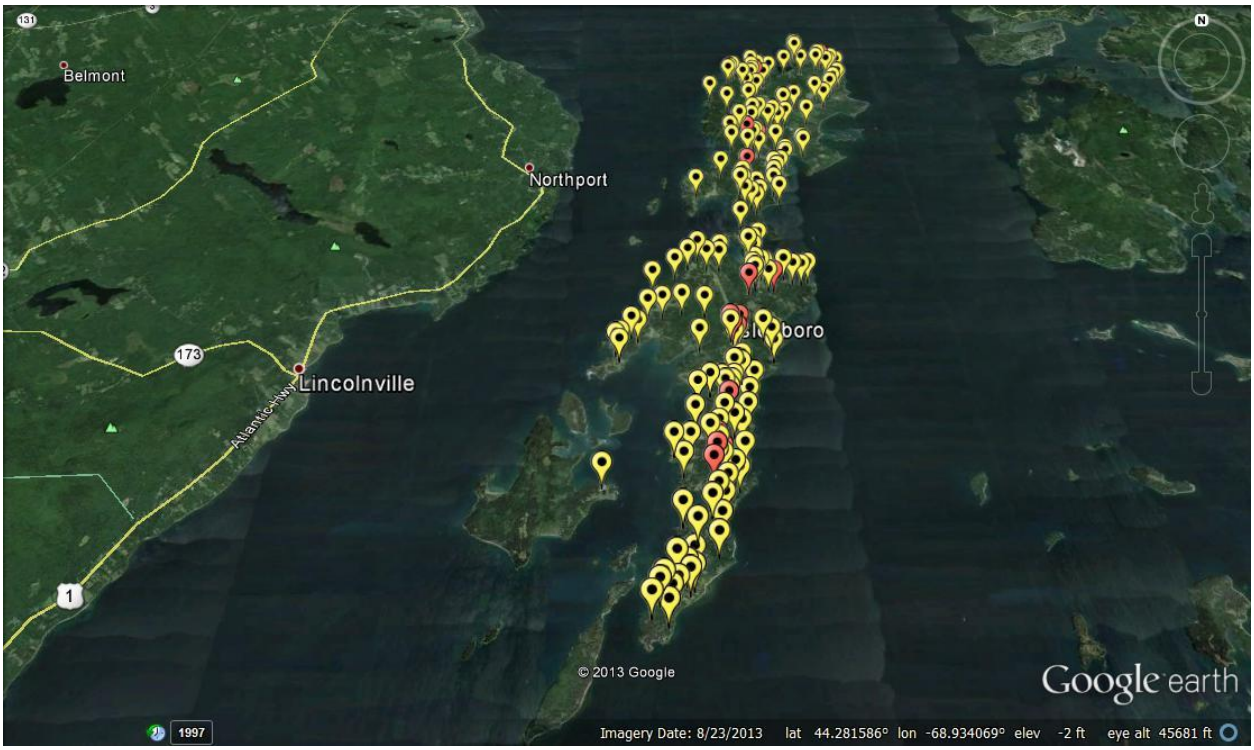
Respondents had the choice to complete Tilson's survey online or to submit a hard copy. 773 surveys were mailed in total, including 291 surveys to addresses on Islesboro for year-round residents, 411 surveys to off-island addresses for seasonal residents, and 71 surveys to on-island businesses. Tilson received 227 responses, 204 residential and 23 business, for an overall response rate of 29.4 percent. Tilson also collaborated with the Islesboro Central School to survey current high school students on their opinion of internet options on the island. Tilson received 24 student responses from 9th to 11th graders.

The geographic distribution of residential and business responses is fairly even across the island:[9]

[8] Pg. 11, *Four Years of Broadband Growth*, June 2013. The White House Office of Science and Technology Policy & The National Economic Council.

[9] Residential responses are shown in yellow and business responses are shown in red.

Figure 6: Geographic Distribution of Survey Responses

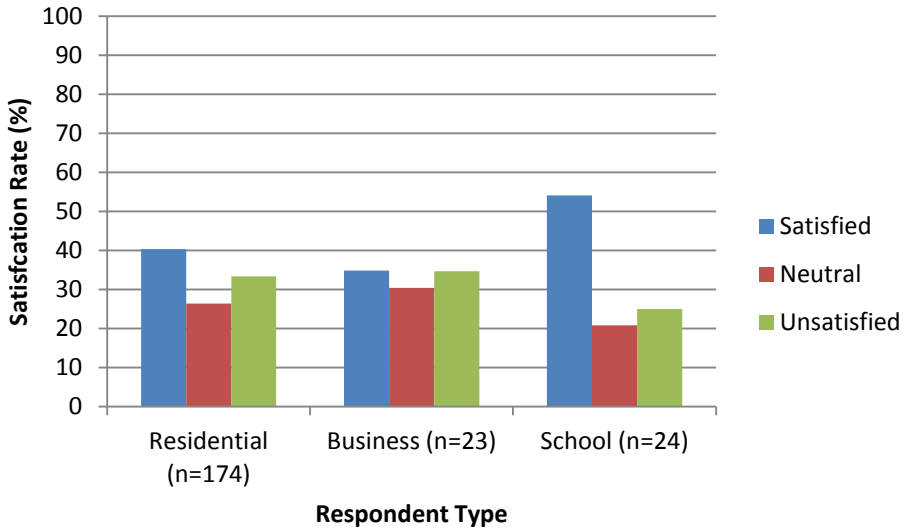


Copies of the residential, business, and school surveys are presented in the attached appendix, which include full survey results. For analysis purposes, all skipped questions by respondents were classified as "No response", and are not included in the percentages cited below.

There were several key findings in the survey:

- Overall, respondents reported higher satisfaction levels with current phone and video service than with current internet service.
- Both residential and business respondents expressed strong interest in improved internet service.
- Residential respondents did not indicate an overall willingness to pay more for improved internet service compared to current service pricing. Business respondents expressed a higher willingness to pay more for improved service, but not significantly.
- Survey responses seem to suggest market uptake of new phone and video services could be low.
- A majority of surveyed schoolchildren perceive internet options on the island to be high speed, but reported mixed satisfaction levels with current service.

Figure 7: Respondent Satisfaction with Speed of Current internet Service[10]



Residential Survey Results

As stated above, Tilson received 204 residential survey responses. 38 percent of respondents are year-round residents and 62 percent are seasonal residents. Respondents are generally older in age, with 65 percent over 60 years old compared to 31 percent between 40 and 59 years old and 5 percent between 20 and 39 years old.

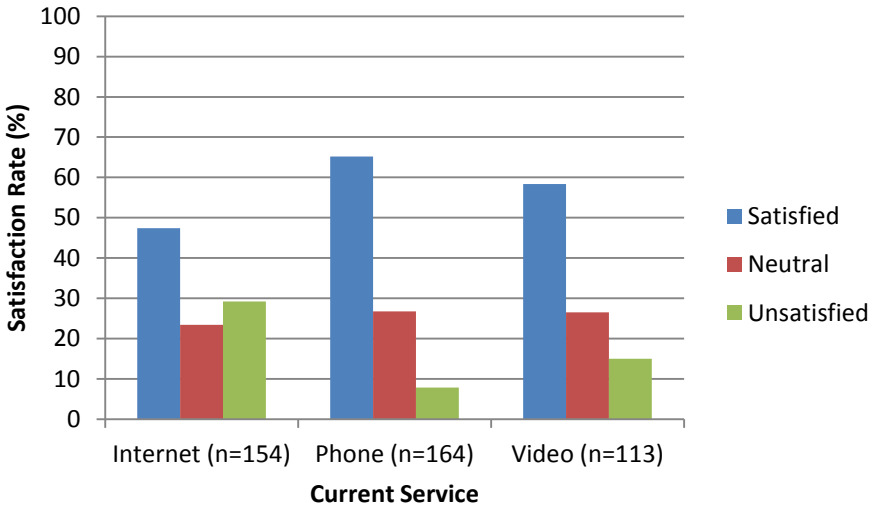
For subscription, 81 percent of residential respondents have an internet connection in their home on Islesboro. A majority subscribe to FairPoint's DSL service (88 percent), while some instead subscribe to Midcoast/GWI's fixed wireless service (12 percent). Half of those who do not have an internet connection in their home use a cellular hotspot for internet access. For use, respondents most commonly average between 1 and 3 hours per day (60 percent) using the internet at home. For price, two-thirds of respondents reported paying between $26 and $50 per month for internet service.

For phone and video, 82 percent of residential respondents subscribe to a phone service in their home on Islesboro and 56 percent subscribe to a video service. Of these households, 94 percent subscribe to FairPoint's phone service, whereas video subscription is divided between Dish (21 percent) and DirecTV (74 percent). Seasonal residents appear less likely to subscribe to video, as a majority of seasonal respondents (54 percent) do not currently have a video service in their home on Islesboro. For price, a majority of respondents (54 percent) pay between $25 and $50 per month for phone service. Video subscription costs vary, with 30 percent of respondents paying between $51 and $75 per month and 32 percent paying between $76 and $100 per month.

[10] Student satisfaction rates are based on connection speeds at students' homes.

Respondents reported higher satisfaction levels with current phone and video service than with current internet service. For phone, 65 percent of respondents expressed being satisfied with their current service, 27 percent are neutral, and 8 percent are unsatisfied. For video, 58 percent of respondents expressed being satisfied with their current service, 27 percent are neutral, and 15 percent are unsatisfied. For internet, 47 percent of respondents expressed being overall satisfied with their current service, 23 percent are neutral, and 29 percent are unsatisfied.

Figure 8: Satisfaction with Current Services among Residential Respondents



Year round and seasonal respondents produced relatively similar results for internet satisfaction: 43 percent of year round respondents are satisfied with current service, 22 percent are neutral, and 35 percent are unsatisfied. 51 percent of seasonal respondents are satisfied with current service, 24 percent are neutral, and 26 percent unsatisfied. Respondents were also asked if their satisfaction with the speed and reliability of current internet differed. 40 percent of respondents reported being satisfied with the speed of current internet service, 26 percent are neutral, and 33 percent are unsatisfied. 45 percent of respondents reported being satisfied with the reliability of current internet service, 20 percent are neutral, and 35 percent are unsatisfied.

When asked if they consider current internet service on the island to be high speed, respondents were almost equally split, with 52 percent believing current service qualifies as high speed. A majority of seasonal respondents (52 percent) did not believe current internet service is high speed, compared to 41 percent of year round respondents. For applications, respondents reported wanting to be able to do email (21 percent), web browsing (19 percent), streaming video (16 percent), peer-to-peer (12 percent), large file transfer (12 percent),

interactive video (7 percent), remote office connectivity (7 percent), and voice services (5 percent).

78 percent of residential respondents indicated that they are interested in an improved internet service, compared to 17 percent being neutral and 5 percent being uninterested. Of these respondents, 90 percent of year round respondents indicated being interested in an improved internet service, compared to 73 percent of seasonal respondents. When asked why they are interested in an improved service offering (if applicable), 41 percent of respondents cited the speed of current internet service, 32 percent cited reliability, 21 percent cited price, and 6 percent cited customer service. Overall, respondents did not indicate a strong willingness to pay more for an improved internet service compared to current service pricing, with 33 percent unwilling to pay any additional amount, 20 percent willing to pay up to $10 more per month, and 22 percent willing to pay an additional $11 to $25 per month.

Business Survey Results

As stated above, Tilson received 23 responses from businesses based on the island. Compared to residential respondents, business respondents were younger on average: 59 percent are between 40 and 59 years old and 41 percent are between 40 and 59 years old.

For subscription, all business respondents currently have an internet connection in their business. 83 percent of respondents work from home, 89 percent of who use the same internet connection for residential and business purposes. A majority subscribe to FairPoint's DSL service (91 percent), while some instead subscribe to Midcoast/GWI's fixed wireless service (9 percent). Business use varies, with 30 percent reporting average internet use between 0 and 1 hour per day, 26 percent reporting average use of 1 to 3 hours per day, and 35 percent reporting average use of more than 6 hours per day (35 percent). For price, a majority of respondents (53 percent) reported paying between $26 and $50 per month for service.

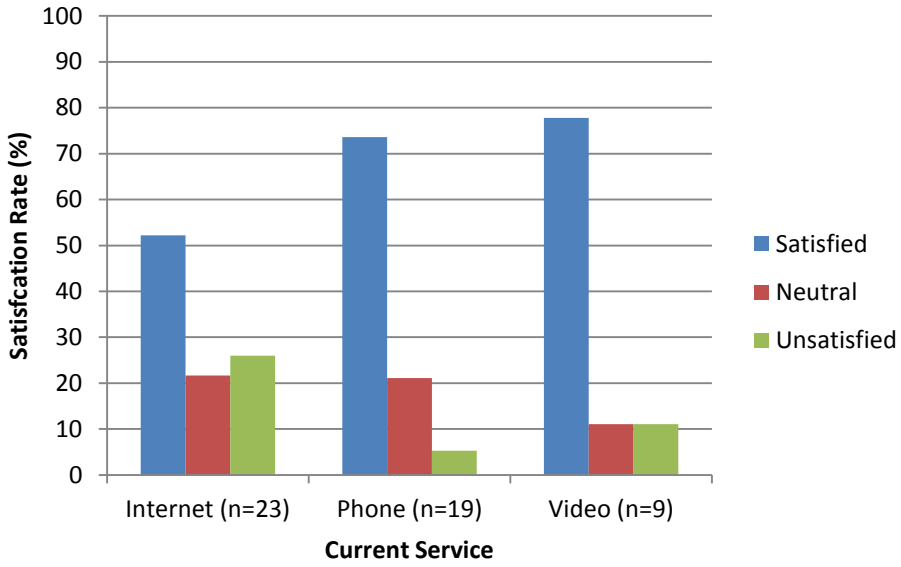
For phone and video, 70 percent of business respondents subscribe to a phone service and 46 percent subscribe to a video service. Of these, 90 percent subscribe to FairPoint's phone service and 75 percent subscribe to DirecTV's video service. For phone, 31 percent of respondents pay between $26 and $50 per month for phone service and 38 percent pay between $51 and $75. A majority of respondents (57 percent) pay between $76 and $100 for video service.

Like residential respondents, business respondents reported higher satisfaction with current phone and video service than internet service. For internet, 52 percent of respondents expressed being satisfied with their current service overall, 22 percent are neutral, and 26 percent are unsatisfied. For speed and reliability, 35 percent of respondents reported being satisfied with both aspects of current service, 30 percent are neutral, and 35 percent are unsatisfied.

For phone, 73 percent of respondents expressed being satisfied with their current service, 21 percent are neutral, and 6 percent are unsatisfied. For video, 78 percent of respondents

expressed being satisfied with their current service, 11 percent are neutral, and 11 percent are unsatisfied.

Figure 9: Satisfaction with Current Services among Business Respondents



When asked if they consider current internet service on the island to be high speed, respondents were almost equally split, with 52 percent believing current service qualifies as high speed. For applications, respondents reported wanting to be able to do email (18 percent), web browsing (18 percent), large file transfer (14 percent), streaming video (11 percent), peer-to-peer (11 percent), interactive video (11 percent), remote office connectivity (10 percent), and voice services (6 percent).

86 percent of businesses indicated that they are interested in an improved internet service, compared to 9 percent being neutral and 5 percent being uninterested. When asked why they are interested in an improved service offering, 37 percent of respondents cited the speed of current internet service, 26 percent cited reliability, 26 percent cited price, and 12 percent cited customer service. Overall, respondents indicated mixed willingness to pay more for an improved internet service compared to current service pricing, with 23 percent unwilling to pay any additional amount, 27 percent willing to pay up to $10 more per month, 14 percent willing to pay an additional $11 to $25 per month, and 14 percent willing to pay an additional $26 to $50 per month.

School Survey Results

Tilson received 26 responses from 9th to 11th graders currently attending Islesboro Central School. 39 percent of respondents are in 9th grade, 35 percent are in 10th grade, and 26 percent

are in 11th grade. Of these students, 18 live on the island full time, 1 lives on the island part time during the school week, and 7 commute daily from the mainland.

93 percent of respondents have an internet connection in their home, 74 percent of whom subscribe to FairPoint's DSL service. At home, 28 percent of respondents indicated they use the internet between 1 and 3 hours per day, 44 percent reported average use between 3 and 6 hours, and 24 percent reporting average use of more than 6 hours per day. At school, 19 percent of respondents indicated that they use the internet between 0 and 1 hour per day, 46 percent said between 1 and 3 hours per day, and 31 percent said between 3 and 6 hours per day. Respondents reported using the internet for web browsing (21 percent), email (20 percent), streaming video (18 percent), peer-to-peer (10 percent), online gaming (9 percent), large file transfer (9 percent), and interactive video (5 percent).

Respondents reported higher satisfaction with internet at school than service options available at their homes. 54 percent of respondents reported being satisfied with the speed of current internet service in their homes, 21 percent are neutral, and 33 percent are unsatisfied. By comparison, 67 percent of respondents are satisfied with the speed of current internet service at school, 21 percent are neutral, and 12 percent are unsatisfied. For reliability, 45 percent of respondents reported being satisfied with the reliability of current internet service, 20 percent are neutral, and 25 percent are unsatisfied. When asked if they consider current internet service on the island to be high speed, a majority of respondents (71 percent) believe current service qualifies as high speed. 75 percent believe current internet service at school is high speed.

Economic Impact of Broadband on Islesboro

Research has shown that investments in broadband infrastructure can dramatically improve economic development in rural communities. Broadband enhances productivity, makes firms more efficient, facilitates commerce, attracts jobs, increases consumer options, and saves residents money.

By transferring values from peer-reviewed economic valuations of the impact of broadband on communities, Tilson has developed estimates of the impact of the Town's proposed actions, with a focus on increasing gross domestic product (GDP), creating jobs, and enhancing consumer well-being on Islesboro.

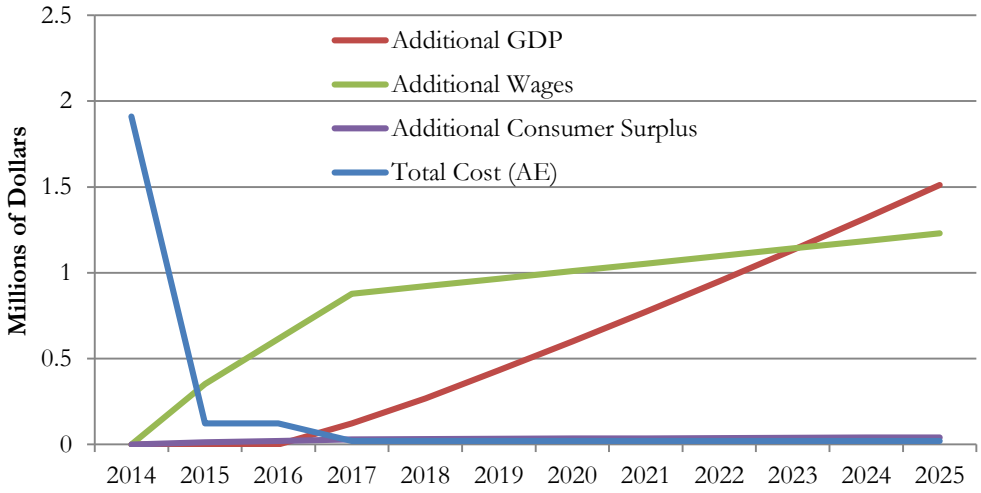
The economy of Waldo County, Maine has not grown substantially over the past ten years. While it is difficult to determine precisely how Islesboro's GDP has changed over this period, it likely has not deviated from the general trend of the area. Tilson believes developing universally-available broadband infrastructure on the island has the potential to increase GDP growth on the island from 0.3 percent to at least 1.2 percent in five years.

This estimate represents $8.8 million in additional goods and services sold on the island over ten years. This figure is open to debate. However, a large increase in broadband penetration

usually results in a significant increase in output. In a study of 22 Organization for Economic Cooperation and Development (OECD) member countries, Koutroumpis et al. (2009) found that an increase in broadband penetration of 10 percent added 0.25 percent to GDP growth on average.[11] In a similar study, Czernich et al. (2009) found that an increase in broadband penetration of 10 percent added 0.73 percent to GDP growth on average.[12]

A pertinent case study in the U.S. is Lake County, Florida, a rural area north of Orlando, which saw its economic output double relative to its neighboring counties within five years of a major broadband build out to the county's community anchor institutions (Ford and Koutsky, 2005).[13] Therefore, Tilson believes its estimates for Islesboro may be conservative. As shown in Figure 10 below, the positive impact of broadband development on Islesboro's economy compounds year after year while there is fixed upfront cost to deploy the network:

Figure 10: Additional GDP, Wages, and Consumer Surplus vs. Total Cost of Project



In addition to increasing local GDP, broadband development also creates jobs. Unlike economic output, which typically takes at least two years for communities to begin reaping the full effects of an investment, job creation occurs immediately. Broadband investments affect employment in three ways.

- Direct Jobs (telecommunications technicians, construction workers, and manufacturers of telecom equipment)
- Indirect Jobs (upstream suppliers and sellers of raw materials)
- Induced Jobs (from the household spending resulting from the new direct and indirect jobs)

[11] Koutroumpis, P. 2009. The economic impact of broadband on growth: A simultaneous approach. *Telecommunications Policy*. Vol:33, Pages: 471-485.

[12] Czernich, N., Falck, O., Kretschmer, T. & Woessman, L. 2009. Broadband Infrastructure and Economic Growth. *The Economic Journal.* Vol: 121, Pages: 505-532.

[13] Ford, G. and Koutsky, T. 2005. Broadband and Economic Development: A Municipal Case Study from Florida. *Review of Urban & Regional Development Studies. Vol: 17, Pages: 219-229.*

These jobs tend to be higher paying, technology-oriented jobs, some of which are temporary but many are stable and more or less permanent improvements to the region's economy. A study of broadband development in rural Kentucky found that every 1 percent increase in broadband adoption yielded a 0.14 percent increase in employment (Shideler et al. 2007).[14] This factor suggests that 30 new jobs will be created in the mid coast Maine region (not all on Islesboro) by 2025 as a result of the Selectmen's proposed actions. Assuming these jobs pay Waldo County's median wage, Tilson estimates approximately $1.1 million in state and local tax revenue will be generated over the next ten years.

Lastly, broadband investments increase consumer surplus. Consumers are not necessarily better off just because economic output increases. An increase in GDP just means that they are spending more. That being said, broadband access empowers consumers to both pay less for goods than they otherwise would have purchased and to purchase goods and services that were not available before. For example, broadband allows consumers to enjoy almost limitless video content for little or no cost. Without it, consumers pay more to rent films and or subscribe to satellite television. This phenomenon is termed "consumer surplus".

For the purposes of this exercise, consumer surplus is defined as the amount that consumers benefit from purchasing a product for a price that is less than what they would be willing to pay. In a study of the 40 million U.S. households with access to broadband, Greenstein and McDevitt (2009) found that broadband access increased consumer surplus by between $120 and $167.50 per household, per year.[15] Tilson's economic analysis assumes that year round Islesboro residents would enjoy this full benefit while seasonal residents would enjoy 30 percent of consumer surplus benefit. This translates to a total increase in surplus of between $330,000 and $460,000 for Islesboro.

Overall, Tilson believes that investment in broadband on Islesboro would be a strong contributor to economic development on the island and offers a range of public benefits. Improving broadband access would supplement Islesboro's traditional economic activities, while also supporting conditions needed to foster a new, low impact economy. Due to these added public benefits, Tilson recommends that investment in broadband infrastructure is considered not only through a lens of the network's profitability, but also through a long-term investment in the sustainability of the community and economic development on the island.

[14] Shideler, D., Badasyan, N. & Taylor, L. 2007.The Economic Impact of Broadband Deployment in Kentucky. *Regional Economic Development*. Vol: *3*, Pages: 88-118.

[15] Greenstein, S. and McDevitt, R. 2009. The Broadband Bonus: Accounting for Broadband Internet Impact on U.S. GDP. NBER Working Paper No. 14758.

Strategies for Improving Broadband on Islesboro

Tilson is not aware of any privately-funded broadband upgrades being planned for Islesboro, and doubts that there is a business case in the future to do so. As there is not a viable market-based business case for an existing commercial internet service provider to invest the full amount required to improve broadband facilities on the island, the incumbent service provider, FairPoint, or a new service provider would need to receive an external investment to be enticed to pursue a project on Islesboro. This investment could come from a number of different private or public sources.

As the Town Selectmen have expressed that taking no action to improve broadband availability on the island is not viable, Tilson proposes the following strategies:

1. The Town partners with the incumbent service provider, FairPoint, to upgrade existing facilities on Islesboro to serve all premises on the island at faster speeds. FairPoint would construct, maintain, operate, and provide service on the network and would cover all ongoing operating costs. Based on our initial conversations, FairPoint would need some additional external investment of an as yet undetermined amount to do so.

2. The Town partners with Time Warner Cable to build a new DOCSIS 3.0 cable network on Islesboro, which would be the same technology that Vinalhaven and North Haven have, and provide internet, voice, and video service to all premises on the island. Time Warner would construct, maintain, operate, and provide service on the network and would cover all ongoing operating costs. Based on our initial conversations, Time Warner would need some additional external investment of an as yet undetermined amount to do so.

3. The Town partners with another existing commercial internet service provider, such as Axiom, GWI, OTT or Tidewater Telecom, to build a fiber-to-the-home network on Islesboro serving all premises on the island. The service provider would construct, maintain, operate, and provide service on the network and would cover all ongoing operating costs. Based on our initial conversations, these carriers would need some additional external investment of an as yet undetermined amount to do so.

4. A private community-oriented entity builds a fiber-to-the-home network to all premises on the island. The entity would construct, maintain, and operate the network. The entity could partner with a private internet service provider to provide service to customers. The entity would own the network and be responsible for all ongoing operating costs, which would be paid using network revenues from customer subscriptions.

5. The Town pursues a joint venture with a private community-oriented entity to build a fiber-to-the-home network to all premises on the island. The venture would construct, maintain, and operate the network. The venture could partner with a private internet service provider to provide service to customers. The venture would own the network and be responsible for all ongoing operating costs, which would be paid using network revenues from customer subscriptions.

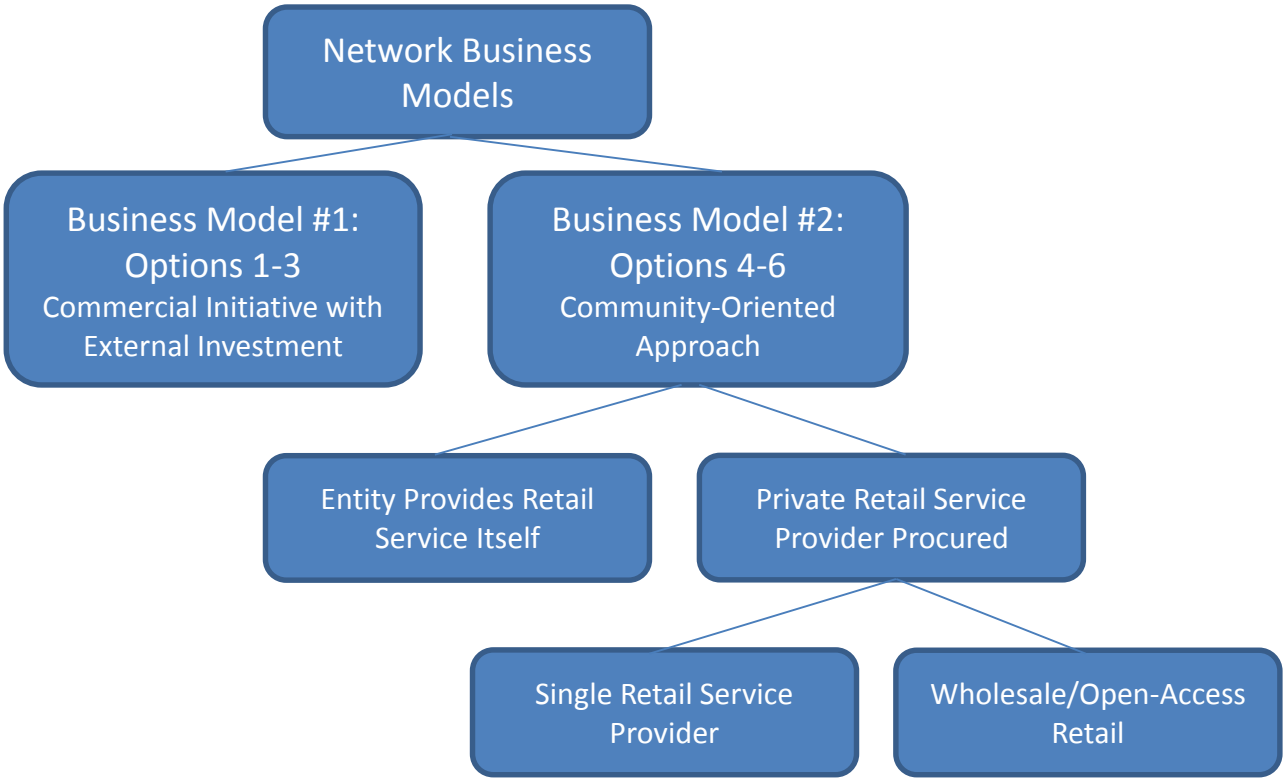
6. The Town builds a fiber-to-the-home network serving all premises on the island. The Town could partner with a private internet service provider to provide retail service to customers. The Town would own the network and be responsible for all ongoing operating costs, which would be paid using network revenues from customer subscriptions.

As the Town explores these possible scenarios, Tilson believes the six options fall into two primary business models:

1. Business Model #1: Commercial Initiative with External Investment (Options 1-3)
2. Business Model #2: Community-Oriented Approach (Options 4-6).

As the Town evaluates which of the six options is best for residents and businesses moving forward, each business model has a number of factors the Town should consider. The following section details the feasibility of partnering with industry, considerations for each business model, and lessons learned from other municipal broadband projects to help steer the Town's decision making process:

Figure 11: Business Model Options



Market Survey

Tilson conducted a general market survey of six Maine-based commercial internet service providers and the incumbent service provider on the island, FairPoint, to gauge interest in collaborating with the Town:

The following service providers expressed interest in participating in the Town's initiative:

Business Model #1: Commercial Initiative with External Investment

- Potentially interested parties include Axiom Technologies, FairPoint Communications, GWI, Tidewater Telecom, and Time Warner Cable.

Business Model #2: Community-Oriented Approach

- Potentially interested parties include Axiom Technologies, GWI, OTT Communications, and Tidewater Telecom.

Axiom indicated interest in participating in either business model and has a track record for effectively advancing broadband in hard to serve coastal communities. The company is expanding its presence in the mid coast area with new operational support based in Rockland. However, Axiom currently provides service primarily using a fixed wireless technology, and does not have commercial experience providing fiber to the home. Tilson believes Axiom's potential

for contributing capital to a new build is limited, and the company could play a more effective role as a service provider on the network. Axiom does not have its own IP video product.

Tilson met with FairPoint to discuss the potential for upgrading existing service on the island. There are two potential ways to do so, both of which would utilize existing fiber infrastructure on the island to provide faster speeds. First, FairPoint could install additional remote terminals to provide fiber-to-the-node in neighborhoods with copper connections between the node and a customer premise for an advanced DSL service. Second, FairPoint could build a fiber-to-the-home (FTTH) network to every premise on the island. Tilson proposed these two scenarios during the meeting, and FairPoint was clear that external investment would be required to entice the company in either case. Tilson requested a range of external investment contribution for each option, and FairPoint indicated they would welcome a further conversation on that topic.

GWI indicated interest in participating in either business model. However, Tilson believes GWI's potential for contributing capital is limited, and the company could play a more effective role as a service provider on the network. GWI does have some limited experience providing fiber to the home. GWI does not have its own IP video product.

OTT Communications indicated interest in participating in the second business model as a service provider, as OTT currently has limited capital availability recently emerging from bankruptcy. Like GWI, OTT does not have its own IP video product; the company bundles internet and voice service with a satellite video provider.

Oxford Networks is not interested in participating in either business model. Oxford recently built a FTTH network in Lewiston, ME. However, due to slow customer uptake on the network, the company has shifted its efforts away from the residential market and is focusing all available new capital investments on business service.

Tidewater Telecom indicated interest in participating in either business model. Tidewater has its own IP video product. Tilson provided Tidewater's engineering team with road mileage, parcel lot, and premise location data to conduct further due diligence to be able to provide the Town with an understanding of the level of external investment might be required.

Time Warner Cable (TWC) indicated interest in participating in the first business model as a network owner. TWC was clear that external investment would be necessary for the company to build a DOCSIS 3.0 cable network on the island. Tilson provided TWC's engineering team with road mileage, parcel lot, and premise location data to conduct further due diligence to be able to provide the Town with an understanding of the level of external investment contribution required.

Business Model Considerations

In terms of service quality, FTTH would deliver a higher quality service than a DSL or cable system that uses a hybrid fiber/copper-based system. That being said, there are a number of other factors the Town needs to consider to determine which business model is the right fit for the community moving forward, including:

- Cost
- Competition
- Long-term financial sustainability
- Operational responsibility
- Customer service

Cost: Costs are more fully detailed in the next section. In Business Model #1: Commercial Initiative with External Investment, Tilson estimates between $1.24 million and $2.48 million of upfront investment would be needed to entice a commercial service provider, either FairPoint or another company, to construct, maintain, operate, and provide service on a network on the island.

In Business Model #2: Community-Oriented Approach, Tilson estimates $1.6 million would need to be raised to cover the fixed upfront cost of constructing the backbone fiber-to-the-curb (FTTC) network, and up to an additional $880,000 to construct customer connections to every premise on the island. The incremental investment range will depend on the type of FTTH technology the entity selects and how variable costs for customer connections are covered.

Comparing the two business models, Tilson appreciates the importance of cost and the difficulty in choosing a model without a more specific range for external investment contribution. However, it is difficult to confidently state a more specific amount at this point in time as a private company bidding on a competitive procurement would need to complete an in depth engineering analysis that models their construction and operating costs. Tilson recommends that the Town proceeds into a formal process to procure specific information from service providers about the required amount of investment needed to pursue a commercial initiative. With this information in hand, the Town will be able to better understand the needs for network construction, maintenance, network operation, and service provision moving forward.

Competition: In Business Model #1, the Town would maintain the current relationship structure that is has with an incumbent service provider if it chooses FairPoint to upgrade existing facilities or another company to construct a new network. By this, we mean that the Town will not have ownership of the network or operational responsibilities.

In Business Model #2, the network owner would operate the network facilities, and have the ability to select service provision through a competitive procurement process. This opens up potential opportunity to pursue an open-access, wholesale retail model where network customers could choose among multiple service providers. However, due to the small number of customers on Islesboro, Tilson does not believe the local retail market could effectively support a wholesale, open-access model with multiple service providers. While competition would benefit customers, the island does not have a sufficient customer base. Therefore, the network owner would either have to select a private service provider or provide service itself.

Partnering with other communities in a cooperative structure might help build economy of scale for a better broadband business model. However, Islesboro should carefully weigh that benefit against the potential 'deal complexity' that it might introduce. Such an analysis is beyond the scope of this report, but as part of the close out of this phase of planning, Tilson would be happy to facilitate a discussion about such a model, and then study it in greater detail as part of a follow-on engagement.

Long-term financial sustainability: In addition to the investment required to construct a network, maintaining, operating, and providing service on a network entails a number of ongoing expenses. Commercial network owners use revenues generated from customer subscriptions to cover these fees. Revenues are based on pricing for telephone, internet, and video service, which service providers offer as a single or bundled option.

In Business Model #1, the commercial service provider would cover these annual fees in the same way that FairPoint currently does. In other words, the Town would not have any long term financial risk in paying the network's ongoing operating expenses.

In Business Model #2, the network owner would be responsible for using the revenues generated by customer subscriptions to cover its operating costs. Tilson assumes that a community-oriented approach would include a basic phone and internet service offering on the network. As evidenced in the Town survey results, many residents currently subscribe to satellite video service as well, such as DirecTV or Dish. Provisioning video service would require IPTV technology on a FTTH network.

This is an important point to consider for two reasons. First, if video service is not offered on the network or customers do not want to switch from satellite service to IPTV, the network owner loses a substantial revenue stream. Without this revenue stream, the network owner must consider if revenues from phone and internet service can cover the annual operating costs of the network. Second, not all retail service providers are able to deliver IPTV service because doing so requires a significant investment in network head end equipment. These points are important to consider in the context of long-term financial sustainability and customer satisfaction.

Tilson estimates annual operating costs for a FTTH network would be approximately $206,000 per year: [16]

CMP & FP Pole Attachment Fees	$	31,500
CMP Dark Fiber Lease	$	8,200
State Telecom Taxes	$	21,700
Pole Work	$	10,500
Cable Replacement	$	5,000
Internet Uplink	$	39,000
General & Administrative	$	90,000

General and Administrative costs assume the network owner employs one full-time employee to perform necessary field services and back office administration during network operations, as detailed below. Tilson also estimates that the network owner would need to consider including some costs for marketing efforts on the island. This would be a non-recurring cost, and would not necessarily need to be spent all at once.

Operational responsibility: If the Town pursues a commercial initiative, the chosen partner would perform all the necessary responsibilities that go along with operating a network. If the Town pursues a community-oriented approach, there are a range of day-to-day responsibilities that would require staffing by the network owner. Operating a residential broadband network requires on-call maintenance services 7 days per week, 24 hours per day, and 365 days per year, which would necessitate hiring at least one full-time employee to perform service provisioning and troubleshooting, network maintenance, invoicing and collections, regulatory and contract compliance, and marketing.

Operational responsibilities include the following field services and back office administration:

- Add-move-change management. Management of all network moves, adds, and changes.
- Maintenance coordination. Route maintenance management, including coordination with the Dig Safe program to ensure that all locates are marked in a timely fashion.
- Department of Transportation (DOT) and local road job management. Processing of all road job notices, including identifying impacted facilities, managing contractors, ensuring timely transfers, performing road job impact evaluations, and reporting evaluation results.
- Management of a tree trimming program. Providing route patrolling, planning, and oversight of contractors, and manage third party tree trimming contractors when tree trimming is needed.

[16] GWI provided quotes for several tiers of internet backhaul. They recommended 500 Mb as sufficient bandwidth based on the number of customers on Islesboro, with a cost of $3,250 per month. GWI examined another network they operate with 1 Gb uplinks to 500 units (~2,000 customers), and peak utilization on the network is less than 200 Mb. For comparison, a 1 Gb uplink would cost $5,000 per month and a 2 Gb uplink would cost $7,750 per month.

- Restoration management. Management of all restoration activities following network damage (e.g., hurricane blow-down, pole strikes from cars, etc.), including notification and communication with customers and local management of restoration crews.
- ISP maintenance. Maintenance of networking equipment and mechanical systems in CO location(s).
- Contract administration. Includes license agreement management with pole owners.
    - Logistics support, inventory management (including critical spares), and warranty management.
- Insurance claim management. Administer insurance claims for casualty claims around matters such as pole strikes and fires.
- Regulatory matters. Perform required Public Utilities Commission reporting (annual, accident, etc.) and monitoring of relevant PUC rulemaking and other regulatory matters that affect the network.

This work can be contracted to outside parties; Tilson performs these activities for several clients. However, it is critical that the Town understands that a community-oriented approach entails a need for network owner to take a long term role in network operations.

Customer service: At the beginning of Tilson's engagement, the Town Selectmen expressed a concern that residents are not satisfied with current customer service by the incumbent service provider, in particular with prolonged, widespread service outages experienced after a recent storm.

In Business Model #1, customer service would depend on the company with which the Town chooses to partner. There are two primary components to customer service: field service and administration. For field service, the Town should consider if the company will have field staff located on the island full time or in close proximity to be able to perform troubleshooting and resolve customer problems quickly. For administration, the Town should consider if customers will be able to easily access support staff to resolve issues with billing or changing service.

In Business Model #2, a community-oriented approach would give the Town more local control of customer service. That is not to say that customer service would be inevitability better than under the commercial initiative; the network owner would have full responsibility for performing field service and administration. If the network owner decides to contract out facets of operations, the Town should consider where these resources are located and how their placement would affect response time and accessibility.

Business Model Case Studies: Chattanooga, TN and Leverett, MA

To date, the industry standard for FTTH has been Verizon FiOS. First announced in 2004, Verizon initially planned to invest $23 billion over ten years to construct FTTH facilities to 19 million homes throughout the Northeast U.S. The network offers customers a bundled service of internet, phone, and video with download speeds up to 50 Mbps, making FiOS internet approximately five times faster than the average Northeast cable company's service. [17]

During the network build out, Verizon's average fixed FTTC and variable costs were observed to be roughly $700 per premise and $650 per premise respectively, totaling $1,350 per premise. However, Verizon has struggled to recuperate its capital investment in the network due to slow service uptake, and, the company announced in September 2012 that it would discontinue FiOS deployment.[18] Today, FiOS is only available in the Northeast's primary metro areas, including Boston, New York City, Philadelphia, and Washington D.C.

Recognizing the public value of broadband access and the limited number of advanced projects undertaken by the private sector, a number of U.S. cities have initiated their own plans to develop broadband networks. New York City began planning the nation's largest outdoor WiFi wireless network in late 2013, which will cover 95 blocks in Harlem and will provide free 2 Mbps download speeds to the area's 80,000 residents.[19] Los Angeles is planning a fiber-based network to provide free internet service to its 3.5 million residents with download speeds between 3 Mbps and 5 Mbps.[20]

In addition to these ambitious plans in major urban centers, smaller cities and municipalities across the country have also undertaken initiatives to improve broadband access for citizens and local businesses. Two of these efforts by Chattanooga, TN and Leverett, MA are both pertinent to Islesboro's initiative and can provide important lessons learned and considerations for the island:

1. Chattanooga and Leverett both utilized municipal bonds to construct their FTTH networks.
2. Chattanooga and Leverett established municipally-owned entities to perform the range of responsibilities in network operations and assume financial risk of operations.
3. Leverett's network will not provide a video product, whereas Chattanooga's network delivers an IPTV service.
4. Chattanooga is served by a municipally-owned power utility, which decreased capital costs of constructing the network due to lower make ready expenditures.

[17] Customers have the option to upgrade to 100 Mbps.
[18] http://www22.verizon.com/idc/groups/public/documents/adacct/goldman_vz_transcript_092012.pdf
[19] Story is available at http://mashable.com/2013/12/10/new-york-city-harlem-wi-fi-network/.
[20] Story is available at http://www.theverge.com/2013/11/5/5070520/los-angeles-planning-to-bring-free-fiber-based-internet-to-its-residents.

Chattanooga, TN

The Chattanooga Electric Power Board (EPB) is a municipally-operated power utility serving the City of Chattanooga, TN. EPB has been a national leader in using fiber infrastructure to improve power service and broadband availability for residents and businesses. After deploying fiber in pieces of its distribution system, EPB decided to undertake a citywide deployment to fully automate its infrastructure serving 170,000 homes, businesses, and devices (street lights, substations, etc.).[21]

As a power utility, EPB's primary goal was to install 1,200 switches throughout its distribution network and advanced metering infrastructure at all premises in the city. EPB designed an 8,000-mile fiber network passing all 170,000 service locations, which it planned to deploy over 10 years starting in 2008. However, in 2010, EPB received a $111 million federal ARRA grant from the Department of Energy, which enabled the organization to advance construction to be completed in three years. The total project cost approximately $340 million; the city passed a $229 million municipal bond to provide matching funds. The loan was structured so that EPB's electric division would loan the cable/internet division sufficient funds, and then the loan would be repaid using revenue generated from network subscriptions.

Now fully built, EPB's fiber network has been a resounding success. For power service, EPB's automated switches have cut outage durations by over 60 percent. Moreover, with fiber passing every home and business in the city, totaling roughly 150,000 premises, EPB created a division to provide retail internet, voice, and video services to customers.[22] EPB's FTTH network is a GPON design, meaning it has a passive architecture with bandwidth capabilities up to a Gigabit per customer.

For retail service, EPB initially offered three tiers of internet at symmetrical speeds of 15 Mbps, 30 Mbps, and 50 Mbps. However, after realizing it did not have to invest additional capital to advance service speeds, EPB has doubled delivered upstream and downstream speeds in each subsequent year. Today, EPB offers two tiers of internet service: symmetrical 100 Mbps for $57 per month and symmetrical 1 Gpbs for $69 per month.[23] Customers can also purchase bundled services: an internet and TV package costs $110 per month and a Triple Play package (internet, phone, and video) costs $125 per month. EPB has achieved market uptake above its initial projections, with 53,000 current residential customers and 4,500 business customers.

Like Islesboro, EPB had to initially decide if it wanted to own and operate a FTTH network and provide retail service. After deciding to pursue a FTTH solution, EPB was sued by Comcast and the Tennessee Cable Television Association.[24][25] Both parties claimed that EPB was improperly

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[21] Information on EPB's network was obtained in a phone interview with Danna Bailey, EPB's VP Corporate Communications (baileydk@epb.net).

[22] EPB purchased and operates its own IPTV head end, which has High Definition service capabilities.

[23] Basic VoIP phone service starts at $23 per month.

[24] *Comcast of the South v. Electric Power Board of Chattanooga.* Court of Appeals of Tennessee at Knoxville. Filed May 13, 2009. Available at http://www.leagle.com/decision/In%20TNCO%2020090513587.

using electric utility funds to subsidize its cable/internet venture. However, both lawsuits were dismissed on the basis that the case did not present a justifiable controversy and the parties did not have standing to bring the action.

In terms of operational responsibilities, EPB cited implementing business systems, adapting customer service culture to include a focus on marketing, and provisioning/troubleshooting service inside customers' homes as challenges to which the organization had to adapt when it became a network operator.[26]

Overall, EPB's efforts have provided a model for cities around the U.S. on how to effectively advance power and telecom service for residents.

Leverett, MA

The town of Leverett, MA is located roughly 30 miles north of Springfield, MA. Like Islesboro, the town's residents have limited access to broadband infrastructure, which currently consists of satellite service and limited DSL coverage with speeds in the single-digit Mbps range. To address the issue, a municipal bond issue was approved in April 2012 to finance the construction of a town-wide FTTH network.

This FTTH network will connect to the internet via the MassBroadband123 middle mile network, which, like the Three Ring Binder in Maine, was ARRA-funded.[27] The MB123 network offers open-access middle mile fiber throughout central and western Massachusetts, where there was previously minimal fiber-based communications infrastructure.

Leverett's proposed FTTH network is similar in scope to Islesboro's project. The network will have an Active Ethernet architecture that serves approximately 800 premises and covers 39 road miles. Once constructed, the network will be managed by a Municipal Lighting Plant (MLP) entity owned by Leverett.

In terms of service, the Town is planning for the network to provide broadband internet access and phone service to subscribing households and businesses, but no video service. The Broadband Committee has selected the following standards for the network:

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[25] *Tennessee Cable Telecommunications Association v. Electric Power Board of Chattanooga.* Court of Appeals of Tennessee at Nashville. Filed August 26, 2009. Available at http://www.leagle.com/decision/In%20TNCO%2020090827620.

[26] As a power company, EPB had previously only worked on the exterior of customers' homes. With telecom service requiring technicians to enter premises to install and repair service, EPB made a concerted effort to train field staff on best practices for working inside homes.

[27] MB123 is owned by the Massachusetts Broadband Institute, a state agency, whereas the Three Ring Binder is owned by Maine Fiber Company, a privately held company.

- The network will connect every household in Leverett, regardless of distance, household density, or service usage.
- The fiber count capacity will be enough to reach all developed and undeveloped parcels of Leverett and provide redundancy.
- The network will be built with the capacity to serve cell towers which could eventually be built near the network.
- Leverett will own the network infrastructure from the middle-mile nodes up to, and including, the optical network terminals at the customer premise.
- The network will provide a 1 Gbps symmetrical connection for every customer that orders service.
- There will be a private party who operates as a single point of contact for one-call trouble-shooting and customer service.
- The network will include the capability to support "smart-grid", medical monitoring operations, and other high-bandwidth/high-availability operations.
- The network will be serviced by third-party network maintenance, including routine and disaster-related services under contract with either the MLP or the service provider/operator contracted by the MLP.

Like Islesboro, the Town's efforts to date have been guided by the Town Select Board. The three-member board has been supported by a Broadband Committee composed of six volunteer residents with domain expertise. In November 2011, the group secured a planning grant of $40,000 from the Massachusetts Broadband Institute, the owner of the MB123 network, to design the network. The Town subsequently conducted a competitive procurement to select a firm to perform a detailed FTTC design.[28]

Following the completion of the design and approval of public funds, the Town released a Request for Information (RFI) in September 2012 to gauge industry interest in providing services as a construction, maintenance, network operator, or service provider vendor. A copy of the RFI has been attached as an appendix to the report.[29] The RFI provides a useful framework to understand the roles of various players involved in the construction and operations of the network:

> ***Construction***: Firms which provide fiber cable installation and required construction services including, but not limited to, digging trenches and duct banks, building conduit, pulling cable, erecting facilities, installing initial electronics, and other functions to connecting the network together or to users.
>
> ***Maintenance***: Firms who repair broken fiber cables, provide replacement fiber, fix broken aerial structures, replace compromised facility structures, and generally keep the network's physical elements in working order

[28] A copy of the Request for Proposals (RFP) is included as an attachment.
[29] Industry responses can be found on the Town's website: https://www.dropbox.com/sh/mh6fjdqqrx0fjwp/k9XUwh7Q31.

Network Operator: Firms responsible for the operation of the network including managing the performance of the switches, servers, software, and data traffic within the network. The Network Operator will have the relationship with the network hubs and interconnections, run the Network Operations Center, and dispatch maintenance and other technical resources to provision, maintain, and repair the network as needed

Service Provider: Firms who manage the customer relationship, either directly or white-labeled as the MLP. These firms handle billing, process payments, provide customer relations, provide technical support, undertake home installations, and serve as a customer service contact

In May 2013, the Town released a Request for Proposals (RFP) for FTTH installation, splicing, termination, testing, and maintenance services. The Town received eight responses and selected Millenium Communications Group, a New Jersey-based telecom firm, as the contractor to build the network. Millenium's bid amount was $2,275,731.

The Town has yet to release an RFP for providing service on the network. An important difference between Islesboro and Leverett to note is that there is state-led effort in Massachusetts to build last mile service off the MB123 network. The Commonwealth recently approved $40 million for the last mile effort. Therefore, municipalities in central and western Massachusetts face a different dynamic in terms of network operations and retail service than communities in Maine that have access to the Three Ring Binder.

The Town's primary point of contact for questions and issues related to the FTTH effort is the Leverett Town Administrator, Marjorie McGinnis (townadministrator@leverett.ma.us). Additional information on the Leverett Broadband Committee's work can be found on the Town's website: http://leverett.ma.us/content/broadband-committee.

Investment Required to Improve Broadband on Islesboro

As stated before, Tilson does not believe there is a viable market-based business case for an existing commercial internet service provider to invest the full amount required to improve broadband facilities on the island. As a result, the incumbent service provider, FairPoint, or a new service provider would need to receive external investment to be enticed to pursue a project on Islesboro.

In Business Model #1: Commercial Initiative with External Investment (Options 1-3), Tilson estimates between $1.24 million and $2.48 million of upfront investment would be needed to entice a commercial service provider, either FairPoint or another company, to construct, maintain, operate, and provide service on an improved network on the island. This amount covers a range of 50 percent to 100 percent of the estimated cost to construct a FTTH network on the island. Advanced DSL and DOCSIS 3.0 cable construction costs run approximately in the same range.

In Business Model #2: Community-Oriented Approach (Options 4-6), Tilson estimates a total investment of $2.48 million would be required to construct a new FTTH network on the island, with a fixed cost of $1.6 million. This capital amount could be raised through private contributions, a municipal bond, property taxes, or other means, depending on how the owning entity is structured and governed. Moving forward, the network owner would be responsible for covering annual operating costs, which Tilson estimates would be $206,000 per year.

For Business Model #2, Tilson developed a capital model that includes costs for the labor, materials, and professional services needed to construct an active or passive FTTH network on Islesboro and an active FTTH network on Seven Hundred Acre Island and Minot Island:

Figure 12: Cost Estimates of Network Options

	Islesboro AE	**Islesboro PON**	**700 Acre Island AE**	**Minot Island AE**
Total Cost	$ 2,477,341	$ 2,245,933	$ 113,890	$ 54,322
FTTC Cost	$ 1,603,720	$ 1,606,245	$ 95,514	$ 49,195
Per Mile Cost (FTTC)	$ 37,858	$ 37,920	$ 33,686	N/A
Per Mile Cost (FTTC+Variable)	$ 58,481	$ 53,018	$ 40,167	N/A
FTTC Cost Per Premise	$ 2,127	$ 2,130	$ 6,368	$ 12,229
Variable Cost Per Premise	$ 1,159	$ 848	$ 1,225	$ 1,282
Total Cost Per Premise	$ 3,286	$ 2,987	$ 7,593	$ 13,511

Fiber-to-the-Home Cost Estimate

The total cost of each FTTH design includes the following components, which are detailed in the attached appendix:

- Construction
  - Make ready
  - Aerial installation
  - Conduit installation[30]
  - Fiber cable
  - Splicing
  - Traffic control
- Professional Services
  - Project management/engineering
  - Legal and regulatory
- Network Gear
- Microwave Links (only applicable for Seven Hundred Acre Island and Minot Island)
  - 1 Gbps FDX equipment
  - Installation
- Customer Connections/Service Drops
- Bonding
- 10% Overall Contingency

As stated in the Executive Summary, the network costs contain two components: a fixed capital expenditure needed to construct facilities that pass each premise on the island and a variable cost for connecting homes and businesses with service from the street curb. The fixed FTTC amounts presented above include all costs for construction, professional services, microwave links (for Seven Hundred Acre Island and Minot Island), bonding, project contingency, and fixed network gear. Variable costs include service drops and variable network gear. Network gear is broken out into fixed and variable components because certain equipment must be installed to serve the first network customer (cabinet and chassis), while other equipment (cards and SFP) can be purchased and installed as additional customers subscribe to the network.

Tilson's cost estimates assumed that all service drops from the FTTC network are aerial connections. The Selectmen have indicated that some service drops will be underground, so Tilson has included an option in its model for installation of new conduit for service drops. As properties across the island have varying driveway lengths and visual preferences, individual household connections will cost different amounts and the network owner must consider how these variable costs will be covered. In a desktop survey, Tilson estimated an average 250 foot service drop length per premise for the island. Average connection costs are estimated to be $1.67 per foot for aerial installation. Estimated underground costs for service drops in new conduit would be $2.79 per foot.

[30] Since there are no utility poles on Minot Island, Tilson assumed fiber would be installed in conduit that would be laid directly on the ground, not buried.

In Business Model #2, the network owner will need to obtain regulatory approval as a competitive local exchange carrier (CLEC) from the Maine Public Utilities Commission. CLEC status is required to execute a pole attachment agreement with CMP and FairPoint, the owners of existing utility poles on the island, which is needed to be able to install fiber cable in the public right-of-way.

Fiber-to-the-Home Network Design

Tilson believes the FCC's Tier 5 threshold for both download and upload speeds (10 Mbps), with scalability to 1 Gbps service without major recapitalization, is well suited to be a universal service standard on Islesboro. Tier 5 speeds will provide the island with sufficient bandwidth for internet, video, and voice applications for the foreseeable future, including those activities survey respondents want to be able to do. This standard enables the Town to pursue either of Tilson's proposed business models.

The following section provides an overview of two types of FTTH network architecture, active and passive, and contemplates a high level FTTH design for Islesboro, Seven Hundred Acre Island, and Minot Island. For the purposes of the study, Tilson assumed a technology solution for Seven Hundred Acre Island and Minot Island that is consistent with Islesboro's solution.

Defining Broadband

Broadband is defined by the amount of data that a consumer can download or upload from the internet in a given second. This measurement is known as bandwidth, and the greater a consumer's bandwidth is, the faster the connection. Connection speeds are generally measured in kilobits per second (Kbps), megabits per second (Mbps) or gigabits per second (Gbps).[31]

In the U.S., broadband standards are defined by the FCC, which regulates interstate and international communications by radio, television, wire, satellite and cable. The FCC uses a tiered approach to define broadband based on download and upload speeds for wireline and wireless technologies:[32]

[31] 1 Gbps = 1000 Mbps = 1,000,000 Kbps.

[32] Pg. 5. The ConnectME Authority, 2012. *Developing Broadband in Maine: Strategic Plan.* Available at http://www.maine.gov/connectme/grants/ntia/planning.shtml.

Figure 13: FCC Speed Tier Upload and Download Speeds

FCC Speed Tier	Download Speeds	Upload Speeds
1st Generation Data	200 Kbps to 768 Kbps	200 Kbps to 768 Kbps
Tier 1	768 Kbps to 1.5 Mbps	768 Kbps to 1.5 Mbps
Tier 2	1.5 Mbps to 3 Mbps	1.5 Mbps to 3 Mbps
Tier 3	3 Mbps to 6 Mbps	3 Mbps to 6 Mbps
Tier 4	6 Mbps to 10 Mbps	6 Mbps to 10 Mbps
Tier 5	10 Mbps to 25 Mbps	10 Mbps to 25 Mbps
Tier 6	25 Mbps to 100 Mbps	25 Mbps to 100 Mbps
Tier 7	> 100 Mbps	> 100 Mbps

The FCC currently defines 3 Mbps downstream and 768 Kbps upstream as the minimum threshold speeds for broadband, with some regulatory decisions defining basic service as 4 Mbps downstream and 1 Mbps upstream.[33] As shown in the table above, the current standard translates to a minimum Tier 3 downstream and Tier 1 upstream connection to qualify as broadband service.

The rapid advancement of delivered data speeds in the U.S. has caused the FCC to recently change the definition of broadband. In 2000, only 4.4 percent of American households had a broadband connection (as currently defined) in their homes. By 2010, that number had jumped to 68 percent. Moreover, since 2010, average delivered speeds in the U.S. have doubled overall, and today roughly 94 percent of Americans have access to wireline or wireless broadband speeds of at least 10 Mbps downstream. As a result, the FCC raised the minimum threshold for download speeds from Tier 1 to Tier 3 in 2010, and is now considering increasing the downstream threshold to Tier 5.[34] This evolving baseline reflects a growing need for higher bandwidth as Americans increasingly use the internet and communications technologies in all aspects of their lives.

In Maine, the ConnectME Authority, the leading state agency focused on broadband development, has adopted the FCC's tiered definition as the basis for evaluating broadband projects for funding. The Authority considers download and upload speeds at and above Tier 1 as qualifying as broadband service, but has a stated preference for funding projects providing Tier 3 service or better.[35]

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[33] Sixth Broadband Report, 25 FCC Rcd 9556, 9563 ¶10 (2010). The FCC's National Broadband Plan considers 4Mbps and 1Mbps downstream as the minimum threshold for broadband.

[34] Pg. 4. *Four Years of Broadband Growth*, June 2013. The White House Office of Science and Technology Policy & The National Economic Council.

[35] Pg. 5. The ConnectME Authority. 2012. *Developing Broadband in Maine: Strategic Plan.* Available at http://www.maine.gov/connectme/grants/ntia/planning.shtml.

In terms of functionality, the following table shows download speeds required for a range of common internet-based activities:[36]

Figure 14: Minimum Download Speeds per User for Internet-based Activities

Activity	Minimum Download Speed (Mbps)
Email	0.5
Web browsing	
Job searching, navigating government websites	0.5
Interactive pages and short educational videos	1
Streaming radio	Less than 0.5
Phone calls (VoIP)	Less than 0.5
Watching video	
Standard streaming videos	0.7
Streaming feature movies	1.5
HD-quality streaming movie or university lecture	4
Video conferencing	
Basic video conferencing	1
HD video conference and telelearning	4
Gaming	
Game console connecting to the Internet	1
Two-way online gaming in HD	4

Download and upload speeds depend on the type of communications technology service providers utilize. There are a number of different technologies currently available to residential and business users, which offer varying bandwidth capabilities:[37]

[36] FCC Broadband Speed Guide. Available at http://www.fcc.gov/guides/broadband-speed-guide.
[37] Pg. 5. The ConnectME Authority. 2012. *Developing Broadband in Maine: Strategic Plan.* Available at http://www.maine.gov/connectme/grants/ntia/planning.shtml.

Figure 15: Download and Upload Speeds by Communications Technologies

Technology	Download & Upload Speeds
Dial-up	Up to 56 Kbps
2G Mobile	Up to 100 Kbps
3G Mobile	384 Kbps – 2 Mbps
4G Mobile[38]	2 Mbps – 100 Mbps
Satellite[39]	200 Kbps – 2 Mbps
DSL	768 Kbps – 6 Mbps
Traditional Cable	1 Mbps – 10 Mbps
DOCSIS 3.0 Cable	1 Mbps – 30 Mbps
Fixed Wireless	1 Mbps – 10 Mbps
T-1	1.5 Mbps
Fiber Optic	Up to 1 Gbps

The speeds shown above are averages achieved for each technology. Higher speeds are possible for certain technologies depending on network layout and user saturation. If a user is located close to a network node, which houses the networking equipment that sends the network signal, and overall network use at that point in time is low, he will obtain higher connection speeds. As some residents of Islesboro have likely experienced, if a DSL subscriber is located close to FairPoint's remote terminals he can achieve higher download speeds around 15 Mbps.[40] However, as one moves farther away from the remote terminal, download and upload speeds decrease.

Selecting a Community Service Standard and Technology Solution

Tilson believes the FCC's Tier 5 threshold for both download and upload speeds (10 Mbps), with scalability to 1 Gbps service without major recapitalization, is well suited to be a universal service standard on Islesboro for the foreseeable future. Tier 5 will provide the island will sufficient bandwidth for data, video, and voice applications, including those activities survey respondents want to be able to do.

Second, this standard enables the Town to pursue either of Tilson's proposed business models. Either a FTTH network or a DOCSIS 3.0 cable network could deliver symmetrical speeds,

[38] Islesboro currently has 4G mobile access in the Dark Harbor vicinity around Pendleton Yacht Yard from the wireless tower located near the intersection of Derby Road and Pendleton Point Road.

[39] Current satellite service may achieve broadband level speeds, but the excessive latency or delay and data cap precludes the use of many broadband applications.

[40] FairPoint has two remote terminals on the island, one located on the southern half of the island at the intersection of Derby Road and Pendleton Point Road and one located on the northern half of the island at the intersection of Heald Road and Main Road.

meaning equal download and upload speeds, at this standard, which gives the Town some flexibility for selecting a business model that delivers an effective solution to residents and is also economically feasible. If FairPoint were chosen to partner with the Town, Tilson believes a fiber-to-the-node network could provide an advanced DSL service that provides speeds in the range of 16 Mbps downstream and 3 Mbps upstream, which would be a similar range to the "FairPoint Fast" service in the former FiOS territory the company now owns in Eliot, Maine. On the other hand, advanced DSL infrastructure is not scalable to speeds of 1 Gbps, and thus is less future proof. A relevant advanced DSL project to consider is the recent broadband upgrade in Cornwall, England. The project includes a fiber-to-the-node network with copper connections to 50 percent of the 250,000 homes and businesses in the region, with connection speeds ranging between 40 Mbps and 80 Mbps.[41]

Lastly, considering the gap between Islesboro's current service and the national average, symmetrical 10 Mbps service would help the Town better compete with other communities to attract young residents and businesses. As noted in the previous section, 91 percent of the U.S. population has access to wired advertised download speeds greater than 10 Mbps according to the White House Office of Science and Technology Policy. Should the FCC decide to raise the minimum tier for broadband service again, 10 Mbps upstream and downstream would qualify as broadband.

Tilson did not consider 4G Long Term Evolution (LTE) mobile as a viable broadband solution for Islesboro. While LTE could provide a potentially high quality service, current carrier policies on data caps make this uneconomic for residential broadband use, particularly as bandwidth demand changes. Should carriers lift these caps, then such a solution might work. A capital estimate for such a build out was not in scope for this report. That being said, Tilson's proposed FTTH network design could support additional wireless backhaul on the island.

If the Town decides to pursue Business Model #2 and wants to achieve a universal Tier 5 service on the island, Tilson recommends a FTTH solution. FTTH is a commercially-proven technology for fast residential and business broadband service, and would enable the Town to scale service to higher speeds in the future without significant new capital investment. The following section details two types of FTTH network architecture.

Fiber-to-the-Home Network Architecture: Active vs. Passive

The average operational life cycle of a FTTH network is typically 20 years. A FTTH network on Islesboro would consist of several components, including backhaul facilities, FTTC facilities, and service drops. Backhaul service is the backbone bandwidth that connects a town's CO, the aggregation point of the local network, to the internet. FTTC includes all fiber between the CO and each premise's driveway. Since fiber cable is attached to roadside utility poles, the FTTC

[41] Additional information on the Cornwall, England project is available at the following websites: http://www.superfastcornwall.org/about-sfc, http://recombu.com/digital/news/superfast-cornwall-what-is-it_M10880.html

footprint on Islesboro will mirror the road layout on the island. A service drop is the connection between the street curb and a premise.

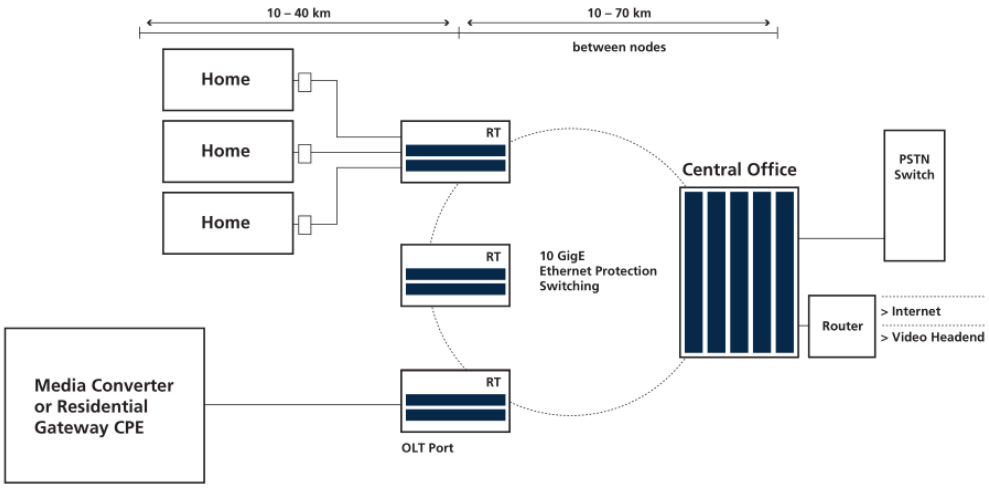
A FTTH network can be similarly be broken down into its inside plant (ISP) and outside plant (OSP) components. ISP includes the networking gear located in the CO, which converts the backhaul signal to a signal that can be distributed to end users. OSP includes all facilities from the exterior of the CO to the premise, which includes steel strand that is attached to utility poles, fiber cable that is lashed to the strand, and service drops from the street curb to each premise.

These terms are important because they dictate the timing of capital deployment during a network build out, as further detailed below.

There are two primary types of FTTH technology: Active Ethernet (AE) and Passive Optical Networking (PON). Each type of network architecture can serve both residential and business applications with Gigabit upload and download capabilities. The primary difference is that in an AE network each premise is served with a dedicated fiber feed and bandwidth, whereas in a PON network bandwidth is split among users. In other words, AE is a point-to-point network whereas PON is a point-to-multipoint network.

An AE network involves point-to-point fiber connections that are deployed from the CO to each premise being provided with service:

Figure 16: Active (AE) Fiber-to-the-Home Architecture

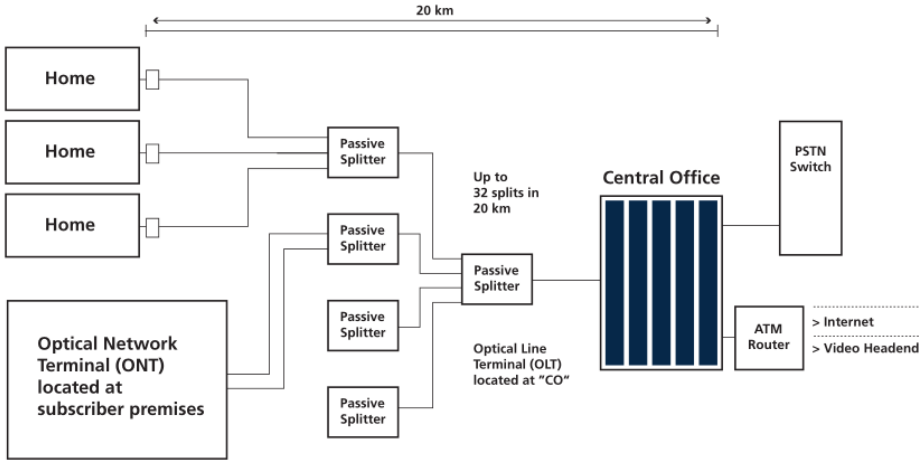


As illustrated above, each pair of fibers connecting to a consumer premise is fed from the local CO. The fiber from the CO terminates in an Optical Networking Terminal (ONT) at each premise, which converts the fiber's light signal to be transmitted over Ethernet (CAT5) wiring inside the

home or business. Since each pair is a dedicated feed, there is no sharing of network bandwidth among end users.

PON networks deliberately involve the sharing of bandwidth across a number of end users:

Figure 17: Passive (PON) Fiber-to-the-Home Architecture



PON networks have equipment located in their OSP facilities called optical splitters, which enables up to 32 end users to share bandwidth being transmitted from the local CO.[42] The short distribution component from each splitter to a premise is the only part of the network dedicated to each end user.

Comparing AE and PON FTTH capabilities, each networking technology has relative pros and cons:

- **Bandwidth**. AE offers dedicated, symmetrical bandwidth that is nearly limitless. It is considered to be more future proof than PON because network upgrades only require changing signal equipment in the CO, whereas upgrading a PON network requires installing new equipment in the network nodes (where bandwidth is split).

- **Capital costs**. The costs for deploying an AE network are higher than for a PON network because AE requires higher fiber strand counts. That being said, PON optronics, which transmit the network signal, are generally more expensive than AE optronics, especially for high speeds. In terms of range, AE optronics can reach consumers that are located up to 70 km away from a CO, whereas PON customers must be within 20 km of a CO because splitters degrade signal strength.

[42] There is PON equipment commercially available designed to accommodate up to 64:1 splitting.

- **Operating costs**. Troubleshooting and maintenance costs for AE and PON networks depend on the network location of restoration incidents. While the aggregation device at a node in an AE network is complex due to the number of fiber strands terminating there, troubleshooting with an AE network's router is typically considered to be easier than doing so in PON splitters.

- **Customer premise equipment**. CPE devices, which include the ONT, are interoperable for AE and PON networks.

- **Video**. Broadcast video can be offered relatively easily over a PON network as an RF overlay, whereas IPTV technology needs to be used in an AE network. IPTV requires a service provider to invest in head end networking equipment, which requires substantial investment.

Overall, a passive network has lower deployment costs and is considered by some to be better suited to residential consumers' smaller bandwidth requirements. Conversely, AE architecture is considered by some to be better tailored for business applications due to higher bandwidth capabilities and to be a more stable technical standard by avoiding costly equipment and network upgrades in a future scaling event.

Network Backhaul Requirements

For Tier 5 upstream and downstream service, Tilson believes that 500 Mbps of backhaul bandwidth should be a sufficient starting point for a FTTH network on Islesboro.[43] At present, the only existing communications facility capable of providing a backhaul service to the island is a subsea fiber cable owned by FairPoint. While FairPoint may have the technical capacity to lease dark fiber capacity on its cable, the fiber is not available on an open-access basis and would be subject to negotiation. The Town indicated that FairPoint previously conveyed during a ConnectME Authority grant application effort there is not availability of backhaul capacity on their subsea fiber line. This scenario of backhaul utilization raises a competitive dynamic if FairPoint is not the network operator.

An alternative option for backhaul is to lease fiber from Central Maine Power (CMP). CMP does not currently have any subsea fiber deployed anywhere in Penobscot Bay, but the company is planning to upgrade the current 12kV subsea power line between Islesboro and Northport, ME. Fiber is commonly installed in power lines for the operator to regulate electricity transmission. Tilson reached out to CMP's lead point-of-contact for the project, Sarah Mazurek (Sarah.Mazurek@cmpco.com), who agreed to include up to 24 strands as part of the cable installation. Tilson requested that 10 strands be reserved for a potential future FTTH build out on the island. It is unlikely that all 10 strands would be needed to operate a network on the island, but due to the relative low cost of including back up strands in the initial build, Tilson recommends having extra fiber available in case it would be needed in the future. CMP estimates that the installation of the new cable will be complete in early 2015.

[43] Based on consultation with GWI's network engineering team, who provided the backhaul quote for the OPEX budget with a recommendation for 1 Gbps for 10 Mbps per household universal service standard.

Leasing CMP's fiber would enable the network owner to connect a CO on the island to Northport, where a lateral would need to be built between the subsea cable's termination point and the Three Ring Binder. The Three Ring Binder runs from Northport to the internet point-of-presence in Boston, MA, thus providing the necessary backhaul to serve a FTTH network on Islesboro via the Town's chosen service provider.

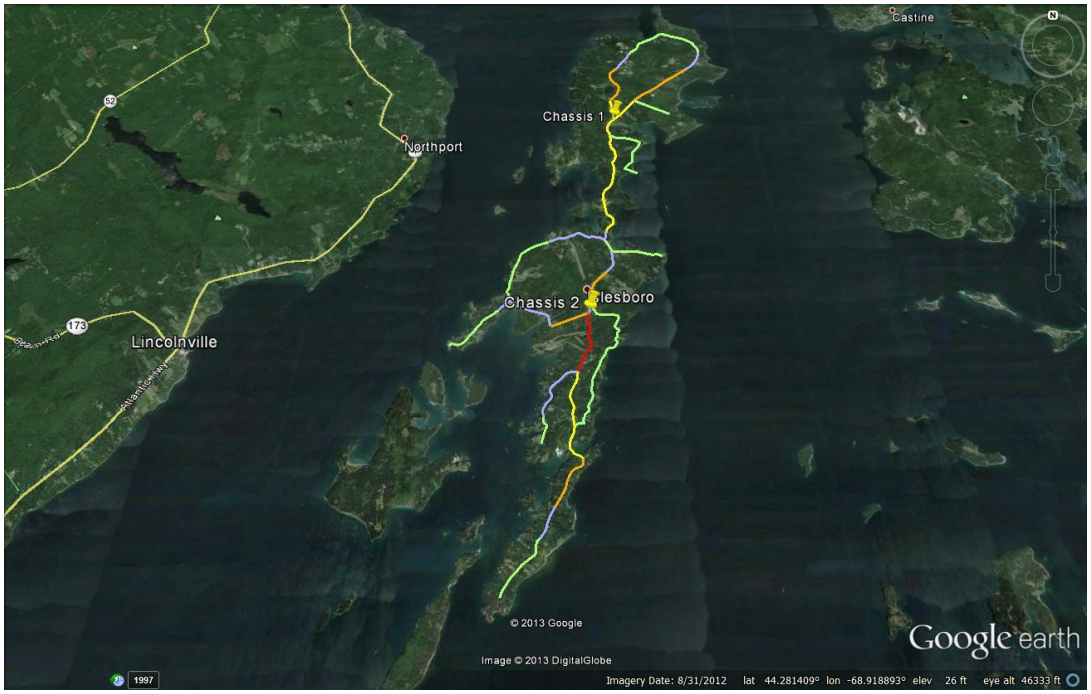
Islesboro Fiber-to-the-Curb Network Design

Using road layout, parcel lot, and premise location data provided by the Town, Tilson conducted a desktop survey to develop a FTTC design that reaches all occupied properties on Islesboro. Tilson's design assumes an AE architecture for OSP, with dedicated fiber feeds between the CO and each premise. A passive architecture would have smaller strand counts, as service between the CO and neighborhood nodes (where splitters are located) could be aggregated. However, for the purposes of initial estimation, AE and PON capital amounts in a network of this scale are comparable.

For ISP equipment, a FTTH network on Islesboro would need two chassis (assuming full network uptake). A chassis is the primary networking gear location in the CO that contains optronics to transmit the network signal. The chassis model Tilson used in the design has a maximum capacity of 504 end users, necessitating the need for two.[44] Based on the island's premise layout, Tilson located one chassis at Meadow Pond Road and Main Road (Chassis 1) the intersection of Mill Creek Road and Main Road (Chassis 2):

[44] For Islesboro, Tilson believes an AdTran 5000 chassis would be well suited for the number of users. This model has a maximum capacity of 504 end users, but other AdTran models and equipment from other manufacturers can accommodate a range of customer counts.

Figure 18: Islesboro Fiber-to-the-Curb Layout



Based on these chassis locations, which would be installed in cabinets mounted on roadside utility poles, Tilson developed fiber strand counts to provide dedicated pairs of fibers into each premise on the island. The resulting FTTC network would contain fiber cable with strand counts between 12F to 432F:[45]

Figure 19: Islesboro Fiber-to-the-Curb Strand Allocation

Strand Count	Road Footage	Portion of FTTC Footprint
12F	50,266	22%
24F	34,495	15%
48F	55,010	25%
96F	30,412	14%
144F	30,619	14%
288F	17,615	8%
432F	5,253	2%

[45] The map shows all fiber counts 48F and above. Green indicates 48F, purple indicates 96F, orange indicates 144F, yellow indicates 288F, and red indicates 432F.

In total, the FTTC network on Islesboro would cover 42.36 road miles and be attached to an estimated 1,392 utility poles.[46] The actual amount of fiber cable used in FTTC footprint would be 10 percent more than the road mileage covered, or 46.56 miles, due to cable sag between utility poles, slack built into the network to accommodate future modifications and repairs, and road crossings.

Seven Hundred Acre Island and Minot Island Network Design

The Town also asked Tilson to complete a high level design for broadband facilities on Seven Hundred Acre Island and Minot Island with a technology solution consistent to Islesboro's. As there is no fiber currently serving the islands and no plan to do so in the future, Tilson considered a 1 Gpbs microwave backhaul configuration from Islesboro Central School to each island. The school was selected as collocation site because it has line-of-sight to each island, which Tilson determined in a desktop survey. Each island would need its own chassis; since the number of premises on each island is much lower than the main island, Tilson chose a smaller, less expensive model. Lastly, due to the small number of households on each island, passive architecture is not appropriate and Tilson would recommend an AE solution.

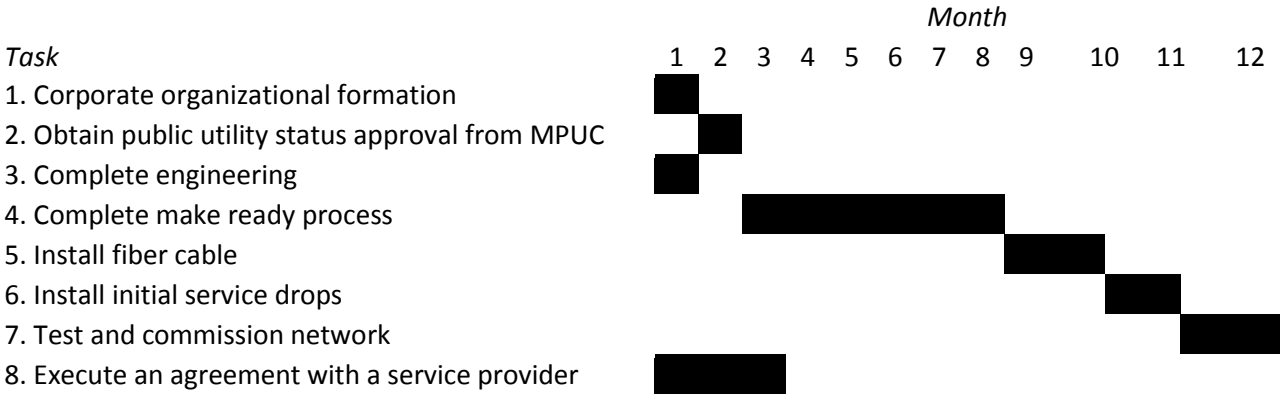
Construction Timeline

For Business Model #1, the commercial service provider's construction timeline would depend on their needs and negotiation with the Town. For Business Model #2, Tilson estimates that it would take a total of 12 months to construct a FTTH network on Islesboro and the two outlying islands. This timeline includes the following activities, some of which overlap:

1. Corporate organizational formation: 1 month
2. Obtain public utility status approval from the Maine Public Utilities Commission: 1 month
3. Complete engineering: 1 month
4. Complete make ready process: 6 months
5. Install fiber cable: 2 months
6. Install initial service drops: 1 month
7. Test and commission network: 1 month
8. Execute an agreement with a service provider: 3 months

[46] This assumes a 160 average pole span on the island, which was determined by the Tilson team during the route ride out with Page Clason.

Figure 20: Projected Network Construction Timeline



Conclusion

Through this study, Tilson aims to provide the Town with a platform to explore potential options for improving broadband on Islesboro. For next steps, the Town needs additional information from the commercial service provider community to effectively evaluate the value of all possibilities. Tilson recommends that the Town proceed into a formal RFI process requesting specific information from service providers about the required amount of investment needed to pursue a commercial initiative. With this information in hand, the Town will be able to better understand the needs and evaluate the options for network construction, maintenance, network operation, and service provision moving forward.

Regardless of the business model and technology solution the Town chooses, Islesboro residents and businesses will benefit from improved broadband access. Broadband development can play a key role in helping Islesboro develop its economy and sustain its year round community, benefitting all members of the community.

Appendix

National Broadband Availability Map

Residential Survey and Results

Business Survey and Results

School Survey and Results

Economic Benefit Analysis

FTTH Cost Estimates Detailed

Town of Leverett, MA Request for Information

Town of Leverett, MA Request for Proposals: Fiber to the Curb Network Design

Town of Leverett, MA Invitation for Bid: Fiber Optic to the Home Installation, Splicing, Termination, Testing, and Maintenance Services