


Rural Broadband Inventory Survey
Leelanau County
Board of Comissioners


Prepared by DCS Technology Design

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Contents

History (Literally) 3
Overview 5
The Report Structure 6
FCC Form 477 and RDOF 10
Cabled Service Areas 16
  Total Served vs Unserved 17
  Composite Served and Unserved area maps 18
  DSL Service Areas 19
  GTB Fiber 22
Wireless Technologies 23
  Cellular 23
    AT&T Signal Coverage Map 26
    T-Mobile Signal Coverage Map 27
    Verizon Signal Coverage Map 28
  Cellular Fixed Wireless Residential Services 29
  Mobile Virtual Network Operators (MVNO) 30
  Wi-Fi Technologies 31
    Cherry Capital Communications 33
    186 Networks 35
    Elevate Net 36

Agri-Valley 38
Agri-Valley CBRS Map 39
Agri-Valley Band 71 Map 40
Satellite Internet 41
Traditional Satellite Internet 41
The Newcomers 42
The Townships 44
Bingham Township 45
Centerville Township 46
Cleveland Township 47
Elmwood Township 48
Empire Township 49
Glen Arbor Township 50
Kasson Township 51
Leelanau Township 52
Leland Township 53
Solon Township 54
Suttons Bay Township 55
Appendix A – Definitions 56
Notes: 58

History (Literally)

Fact: Based on the 2010 US Census, 97% of the United States is Rural, but only 19.3% of the population lives in rural areas.

On July 4th, 1861, President Abraham Lincoln was speaking to a Special Session of Congress, when he said [the purpose of government was] "*to elevate the condition of men - to lift artificial weights from all shoulders - to clear the paths of laudable pursuit for all - to afford all, an unfettered start, and a fair chance, in the race of life*". Less than a year later, he signed the Homestead Act, which offered free land for those willing to move to it and cultivate it, a*n unfettered start, and a fair chance, in the race of life*.

The World's first Hydroelectric Power Plant went online in 1882, and by the 1920's, electricity had become a common convenience in all major urban areas. However, electricity was still not being distributed to rural areas because of the general belief that the infrastructure would be cost prohibitive. Even though, in that era, it was increasingly evident that electricity had become more than just a convenience, it was becoming an essential utility "*in the race of life*".

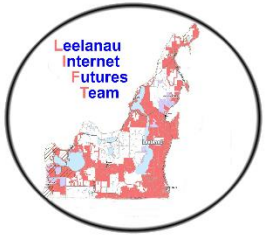
There were many individual efforts throughout the 1920's and into the 30's to test the economics and viability of how electricity could be distributed throughout all rural areas. But it wasn't until 1933 that the Tennessee Valley Authority (TVA) was created (motivated not so much to get electricity to rural areas, but rather to create jobs), and then in 1935, the Rural Electrification Administration was established, which led to the Rural Electrification Act of 1936. In 1939, that act became a department of the United States Department of Agriculture (USDA) and was charged with administering loan programs for electrification (and by then, telephone service) in rural areas. The USDA (along with other government departments) continue to sponsor similar grants and loan programs for rural needs today. But how are they doing?

The Homestead Act, and the Rural Electrification Act were both pivotal points in the history of Rural America, that were meant to give all Americans "a fair chance, in the race of life". 100 years have gone by since electricity progressed from a luxury convenience to an essential utility, and our country today is at another pivotal moment.

Following a remarkably similar timeline as the evolution of electricity, in the early 1980's, a government experiment called ARPANET was developing and adopting the protocols that would enable their research to become the Internet as we know it today. Curious though that in today's technology age, when so many technological advancements develop so rapidly, that the progression of Internet in Rural America looks so much like electricity's progress a century ago, when times were thought to be less hurried. Is it going to be 2036 before Rural Broadband becomes a priority?

Unpredictably, since the beginning of 2020, the world has experienced challenges unlike anything today's generations have ever seen. We can look at history and reflect on similar challenges from the past, but not much from those times are applicable to these most recent tests. Questions that have been in the works for several years, have suddenly taken on new importance, and Broadband Internet to Rural America is topping that list. Broadband Internet is taken for granted in Urban America (which is only 3% of the geography). But (sadly) it took a pandemic to realize how isolating "living in the country" could be, when, without access to basic internet services, it can have such an impact on your livelihood, education, health, and welfare. Access to high speed, reliable internet has become perhaps even more important to Rural America today, than electricity was just 100 years ago. The past two years have proven that, finally making it one of Americas top priorities.

In 2016, a survey of Leelanau County business owners, residents, schools, government, and other stakeholders throughout the county, was conducted by the Leelanau Peninsula Economic Foundation, which focused on many issues. The important outcome of that survey relative to this report is that one of the top barriers to growth and progress across the county was the lack of access to high-speed internet services. That led to the formation of the Leelanau Internet Futures Team (LIFT), which has accomplished much since 2016 in defining the needs and requirements for high-speed internet across all of Leelanau County. Through the efforts of LIFT, the needs have been well defined, demographics have been well documented, and progress has been made in expanding services (mostly through wireless). But perhaps an indirect accomplishment, LIFT has also expanded its knowledge and understanding of the obstacles that have prevented widespread adoption of internet. Two of those obstacles are symbiotic. Accurate planning, and funding. This study is more about the former, which is vital to supporting the pursuit of the latter.



Overview

The USDA is the branch of the US government most committed to the development of Rural America. Through programs like ReConnect, a Broadband loan and grant program (and a descendant of the Rural Electrification Act of 1939), the USDA continues to pursue the development or Rural Broadband. The Federal Communications Commission (FCC) has also joined the government resource pool for Rural Broadband funding through programs like Connect America Fund (CAF and CAF II) and the more recent Rural Digital Opportunity Fund (RDOF, an important development for Leelanau County in the last 18 months and covered further down in this report). However, these programs are still falling short for many reasons; lack of accurate information is one of the leading flaws, and too much funding is being wasted. Although this study does not directly address the funding requirements, it is intended to provide a more precise set of data to help target funding sources more precisely, serve as a tool to better coordinate efforts between government and ISPs, and generally focus funding on the technologies that make the most sense for different areas.

Technology Life Cycle

What does Technology Lifecycle mean, and why is it important to Rural Broadband Planning? Basically, part of planning for any long-term investment into a telecommunications technology should consider how long a technology, or parts of it will remain useful, and what kind of costs should be planned for when it is time to refresh or replace the systems or its parts.

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Today, Fiber Optics is the leading performance technology, and in most cases, the most economical over the long term, but there are situations where wireless technologies can fill the gaps more economically, at least for the short term. By understanding which technologies are available, how well they perform, their "Technology Life Cycle" (see sidebar), and an accounting of precisely where they are located throughout the county, a more logical plan can be developed to bring more immediate services throughout all underserved and unserved areas.

There are several sources that provide some level of service area reporting, and recently the federal government has pushed to find more accurate means to quantify and measure internet availability and performance across large geographic areas. All these efforts do provide some value, but they still leave gaps in the information that are difficult to fill, or even define. Many of the on-line surveys rely on the technical ability of the consumer, often asking questions that are not easy to answer accurately, reducing the viability of the data being collected. Also, a paradox of some of these surveys is that they are online based, making the fundamental question of "How good is your Internet" somewhat meaningless when those that have poor, or no internet cannot respond.

Another example of a self-reporting source for Broadband Access is the FCC Form 477, which relies on the ISPs to self-report their service areas twice a year. Since Form 477 has been a key resource for funding activities (RDOF) in Leelanau County, we will dig a little deeper into that issue in the next section.

This study does not use any self-reporting survey methodologies by Internet Users, Internet Providers, Government Agencies, or other service providers. All the data we collect is done through physical survey of the whole county, by personnel experienced in the technologies we report on, and through interviewing the ISP's, gaining valuable insight from them. Performance parameters, when included in the report, are based on technical specifications and standards of the technologies we have identified. As such, due to the many variables that can affect performance, much of the data may not represent actual performance, but rather expected performance. We feel that this is the correct approach to reporting certain performance characteristics of the different technologies, since actual performance may be an indicator of undetected problems within a technology or service area, which might be being assumed as the norm.

The study provides Leelanau County a report-based framework that can be used to help decision makers sort through and understand the various technologies available to aid in the planning and working with potential funding sources and ISP's. It is an accurate snapshot of what technologies are available, and some of what is being planned, across the county, down to the parcel level. Following are technical descriptions, charts, and most important, Geographical Information Systems (GIS) based maps of the entire county showing a very precise inventory of what is available to businesses and homeowners. The maps provide a level of detail and granularity that is not typically available elsewhere, and the accompanying GIS data files are being made available to the County for their use (more on this below). The report is technical in nature but compiled in a format that is hopefully informative for all readers.

The Report Structure

The data in this report was collected and constructed using GIS tools and technology, which allows the data to be presented using tables, graphics and most important to the intent of the report; maps, with the data itself compiled in an underlying database. This allows the data, and the maps to be easily maintained and updated as needed. It can be configured for myriad purposes and integrated into other GIS systems for even greater functionality. The foundation layer of the maps is the GIS property maps for all Leelanau County. Through a physical survey of practically every road mile, available and planned technologies have been identified, (in some cases measured), and plotted. It is supported by additional information about the technologies, with information on how some should be performing, and how some are actually performing.

Technology Life Cycle – cont.
Telephone

If you are older than most "Millennials", then you have likely witnessed the end of the "landline" and a shift to cellular. However, the copper wires that used to connect that old telephone (even the ones with dials) are still there, and in many cases, are still being used for your home phone calls today. Yes, we mean the calls from your "Smartphone".

There are still far more copper telephone lines in place today, especially in rural areas, than any other media, and much of it is likely 40 to 50 (or more) years old. When copper lines were first built, they were meant to support just analog telephones. When digital phones came out, with a little tweaking, the same copper wire worked for them. Then, as the "World Wide Web" began to catch on, it was figured out that, with a little more conditioning of those same copper wires, higher capacity digital technologies like "ISDN" and "DSL" could still use the same wire (which not only brings higher speed data services, but also supports services like "Voice over IP" and Wi-Fi calling on your smartphone, from inside your home). But the bandwidth and distance limitations of twisted pair copper wires have been pushed to their limits, and digital technologies, like DSL that depend on old telephone wires, can no longer compete with newer, and higher speed technologies. So, it is unlikely to see any substantial new construction for copper telephone lines in the future. But the history of this infrastructure establishes a good basis for predicting the lifecycle potential of the next two technologies. So, although it is nearing the end of widespread use, the copper twisted pair cabling used to support a variety of different technologies for over a century, established that we can build a cabling infrastructure outdoors, that can be adapted to technology changes, and not have to be replaced for 50 or more years.

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Due to the magnitude of data compiled, not all the information is visible in the PDF version of this study but can be zoomed in and viewed on-line once the county can incorporate the data into their GIS platform. This information can be shared however the County deems necessary. The PDF version does provide a very comprehensive version of the study and will make the on-line data much easier to understand and navigate.

On top of the base layer maps provided by the county, the first technology covered is cabled technologies, which include Cable TV, Fiber Networks, and DSL networks. The Cable TV and Fiber based networks provide the highest level and most consistent performance throughout their service areas. Fiber is also becoming the most economical to build, with the longest expected lifecycle. Both Cable and Fiber are scalable technologies that can support increasing capacity demands for many decades. For example, Cable TV has existed in the area since the 60's and 70's, and parts of that coax infrastructure is still in service and will continue to scale and evolve with demand for many years to come. However, most new construction for any cable or internet provider is being planned with fiber optics. Much like Cable has done for the last 50 years, today's Fiber technology will provide an infrastructure that will last the next 50 years, or more. The current capacity being delivered by fiber to the home doesn't begin to tap the capacity of the fiber itself. In experiments, the capacity of the type of fiber optic cable being installed in homes today, has been demonstrated to be 100,000 times the 1 Gb/s speeds being offered in current Fiber to the Home services. And since the fiber systems themselves are mostly passive, meaning no electrical devices needed between the transmission and receiving equipment, the operational costs are far more economical than any copper-based infrastructure. Future upgrades will only need to be in the electronic equipment at the ends of the fiber.

The third cabled technology reviewed is Digital Subscriber Line (DSL), which is the latest technology offered by traditional telephone providers, that are still using their extensive and existing copper infrastructure. The current advantage of DSL is the ability to re-use this infrastructure that was once designed and built for a technology that was never meant to carry anything other than a single analog telephone call. In the early years of digital services over phone lines, which has only become common in the last 30 years, digital services like ISDN (the predecessor to DSL) and DSL itself brought a wealth of new data and video services to the consumer. And until the Cable Modem started to catch on with the Cable TV companies, ISDN and DSL led the performance standards for home and business data and video services. But that era of kilobit

Technology Life Cycle – cont.
Community Antenna Television (CATV)

CATV, or Cable TV began to emerge in 1948, and ironically, was first built only in rural areas. Since TV sales were dependent upon being able to pick up a broadcaster's signal, TV shops were stringing wires from their "Community Antennas" to homes that could not get a good signal because of their location out in the country or in the mountains. By the 60's, the technology had developed and standardized on using Coax Cable which became the basis for all Cable TV systems today. It wasn't until the end of the 70's, that a boom in Cable TV construction started in urban and suburban areas. Metropolitan areas didn't really have a need for cable since TV broadcasters were mostly transmitting from towers within those areas, and simple antennas at your home picked up the three or four channels that were available. But as satellite TV and other broadcast options started to emerge, Cable became a lucrative business opportunity. The systems quickly evolved from 12 channel systems to 160 or more channels in just a few years, all using analog technology, on Coax cable. But the Coax itself was able to handle that expansion. Since then, Cable TV has seen a migration to all digital formats, providing literally 100's of channel options, and more importantly, the inclusion of Cable Modem bringing the first real high speed Broadband Internet into homes and businesses. A lot of areas are still functioning with the same Coax that was strung on poles and buried in neighborhoods in the 70's and 80's, with changes only in the active electronic components, and the technologies at either end. This has proven that Coax based Broadband infrastructure, like its twisted pair predecessor, is robust enough to last and evolve 40 to 50 years.

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per second performance was smothered once other technologies (e.g., Cable Modem and Fiber to the home) started offering megabit and gigabit services for near the same costs.

DSL has survived in rural settings mostly due to its ability to re-use cable that was put in place when the country realized that some level of telephone service was (almost) as important to rural America as electricity. But unlike the old landline services of yesteryear, DSL is very distance sensitive and decreases in performance as it nears the ends of its service areas, unable to reach through the lengths of wire that an analog telephone call used to be able to do. DSL should still work well in the first mile but has many challenges that are difficult to overcome with longer distances.

The next section is on wireless, primarily the major Cellular Providers. As part of the survey for physical cabled technologies, our surveyors collected signal level data for the three major cellular providers, AT&T, T-Mobile, and Verizon Wireless. Tens of thousands of data points were measured automatically while driving practically every road mile in the county, for each of the carriers. These data points have been compiled into the same maps on their own individual layers, so that they can be viewed separately, or with underlying parcel information. These are not predictive heat maps like one would expect when looking at the published "coverage areas" of cellular phone providers. They are instead, actual signal level measurements using the same type of equipment provided to consumers to receive the services of these carriers. When looking at the data, some roads that were commonly traveled during the survey, will have measurements from different days, demonstrating the unpredictability of how wireless signals work, when conditions change. A lot of this common data was removed to reduce congestion on the maps, but there are still instances of signal measurements next to each other that seem to contradict each other. That is simply the nature of wireless technologies.

The next area of wireless technologies is with the unlicensed or "light licensed" (Wi-Fi type) systems provided by Cherry Capital Communications (CCC), 186 Networks (186), and Elevate Net. CCC and 186 have made a commitment to continue to evolve their technologies, moving to Fiber based systems within their current service areas. CCC was very cooperative with information about their systems and plans but did have privacy concerns about locations of certain equipment, which was respected in this report. 186 did not respond to requests for additional information, but what could be obtained through our surveys has been included. 186 has an existing base of customers fed with fiber but are limited in capacity due to the

Technology Life Cycle – cont.
Passive Optical Networks (Fiber)

Passive Optical Networks (PON's) are likely the most common new build being deployed today, and it is being built but all types of ISP's, Cable TV companies, Telephone Companies, and private operators for just about every type of communication requirement there is. There are a lot of technical variations to the PON, but like Twisted Pair and Coax, the important factor relative to Lifecycle is the ability to support all of today's variations of the technologies, and easily migrate and support future technologies.

The designs for most PON configurations are very simple, much like the old, twisted pair designs for telephone. Basically, there is a dedicated fiber (or two) from the main host location to each end point (your home for example). A single strand of fiber can be a dozen or more miles long, and still deliver the full-service offerings reliably to each subscriber. The word "Passive" in PON means that the only electricity needed to make a connection, is the electricity at the transmitter, and the electricity at the receiver. Everything in between is un-powered, light waves passing through a glass fiber. Bundles of these fibers are bound together using the same materials and constructed with the same methods that have been proven on copper and coax-based systems for over a century. So, based on that similarity alone, today's fiber will easily last 50 years into the future. Since it is passive, upgrading to future technologies, is simply just changing the electronics at either end. Further, the fiber optic glass being used today has been tested in the lab to reach more than 100,000 times the gigabit capacity being delivered to most fibered homes today. From an infrastructure, and performance view, the lifecycle of a fiber should easily extend to, and perhaps well beyond 50 years.

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area being fed through a wireless backhaul. Once middle mile fiber service is close to their service area, they can simply tie in at that point, and offer more substantial gigabit services immediately.

A third class of wireless provider, Agri-Valley, is planning a couple of new generation technologies that will bring Wireless Broadband to many areas that are currently unserved, filling in gaps much quicker than most of the known plans for fiber.

The entire study and report, compiled using layers in a common GIS format, provides a tool for efficient planning and engineering of new systems and technologies, supporting additional layers for system construction estimating, comprehensive field testing and verification, master planning and future upgrade strategies.

Finally, this study is a snap shot in time. This project has spanned about 12 weeks since the field survey began, and some areas are seeing changes, good changes. The results reported in this study were probably better than 99% accurate at the time they were recorded. However, within the time it took to complete this work there were new services being constructed that will impact the content of this report. You will note that there are activities in both the Fiber and Wireless, that will bring new services to residents. In this respect, this report should be viewed as a dynamic, living record of the progress of technology in Leelanau County. Through the use of the GIS data and platform, there is an opportunity to continually update this information as Broadband expands through all unserved areas, and offer a new information service for current and future residents throughout the county.

For clarification, the information plotted on the maps and reported in the narratives has been visually verified by physically surveying practically every road mile of Leelanau County. However, many technologies are hidden (and even invisible). Wireless systems especially are difficult to identify without the ability to measure, or without support of the provider. Another example, where Cable systems are buried underground, assumptions had to be made since the cable is not visible, and our surveyors do not open secured vaults and pedestals belonging to cable or telephone companies. Following standard design practices for Cable and Fiber, 99% of the serviceable areas and individual parcels were worked out. Cellular services were measured and documented and show a much more acurate example of the true coverage areas. Other wireless services were dependant upon the ISP support, and what could be visually located.

Technology Life Cycle – cont.
Wireless Technologies

The lifecycle of wireless technologies is a little different than wired infrastructure, mostly because wireless is the air around us, which will never change. So, when upgrading to the next generation wireless, pretty much everything is replaced. But, unlike wired, the old stuff doesn't necessarily go away, it can continue to co-exist with the new. The best example is 3G Cellular, which has seen two major transitions (4G and 5G), with several sub-categories each. Although no longer mainstream, 3G is still operational and a critical part of the nation's wireless infrastructure (see Wireless Section for more on 3G).

When a new family of wireless technologies emerge, there are a couple of common elements that may be re-usable, Towers, and the Fiber Infrastructure that connects them. Yes, even with wireless, we must be thinking about how it all connects, and today that is Fiber. We already mentioned that Fiber can last 50 years, and the other element, Towers, can also last that long if properly maintained. Pretty much everything else, including the antennas, will be replaced. We know that the old doesn't always go away, but as consumer demand continues to grow, we must make room for the new.

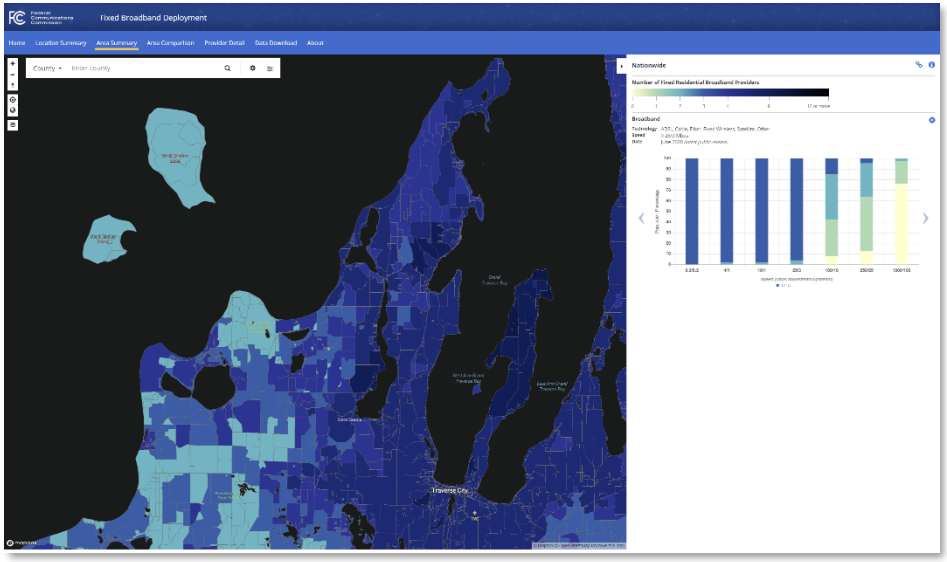
3G was the first cellular "Broadband" standard, introduced 2000. Variations of 4G started in 2010, and 5G has been the promise since before 2020. 6G is in the labs already, but will it be 2030 before we see it?

IEEE 802.11 is the Standards Body that most know as "Wi-Fi". Since its first two published standards in 1999 (A&B), it has gone through 4 more "generational" updates, and today is at 802.11AX, or now known as "Wi-Fi 6" (for the 6th Generation). But like cellular, the old doesn't always go away. Most of the Wi-Fi services still being offered in outdoor wide area applications is Wi-Fi 4, or 802.11N. But new generations of Wi-Fi seem to be on a 3-to-6-year cycle.

FCC Form 477 and RDOF

This report outlines several options for internet access across Leelanau County, existing, and planned. What is important to understand when using this as a planning tool, is what to expect from the various technologies, and which technologies offer the best return on investment, both financially, and through a technology's lifecycle. A fundamental criterion in making those decisions, is the performance capability a technology can offer. Second is how long the technology will last. It is critical to understand when investing in a technology, when it will be time to start planning for the next re-fresh or updates.

Currently, the minimum FCC definition of high-speed internet is 25 Mb/s download speed, and 3 Mb/s upload speed. Even though this threshold, if consistent, is capable to support many basic services such as email and on-line shopping or banking, the world has become far more demanding in what it needs for on-line content and data consumption. Zoom has become the latest generic noun (like Google, Xerox, Kleenex, Band-Aid, etc.) for an activity or application that actually has dozens of options. But if the consumer has a service that barely guarantees 25/3, having a Zoom Meeting can be problematic. To make it worse, even in areas that do report a minimum FCC threshold of 25/3, the technologies that should have that capability, often do not.



FCC Form 477 Interactive Web Map

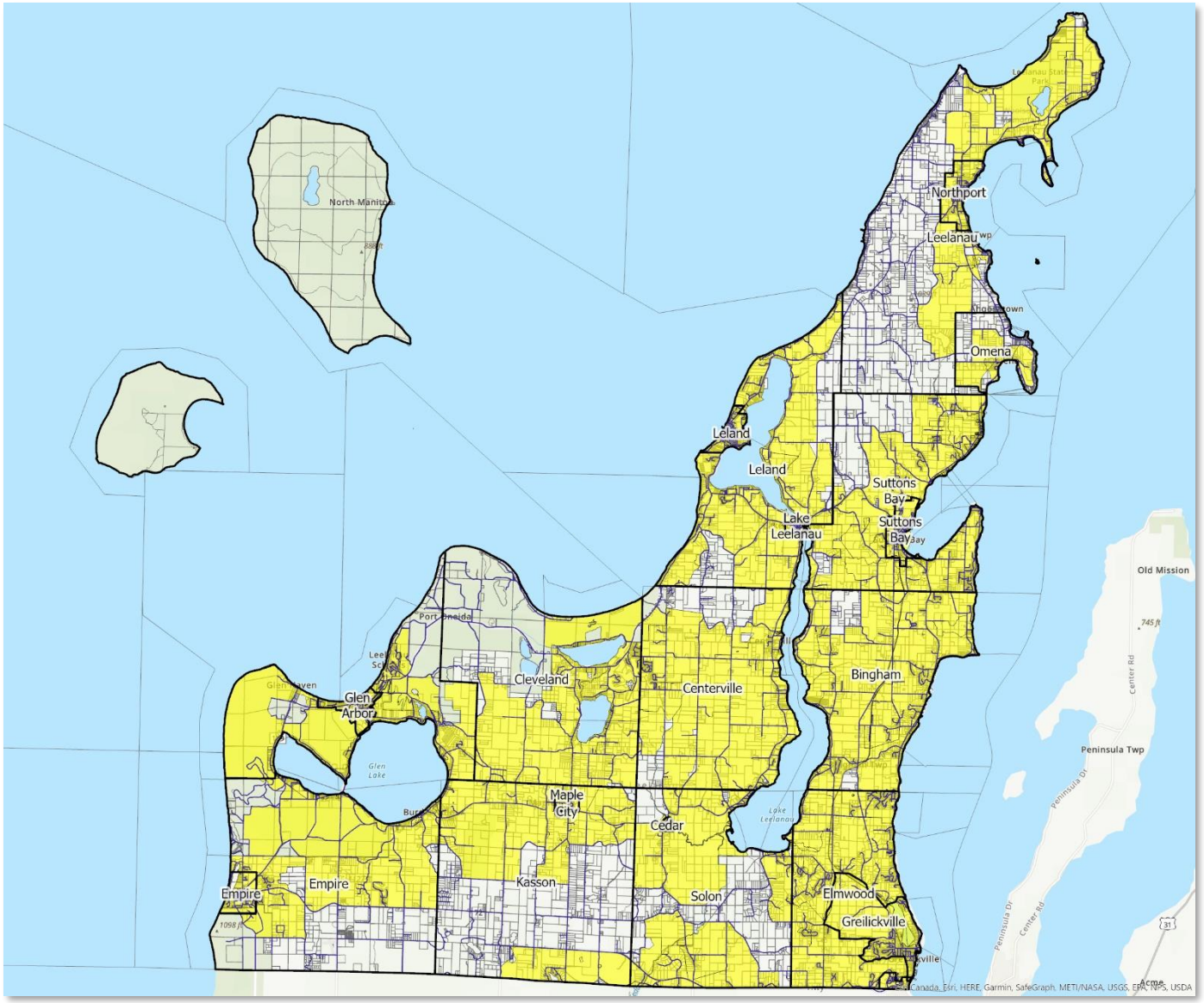
The biggest offender for not performing as promised, is wireless. Regardless of the technology, wireless can have good days and bad days. Wireless is susceptible to environmental elements, distance limitations, network capacity issues, interference issues, and several other concerns that can make wireless very un-predictable. Wireless performance fluctuates based on these conditions, and unless they have the extra performance headroom, or the extra power to overcome the bad weather days, or heavy network congestion days, they fall short, especially in rural areas where they try to cover larger areas with fewer tower sites. Wireless technologies are frequently promoted to have super-fast data capabilities, but if they are operating right at their threshold of minimum performance, it will seem as though it never works right.

But wireless isn't the only technology affected by unpredictable performance. Wired DSL also suffers from degradation and slowdowns as subscribers are further and further away from the host nodes, making it very unpredictable for modern day internet access.

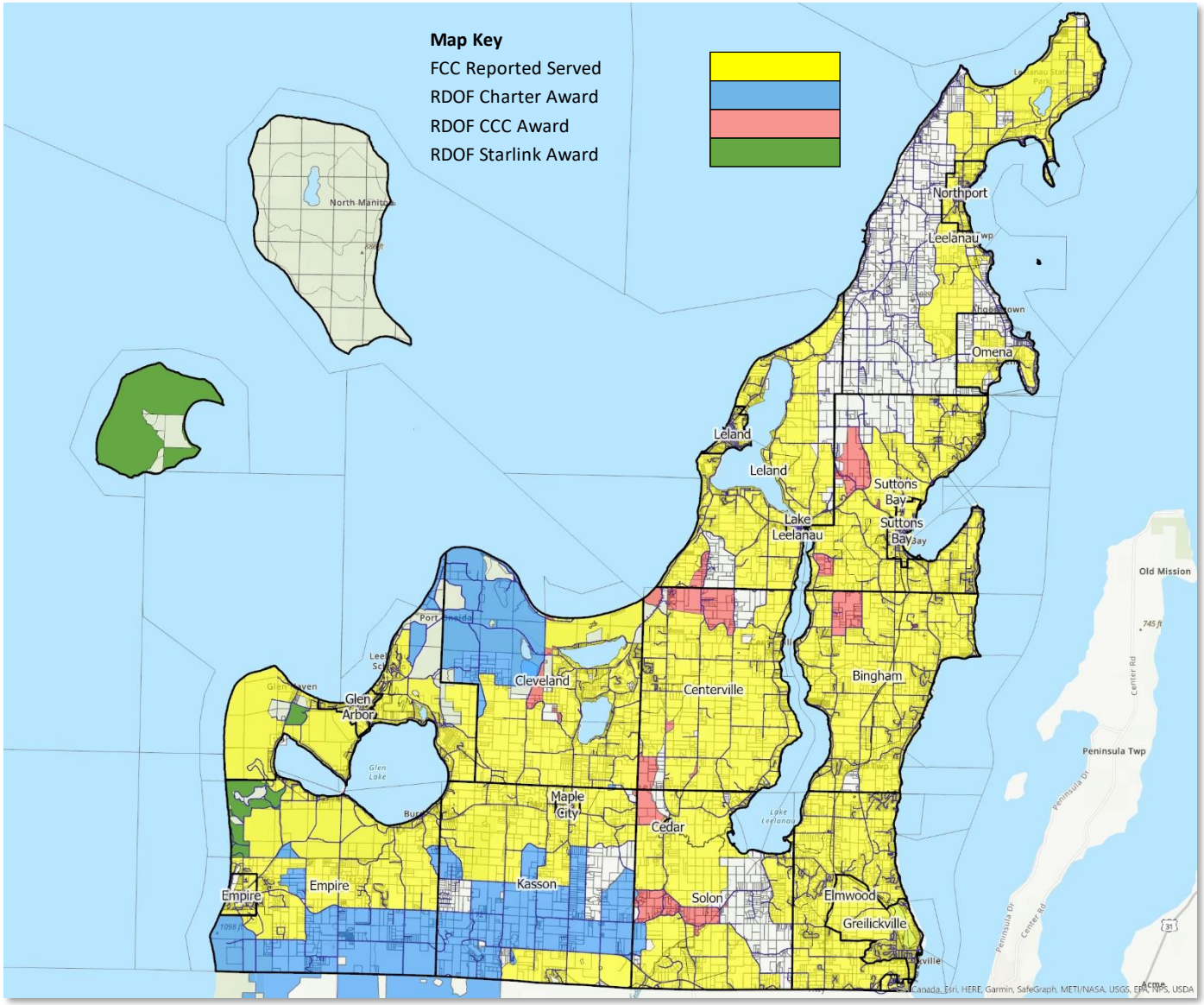
There are reports that the FCC is going to raise the minimum threshold to 100 Mb/s download and 10 Mb/s upload (100/10) as the minimum threshold standard for Broadband Internet. If that happens, only Fiber, Cable, and certain wireless technologies in optimum conditions will be considered true Broadband. Raising the threshold is welcomed by many, but it won't likely have any impact on the technologies themselves, just in how some funding programs qualify the technologies being proposed. With the higher threshold, most wireless technologies, and most DSL installations would no longer be considered "Broadband".

The most prevalent source today for qualifying an ISPs service area and performance thresholds is the FCC Form 477. However, this reporting tool has a major flaw. It is self-reported twice a year by the service providers themselves and aggregated to the census block level. This means that if a single address in a census block is served, then all households in the Census block are reported as served. Additionally, speeds reported by providers do not always match real-world speeds. The following images demonstrate how Form 477 has impacted Leelanau County.

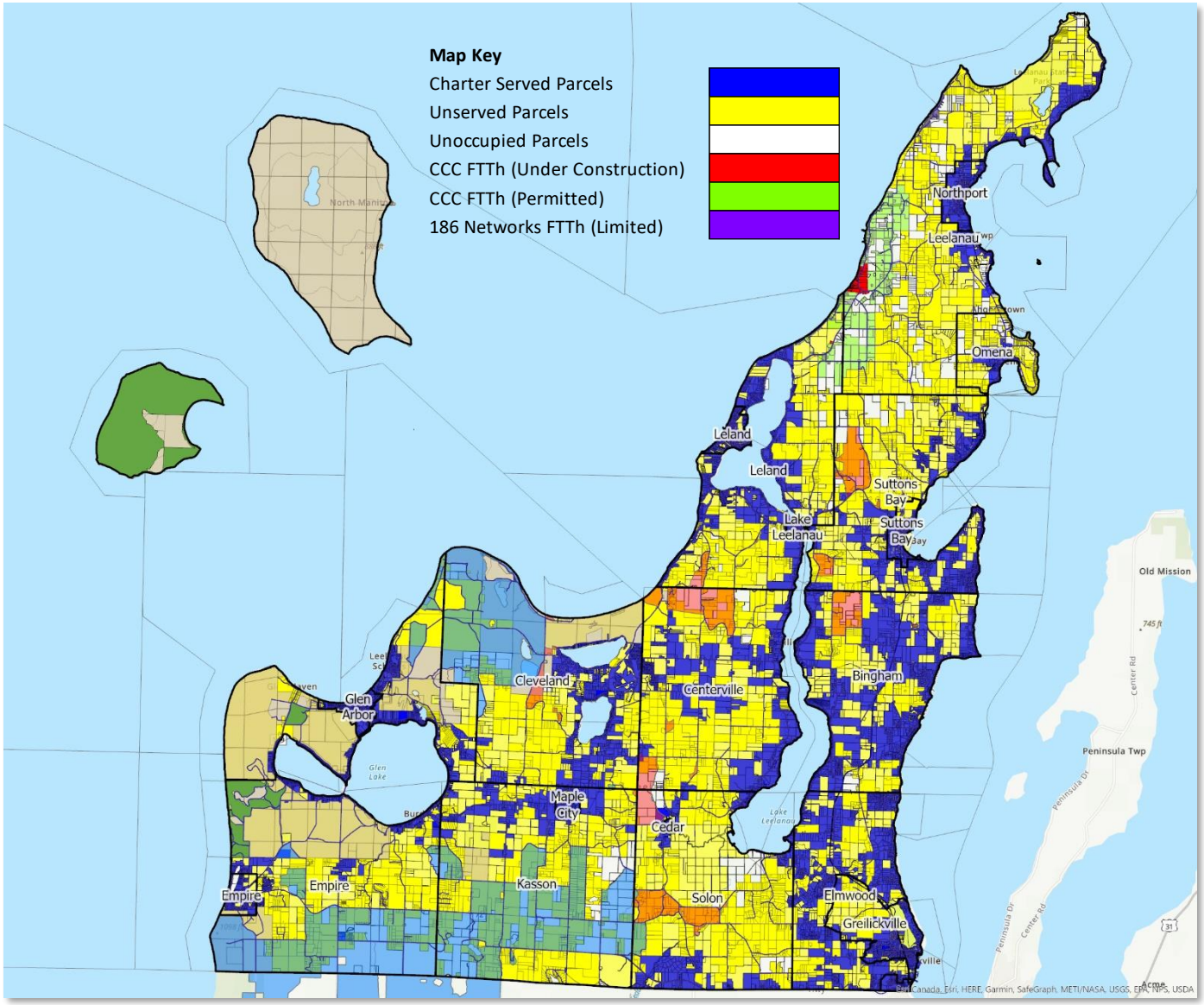
The image on the right is data from the FCC form 477 interactive map. It indicates the areas that have access to Cable only, with a minimum of 25/3 service. The yellow areas indicate that a single cable provider (in this case Charter Communications) offers the minimum threshold service of 25/3, and therefore, these areas do not qualify for federal funding for rural Broadband. The white areas should qualify for federal funding, but in the case of RDOF, some of the areas, especially in the north part of the county, were left out. But on the west side of the county, US Park land (light green) qualified for RDOF.



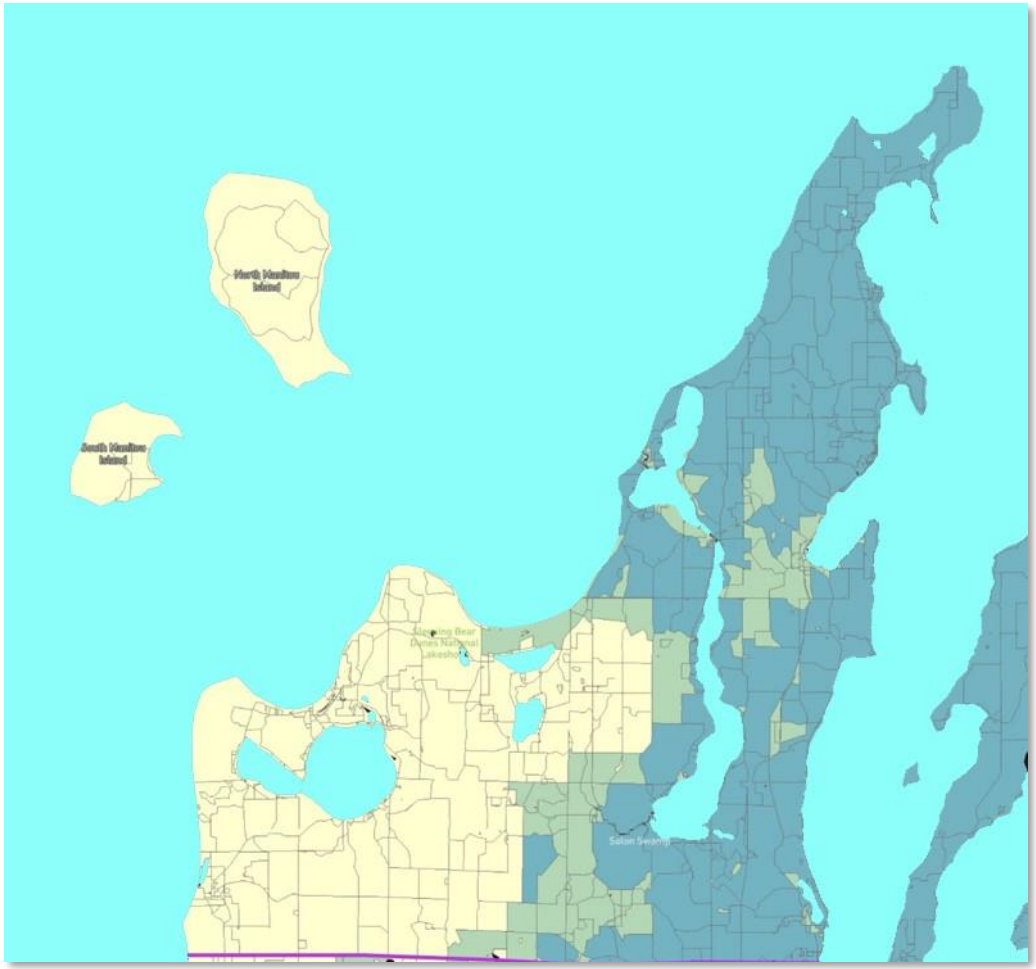
Based on FCC Form 477 the areas that were awarded RDOF funding are shown here. Only the Blue and Light Red areas will receive funding to support new services. The dark green (Starlink) area also qualified for funding but seems irrelevant since it only covers unoccupied areas (separate issue) with RDOF). It is not clear why the remaining FCC identified unserved areas (in white) were not included in the RDOF funding. Note how much of the US Park area that was awarded to both Starlink and Charter. Charter has an obligation now to build fiber through that entire area, even if there are no homes to be serviced.



Based on visually confirming each parcel in the county for served and unserved areas, this map has that data overlayed onto the FCC and RDOF data. For clarity, occupied, but unserved areas are now shown in yellow, and unoccupied parcels are white except those shown as served by 477, (see map on page 18 for clarity on unoccupied parcels). As you can see, actual Charter service areas do not align with the FCC Form 477, leaving many parcels unserved by any cabled type of Rural Broadband. This includes the areas in Leland and Leelanau Townships that are being serviced now by CCC and 186 Networks which should also have qualified for RDOF.



The Census block issue primarily impacts the cabled ISPs, but the same methodology is used for wireless ISP reporting as well. And even though wireless providers advertise speeds that meet FCC minimum, all wireless technologies are susceptible to many factors, such as air temperature, humidity, precipitation, leaves on trees, distance, building materials, etc., which causes confusion and misreporting in the reported coverage areas for wireless.



However, in Leelanau County, the FCC reporting for wireless providers seems to have a much different issue. This map is supposed to show all Fixed Wireless service areas that provide the minimum threshold of 25/3 service. Form 477 reports that 60.28% of the county is covered by only two (2) wireless ISPs at a minimum 25/3 (the dark blueish color on the map to the right), 16.52% is covered by only one (1) provider at 25/3 (light green area) and that the remaining area (23.2%) has no coverage at all by any wireless ISP (yellow area). This does not align with data collected during the survey, and the FCC does not identify who the reporting ISPs are in this report, rendering this data basically unusable. Since Fixed Wireless Carriers that are being reported using the FCC form 477 do include licensed and unlicensed technology providers, including Cellular Providers that offer fixed home services, this map should include at least the six (6) active providers included in this report. The county is certainly not 100% covered, but combined, there are coverage across the entire county, many of them overlapping. Therefore, the wireless data contained in this report is not being compared to the FCC data. See the section on Wireless for actual coverage areas that could be documented.

Cabled Service Areas

Using cabled technologies, specifically Cable TV and Fiber to the home, provides a baseline that is very straight forward, easy to quantify accurately, and gives the clearest assessment of where there are gaps between served and unserved areas. The served areas in Leelanau County today are almost exclusively Charter Cable, but some Charter new build is starting to show up as fiber (not enough yet to differentiate within their service areas). And three other providers, Cherry Capital Communications, 186 Networks, and GTB Fiber are also building, or have built fiber. Both Cable and Fiber are capable of 1 Gb/s data speeds, and Charter does advertise that Gigabit service is available throughout their Leelanau County service area. Any parcel indicated as served by Charter, should have the option of 1 Gb/s service.

Fiber to the home (FTTh) is typically designed to provide a minimum of 1 Gb/s, and many FTTh systems in other parts of the state are offering 2 Gb/s and 10Gb/s services, although the need for that could be the subject of an entirely separate study. Forty times the FCC Minimum Threshold for Broadband Internet, 1 Gb/s today far exceeds what most any typical household can consume on a regular basis. But based on an informal front yard interview with one very tech savvy gamer living north of Northport, a very recent extension to Charters network was installed and operational, and the new subscriber confirmed that he was getting near gigabit speeds consistently. He was thrilled with the new service. This extension was within a conventional cabled area, and it wasn't clear since it was all underground, just how much of the area had this new fiber service, so it was not differentiated on the maps yet as a separate technology. But it is also speculated that all new RDOF extensions by Charter will use FTTh, since even for a Cable Company with extensive existing coax infrastructure, the economics to migrate to fiber just make better sense today.

It is not completely clear yet what service levels the other three fiber providers, CCC, 186 Networks and GTB Fiber, are offering. CCC is in the construction phase of their first build in the county, 186 Networks has active fiber, but it is connected through a wireless connection that is likely well under 1 Gb/s, and GTB Fiber has a well-established backbone infrastructure, but no specifically defined residential or business services areas yet. Since CCC and 186 are both current wireless providers, there is more information on them in the wireless section, and GTB Fiber is a fiber only provider, so more on them later in this section.

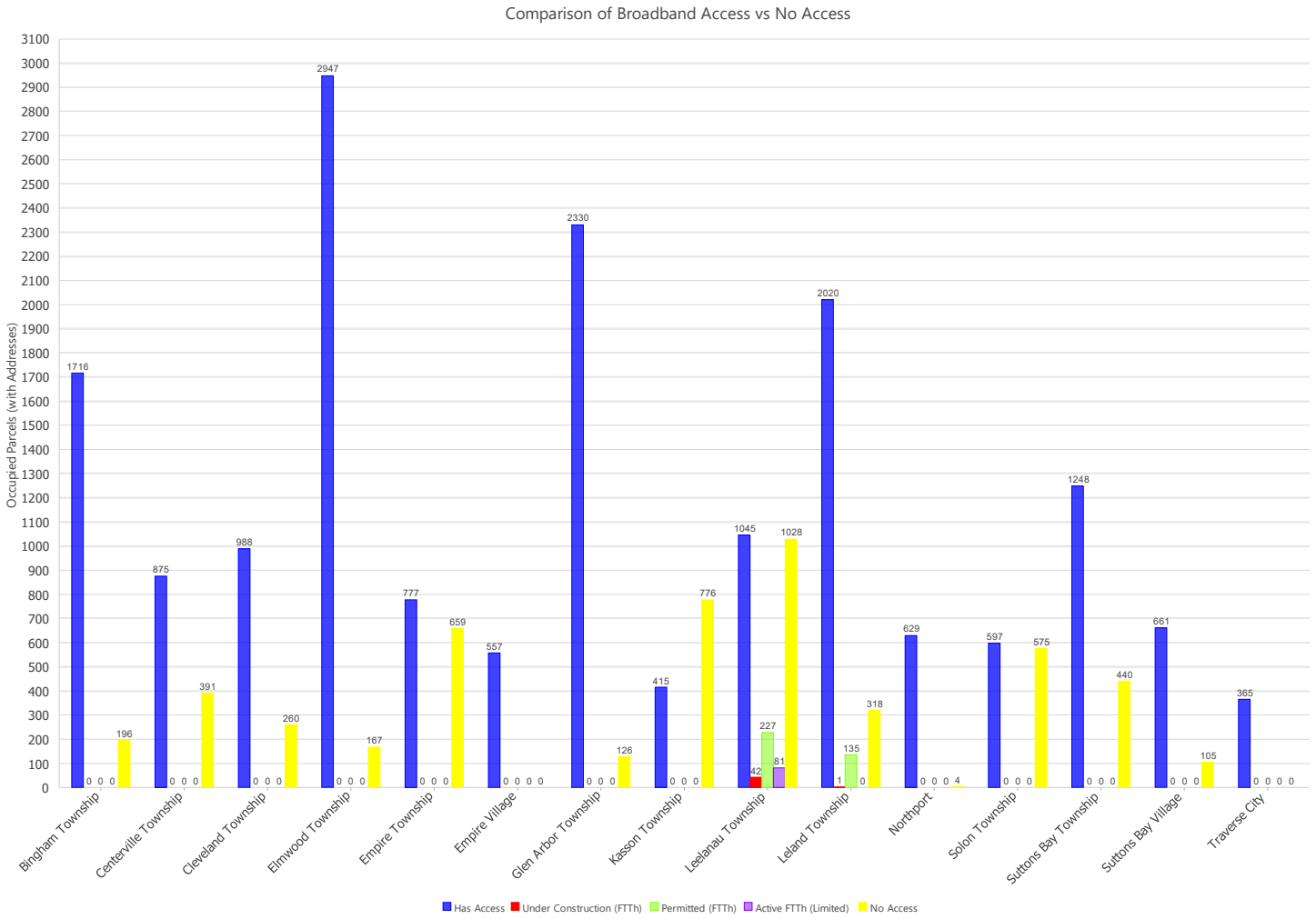
Based on the cabled technologies, the base line service areas are summarized below.

There are approximately 22,701 occupied parcels in Leelanau County. This excludes US and State Parks, Agricultural parcels with no occupancy, and other county, state or federal lands that are not occupied or have no address (Total Parcels is about 24,811). Of these, 17,170 parcels (almost 76%) have access to Cable (Charter Communications). 81 Homes are serviced by 186 Networks' Fiber (limited by backhaul speeds), and 405 homes currently in a wireless service area for Cherry Capital Communications, are either under construction, or have been permitted to get

Fiber services. 5,045 Parcels across Leelanau County remain without access to Cable or Fiber, or a little over 22% of the total occupied parcels within Leelanau County. This is summarized in the table below and broken down by township later in the report.

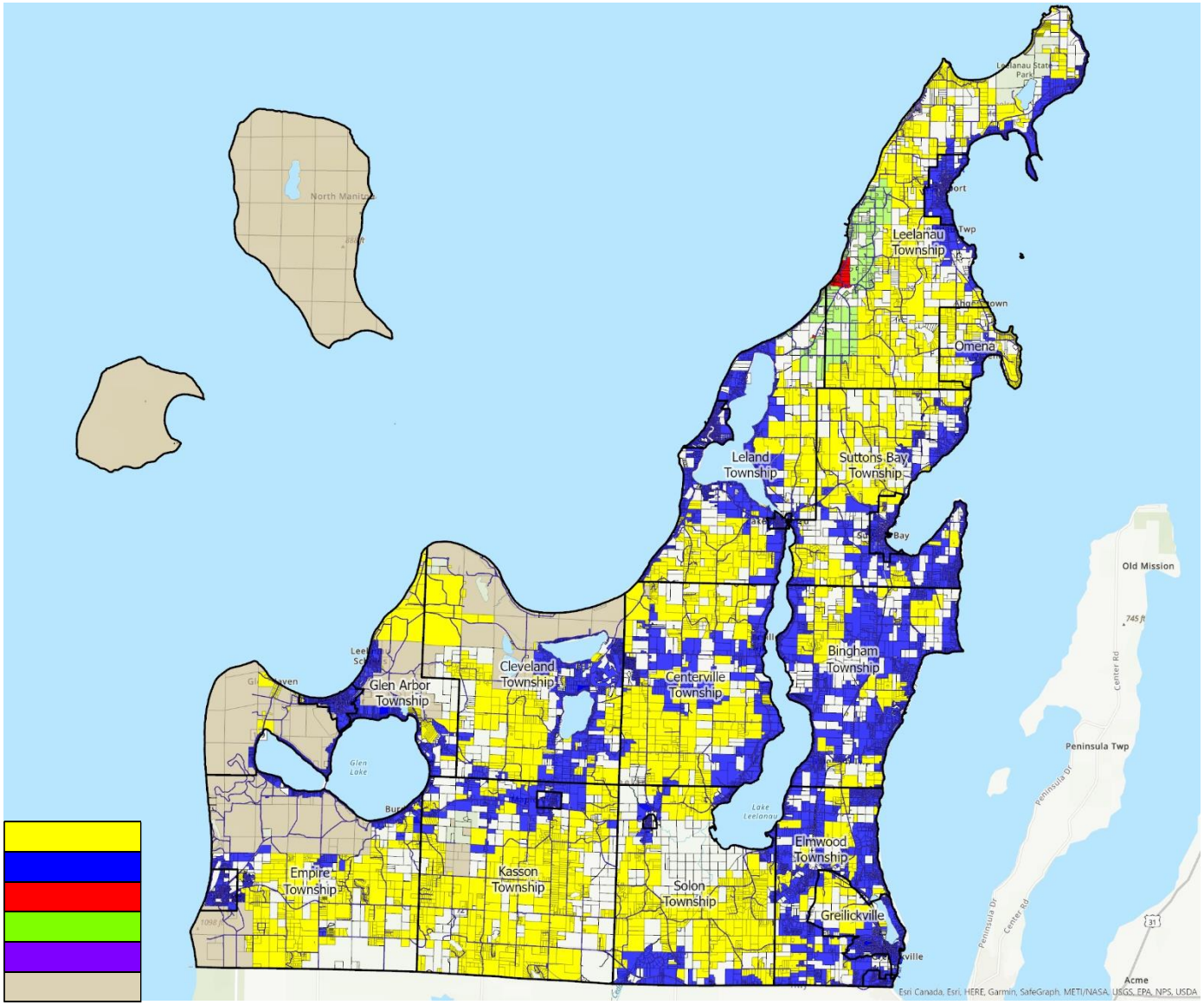
Total Served vs Unserved

Once the County was completely surveyed for Served areas, the data was compiled into an ArcGIS data base, identifying at the parcel level exactly who had access, and who did not. By township, all occupied parcels were counted.



Composite Served and Unserved area maps

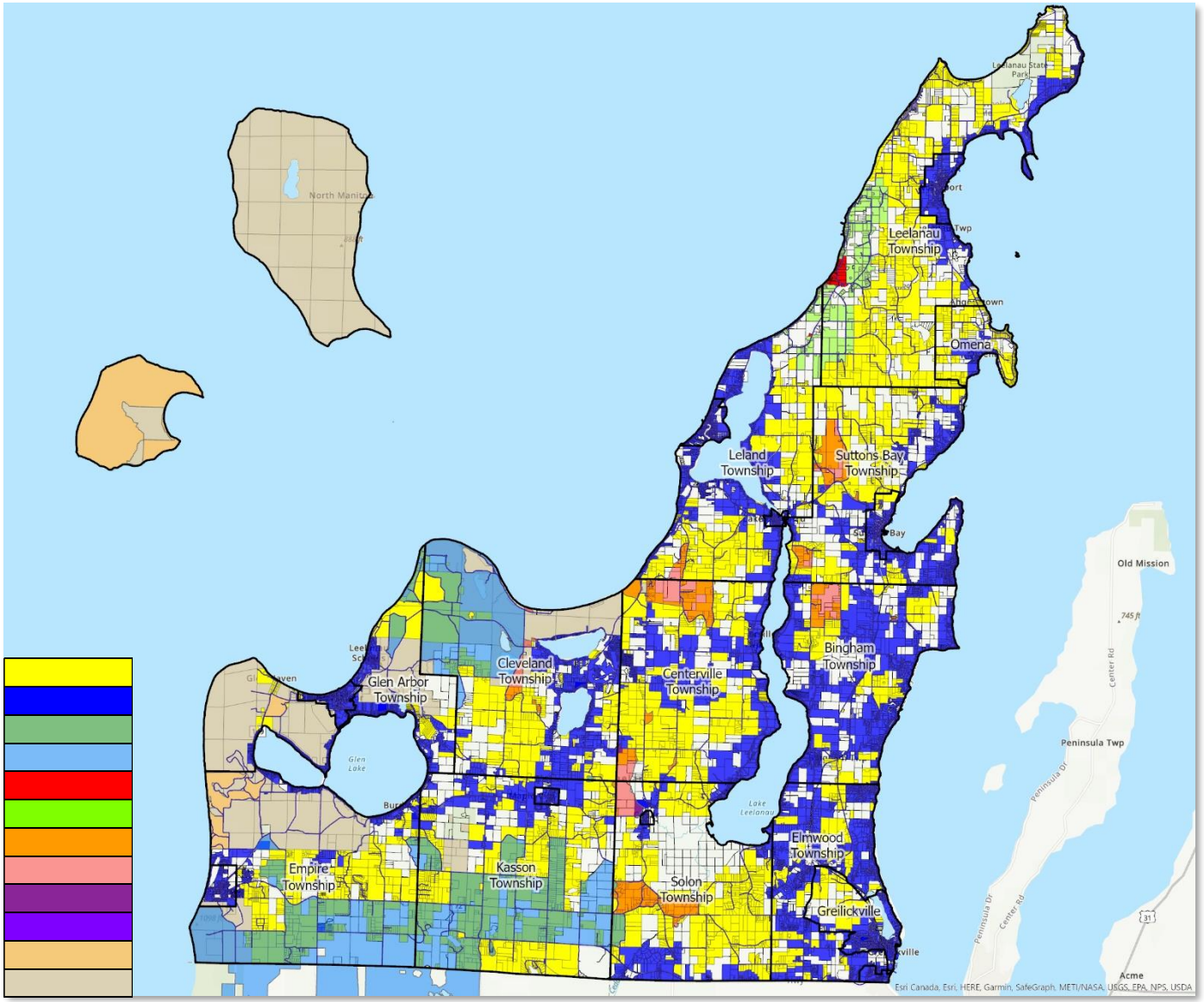
This map shows a composite view of all unservered parcels (yellow), served by Charter (blue), planned and under construction fiber by CCC (red and green), and served by 186 Networks (purple). There are enlarged views of each of the townships later in this report. White represents un-occupied parcels which include Agricurlural, Forested, Wetlands, etc.



Map Key

Unserved Parcels
Charter Served Parcels
CCC FTTh (Under Construction)
CCC FTTh (Permitted)
186 Networks FTTh (Limited)
US National Park Service

We have added the awarded RDOF areas showing where new services should be built by Charter and CCC, based on the RDOF program. The additional served areas are summarized in the Township Section. Note that both Charter and CCC have RDOF awarded areas that are unoccupied parcels.



Map Key

- Unserved Parcels
- Charter Served Parcels
  - Charter RDOF Expansion
  - Charter RDOF Unoccupied
- CCC FTTh (Under Construction)
- CCC FTTh (Permitted)
  - CCC RDOF Expansion
  - CCC RDOF Unoccupied
  - CCC RDOF (Charter Overbuild)
- 186 Networks FTTh (Limited)
  - Starlink RDOF
- US National Park Service

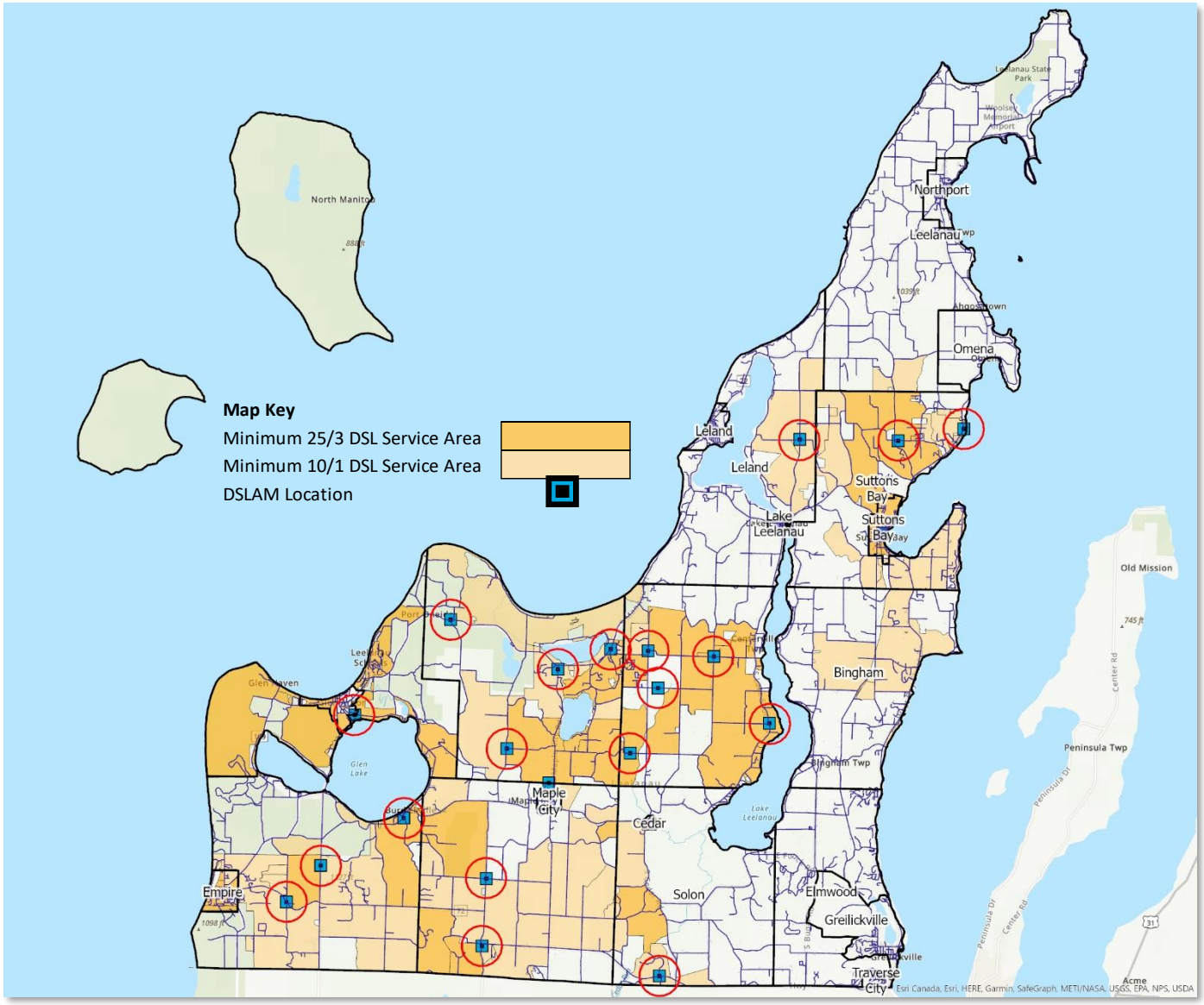
DSL Service Areas

DSL is a service offered by AT&T and Century Link (called Local Exchange Carriers, or LECs) in Leelanau County. DSL stands for "Digital Subscriber Line" (or "Digital Subscriber Loop" in some circles). There are several versions of DSL, each with multiple configurations (or profiles). The two most common versions are ADSL and VDSL for Asynchronous Digital Subscriber Line and Very High-Speed Digital Subscriber Line. DSL was developed to replace earlier digital telephone standards (e.g., ISDN) but still use existing copper lines that were originally installed for Plain Old Telephone Service (POTS) which included dial phones and later, DTMF (Dual Tone Multiple Frequency) which were commonly known as "Touch Tone" phones. Some of the existing phone lines being used, including those in Leelanau County, are up to 60 years old and older. Unless a subdivision has been recently developed, it can be assumed that the existing telephone lines in any area are at least 20 to 30 years old, which is a primary concern with DSL.

DSL has two main components, the DSLAM (Digital Subscriber Line Active Multiplexor), which is located either in a Central Office (CO), or mounted in a ground mounted, or pole mounted outdoor enclosure like the one in the image to the right, and typically fed by fiber (but can be fed with high speed digital copper lines). The second component is the DSL modem, which is installed in the subscriber's home.

The original ADSL (including ADSL2 and 2+) were never capable of meeting the current FCC standard of 25 Mb/s download and 3 Mb/s upload (25/3) speeds, which, as mentioned, are questionable if adequate for today's internet requirements. ADSL2+ was specified at 24/3.5, but only to about 300 meters without repeaters, or "Loop Extenders". ADSL is considered obsolete, but still in use in some areas, and thought to be in service in some parts of Leelanau County, but not the areas on the map below that are reported service areas for DSL.

VDSL and VDSL2 is more common today and is being used in most of the areas in Leelanau County serviced by DSL. VDSL is a synchronous standard, meaning that it runs the same data rates downstream and upstream. At the high end of VDSL, some profiles can reach 200 Mb/s up and 200 Mb/s down, up to about 300 meters from the DSLAM, and require several pairs of copper wire for each circuit. It could not be confirmed if either LEC offered these higher level VDSL services. The more common profiles in use today are 8a through 8d, and have a maximum rated line rate of 80/20, again up to about 300 meters. On a clean copper pair, this standard should still deliver the FCC minimum (25/3) up to about a kilometer away from the DSLAM.

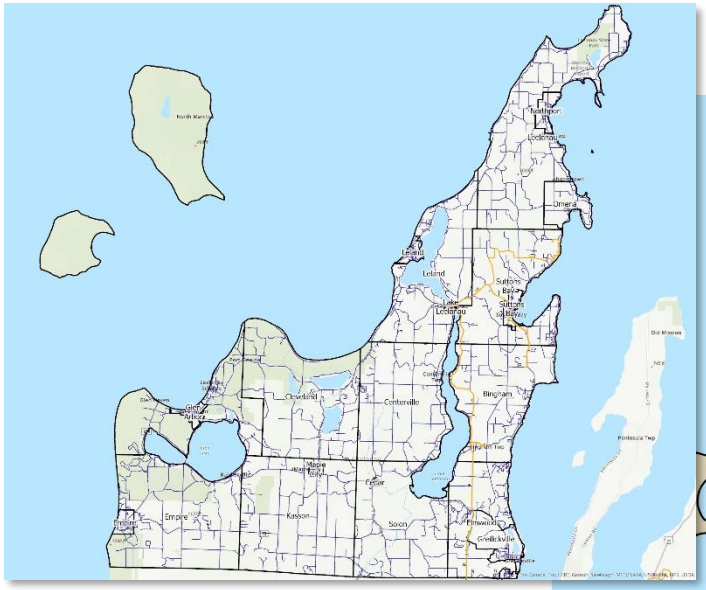


The DSL service areas are shown as reported by the two DSL carriers, and the DSLAM's were all located during the survey. The darker tan colored areas are the only areas expected to meet the FCC minimum of 25/3 based on reporting by the carriers.

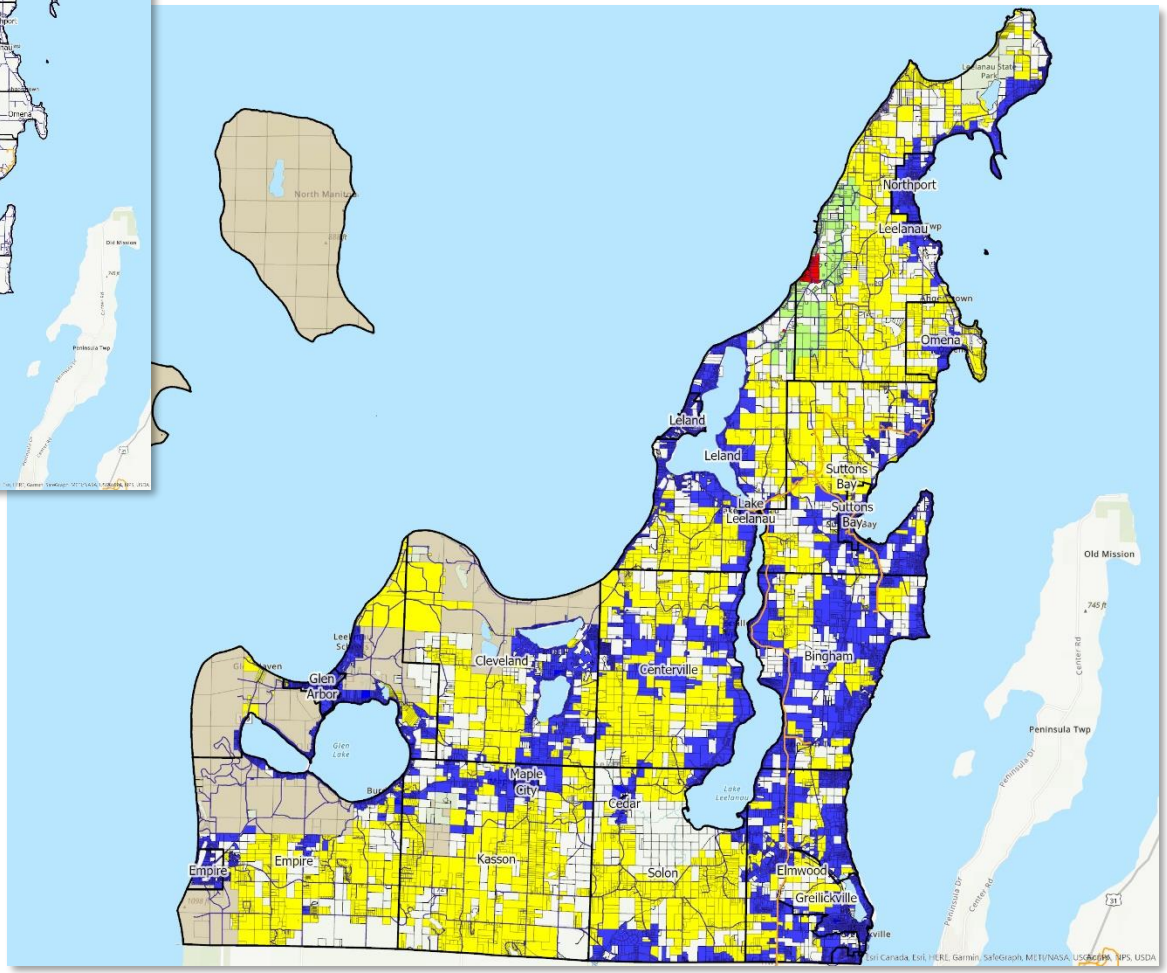
The red circles around each of the DSLAMS represent approximately 1000 meters from the DSLAM, and the limit before severe signal loss without loop extenders. While talking with residents who had DSL, none reported having satisfactory DSL service, but those living close to a VDSL DSLAM should be getting above FCC minimum threshold service.

GTB Fiber

GTB Fiber is owned and operated by the Grand Traverse Band of Ottawa and Chippewa Indians, and is beginning to outline service areas for expanded residential and business services. Actual service levels and areas are were not available for the publishing of this report, but additional information can be requested by contacting GTB Fiber.



The smaller inset map above shows the existing fiber currently in place and operational, and the larger map on the right shows the route with currently unserved areas that it passes through.



Wireless Technologies

Cellular

5G has been promised by Cellular companies now for well over a year, and most of them will claim “Nationwide Coverage”. Unfortunately, only one provider, T-Mobile, has launched 5G services in Leelanau County, and that is from a single tower behind the Glenn Arbor Fire Department. This is great news for T-Mobile subscribers in the Glen Arbor area, but doesn’t help the rest of the county. At the time of this survery, neither Verizon or AT&T had launched any 5G services, even though their reported coverage area maps may lead some to believe different.

Knowing that 5G should be available, our survey team was equipped with 5G devices for all three major carriers, to measure signal levels and sample data speeds around the County. It was confirmed that T-Mobile did in fact have 5G in the Glen Arbor area, but no where else. Our AT&T and Verizon devices failed to detect 5G anywhere in Leelanau County (and each recorded 10’s of thousands of data points).

On the other hand, 4G LTE was widely available, although not nearly as well covered as the carriers coverage maps indicate. The following maps are based entirely on 4G LTE, and provide a pretty acurate image of cell phone (including data) coverage by carrier. These maps are actual signal level measurement points, and not predictive heat maps that show large areas. Since they cover most of the roads in the county, it is easy to associate what you might expect inside a home or on agricultural equipment in a field simply by locating the data points closest to those locations.

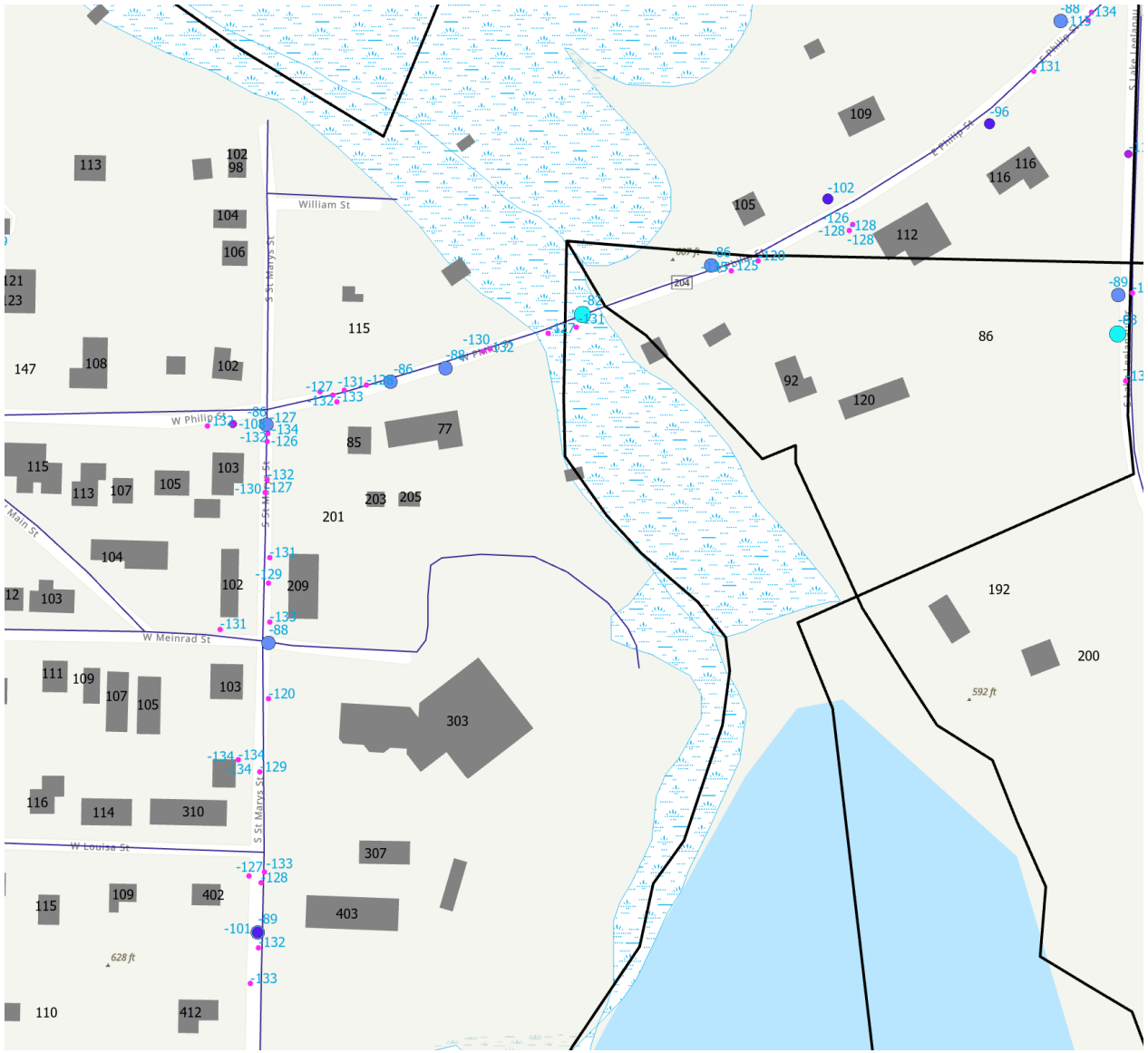
3G UMTS was also measured when detected, but since it, at its very best, has a maximum theoretical download speed of 14 Mb/s, was not tracked for this survey. It still works well for On-Star and other low bandwidth applications (including agricultural), but not a technology to consider for High Speed Rural Broadband. 3G has taken a subservient role in today’s line up for potential Broadband Internet applications, and many might call it obsolete, but it is important to understand that it is still operational almost anywhere 4G or 5G can be found, and will remain a gap filler for those applications that don’t require gigabit speeds to function.

The key to the right shows the range of signal levels that were measured. In a perfect environment, 4G LTE can be can be expected to deliver data rates of up to 100 Mb/s (or higher). But that will be limited to the higher end of the “Excellent” signal level range. The “Good” signal level range will deliver up to 50 Mb/s with optimum conditions, and the good to fair will likely offer aound 10 Mb/s or less. The remaining two ranges will drop into the Kb/s range to no service.

The signal level testing was an automatic function of the equipment while surveying for cabled technologies. Actual speed tests, like those listed here, required using a standard speed test app to be loaded on the device and run testing manually. Note that the first line item was tested near the base of a co-located tower site that was hosting both AT&T and Verizon. Both of these carriers showed excellent signal levels of -63 dBm and -62 dBm respectively.

Interesting to note that AT&T recorded a signal level 1 dB less than Verizon, but the data rate was less than half that of Verizons. Both are using 4G-LTE, so there were likely other factors involved, such as possible a much higher congestion rate on the AT&T network at the time of testing. At these data rates, this speed difference would not be noticed by users just "surfing the web", but is another example of how complex it can be predicting expected internet performance on these types of networks. For this reason, the examples shown on these pages cannot be construed as a scientific in depth propogation study of the three cellular networks, but rather just a performance sampling using the same types of devices that any consumer would be using for service. Following is another example of how much cellular performance can vary day to day.

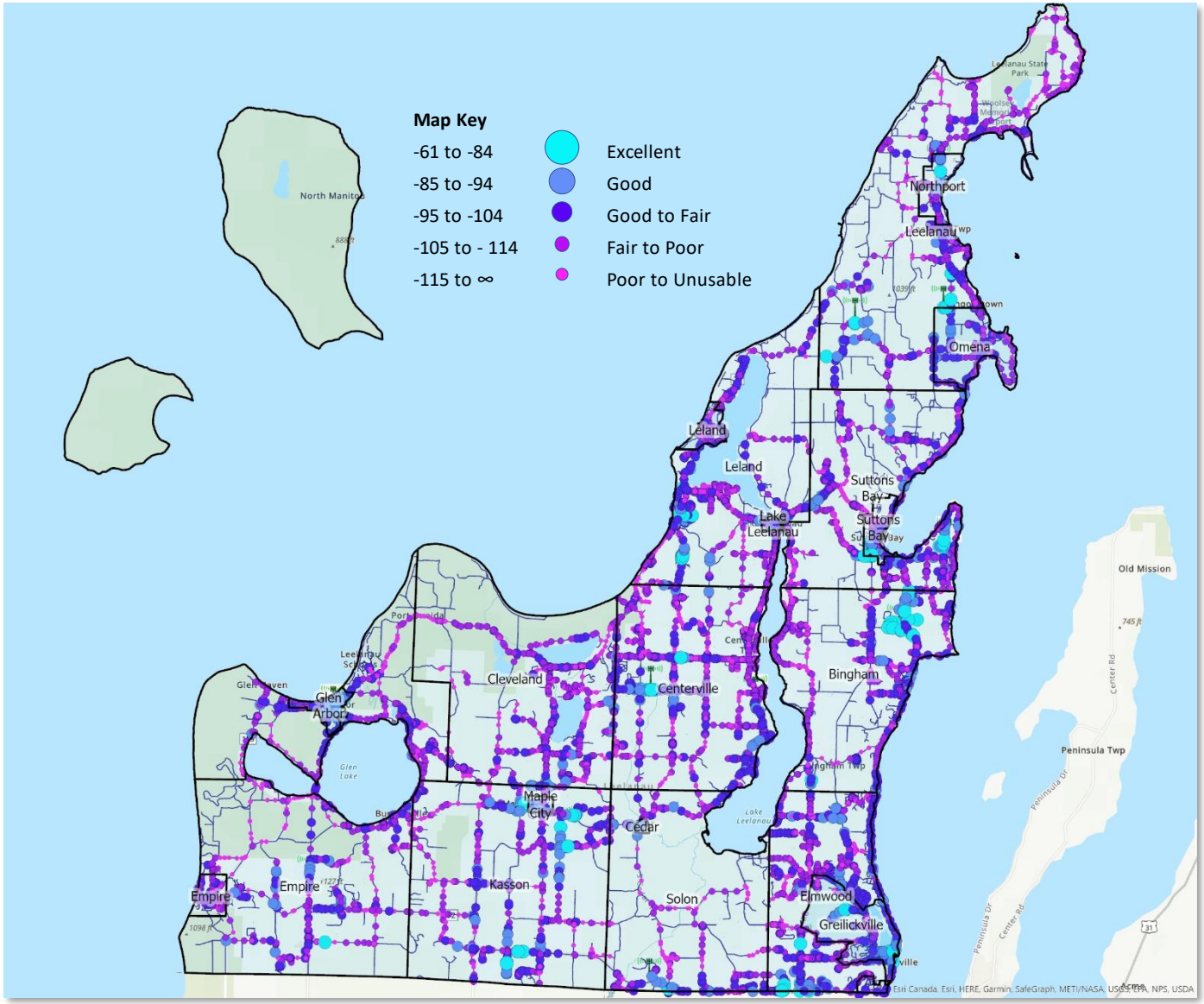
Cellular Speed Test results			
	Download speed in Mb/s		
LOCATION	Verizon	T-Mobile	AT&T
Kovarik Rd & Jelinek Rd intersection (Gill's Pier area)	110.34	no connectivity	52.81
Carlson Rd & E Onomonee Rd intersection(Leelanau Twp area)	0.69	6.64	0.42
N Swede Rd & E Rudy Rd (Leelanau Twp area)	0.59	15.89	49.45
Center Rd & Donner Rd (Bingham Twp area)	18.51	6.82	28.1
N Dumas Rd (Suttons Bay area)	11.34	4.68	2.72
S Manitou Trail & S. Townline Rd (Maple City area)	35.36	no connectivity	24.49
W Western Ave & S Glen Lake Rd (Glen Arbor area)	13.11	70	85.82
M-22 (Empire area start of town)	69.09	1.96	3.87
M-22 (other end of town)	0.67	1.75	0.78
M-22 & W Empire Hwy M-72	80.47	5.02	45.01
M-22 & W. Welch Rd (Glen Lake area)	7.39	no connectivity	1.31
Homestead Resort Glen Arbor	8.52	31.26	40.13



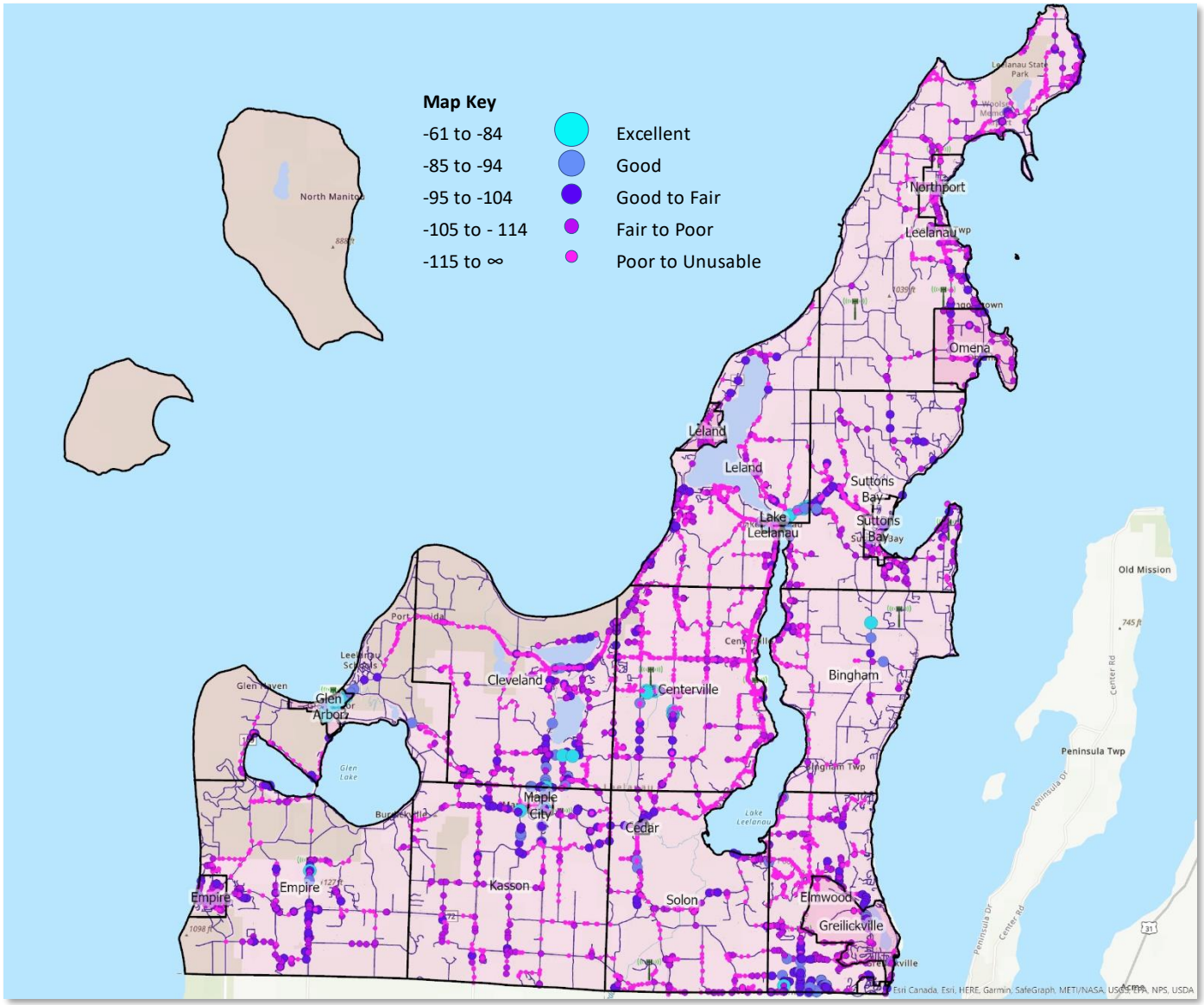
This is an enlarged view of the area at the Lake Leelanau Narrows, which was traveled frequently by our surveyors. This is T-Mobile and shows signal levels from multiple days. Note that there is one single "Excellent" reading right on the bridge crossing the channel, but almost all other readings range from "Poor" to "Good". The one excellent reading was at the low end, -82 dBm, but demonstrates how volitile wireless signals can be, and why it is so difficult to predict how they will perform with any consistancy.

Although not visible on the other maps in this report, this level of detail is part of the GIS files that are included with this report. The county will determine how this data can be accessed and used.

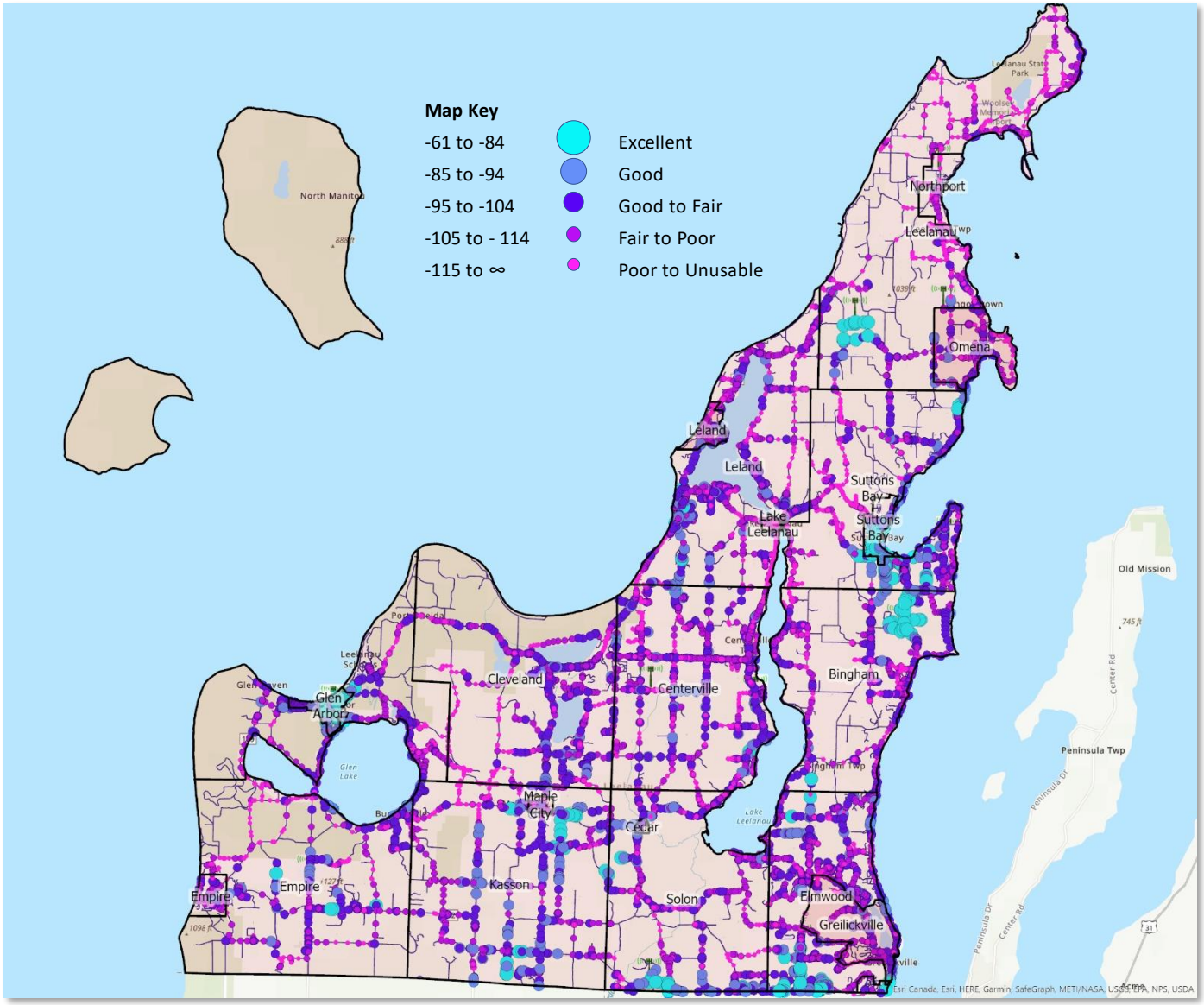
AT&T Signal Coverage Map



T-Mobile Signal Coverage Map



Verizon Signal Coverage Map



Cellular Fixed Wireless Residential Services

Some areas have available Fixed Wireless Services offered by the same wireless carriers offering cell phone services. Although it is based on the same system and technologies that would allow you to use your phone as a Hot Spot, it does offer some performance advantages.

It is offered only in certain areas where using additional equipment in a semi-permenant home or business installation, can provide a measurable performance advantage over your Smartphone. Using 4G-LTE technology, (same connection as your smartphone), it uses a "modem" rather than a phone like device, usually with a "fixed" external antenna mounted indoors or outdoors. The modem basically connects to the cell tower in the exact same manner as the cell phone would, but prioritizes a data only connection, providing better Internet connection speeds then a cell phone set up as a hot spot, or even a dedicated hot spot would provide. In some cases, a separate booster may also be used in the home or business, but that is not discrete to just data connections like a modem is. A booster can help both data and voice connectivity. In both cases, the modem and the booster, the antenna can be directional and fixed, not moving around like a handheld device would be, which helps keep the signal level consistant.

AT&T Fixed Wireless Service Area

AT&T advertises a small service area between Omena and Gills Pier area for Fixed Wireless in the Home, which aligns with a good Cellular coverage area shown on the map on page 26. Since it is a technology using the same 4G LTE technology as your smart phone, there may be service offered in other good coverage areas around the county, but not necessarily advertised.

Verizon doesn't seem to offer Fixed Wireless for Home or Business in Leelanau County, even though they do have close to comparable service levels with AT&T, and appear to offer this type of service in more markets across the US than AT&T. But an external antenna with a booster and dedicated hot spot inside the home may improve the performance over using a smartphone as a hotspot.

T-Mobile is currently the only provider offering 5G services, and only in the Glen Lake Area so far. Like Verizon, T-Mobile does not seem to offer Fixed Wireless as a specific service. But as they continue to build out 5G within the county, this will offer some good options for home and business internet in areas where T-Mobile will have service. It won't perform like 5G currently offered in Urban areas, and that type of "Ultra Wideband" service won't be available in Rural areas any time soon since that technology requires "microcells" (small cell sites on light poles,

buildings, and other structures) located within hundreds of feet of each other, rather than dozens of miles between cell towers, as is the case in rural areas. Unfortunately, as can be seen in the signal level map on page 27, T-Mobile has the least amount of 4G-LTE coverage in the county, which will impact their migration to 5G, since they use the same towers. T-Mobile has far fewer towers in operation in Leelanau County than the other two providers, but they do appear to be expanding more radidly then the other two. The surveyors did pick up random 5G readings in the Leland and Omena areas, but the source could not be verified, and it wasn't consistant.

Mobile Virtual Network Operators (MVNO)

We have all seen the advertising for alternative cellular providers like Boost Mobile, Cricket and Straight Talk (and many others). Since this is a study, or inventory of the available technologies across Leelanau County, it seems that the question may be asked about these alternative providers, who they are and what can they offer. This same category also applies to alternate Wireless Internet providers offering services in rural areas. With some exceptions, all of these alternate providers purchase "bulk bandwidth" from the three national providers (AT&T, T-Mobile and Verizon), and regional carriers like US Cellular, and re-sell it as their own. In many cases, they may be relegated to an older technology that is still operational (like 3G), or may be limited in features they can offer as compared to their host providers, however, they might also be offering the latest technology as well. In any case, since they do not own their own networks, they can be a better economical alternative for limited or equal services, but typically cannot offer anything beyond what the Big 3 have in place.

Wi-Fi Technologies

Wi-Fi, or more technically, 802.11x technologies, have become a pervasive expectation among most people carrying any type of internet device. First question many people ask when walking into a restaurant or other public establishment, is “what’s the Wi-Fi password”? Most businesses today try to offer free Wi-Fi as they know it is what their patrons expect, and it is good for business. It is also the most used method of networking within peoples homes, and is expected to be an option in most workplaces as well.

The name Wi-Fi is another generic noun (like Zoom) that refers to dozens of technologies and standards, that were mostly developed over the years for local area networks (LANs). And although a couple of the standards do cover longer distance point to point and point to multipoint applications, it was never a very good set of standards to develop full wide area networks, especially ones to cover entire counties. Most of the 802.11 family of standards use unlicensed 2.4 and 5.2 GHz frequency bands, which is great for gaining wide acceptance of the technology, but also the problem; the bands are not protected from interference issues or overuse. The pioneers in this industry that have pushed it beyond all limits, and managed to bring some level of Internet, especially to rural areas, have done a remarkable job with the technology. But it is still not a good choice for building a county wide wireless strategy on.

Three notable pioneers in this area have developed their systems to go above and beyond what they were ever designed to do. They pieced together working networks that provide a service, some areas working better than others, but filling gaps that otherwise went unserved. Cherry Capital Communications, 186 Networks, and Elevate Net.

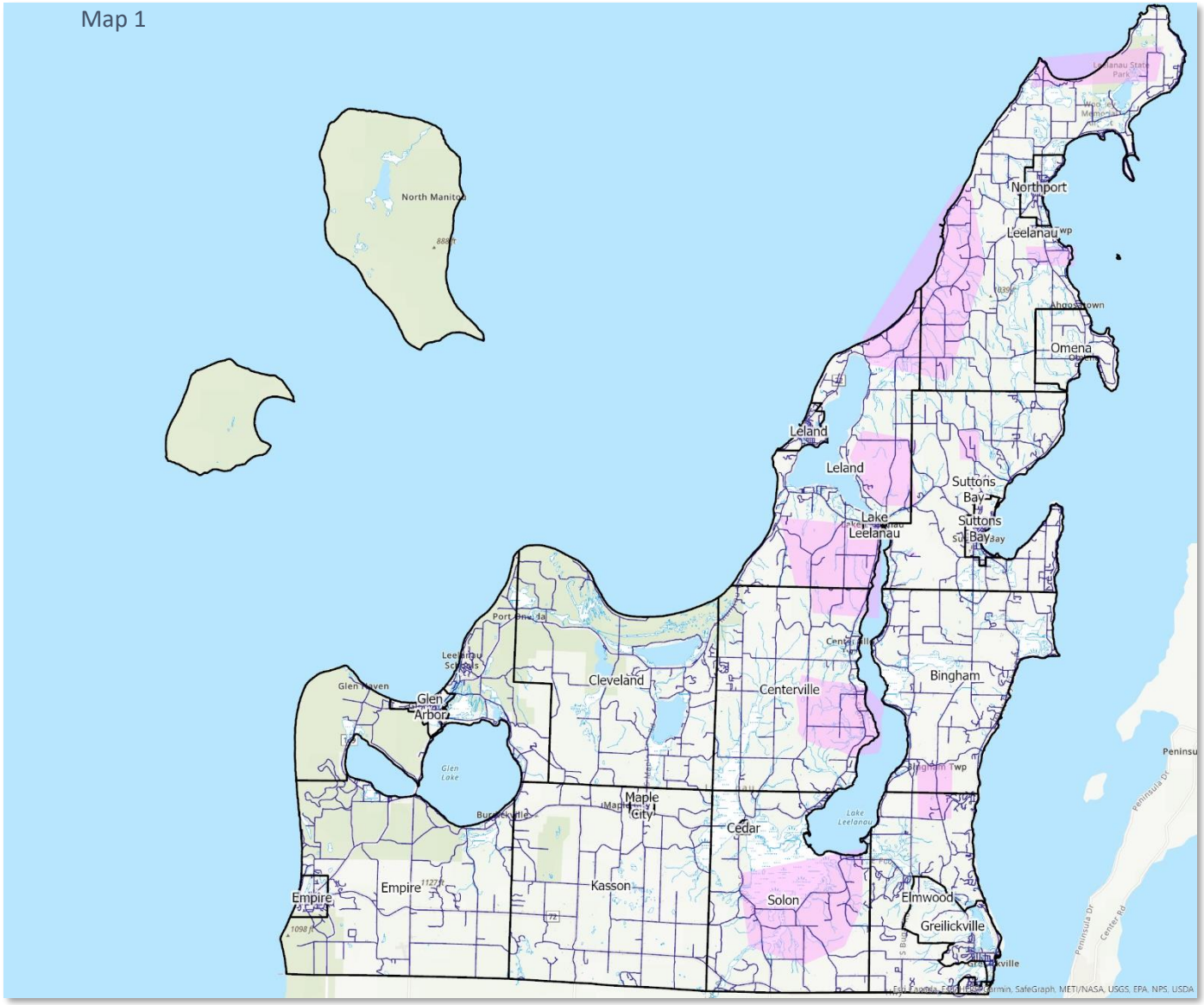
Cherry Capital Communications has an active network in Leelanau County and has provided their coverage map below (See Map 1). As mentioned earlier in this report, there are privacy concerns with Michigan Public Service Commission (MPSC) rules and guidelines, and certain equipment and customer locations were not specifically identified. But the coverage map does show the areas where service exists, and will continue to serve those areas for some time to come. However, Cherry Capital Communications is working to make an investestment in the technology by migrating these service areas to fiber based networks (Map 2). Cherry Capital Communications is also one of the two recipients of RDOF funding, and is obligated as such to provide fiber to those RDOF areas indicated on several of the maps contained in this report.

186 Networks, which have wireless systems in the northern part of the county, have also shown a commitment to the county by migrating some of their systems and customers to a fiber based distribution network (Map 3). Theirs is active in the Christmas Cove area, and currently uses a wireless link to feed it. It is not clear the exact technology being used for the link, but appears to be either a 5.2 Ghz unlicensed link, or a 5.8 to 6.2 licensed link, either of which could be capable of 200 to 300 Mb/s. Depending on some of the equipment, and actual distance of the wireless link (it appears to be relayed once to get back to Elk Rapids), the speeds could be better then that. 186 Networks did not respond to our

requests, but their efforts have been documented in the enlarged map below, showing the area covered by fiber. Their wireless coverage area appears to reach well beyond their current fiber covered area.

Elevate Net has been operational in two communities and their surrounding areas for a number of years, Maple City and Omena (Maps 4 & 5). The main services located for Elevate Net are based on County owned towers, giving them additional coverage based on the higher mounting heights aforded them with the commercial towers. Actual performance data is not available, but based on 802.11 standards, it can be expected that much of the service areas shown below can meet and exceed FCC minimum 25/3 requirements (subject to normal environmental and potential interference conditions discussed earlier).

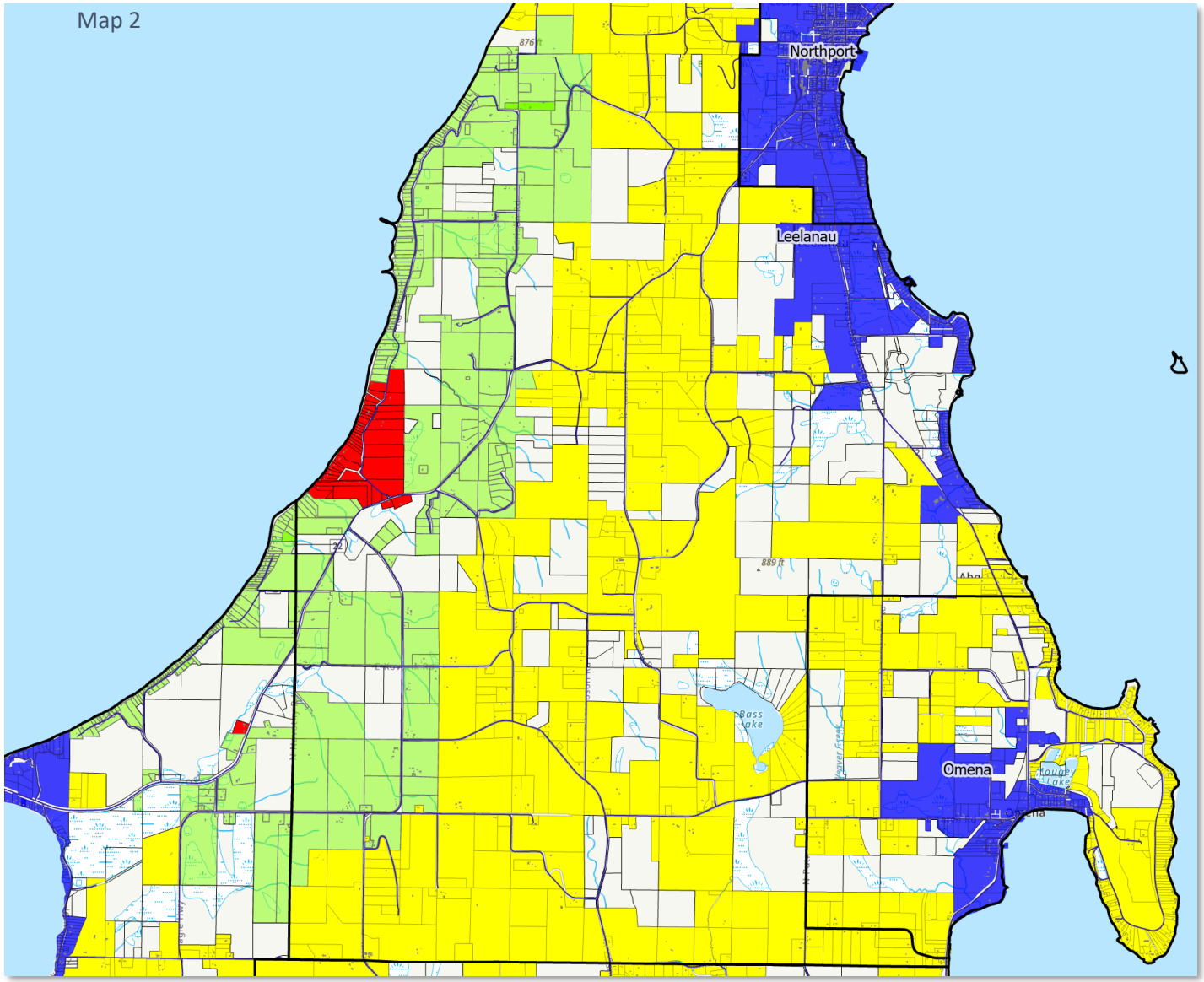
Map 1



Cherry Capital Communications

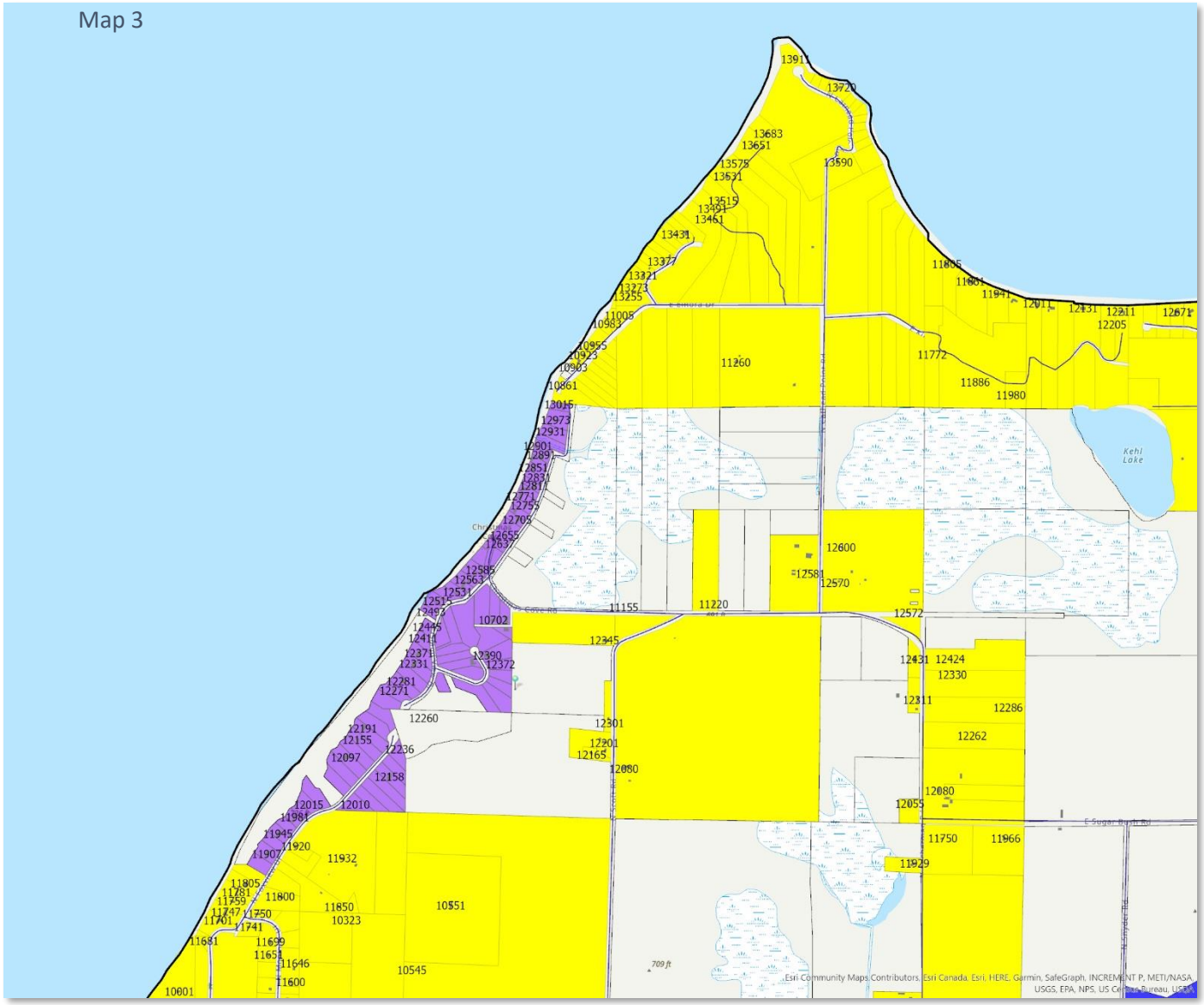
Cherry Capital Communications has active wireless systems in the pink highlighted areas to the left. In speaking to customers in two of these zones, they are very happy with the Internet Performance they are experiencing.

Map 2



Cherry Capital Communications has also begun building fiber in their Gills Pier service zone. The red area is under construction, and the green area has been permitted for construction. It is assumed that the backhaul for this fiber area will be fiber since there are “Middle Mile” options near the main CCC node feeding this expansion. (Note, the data on this map was collected in June of 2021, so may be outdated. Look for updates on Cherry Capitals web site.)

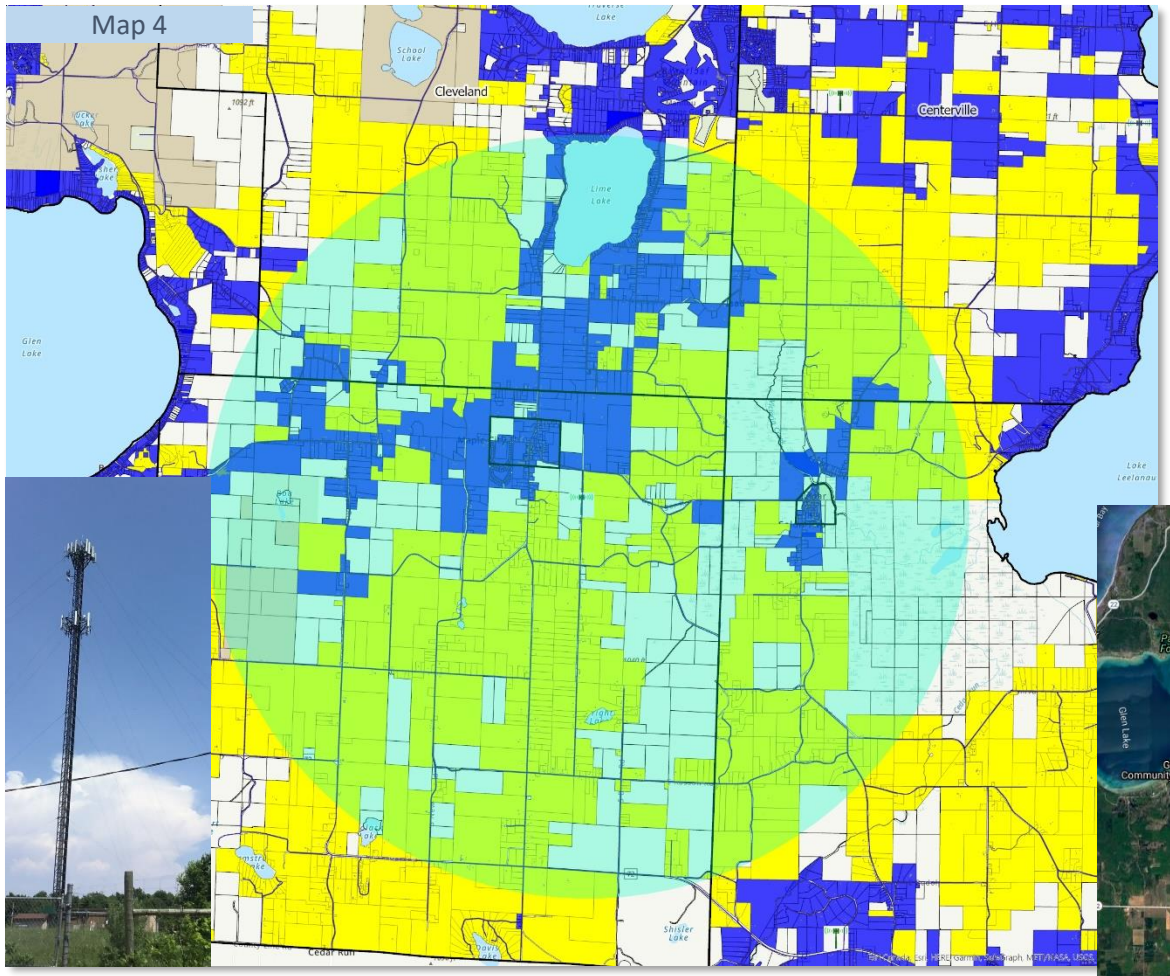
Map 3

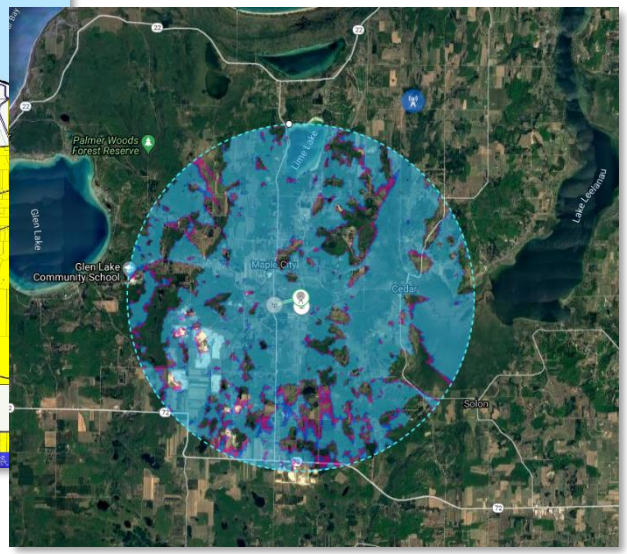


186 Networks

186 Networks has wireless subscribers across Northern Leelanau County, and this concentration highlighted in Purple have fiber cabled to their homes, being fed from a private tower (blue push pin) connecting back to Elk Rapids across the Grand Traverse Bay.

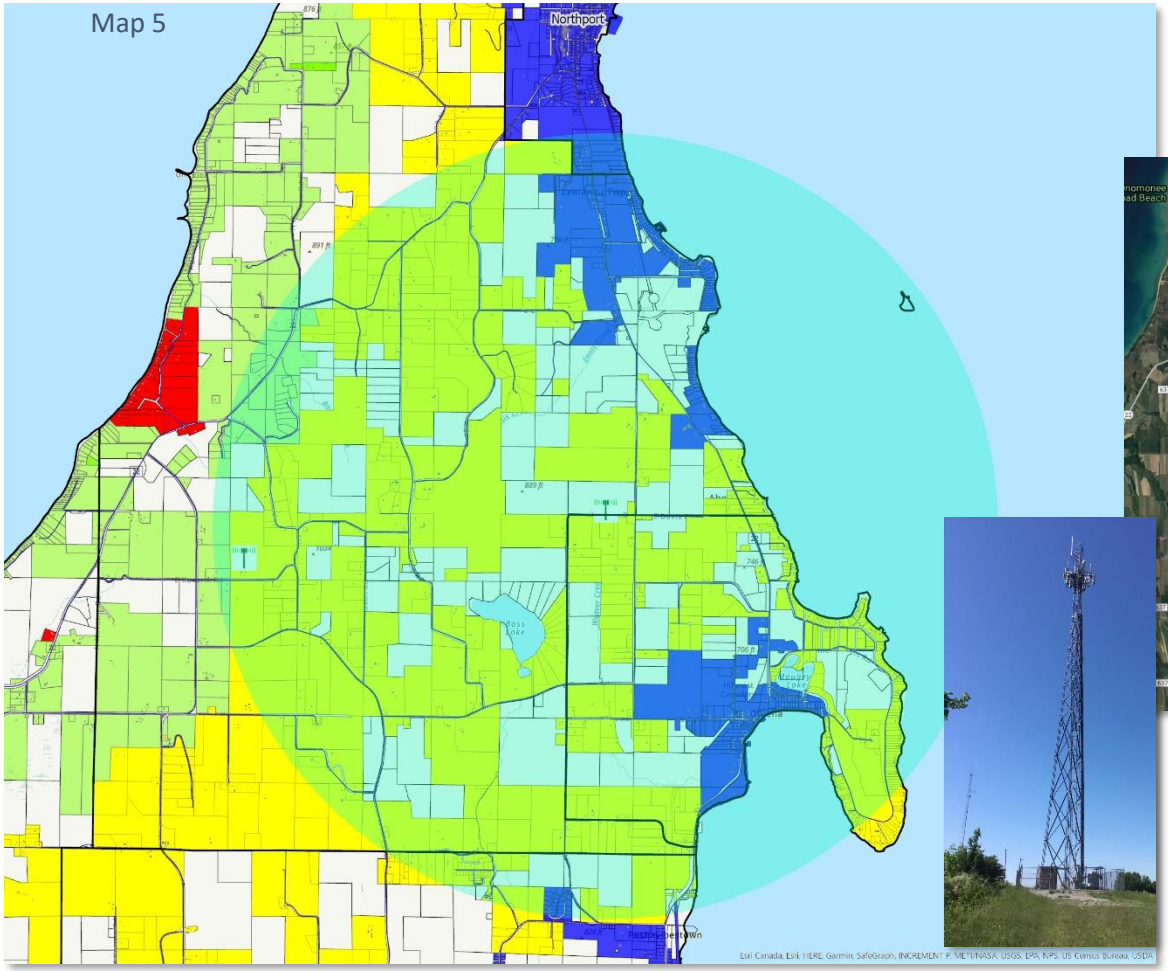
Elevate Net operates from two Leelanau County tower locations in Kasson Township (Maple City Area) and Leelanau Township (Omena Area).

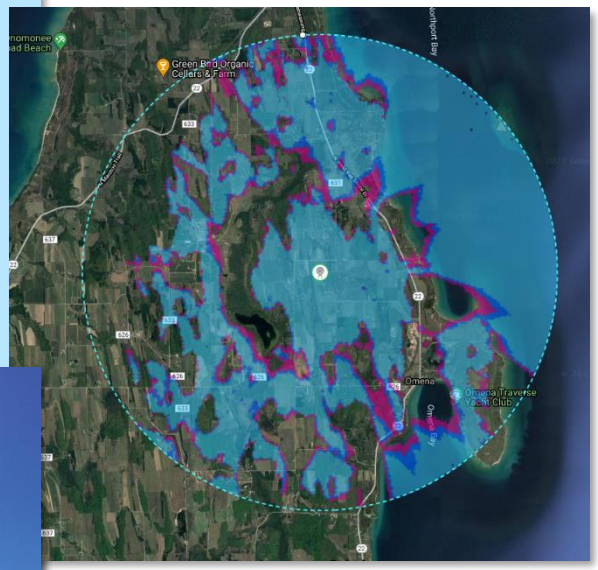




The images below show the Maple City area approximate service area. Actual performance of the wireless requires field verification based on the location and distance from the tower (located in the center of the aqua circle. The service area is overlayed on the surveyed served and non-served cable areas to show how much unserved areas (yellow-green) can be serviced with this wireless alternative.

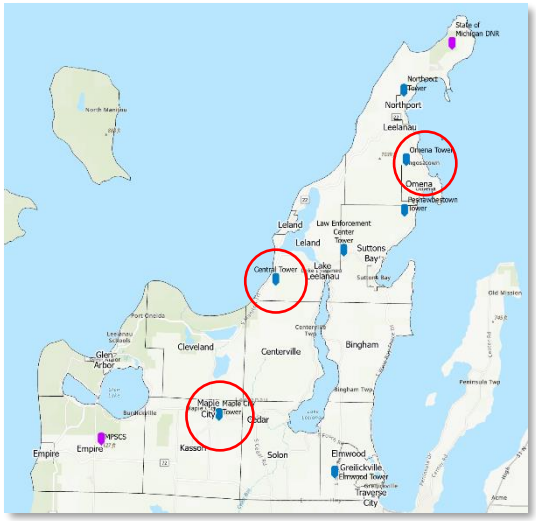
Elevate Net's second service area is centered around Leelanau County's Omena tower located in the northern part of the Omena Community. Again, the service area shown in Aqua is overlayed on the served/unserved area map showing how much of the unserved areas in Leelanau Township may be currently servicable by Elevate Net.





Agri-Valley

The third wireless (soon to be) option is a licensed wireless technology built similar to a Cellular network, but designed to focus more on reliable data services. Agri-Valley has proposed a network, using existing County towers, and operating in two bands, the new 600 Mhz band referred to as Band 71, and another new technology called Citizens Broadband Radio Service (CBRS) which operates in the 3550 to 3650 Mhz range. The higher frequency does not cover the geographic area that Band 71 can, but the technology behind CBRS is a new methodolgy of bandwidth management, and how it is prioritized for different uses, providing a different set of advantages.



Band 71 is a very desirable space for any wireless operator to own, as it is currently the lowest frequency band in the United States available for new generation wireless technologies. The lower frequency means that it can cover more geographic area than any of the cellular bands at higher frequencies. This band used to host UHF TV channels, and with the advent of Digital and High Definition TV in the 1990's, the US started moving all TV channels to lower frequencies, freeing up this area of the spectrum. Agri-Valley was awarded exclusive rights to part of this band, giving them a vehicle to offer a new level of reliable wireless data services. T-Mobile has rights to part of Band 71, but the other major cellular providers using higher frequency bands, do not have the far reaching coverage that Band 71 offers. Agri-Valley will be launching services based on existing 4G-LTE and 5G technologies, but with enhancements making it an ideal technology for Rural High Speed Broadband. This is a very promising development for Leelanau County to fill the unserved gaps and provide a more immediate alternative to 5G services.

Value	Color
-130.00	
-125.00	
-120.00	
-115.00	
-110.00	
-105.00	
-100.00	
-95.00	
-90.00	
-85.00	
-80.00	
-50.00	

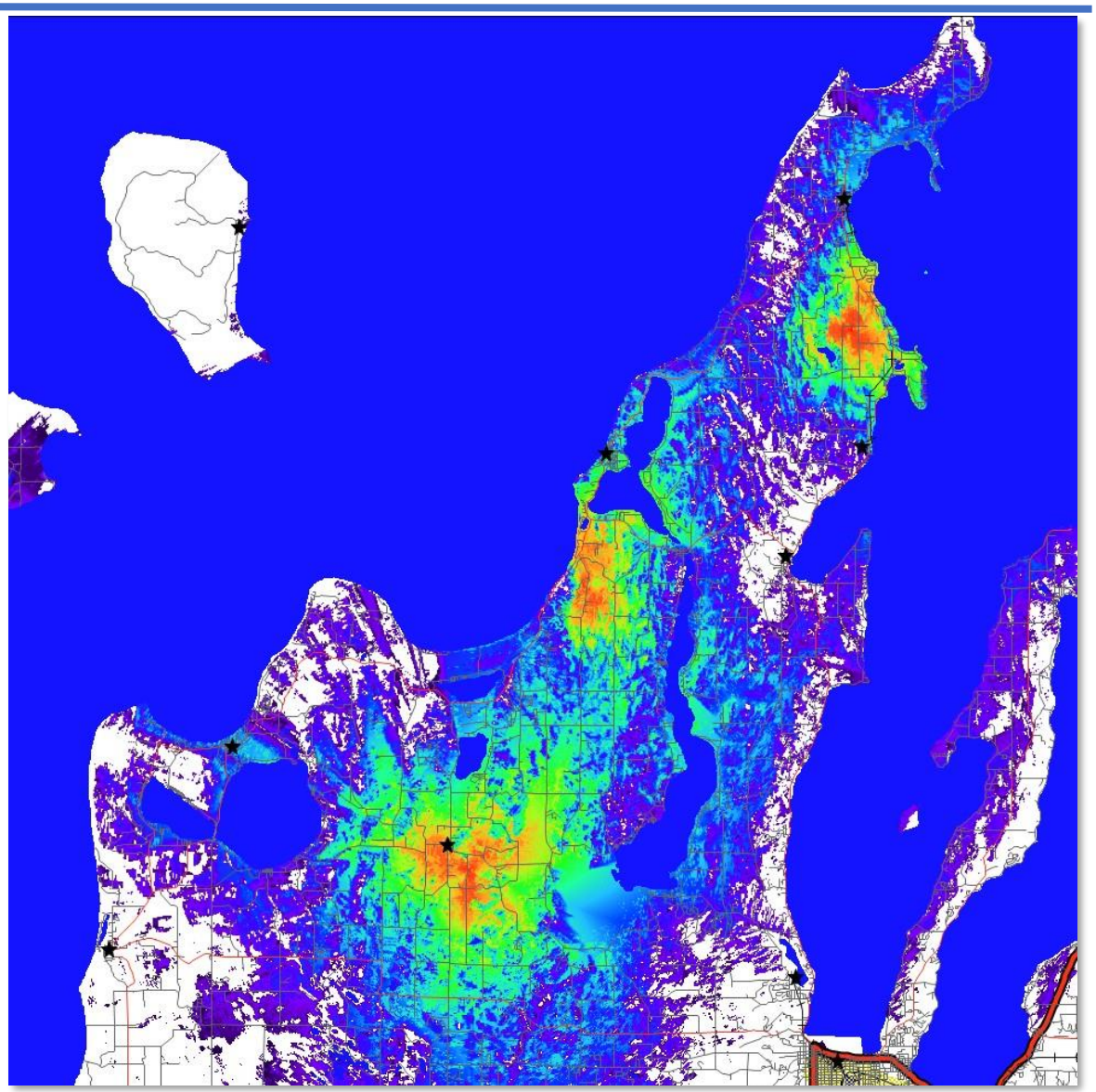
Following are a set of "predictive" coverage maps, for both Band 71 and CBRS, generated using computer models. It is predictive only at this point, and all actual performance will need to be field verified after the new systems have been launched. But as a reference, along with the predictive coverage areas, here are some guidelines of what might be expected from the two new systems. The chart to the left depicts the estimated signal levels based on the computer models. It is expected that any area receiving -100 dBm or better (smaller numbers are better in this chart), will see data rates easily exceeding FCC minimum thresholds.

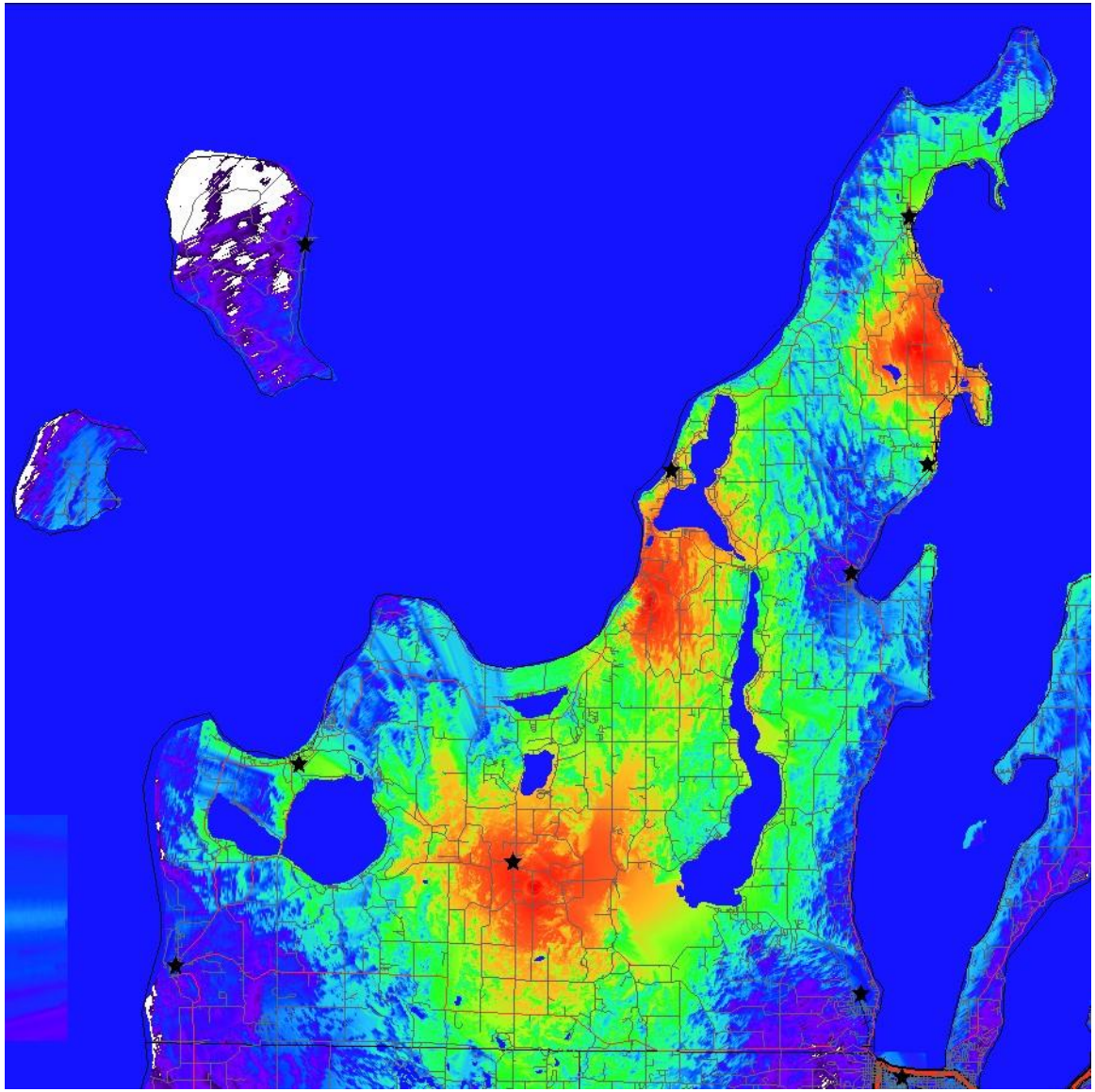
The initial plan is using three County tower locations, Omena, Central Tower, and Maple City (shown in the insert above).

Agri-Valley CBRS Map

CBRS is not a new licensed band, rather an existing band that has been used for years for Satellite and Military applications, but is becoming more available as those technologies move to other spaces in the spectrum. During the transition, and to preserve the usage by incumbent technologies, the FCC has granted (through auctions) “Priority Access Licenses” (PALs) to service providers, giving them priority access to segments of this band permitting faster deployment of new generation services like 5G. This is a lower cost entry for service providers than the traditional spectrum licensing process and will bring High Speed wireless services to areas much quicker than before. The predictive map shows the estimated coverage areas for the initial three towers.

Value	Color
-130.00	
-125.00	
-120.00	
-115.00	
-110.00	
-105.00	
-100.00	
-95.00	
-90.00	
-85.00	
-80.00	
-50.00	





Agri-Valley Band 71 Map

Band 71 is one of the newest spectrum allocations by the FCC for wireless services, and was sought for its ability to cover larger geographic areas without needing higher power levels. This predictive computer model shows good to excellent coverage through most of the county (-100 dBm or better) with almost the entire county being within an acceptable level of -115 dBm, which should yield acceptable performance throughout the entire county. Once the systems are up and operational, actual field tests will be used to update the coverage area maps.

Value	Color
-130.00	
-125.00	
-120.00	
-115.00	
-110.00	
-105.00	
-100.00	
-95.00	
-90.00	
-85.00	
-80.00	
-50.00	

Satellite Internet

Traditional Satellite Internet

To round out the wireless options for Internet in Leelanau County, Satellite Internet does require at least an honorable mention. There are two major providers that have offered services for years, Hughes Net and ViaSat (formally Excede), and two newcomers using a different type of satellite technology.

Both ViaSat and Hughes use "Geosynchronous" or "Geostationary" satellites to offer their services. Both terms refer to the same constellation of satellites directly aligned with the equator, approximately 22,300 miles above the earths surface. Traveling at the same relative speed of the earths rotation, they appear to remain in the same stationary, or synchronous location relative to one looking up from earth (since both are rotating/orbiting at the same relative speed).

From that vantage point, satellites used for internet (and other communications) can aim their antennas at entire regions, called footprints, and a single satellite can cover entire continents. Most of the United States is currently served by ViaSat-2 for ViaSat, and HughesNet is using Echostar XIX for most of their US residential internet services.

The advantage of Hughes and ViaSat is that they can offer service almost anywhere on earth where their satellites are pointed, and can achieve FCC minimum threshold data rates of 25/3. However, the data rates, and service level itself are subject to many variables and limitations. The ground antenna (dish) or earth stations require a clear line of sight with the satellite above the equator. In the northern hemisphere of the earth, that means a clear line of sight looking south towards the equator, at whatever "elevation" and "azimuth" (the angle off the horizon, and east/west coordinate) the satellite is located. This can be challenging in areas that are heavily wooded, or in hilly or mountainous regions when located on the north side of a mountain. The other disadvantages have to do with the amount of data you can use in a given period of time, and the distance it has to travel to bounce off the satellite and back to earth (twice).

Latency is the term used to describe how long it takes for the data stream to start after you have sent a request over the internet to look at a web page. In the case of a cabled network, that request needs to travel through possibly a couple thousand miles of fiber optic cables to view a web page that is located on a server in, for example, Quincy Washington (a major data center hub for North America). This communications is still near the speed of light, so it can seem at times, almost instant. On the other hand, using geosynchronous satellites, that request has to travel at least 44,600 miles to that same server, and then 44,600 miles back. You can get 25 Mb/s through satellite, but you may be waiting several seconds before it starts. Think of it as a hot water faucet on your sink. When you turn it on, the hot water has to get from the water heater, through the pipes in your house, before you get hot water. If it worked like Satellite, the hot water heater would be located at the water

tower in town, and you would have to wait that much longer before you got hot water, but once it started, you still get the same full pressure until you shut it off.

The other issue is that most reasonably priced data packages have data caps. Once you have reached your data cap for the month, that hot water source gets moved from the full pressure of the water tower, to a garden hose still located at the water tower.

The Newcomers

In a new technology field that is starting to develop rapidly, two new providers have relevance to the purpose of this study. Starlink, which has been very publicly secret about their technology and plans, and OneWeb, which has not gotten near the press coverage and have remained virtually unknown in the industry (so far), even though they were established and working on their technology since 2012. There are other entrants in the field that will emerge in the years to come, but these two have offerings that are close to available now (just maybe not fully up to speed yet).

The primary difference that needs to be noted is that Starlink is the only one pursuing the residential market today, where OneWeb is planning to focus on commercial and government (although residential might not be far off for them). Since this report is intended for all potential internet users in Leelanau County, we thought it important to mention OneWeb.

Both companies are building Low Earth Orbiting (LEO) satellite networks (the space up until now where GPS, the Hubble Telescope, Iridium telephones, and the International Space Station occupy). Starlink satellites are around 340 miles above the Earth, where OneWeb will be about 750 miles up, giving them a much broader footprint from each satellite. Starlink's network is approaching nearly 2000 satellites in a network planned to have 30,000 satellites someday. OneWeb has only launched a couple hundred satellites so far and is only planning a network of less than 1000. Starlink is currently beta testing with about 10,000 installations (including some in Leelanau County) that are consistently seeing data rates of around 120 Mb/s, and OneWeb is reporting that they will be able to reach into the gigabit range, although actual ground tests have not been published yet. Since both networks are LEO, the latency issues that plague Hughes and ViaSat should not be a concern with these new systems.

Like Hughes and ViaSat, line of sight is also a concern, but not just to a fixed point over the equator. LEO satellites are moving overhead constantly, and the signal being picked up by a user terminal on the ground is being handed from satellite to satellite as they pass overhead. A larger view of the sky is necessary but doesn't have to be in a particular direction.

Starlink is also an RDOF recipient based on parcels (see FCC Form 477 & RDOF section maps) in Leelanau County which are generally un-occupied US Park areas. This means that they now have an obligation to provide service to these areas within the timeline of the RDOF program (about 6

years). This is very illogical for a couple reasons. The RDOF program is meant to bring Internet services to unserved homes and businesses based on Census Survey blocks. The census blocks used to award funds to Starlink are primarily US Park Service properties, (Sleeping Bear Dunes), and the few residences that are located within those areas appear to be owned by the federal government. The other reason is the fact that if Starlink provides satellite service to these parcels, due to the very nature of the technology it will also be available to the entire county. Satellite provided services cannot be delineated by such relatively small areas. As it stands though, Starlink does already appear to be operational, at least in its Beta program, for the entire county now, making the whole issue irrelevant.

These new Satellite based technologies do offer a lot of promise for Broadband Internet in rural areas and should initially provide exceptional results. And, as mentioned, other competing systems are already in development, like Amazon and their Kuiper project, which is still a few years away from launching new satellites, so not much detail is available yet. Over time though, it is predicted that these technologies, just like all other wireless technologies with finite capacities, will reach limitations and develop their own lifecycle patterns like all wireless communications in general. For example, Cellular Telephone technology has generally evolved into new technology (generations) about every 10 years, although some older technologies tend to remain viable for many years overlapping the newer generations. 3G was first introduced in 2000, and although few consumers would think it is still available, it remains a very important technology for lower bandwidth applications like driver assistance services (e.g., OnStar, SYNC, etc.), agricultural management and field monitoring systems, and remote weather monitoring stations. (See Technology Lifecycle sidebar)

The Townships

The following maps are enlarged views of each township to provide better detail. These maps show all served and unserved layers, as well as RDOF funded areas. They also contain the parcel counts by township of served and unserved. RDOF parcels as counted are included in the unserved count and will change to served once fiber had been built into those areas.

RDOF also covers un-occupied parcels, which are not included in the count of new service areas, only the occupied unserved parcels are included in the RDOF counts. Starlink RDOF awarded parcels are indicated on the maps as well, but do not cover any occupied parcels, and therefore not included in any of the counts. The City Limits of Traverse City within Leelanau County are not included in the following pages since they are 100% served by Charter Communications and have not been a subject of the study, although the 365 homes within Traverse City, Leelanau County are included in the overall served count for Charter served parcels.

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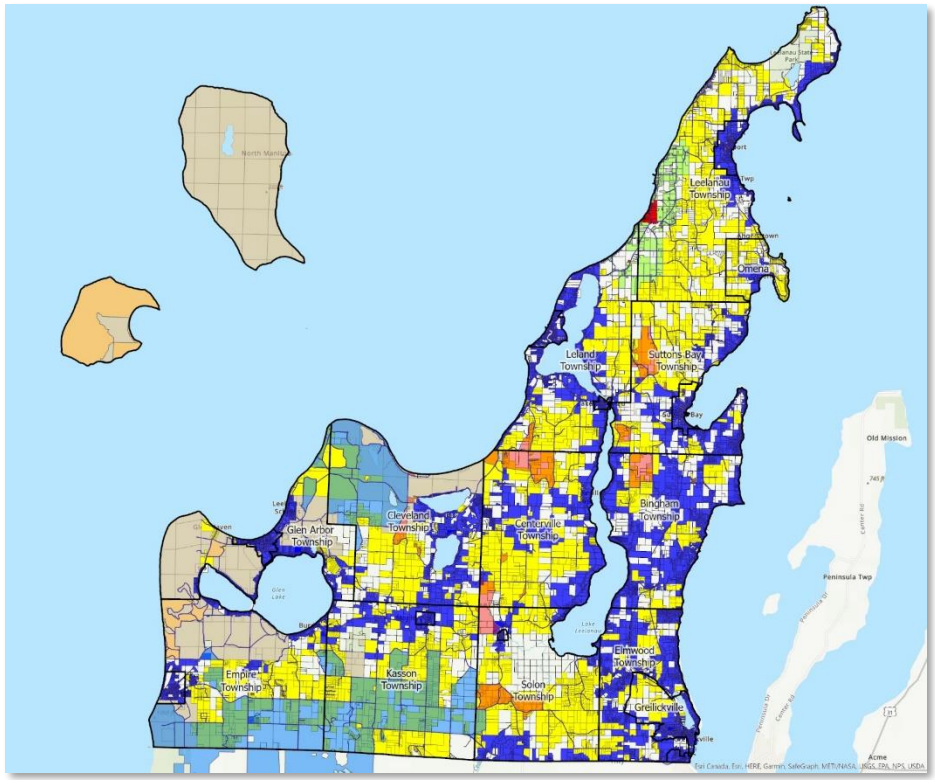
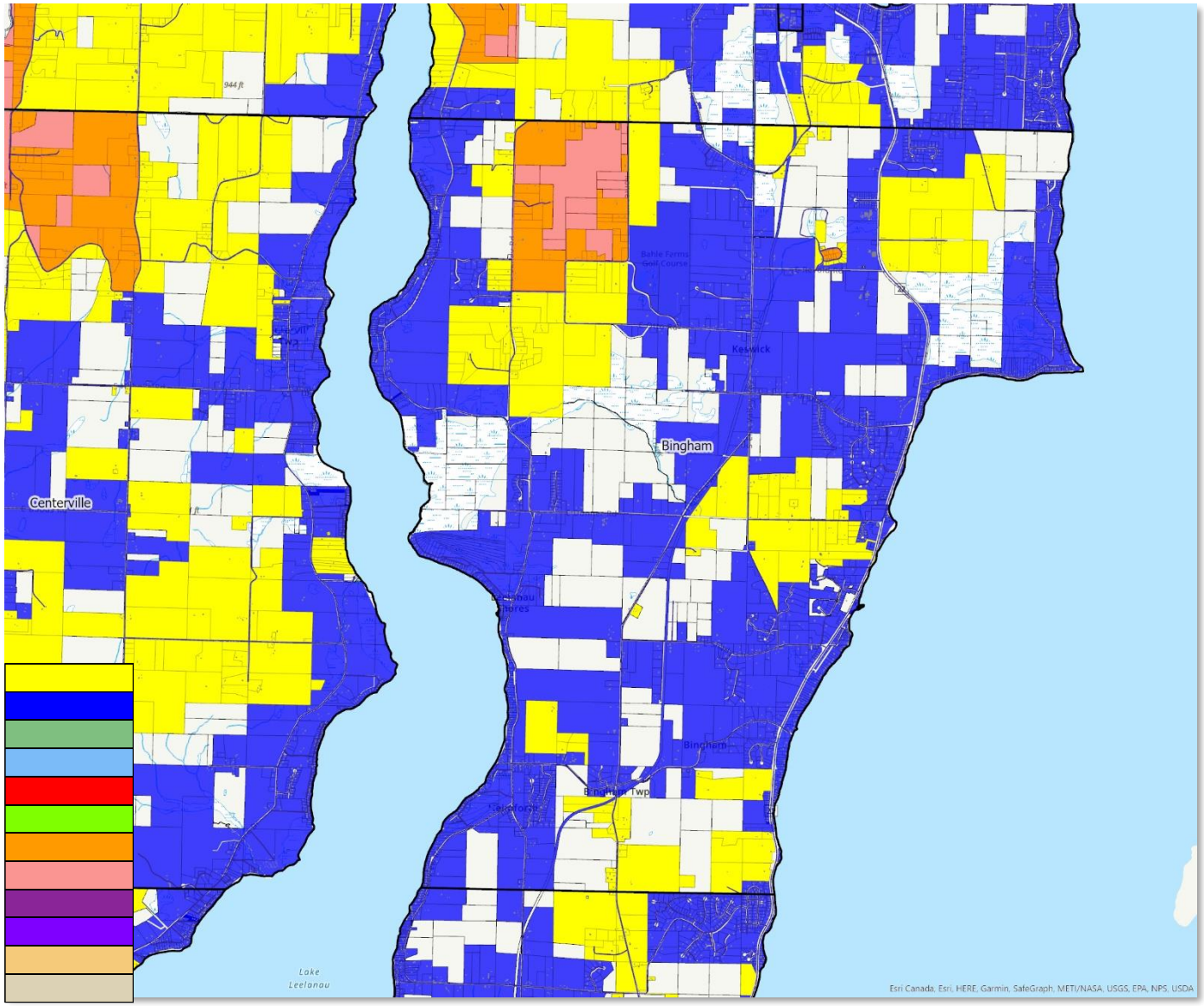


Bingham Township

Parcels	1912
Served	1716
Unserved	196
CCC RDOF	(42)

Will change to served



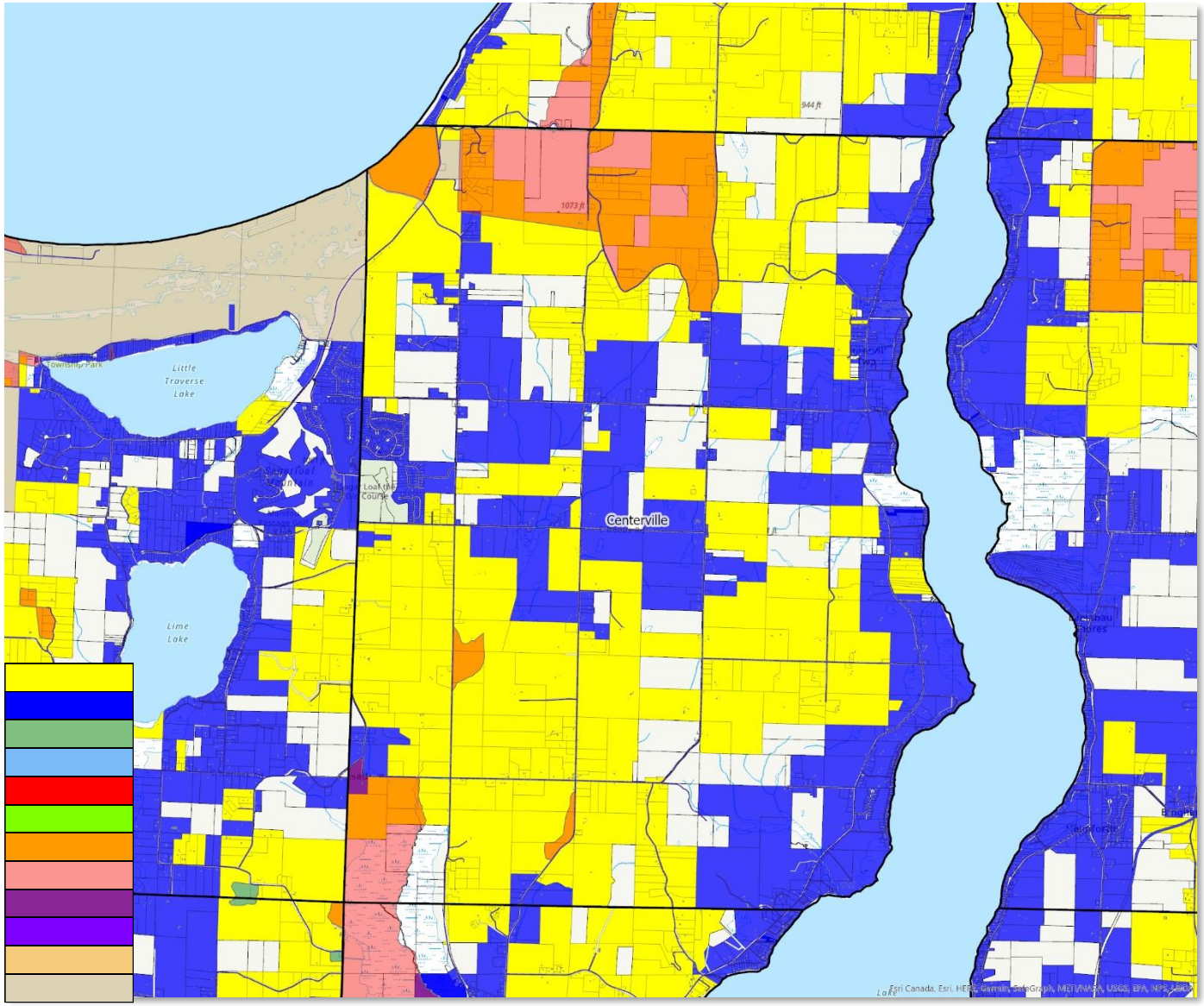
Map Key

- Unserved Parcels
- Charter Served Parcels
  - Charter RDOF Expansion
  - Charter RDOF Unoccupied
- CCC FTTh (Under Construction)
- CCC FTTh (Permitted)
  - CCC RDOF Expansion
  - CCC RDOF Unoccupied
  - CCC RDOF (Charter Overbuild)
- 186 Networks FTTh (Limited)
  - Starlink RDOF
- US National Park Service

Centerville Township

Parcels	1266
Served	875
Unserved	391
CCC RDOF	(87)

Will change to served



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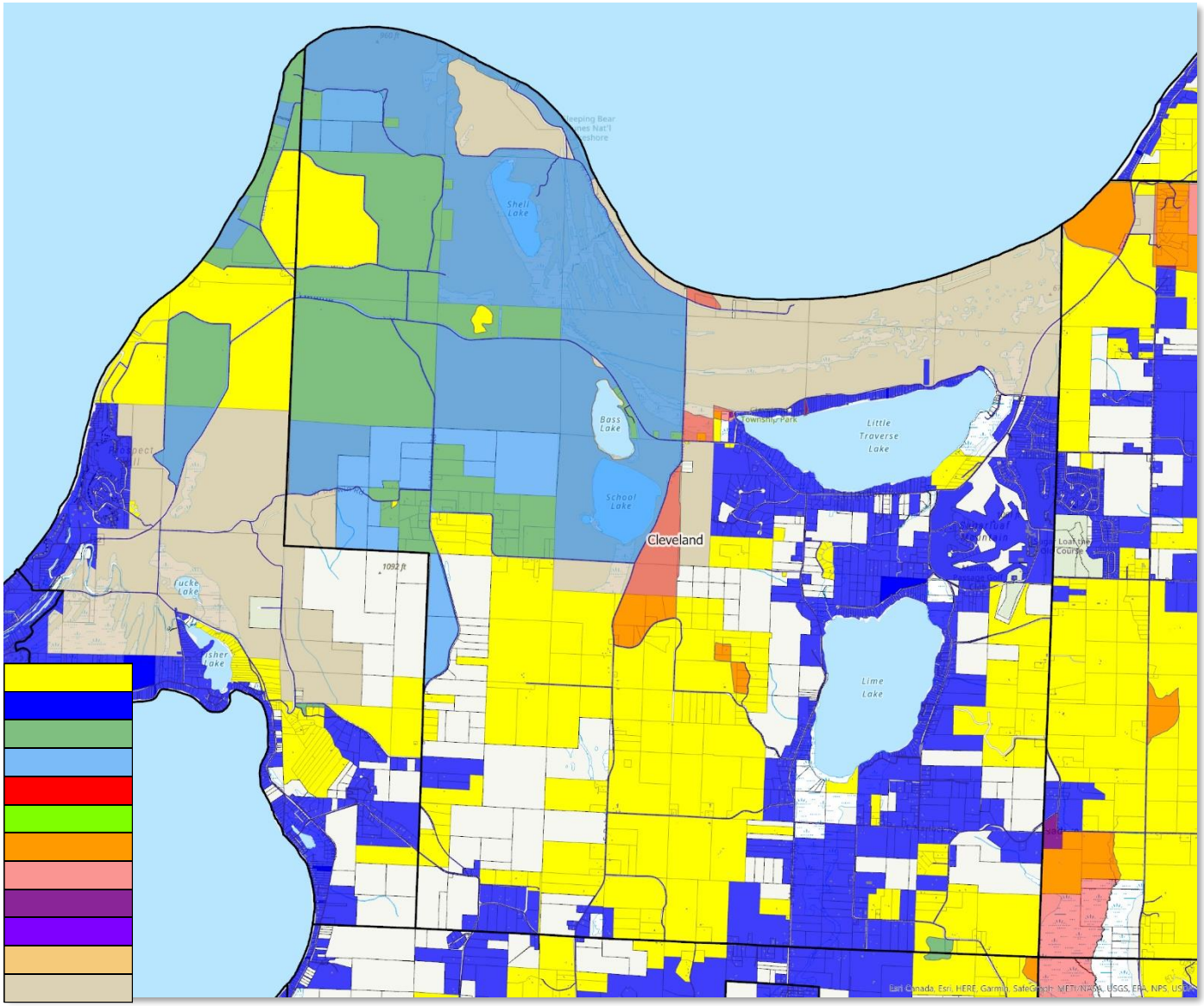
- US National Park Service

Cleveland Township

Parcels	1248
Served	988
Unserved	260
CCC RDOF	(~13)
Charter RDOF	(~42)

Will change to served



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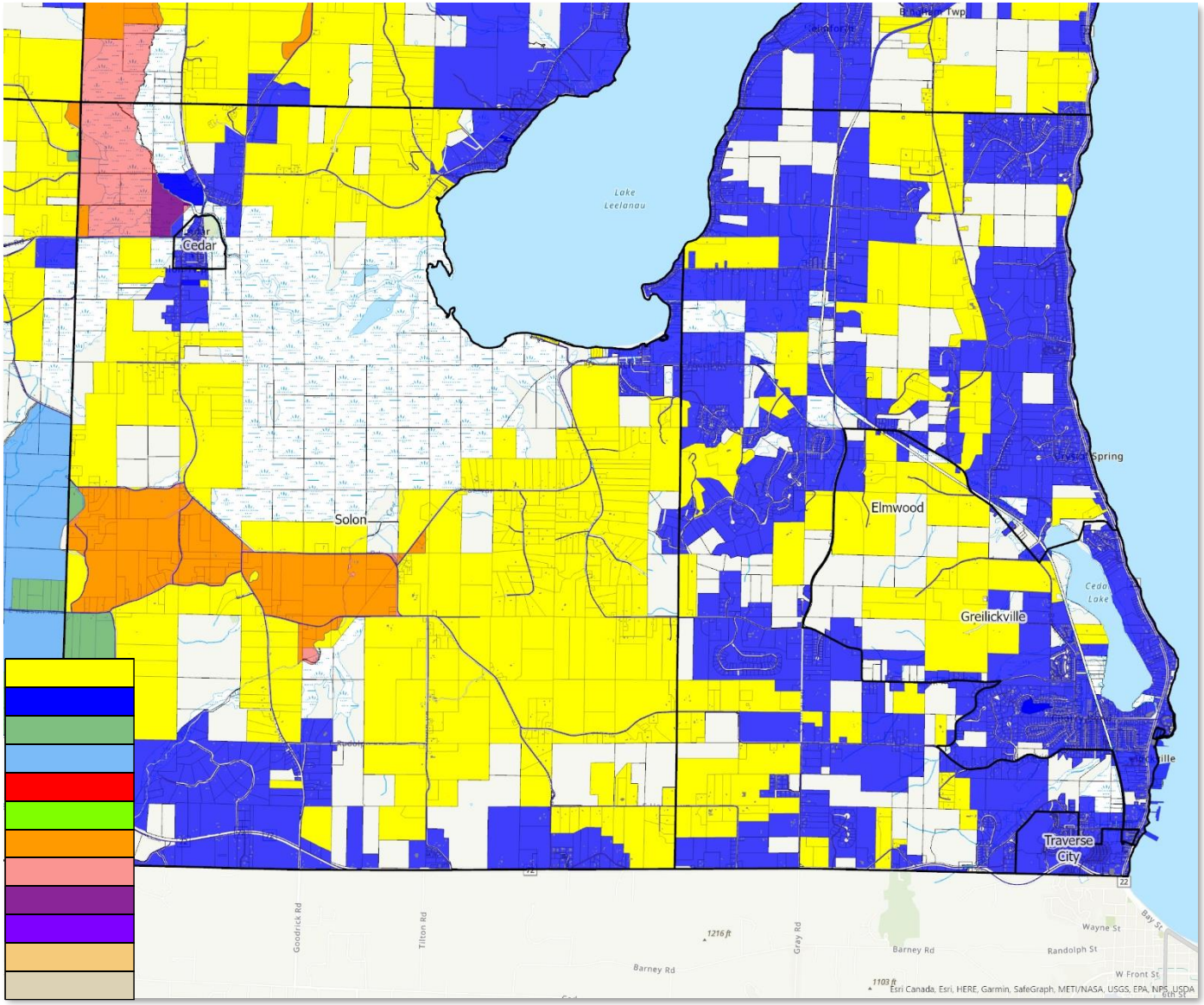
Elmwood Township

Parcels	3114
Served	2947
Unserved	167

No RDOF parcels



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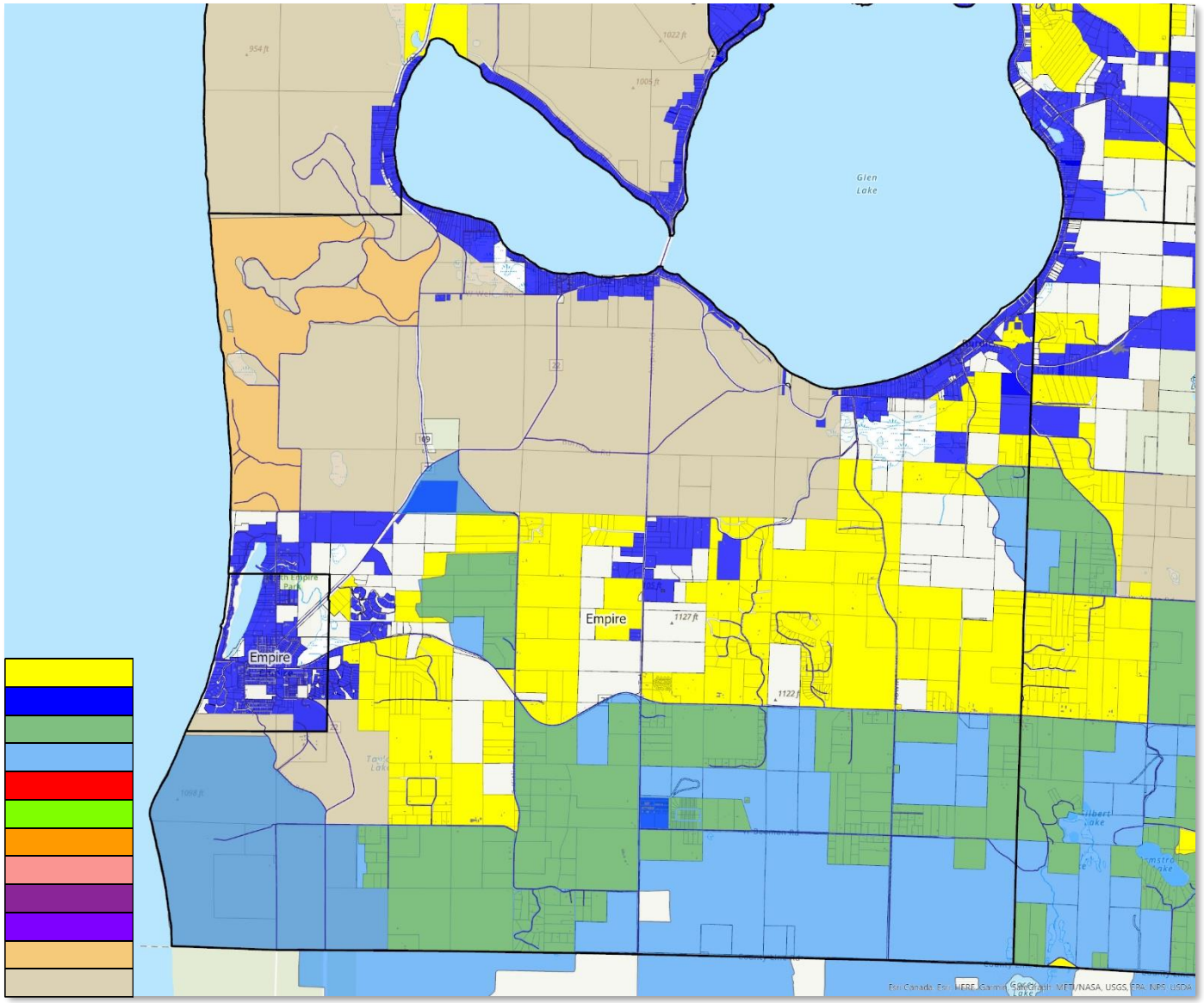
Empire Township

(Including Empire Village)

Parcels	1993
Served	1334
Unserved	659
Charter RDOF	(~439)

Will change to served



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  - CCC RDOF (Charter Overbuild)
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- US National Park Service

Glen Arbor Township

Map Key

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- CCC FTTh (Permitted)
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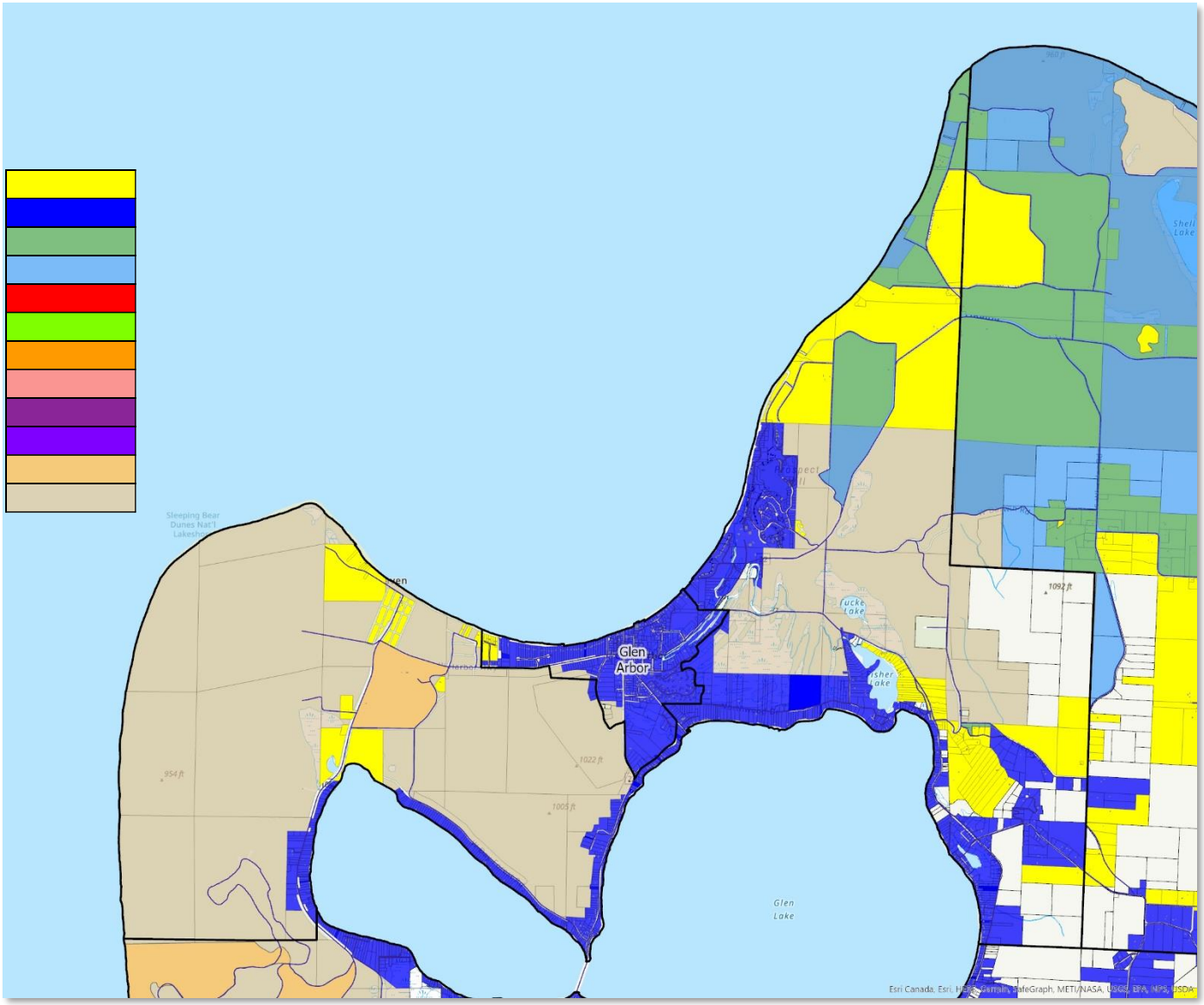
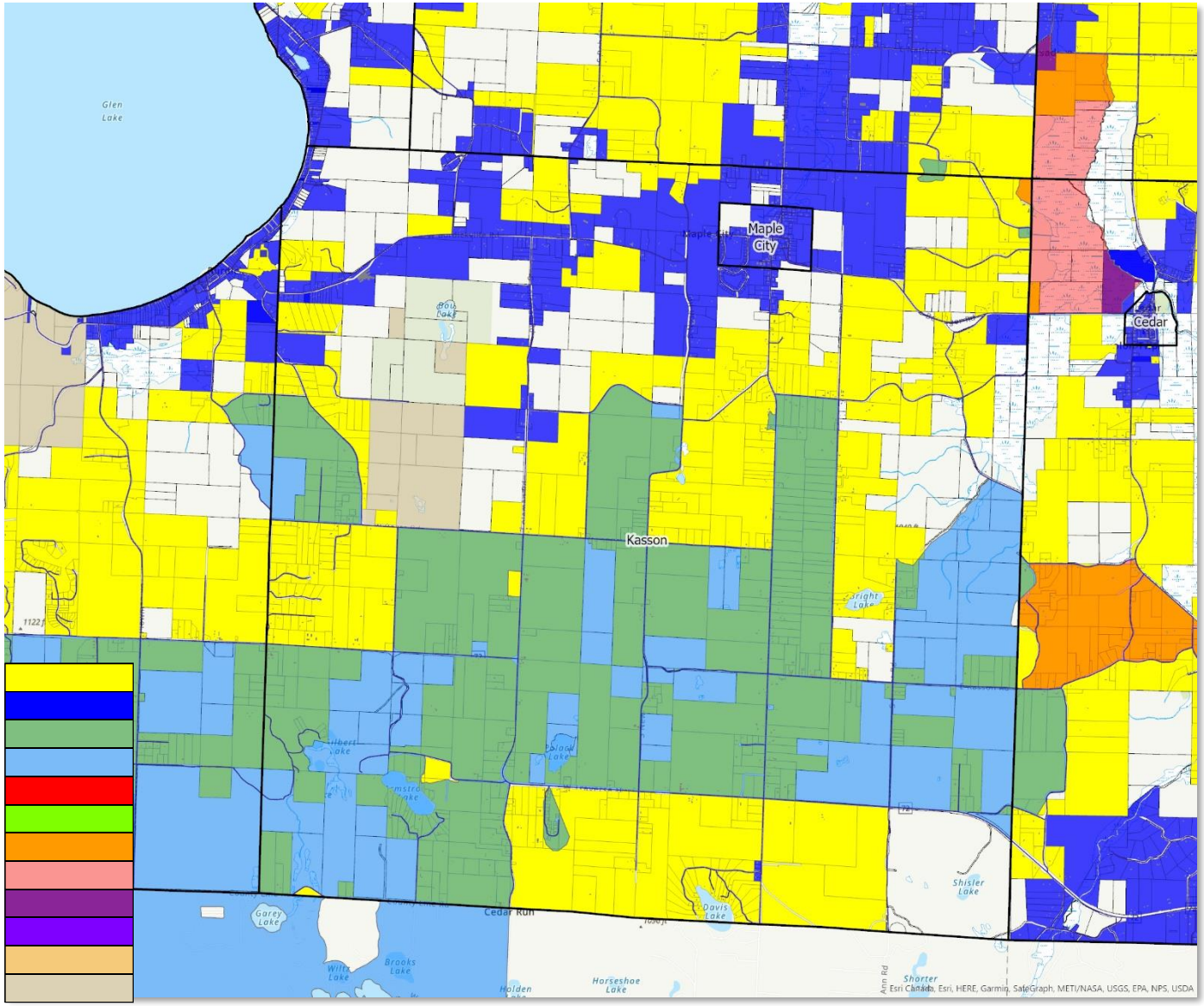


Parcels	2456
Served	2330
Unserved	126
Charter RDOF	(~11)

Will change to served

Kasson Township

Parcels	1191
Served	415
Unserved	776
Charter RDOF	(~317)
Will change to served	



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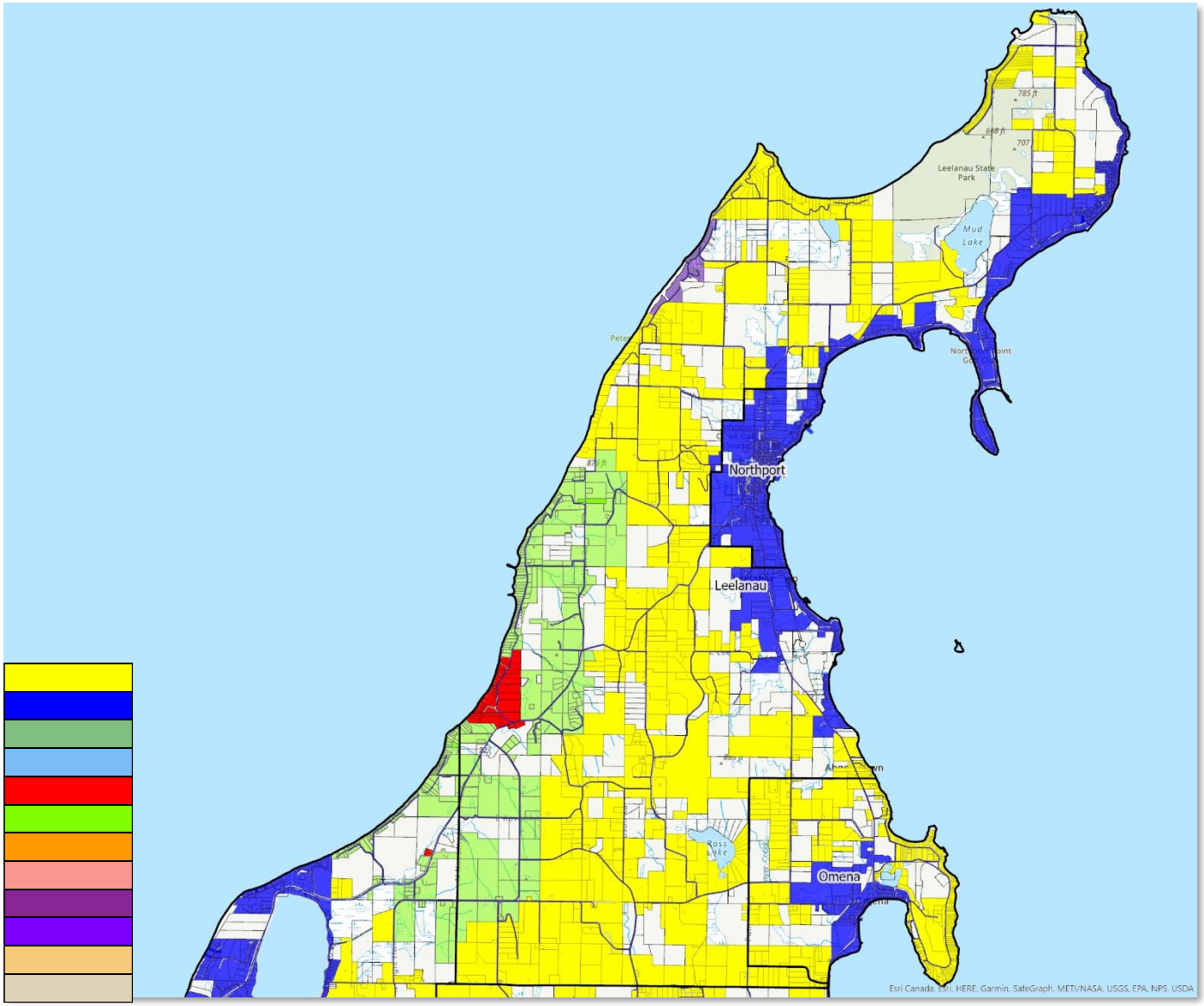
- 186 Networks FTTh (Limited)
  - Starlink RDOF
- US National Park Service

Leelanau Township

(Including Northport)

Parcels	3056
Served(Charter)	1674
CCC (UC)	42
CCC (permitted)	227
186 (Limited)	81
Unserved	1032

No RDOF Parcels



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  - CCC RDOF (Charter Overbuild)
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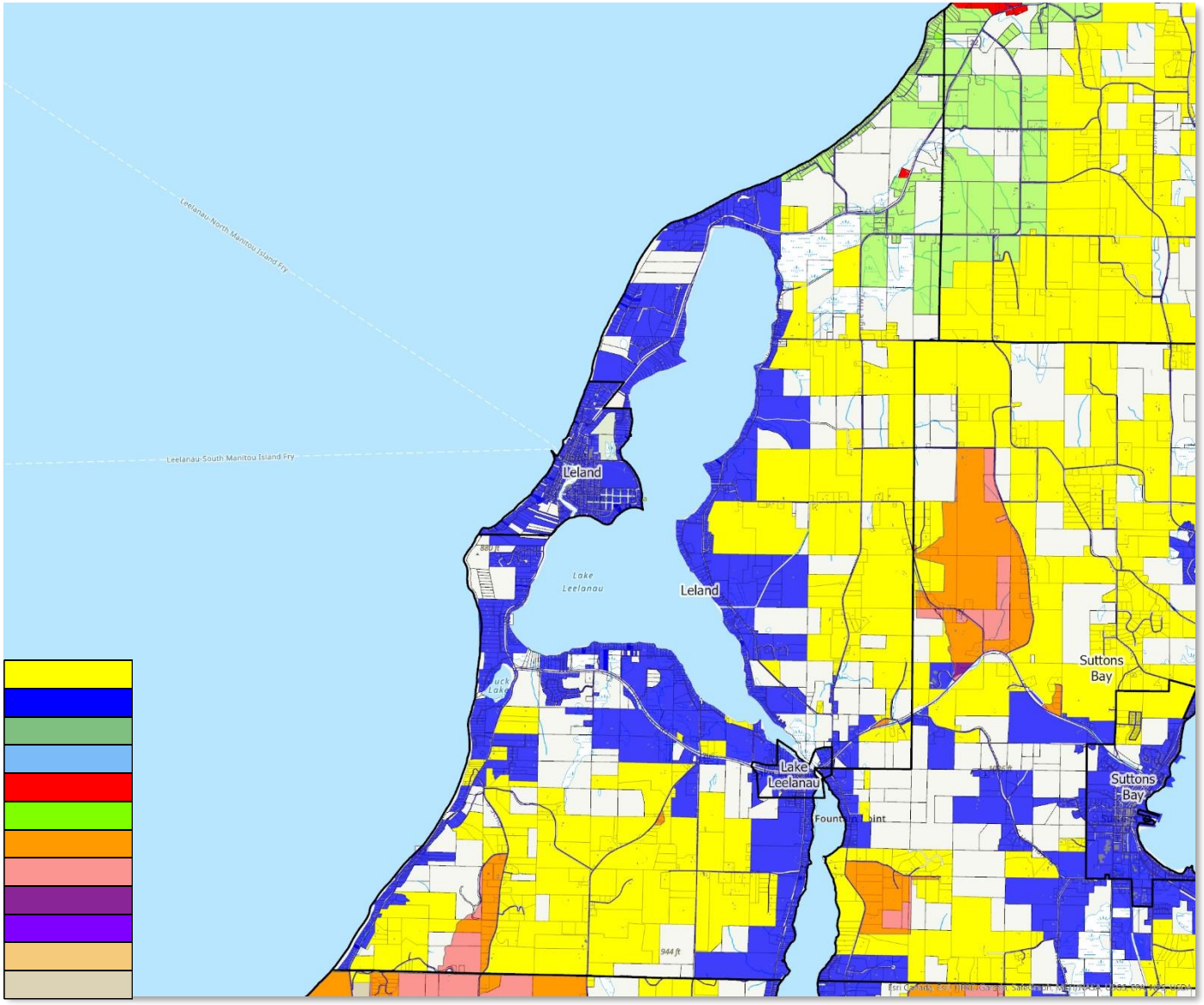
- US National Park Service

Leland Township

(Includes Village of Leland)

Parcels	2474
Served	2020
Unserved	318
CCC RDOF Will change to served	(~21)
CCC (Permitted)	135



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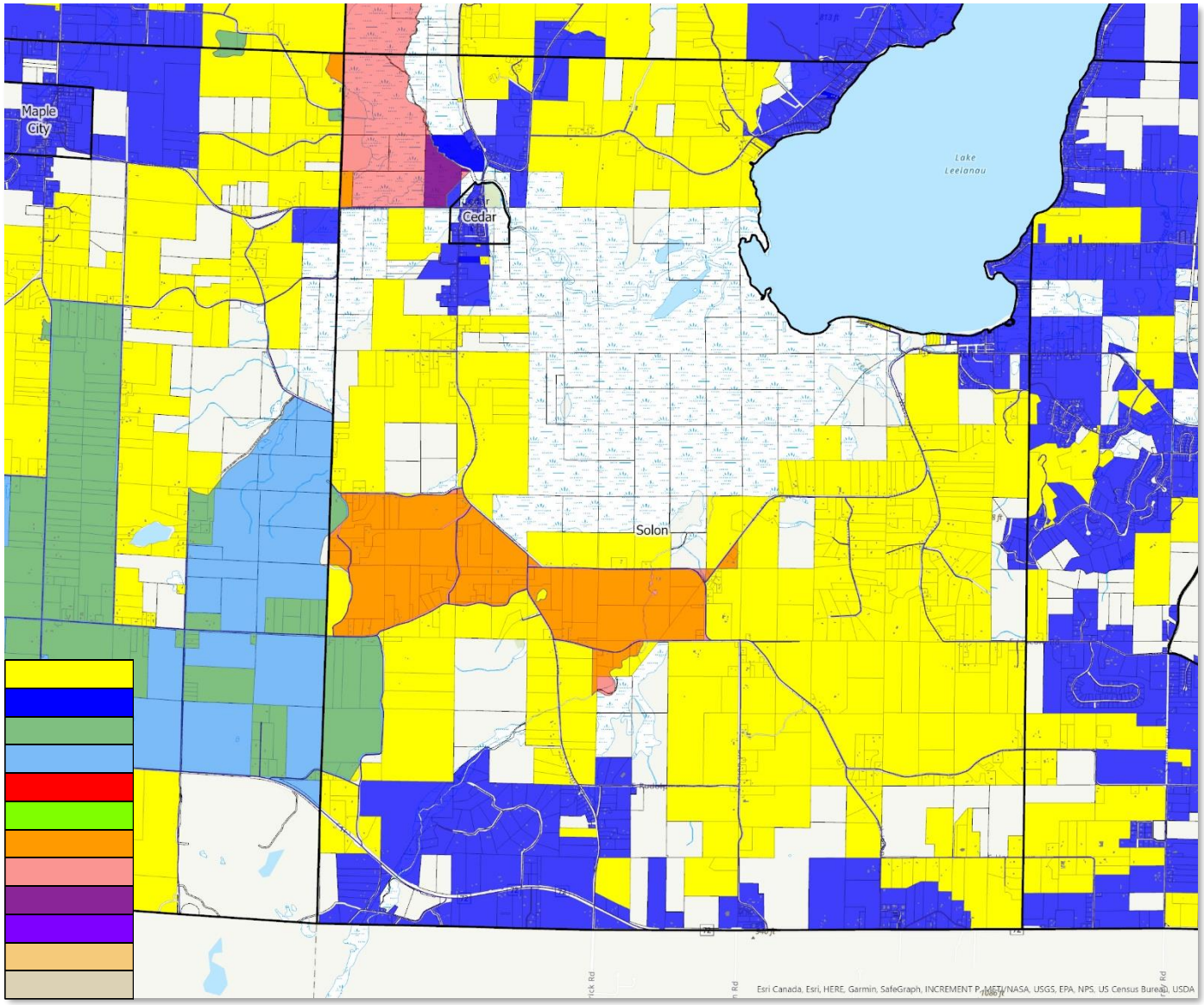
- 186 Networks FTTh (Limited)
  - Starlink RDOF
- US National Park Service

Solon Township

Parcels	1172
Served	597
Unserved	575
CCC RDOF	(~102)

Will change to served



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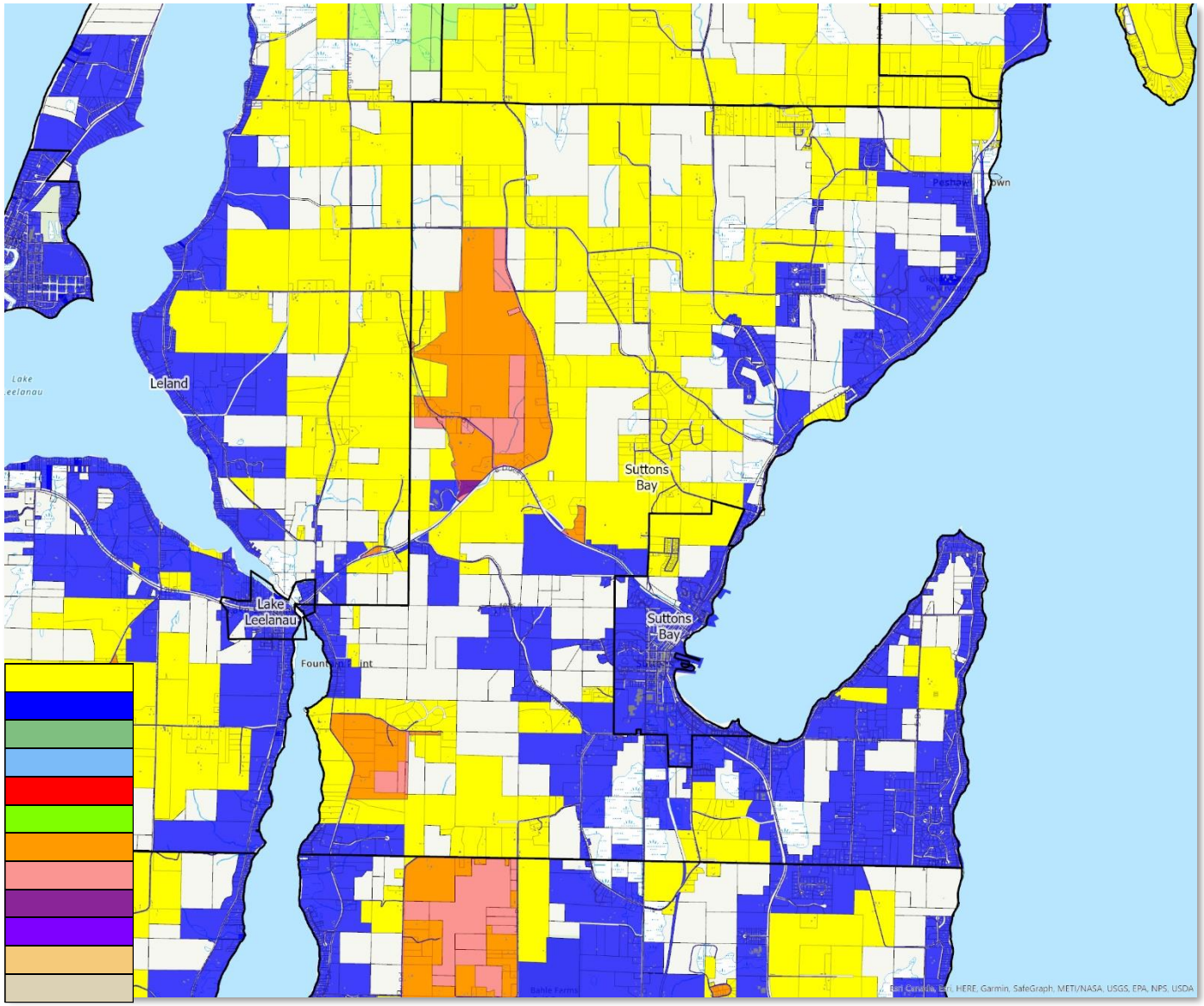
  - CCC RDOF (Charter Overbuild)
- 186 Networks FTTh (Limited)
  - Starlink RDOF
- US National Park Service

Suttons Bay Township

(Includes Suttons Bay Village)

Parcels	2454
Served	1909
Unserved	545
CCC RDOF	(~51)

Will change to served



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Appendix A – Definitions

There are several terms being used to discuss the topic of who has, and who cannot get access to Broadband Internet in various circles. The term Broadband itself has several definitions. For this report, following are clarifications for the use of some of these terms within this report.

bit – A single data bit which is the unit measured relative to time for measuring the speed of data connections. A bit is indicated by a small case "b".

Byte – Typically a packet or group of 8 or more bits, typically not used in measuring connection speed, but more as a measure for capacity, such as in Hard Drives or monthly download limits when data caps are part of a service package. A Byte is indicated by an upper case "B".

Kb/s – Kilobits per second, sometimes abbreviated as Kbps. 1,000 data bits (not Bytes) per second

Mb/s – Megabits per second, sometimes abbreviated as Mbps. 1,000,000 data bits per second

Gb/s – Gigabits per second, sometimes abbreviated as Gbps. 1,000,000,000 data bits per second

Broadband – within this context, Broadband shall mean anything equal to or above the FCC established minimum of 25 Mb/s download speed and 3 Mb/s upload.

Cable – Or Cable Modem, a coax or hybrid fiber coax (HFC) network design capable of Broadband data speeds up to several hundred Megabits per second, with emerging technology that can reach into Gigabit per second speeds.

ISDN – Integrated Services Digital Network, an early development in digital transmission methods for copper telephone lines, it supported early data networking and video conferencing over phone lines and is the predecessor to DSL.

DSL – Digital Subscriber Line, a copper twisted pair technology using traditional telephone lines to deliver high speed data connections, but is highly susceptible to distance limitations, condition of the copper cabling, and overall network usage. Most DSL subscribers are not able to receive minimum Broadband speeds.

Fixed Wireless – Primarily cellular telephone providers that offer data services over various wireless (cellular) technologies. The prevalent technology today is 4G LTE (has different variations) and can offer Broadband speeds depending upon a subscriber's proximity to the providers antenna towers or micro-cells. However, most fixed wireless subscribers cannot receive minimum Broadband speeds from fixed locations, such as their homes if they are not located close enough to the providers facilities.

FTTH – Fiber to the Home, a network architecture using Passive Optical Network (PON) technologies to provide Gigabit speed data connections. It may be abbreviated as FTTx with the "x" meaning that there can be different variations of how the network is designed.

Served or Access – Homes and businesses that have access to, but not necessarily connected to a technology that can provide Broadband connectivity throughout its service area. For this report, only Cable Modem and FTTH qualify as being able to fully offer Broadband services in "Served" areas.

Unserved or No Access – Homes and businesses that may have access to DSL or Fixed Wireless, but not Cable or FTTH. Also applies to rural areas that have no access to any potential Broadband provider other than Satellite, which itself cannot consistently offer Broadband speeds.

ROW – Right of Way, pertaining to the typically 60' to 66' of road easement that is maintained by WCRC or MDOT. Paved or graded portions of roads do not always line up with the center of the ROW, so some survey work may be required to establish exact ROW boundaries for permitting requirements if contemplated for burying fiber optic cables.

MDOT – Michigan Department of Transportation

LCRC – Leelanau County Road Commission

PON – Passive Optical Network

GPON – Gigabit Passive Optical Network

OLT – Optical Light Termination, the device at the headend of a Passive Optical Network providing the connectivity for the fiber

SFP OIM – Small Form Pluggable Optical Interface Module, a small module inserted in the OLT providing the proper fiber optic termination type

Notes: