An Analysis of Rural Broadband Opportunities and Risks

Prepared for the
United States Postal Service
Office of Inspector General
Office of Audit

By
NGI Solutions, LLC

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Columbia Telecommunications Corporation (CTC)

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Contents

1. Executive Summary

The United States National Broadband Plan recognizes broadband Internet as a service to which all Americans should have a minimum level of access, and establishes goals for broadband deployment. Given the U.S. Postal Service's (USPS) tens of thousands of facilities, it might be in a position to use its real estate and buildings as the foundation of a nationwide effort to expand broadband access in unserved areas.

Such a project perhaps represents a natural evolution of the USPS's core mission, "rooted in a single, great principle: that every person in the United States—no matter who, no matter where—has the right to equal access to secure, efficient, and affordable mail service."[1] A packet of letters was the primary form of communications when the USPS was founded, just as an electronic packet of data is the primary form today—so it could be fitting for the USPS to enable Internet access to communities that currently lack it.

1.1 Mapping analysis: approximately 1,000 to 1,600 post offices are located in rural areas

To gauge the feasibility of a USPS wireless broadband initiative, we first analyzed National Broadband Map data to determine how many post offices are located in areas that are currently lacking broadband access (see Section 0). Based on our analysis, we estimate that approximately 975 to 1,600 post offices lie in wholly unserved areas. The great majority of these are located in rural western states and Alaska, with a relatively high concentration on or near tribally managed areas.

We note, however, that while we believe this estimate to be reasonable in light of the data, we are concerned that tracking whether the area around a postal facility is wholly unserved or served carries the risk of undercounting the facilities in communities that could benefit from this project. For example, almost the entire eastern and Midwestern part of the United States (as well as the coastal west) would be left out of this project under an approach that looks at wholly unserved areas. In reality, postal facilities may be in "served" micro-areas and towns that are surrounded by unserved areas. We suggest caution, then, about assuming that the states with postal facilities in served areas would not benefit from the programs contemplated herein. For this reason, we recommend a more qualitative, detailed analysis of candidate sites, representative of the entire nation, if this initiative proceeds.

1.2 Engineering analysis: two technical models for deploying broadband

[1] "The United States Postal Service: An American History, 1775-2006," Booklet. http://about.usps.com/publications/pub100.pdf (accessed August 11, 2011).

If the USPS were to use its facilities in these unserved areas as the foundation of wireless broadband networks, it would have two primary options for network design: carrier-grade[2] or "best-effort"[3] engineering. In Section 3, we explain each of these engineering principles in detail and estimate the costs and engineering challenges associated with deployment at a sample post office site.

1.2.1 Building a carrier-grade network to 1,000 post offices would require $180 million in capital costs and $90 million in annual operating costs

For a carrier-grade network using a technology such as WiMAX[4] (which is optimized for these purposes), the cost is approximately $180,000 per site. The highest single cost is the tower and its construction. That cost will vary based on the state and construction of the rooftop, the surrounding land, and local permitting requirements.

The cost of software for management and provisioning is approximate and may decrease on a per-site basis if it can be shared across multiple areas. Likewise, the cost for facility and power enhancement depends on the facility. If the site already has a generator with sufficient capacity, this item's cost can be reduced significantly. If rooftop reinforcement, extensive facility cabling, or digging across a parking lot are required, the cost may increase.

There is an additional cost for operations, including ongoing maintenance of the tower and electronics, as well as the cost of Internet access and the commercial arrangement at the backhaul location,[5] all of which depend on the details of the location. Internet capacity purchased in bulk outside metropolitan areas may cost $25 to $50 per Mbps per month. Taking into account typical levels of Internet capacity oversubscription, the additional monthly costs per site are likely to be in the range of thousands of dollars per month per site.

Given this pricing, we conservatively estimate a price of $180,000 per site for implementation and $10,000 per month per site for operations. While the price will not increase in a directly linear way (because of economies of scale), we conservatively suggest multiplying this amount by the number of potential sites to reach an aggregate price point.

Thus, assuming an investment by the USPS in 1,000 of the post offices in unserved areas, the minimum capital cost of building a carrier-grade infrastructure will be $180 million, with operating costs of at least $90 million per year.

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[2] We use the term "carrier-grade" to mean a network capable of providing service at a level that consumers expect from commercial carriers when they pay for service; even though those standards are surprisingly low in the context of local phone and data services, they are difficult to achieve without significant expense.

[3] We use the term "best-effort" to describe a network that offers no guarantee of service quality or availability. Best-effort network services are typically offered to end users at no cost, so the provider is not required (i.e., has no contractual agreement with end users) to address issues that preclude a user's access, or that limit the availability of high-quality service at any time (which is common with Wi-Fi connections).

[4] WIMAX is a fourth-generation, or 4G, wireless broadband technology. It supports higher data rates than 3G technologies. In technical terms, WiMAX refers to the IEEE standard 802.16, which dictates the wireless delivery rate of 40 Mbit/s and 1GB using the newest IEEE 802.16M standard.

[5] Backhaul refers to the portion of a communications network that transmits data between end points (e.g., tower locations) and a public Internet connection point or another dedicated network location.

1.2.2 Building a best-effort Wi-Fi network to 1,000 post offices would require $142 million in capital costs and $90 million in annual operating costs

For a best-effort network using Wi-Fi technology[6] the cost is approximately $142,000 per site. All of the costing rationale detailed in Section 1.1.1 also applies here. While Wi-Fi equipment costs about 10 percent of the WiMAX equipment, this has a negligible impact on the construction and operations costs, but will have a significant impact on the overall cost as the number of deployments scales up.

Thus, assuming an investment by the USPS in 1,000 of the post offices in unserved areas, the minimum capital cost of building a carrier-grade infrastructure will be approximately $142 million, with operating costs of at least $90 million per year.

1.3 Feasibility analysis: three business models for deploying broadband

In Section 4, we explore the feasibility, from a business model/financial standpoint, of the USPS developing a carrier-grade or best-effort network. We also examine the feasibility of a more cautious approach—developing a public-private partnership model to incent private sector investment in broadband deployment.

1.3.1 The carrier-grade model carries significant risk for the USPS because of its high costs and low potential revenues

This model requires a significant investment of federal or other government funds because of its high capital and operating costs and modest potential revenues.

As Section 4.1 of this report demonstrates, in a small rural community of a few hundred or a few thousand residents, the revenues associated with the services USPS would provide will be sufficient only to cover operating costs, but not to repay capital costs or enable equipment refreshment. In one case study, for example, with a potential target market of 250 households, if the project achieves 50 percent penetration of the potential market at a monthly fee of $60 per household, the total revenues per month are $7,500—sufficient perhaps to cover the cost of monthly operations.

As a result, the ISP model would require the USPS not only to make an unrecoverable investment in the capital costs for the network, but also potentially to subsidize some operations for an indefinite period.

[6] Wi-Fi is a technology for wirelessly connecting electronic devices over a relatively short range using the IEEE 802.11 standard

1.3.2 The Wi-Fi model offers the USPS a low-cost method to serve the local community and reinforce the centrality of the post office to that community

If the USPS implements free Wi-Fi hotspots in and around post offices, it will likely build good will and reinforce the status of local rural post offices as central to their communities.

While offering free publicly available connectivity may exclude the possibility of earning revenue from users, it might enable the USPS to sell local or national sponsorships based on the potential good will to be created in the target communities. More significantly, in terms of economic feasibility, this model would require only limited USPS or third-party investment.

Further limiting the financial exposure inherent in this model, the USPS would commit only to a "best effort" for maintaining a connection. This sort of best-effort availability would require much lower levels of investment and support than would a fee-based offering.

1.3.3 A low-risk public–private partnership could be undertaken to allow carriers access to USPS real estate with low transaction costs, consistent with the administration's policy to establish uniform procedures

The challenge for a USPS partnership with the private sector is that the key asset the USPS brings to the table is its rural postal facilities, and these structures are unfortunately insufficient to noticeably change the economics of broadband construction. Many post offices in rural areas are one- or two-story structures. These are not usable for carrier-grade wireless technologies, which still require construction of a tower. Given that limitation—and the fact that land in rural areas is typically inexpensive—USPS's asset has some value in lowering costs to carriers at the margins, but not in such a significant way that carriers would likely choose to invest where they otherwise would not.

Altering the economic reality of the U.S. rural broadband market to the point of gaining carrier interest would thus likely require the USPS to assume a relatively large amount of financial risk in the partnership. Given that, the USPS may choose to establish a more conservative public–private partnership that would expose it to a lower level of financial risk, while still offering an incentive to the private sector.

To this end, the USPS could offer wireless carriers a comprehensive lease access agreement that authorizes the installation of network equipment at a large number of post offices and other USPS-owned sites.

This model would leverage the USPS's greatest non-cash asset, in terms of expanding broadband availability: the physical "bricks and mortar" presence of post offices in unserved areas. Also, because the USPS would not be designing, installing, or operating any networks, this approach would require little to no investment. It might even create a modest revenue stream.

It would also be consistent with the Obama administration policy for federal agencies to simplify and streamline communications carriers' access to public property.

1.4 Case studies

Finally, in Section 5, we apply the engineering and financial feasibility analysis to three post office sites representing the type of communities and facilities a USPS wireless broadband initiative might target.

1.5 Conclusion

Based on our analysis of the technical, engineering, and business planning issues, we believe that if the USPS were to build a fee-for-service wireless broadband network, the initiative would entail a very large public subsidy. We therefore recommend a lower-cost community service model that would include Wi-Fi "hot spots" around post offices and other USPS facilities in unserved areas nationwide. We would also recommend that the USPS explore the possibilities for expanding broadband access around its post offices through some sort of public-private partnership, possibly including the creation of a "universal lease" that would enable interested telecommunications carriers to more easily use USPS facilities to support their network sites.

2. Mapping Analysis

This section of the report explains how much of the USPS's footprint is located in areas that are unserved by broadband. The section first defines broadband for purposes of this report (and provides background regarding the federal definition of broadband). It then explains our methodology for assessing the overlap of USPS facilities and unserved areas, and provides our conclusions regarding this question.

2.1 Definitions and terms

The American Recovery and Reinvestment Act of 2009 (ARRA) directed the Federal Communications Commission (FCC) to develop a national broadband plan "to ensure that all people of the United States have access to broadband capability and establish benchmarks for meeting that goal."[7]

The definition of broadband for purposes of national policy has tended to differ depending on the program and the agency at issue. The ARRA broadband funding programs offered a set of definitions for purposes of evaluating grant applications.[8] The FCC's 2009 National Broadband Plan defined "broadband" as "a*ctual* download speeds of at least 4 Mbps and *actual* upload speeds of at least 1 Mbps" in establishing targets for nationwide broadband availability.[9]

Perhaps most importantly for the purposes of this report, in February 2011 the National Telecommunications and Information Administration (NTIA) and the FCC launched the National Broadband Map, a searchable online map of nationwide broadband availability.[10] The map is scheduled to be updated twice yearly with data gathered by a grantee in each state, territory, and the District of Columbia, under the auspices of the NTIA's State Broadband Data and Development Program.

The National Broadband Map tracks the availability of broadband at a range of speeds, with a primary focus on download speeds of greater than 3 Mbps and upload speeds of greater than 768

[7] ARRA, §6001(k). The Act also included another significant provision related to broadband access: it allocated $7.2 billion in funding to promote broadband deployment and adoption nationwide. Those funds were distributed through the Broadband Technology Opportunities Program (BTOP) and Broadband Infrastructure Program (BIP).
[8] The guidance for BTOP and BIP grant applications defined "unserved" and "underserved" areas in terms of access to broadband service: In an unserved census block group or tract, "at least 90 percent of the households lack access to facilities-based, terrestrial broadband service, either fixed or mobile, at the minimum broadband transmission speed." Notice of Funds Availability for Broadband Initiatives Program and Broadband Technology Opportunities Program, 74 Fed. Reg. 33104 (July 9, 2009). An "underserved" area was defined as a census block group or tract that meets one or more of these factors: "(i) no more than 50 percent of the households…have access to facilities-based, terrestrial broadband service at greater than the minimum broadband transmission speed…; (ii) no fixed or mobile terrestrial broadband service provider advertises to residential end users broadband transmission speeds of at least [3 Mbps] downstream…; or (iii) the rate of terrestrial broadband subscribership for the…service area is 40 percent of households or less." Notice of Funds Availability for Broadband Initiatives Program and Broadband Technology Opportunities Program, 74 Fed. Reg. 33104 (July 9, 2009).
[9] "Box 8-1: National Broadband Availability Target," *National Broadband Plan*, Chapter 8, http://www.broadband.gov/plan/8-availability/?search=definition%252C%2bunserved (accessed August 9, 2011).
[10] "About National Broadband Map," http://www.broadbandmap.gov/about (accessed August 9, 2011).

kbps.[11] This report thus defines as "unserved" by broadband any community in which, according to the data underlying the National Broadband Map, speeds of 3 Mbps/768 kpbs are unavailable.

2.2 Methodology

Any attempt to analyze National Broadband Map data is made more challenging by the format in which NTIA offers that data to the public. While Geographic Information System (GIS) "shapefiles" are a standard format for data that correlates to maps, NTIA has not released GIS data and only makes broadband data publicly available in text files. To view this data, it must be translated into a different format—then joined with separate data files that include the corresponding spatial components. Further complicating public analysis, NTIA's data sets consist mostly of massive files that cannot be subdivided. As a result, the NTIA data is in some ways inaccessible absent the type of high-end computing capabilities typically found only in an academic environment.

To address these deficiencies and still provide a useful analysis, we devised a statistically significant methodology that enabled us to estimate, for planning and budgetary purposes, the number of post offices that are located in unserved areas across the United States. Specifically, we identified representative states with manageable data sets (given the processing capabilities of the hardware and software that we have in-house as an engineering firm); analyzed that data; and extrapolated the results of our analysis to a national level.

We analyzed the following representative states:

- Idaho and Wyoming: Selected as representative of largely rural, northwestern states
- Utah: Selected as representative of largely rural, southwestern states
- Maine: Selected as representative of largely rural, eastern states
- Maryland: Selected as representative of (relatively) more densely populated eastern states
- Alaska: Alaska is singular and not representative of any other states, but very significant in terms of analyzing rural areas

We used a mix of data analysis techniques for each state. What we found is that in the more densely populated states, the data sets provided by NTIA through the National Broadband Map are so large as to be challenging to manipulate in an automated fashion, but could be analyzed through county-by-county and town-by-town evaluation with the use of Census and satellite (Google Maps and Street View) data. In those states, we were also able to test our conclusions by drawing on our detailed knowledge of broadband availability and the geography of those states.

Figure 1 and Figure 2 illustrate our findings in two of the states that we analyzed (Idaho and Utah).

[11] Customary shorthand for representing the relationship between download and upload speeds is to separate them with a slash and forgo including the "download" and "upload" language. Downstream speeds are always first in the relationship. Thus, for example, speeds of 3 mbps download and 768 kbps upstream would be represented as 3/768 or 3mbps/768kpbs or 3 down/768 up.

Figure 1: Served and Unserved Post Offices in Idaho

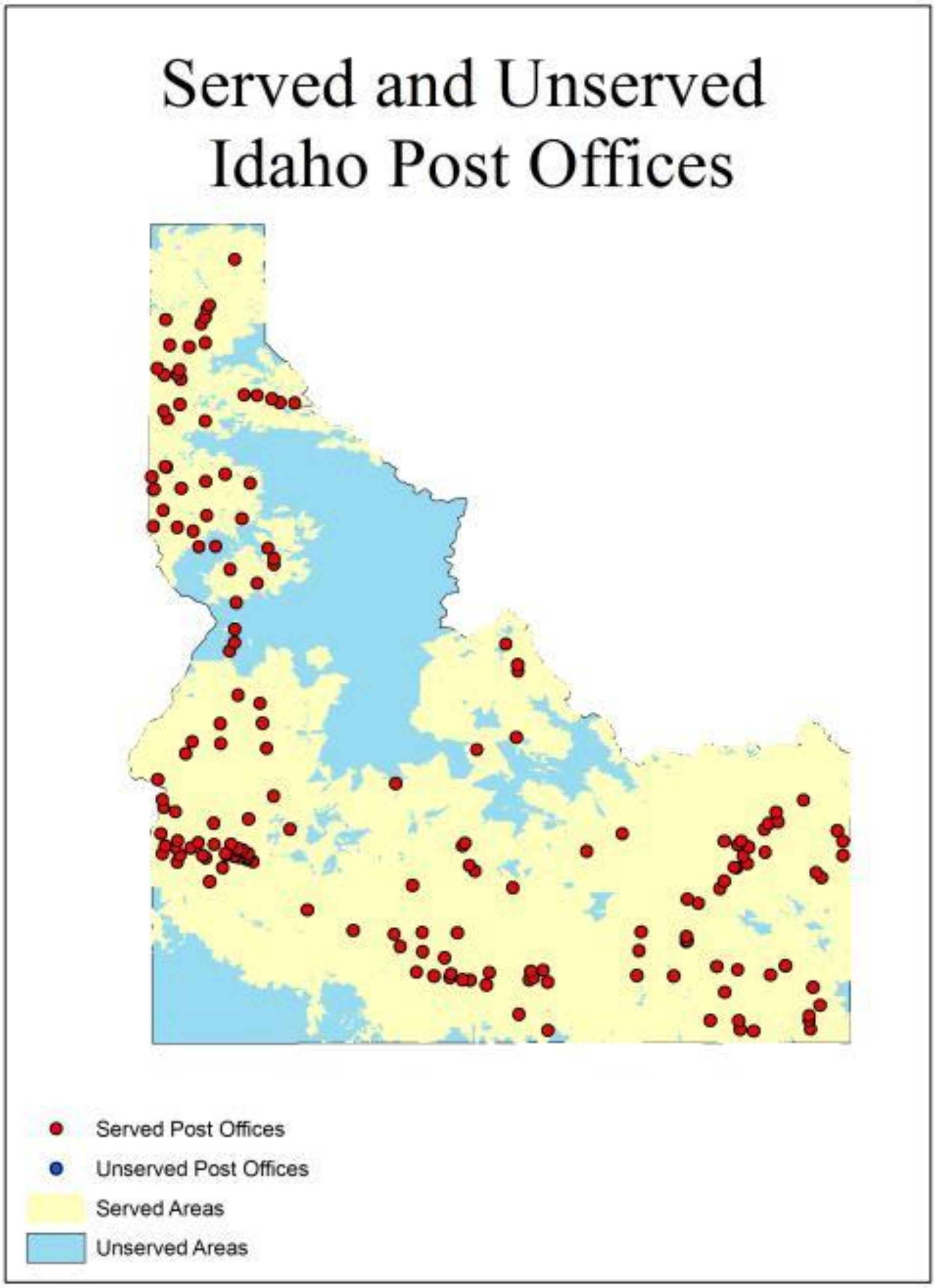
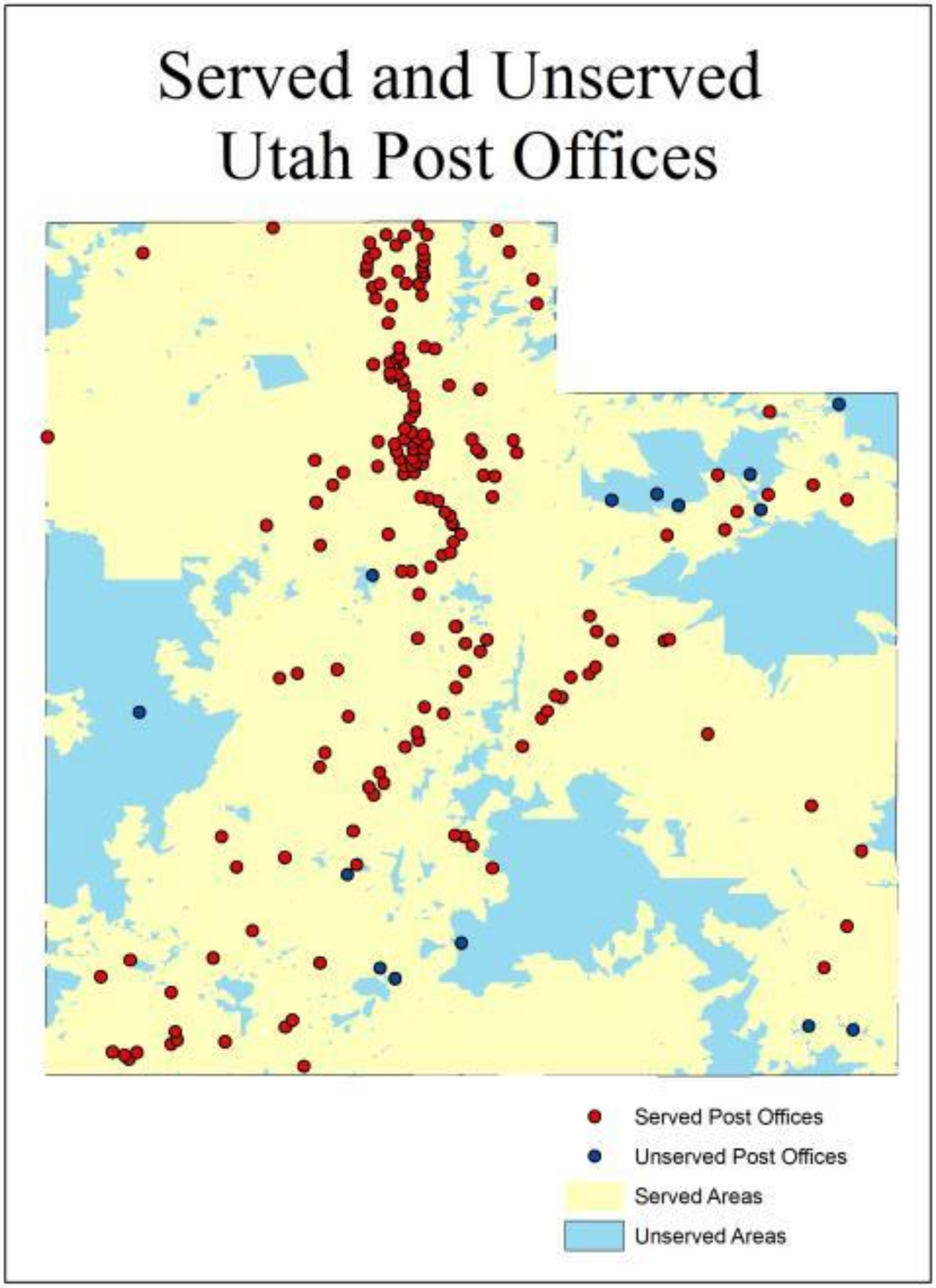


Figure 2: Served and Unserved Post Offices in Utah



2.3 Findings

Based on these efforts, we estimate that no more than 2 percent to 3 percent of all post offices nationally (about 975 to 1,600 out of roughly 32,500) lie in wholly unserved areas. The great majority of these are located in rural western states and Alaska.

We concluded early in our analysis that the bulk of areas relevant to this project will be in the west, so long as the USPS is limiting itself to the President's vision of bringing service to unserved areas as opposed to having a broader role as an Internet Service Provider (ISP). That is because the percentage of unserved geography is much greater across the rural western states than it is in the Midwest and east.

Even in large rural western states, however, our analysis demonstrates that relatively few post offices are in unserved areas. This conclusion seemed highly unlikely to us at first blush, but a more detailed analysis of the data demonstrates that post offices tend to be sited in towns—and rural towns are far more likely to have some form of broadband than are the less populated areas near and around them. As a result, a stunningly high percentage of post offices are located in areas that are considered served. Thus, for example, only 4 percent of post offices in Wyoming are in unserved areas (seven out of 162); in Utah, the number is 7 percent (14 out of 198); and in Idaho, no post offices are in unserved areas—even though large unserved areas certainly exist in that state.

We found that in the more densely populated states, few or none of the existing post offices are located in unserved areas. In western Maryland, for example, the great majority of the geography of rural Allegany and Garrett counties is unserved—but even small towns like Accident, in Garrett County, are served with DSL and cable. In Maine, which is the most rural of the east coast or Midwestern states, only nine of 438 post offices (2 percent) are located in unserved areas.

Alaska, which is the most rural state in the country, is the only outlier in our analysis: 64 percent of its post offices (136 of 212) are located in unserved areas.

We note that these numbers could change, depending on the outcome of recently announced plans to close many post offices, mostly in rural areas,[12] given that those sites are likely to be located in areas classified as unserved.

While we believe this outcome to be reasonable in light of the data, we are concerned that tracking whether the area around a postal facility is wholly unserved or served carries the risk of undercounting the postal facilities in communities that could benefit from this project. For example, almost the entire eastern and Midwestern part of the United States (as well as the coastal west) would be left out of this project under an approach that looks at wholly unserved areas. The result tends to disfavor rural states like Kentucky and West Virginia in favor of the west and Alaska. It is likely that postal facilities may be in "served" micro-areas and towns that are surrounded by unserved areas. We suggest caution about assuming that the states with postal facilities in served areas would not benefit from the programs being contemplated. For this reason, we recommend a more qualitative, detailed analysis of candidate sites, representative of the entire nation, if this initiative proceeds.

[12] Levitz, Jennifer, "Postal Service Eyes Closing Thousands of Post Offices," *Wall Street Journal*, January 24, 2011. http://online.wsj.com/article/SB10001424052748704881304576094000352599050.html (accessed August 11, 2011).

3. Engineering Analysis

This section of the report provides descriptions, illustrative designs, and cost estimates for providing wireless broadband service to the approximately 1,000 to 1,600 post offices located in unserved areas of the United States.

We present two general types of technology:

First, we present a "carrier-grade" network that would be capable of delivering commercial retail services comparable to those offered by national incumbent providers. The currently emerging state-of-the-art in carrier-grade wireless broadband includes a range of different technologies. This analysis illustrates how WiMAX, which is representative of this class of technologies, could be used in a deployment to reach unserved and underserved communities. Because of its reach and its efficient use of spectrum, WiMAX is an ideal technology for the goals that the USPS has articulated with respect to potentially building, owning, and operating its own network. The financial feasibility of that model is discussed in Section 4.1 below.

Second, we present a "best-effort" network that would deliver service to a more limited area and would not offer any guarantee of signal strength or reliability. Despite its limitations, WiFi is far more cost effective than WiMAX and is particularly successful for providing low cost services in areas where no business case exists for high cost deployments. For this class of technology, we discuss WiFi. The financial feasibility of that model is discussed in Section 4.2 below.

3.1 Carrier-grade network: WiMAX

This analysis provides a potential approach for utilizing 1) a sample USPS facility in an area designated as unserved, according to the National Broadband Map, and the adjacent land; 2) off-the-shelf technology; and 3) wireless spectrum designated for wireless broadband that is available in most unserved markets and optimized for this type of application. The deployment is also designed to be cost-effective, yet reliable and suitable for providing a scalable service that compares favorability with the broadband service in served areas. The components are priced conservatively, from well-regarded U.S. firms. Labor is also priced conservatively, taking into account the need for skilled workers to travel to a remote site. It is possible that per-unit prices can be reduced through bulk purchases of equipment, and with a large-scale project subscribing to a uniform set of design principles.

The largest capital expenses are found in the following areas:

- **Towers and antennas.** Antennas are needed to propagate the network signals. These can be located on monopoles, towers, higher rooftops, utility poles, and in building facades. The spacing of the antennas depends on the design of the system and the capacity and Radio Frequency (RF) coverage requirements of the area. More antennas are needed in busy areas, as well as in areas where there are physical obstructions, such as terrain and buildings.

- **Backhaul.** A robust network requires robust connections between towers. Backhaul refers to how traffic on the network is transported from the towers to a public Internet connection point or another dedicated location. The ideal, and increasingly standard, option in today's communication marketplace is fiber optic backhaul. Construction of fiber connections is extremely expensive. The alternative would be to try to gain access to backhaul services through lease agreements.

- **Electronics.** Networks must be activated, or "lit," by electronics. In addition to the initial expense, electronics must be replaced periodically as they age.

- **Power.** Carrier-grade networks require large amounts of reliable power from the local electricity provider. Many private carriers also install back-up batteries and generators to protect against a regional power loss.

3.1.1 Architecture

A potential architecture is shown in Figure 3. Components and prices are summarized in Table 1. The architecture includes a self-supporting tower, two sets of antennas on the tower, and electronics in the post office.

There is also an additional "backhaul" antenna located perhaps 30 km away, either in a served area or in as part of a series of backhaul antennas and repeaters, connecting the facility to its Internet service. As proposed, the backhaul connection (from the site to the outside world) is sized for capacity of 50 Mbps in each direction under good conditions, but the speed can be increased by using larger antennas or towers.

It will also be necessary to have a provisioning system to authorize and connect users and manage security. This equipment will be on a server and will be located at a centralized point away from the post office; this is an asset that is best shared over many users and many tower sites.

The post office interior will host a relatively small amount of additional equipment. This will be a small Ethernet switch, such as a Cisco 2900 series switch, with 10/100/1000 Mbps Power-over-Ethernet ports, a cable patch panel, and an uninterruptible power supply (UPS). The switch will interconnect the backhaul connections with the radio devices serving the surrounding area. There will also be the option of connecting directly into the Ethernet ports on the switch, in order to serve wired devices inside the post office, or to connect to a local WiFi distribution system within and near the post office.

The proposed architecture will serve the surrounding area with approximately 135 Mbps of aggregate bandwidth with individual users able to receive 14 Mbps in the downstream direction and transmit 5 Mbps in the upstream direction. It will be able to reach out to 16 km from the tower (line-of-sight permitting) and provide the highest quality service to users within 10 km, and it will be technically possible to increase the range and capacity through tower height and antenna choice, depending on the needs of a particular geographic area.

The proposed electronics uses two 10 MHz channels in the 3.65 GHz frequency band set aside by the FCC for wireless broadband service. 3.65 GHz capacity is generally available in unserved areas and can be operated in point-to-multipoint mode to reach out to the line of sight (depending on the antenna height). There are some limitations in the use of the 3.65 GHz band where high-power satellite links exist. The limitations are not generally a concern for this service, but in those geographic areas there are other options, including using the 2.5 GHz licensed band or using unlicensed spectrum.

The proposed configuration uses three 120-degree sectors, providing each sector with 45 Mbps aggregate bandwidth. Other configurations include four-sector configuration, providing the same 45 Mbps to a narrower slice of area.

Figure 3: Proposed Site Architecture

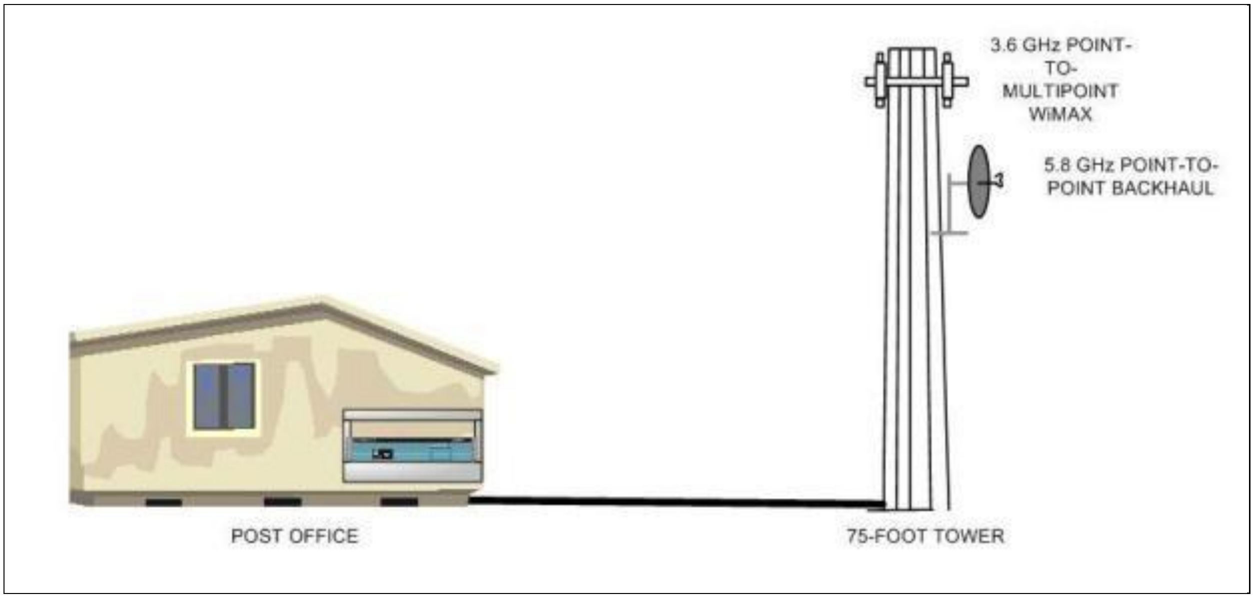


Table 1: Components and Prices for Proposed Site Architecture

Description	Unit Price	Quantity	Total
Tower	$60,000	1	$60,000
Base station	$15,000	1	$15,000
User devices w/external antennas	$500	0	$0
Base station site installation	$8,000	1	$8,000
Detailed engineering	$15,000	1	$15,000
Site router	$3,000	1	$3,000
Enhancement to power/site prep	$25,000	1	$25,000
Software	$30,000	1	$30,000
Backhaul between base stations	$12,500	2	$25,000
Total:			**$181,000**

3.1.2 Power

The components directly powered are the base stations on the poles, the point-to-point Ethernet bridge for backhaul, and the Ethernet switch in the post office. All will need to be powered from the post office. All will be powered through the switch in the post office. The power budget is as follows. Maximum power is estimated to be 250W.

Table 2: Power Requirements

Devices	Maximum Power (W)
Ethernet Switch	30
Three Point-to-Multipoint Base Stations	165
Point-to-Point Ethernet Bridge	55

3.1.3 Tower

The antennas and base stations will be on a self-supporting mast located either on the building rooftop or alongside the building. A 22.5 m tower is proposed. The self-supporting tower is required in order to limit the footprint of the tower; a guyed tower would require additional surface space. The tower will need to have sufficient lightning protection.

The weight of the point-to-multipoint WiMAX base stations is expected to be 2.2 kg apiece. Each antenna will be connected to each connectorized base station over coaxial cable. Each base station will connect to the post office over Cat-5 or higher twisted pair cable, both for power and data connectivity, with each connection grounded.

The weight of the point-to-point Ethernet bridge is expected to be 4.3 kg. The antenna will be connected over coaxial cable. The base station will connect to the post office over Cat-5 or higher twisted pair cable, both for power and data connectivity, with each connection grounded.

The cost of the tower is expected to be approximately $60,000 for materials and installation labor. $15,000 is estimated for soil samples, engineering, and permitting.

3.1.4 Antennas

The proposed sector antennas for the point-to-multipoint service (the WiMAX service facing the subscribers) are 52.2″ x 5.7″ x 3.3″ panel antennas. The weight of each antenna is approximately 3.5 kg.

The proposed antenna for the backhaul is a 1.2 m diameter parabolic antenna. The weight of the antenna is approximately 27.3 kg.

3.1.5 Backhaul

Since, by definition, the area is unserved, the backhaul must be brought in as part of the project. The proposed approach uses a wireless Ethernet bridge from a backhaul location to the antenna site. It assumes there is a location with a tower within the line of sight. This is often the case in the continental U.S. but less likely in Alaska, where unserved regions are widely separated from served regions.

The cost for the Internet capacity and other portions of the backhaul (usually a monthly recurring charge) is not included. It depends on the particulars of the particular arrangement, and varies widely. If a large-scale network is built, one of the most important considerations is the planning and implementation of the "middle-mile" network transporting the Internet backhaul, which may require multiple links or "hops," and therefore multiple tower installations.

3.1.6 Price

The price is summarized in Table 1. (See Appendix B for complete details.) Including all of the components in Figure 3, the cost is approximately $181,000 per site. The highest single cost is the tower and its construction. That cost will vary based on the type of design and constructions or state of the rooftop, the surrounding land, and local permitting requirements. The tower height was selected as a suitable average, but taller towers may be needed in areas where customers or the backhaul connection require connectivity at longer distances.

The cost of software for management and provisioning is approximate and may decrease on a per-site basis if it can be shared across multiple areas. Likewise, the cost for facility and power enhancement depends on the facility. If a generator exists with sufficient capacity, this item's cost can be reduced significantly. If rooftop reinforcement is required, or extensive facility cabling, or digging across a parking lot, the cost may increase.

The price does not include ongoing maintenance of the tower or electronics, nor does it include the cost of Internet access or the commercial arrangement at the backhaul location, all of which depend on the details of the location. Internet capacity purchased in bulk outside metropolitan areas may cost $25 to $50 per Mbps per month. Taking into account typical levels of Internet capacity oversubscription, the additional monthly costs per site are likely to be in the range of thousands of dollars per month per site.

3.1.7 Aggregate price

Given this pricing, we conservatively estimate a price of approximately $181,000 per site for implementation and $7,500 per month per site for operations. While the price will not increase in a directly linear way (because of economies of scale), we conservatively suggest multiplying this amount by the number of potential sites to reach an aggregate price point. Thus, assuming an investment by the USPS in 1,000 of the post offices in unserved areas, the minimum capital cost of building a carrier grade infrastructure will be approximately $181 million, with operating costs of at least $90 million per year.

3.2 Best-effort network: Wi-Fi

This analysis provides a potential approach for utilizing 1) a sample USPS facility in an area designated as unserved, according to the National Broadband Map, and the adjacent land; 2) off-the-shelf IEEE 802.11 (aka Wi-Fi) technology; and 3) unlicensed wireless spectrum suitable for wireless broadband that is available in all unserved areas. The deployment is also designed to be cost-effective, yet reliable and suitable for providing a scalable service that compares favorably with the broadband service in served areas.

The technical and infrastructure issues between carrier-grade and best-effort wireless deployment and service delivery are quite similar, so the rest of this section will outline the areas where there are significant differences.

3.2.1 Architecture

The issues cited in Section 3.1.1 are similar except that antennas for the 2.4 GHz unlicensed band could be used in addition to the 5 GHz antennas detailed in that section.

3.2.2 Power

The power requirements are similar to those in Section 3.1.2 and as depicted in Table 2.

3.2.3 Tower

The tower requirements are similar to those in Section 3.1.3.

3.2.4 Antennas

The issues cited in Section 3.1.1 are similar except that antennas for the 2.4 GHz unlicensed band could be used in addition to the 5 GHz antennas detailed in that section.

3.2.5 Backhaul

The carrier-grade approach uses unlicensed spectrum and Wi-Fi equipment for the backhaul, so all of the issues raised in Section 3.1.5 apply here. The only exception is the need to perform spectrum management and coordination if broadband services are being delivered in the same band as the backhaul.

3.2.6 Price

The price is summarized in Table 3 below. The cost is approximately $142,000 per site. The primary difference in the pricing is due to the lower cost of Wi-Fi equipment when compared to WiMAX. Wi-Fi hardware can be roughly 10 percent of the cost of WiMAX hardware. See Appendix C for complete details. Otherwise, all of the pricing issues described in Section 3.1.6 apply.

Table 3: Components and Prices for Proposed Site Architecture

Network Equipment and Installation Costs			
Description	**Unit Price**	**Quantity**	**Total**
Tower	$60,000	1	$60,000
Base Station	$250	1	$250
User devices w/external antennas	$500	0	$0
Base station site installation	$8,000	1	$8,000
Detailed engineering	$15,000	1	$15,000
Site router	$3,000	1	$3,000
Enhancement to power/site prep	$25,000	1	$25,000
Software	$30,000	1	$30,000
Backhaul between base stations	$250	2	$500
Total:			**$141,750**

3.2.7 Aggregate price

The same issues in Section 3.1.7 apply here, except that the site costs for a Wi-Fi solution would be approximately $142,000. The operational costs would be the same. Thus, assuming an investment by the USPS in 1,000 of the post offices in unserved areas, the minimum capital cost of building a carrier grade infrastructure will be $142 million, with operating costs of at least $90 million per year.

4. Feasibility/Business Model Analysis

In this section of the report, we explore three potential wireless broadband business models, ranging in scope from largest to smallest investments:

- Model 1: USPS builds, owns, and operates wireless networks
- Model 2: USPS creates free Wi-Fi hotspots in and around rural post offices
- Model 3: USPS establishes public-private partnerships for leasing facilities

Each of these models is described in detail below.

4.1 Model 1: Postal Service builds, owns, and operates wireless networks

In the most ambitious of the three potential models, the USPS would become an Internet Service Provider (ISP) and sell wireless broadband services directly to customers (residents and small businesses) near post offices in rural area. This model would potentially have the greatest impact on broadband availability in currently unserved areas, because the USPS would specifically target these communities with high quality, carrier-grade services. But the ISP model would also require the greatest investment and pose some of the greatest challenges.

The ability to deliver true carrier-grade service is essential to this model. When consumers enter into a contractual agreement and agree to pay for service, they expect, rightly, that there be high levels of quality and reliability from the provider. For phone service the general expectation is that the network be operational 99.999 percent of the time—in other words, that it will have no more than about five minutes of downtime per year. Expectations for a broadband Internet connection are only slightly lower—and still require virtually 100 percent uptime.

Where carriers have sold services that did not meet this level of reliability (whether under the promise of guaranteed service levels, or merely "best effort" services), their business models have frequently failed. The difficulty in operating a self-sustaining retail wireless network was highlighted by the failure of EarthLink's Wi-Fi network in Philadelphia in 2008, less than four years after its launch.[13] News reports at the time indicated that consumers were unhappy paying for a service that, because of the propagation characteristics of Wi-Fi's unlicensed spectrum, could not deliver a completely reliable connection. EarthLink could have engineered the network to solve these problems by adding significantly more hardware in the field, but only at very high cost.

[13] Gross, Grant, "Update: EarthLink selected for Philadelphia Wi-Fi network; EarthLink to finance, build and manage network, then share revenue with Wireless Philadelphia initiative" *InfoWorld*, October 5, 2005. http://www.infoworld.com/d/networking/update-earthlink-selected-philadelphia-wi-fi-network-447, (accessed August 9, 2011). *See also*: EarthLink, "EarthLink to discontinue operation of its municipal Wi-Fi Network in Philadelphia," press release, May 13, 2008. http://ir.earthlink.net/releasedetail.cfm?ReleaseID=310055 (accessed August 9, 2011).

Thus, to establish a viable retail ISP business selling data communications services to the public, the USPS would need to make the investment necessary to build a complete carrier-grade network.

While the USPS's real estate would be a key element in that network development, it would be just one piece in a complex and expensive undertaking. The USPS would need to invest in wireless network design, equipment, and construction; operate and maintain the network; and develop internal skill sets or contract out for new customer service, technical support, billing, operations, and maintenance functions.

The costs associated with designing, building, and operating a carrier-grade network would be considerable and are described in the section above.

In addition to the enormous capital costs associated with building a carrier-grade network, the USPS would also face substantial costs associated with operating and maintaining such a network. The USPS would need to hire new staff, including: network engineers, outside plant engineers, network operation center services and staff, and customer support staff for 24/7 help desk service. The USPS would also need to establish field maintenance teams with coverage for every location where the network is deployed.

Finally, as the operator of a carrier-grade network, the USPS would need to ensure the availability of compatible end-user devices for its customers. Because consumer devices in the United States are not interoperable on different carrier technologies (e.g., WiMAX, LTE, GSM, CDMA), consumers would need to own a fixed or mobile device that is able to receive the USPS's network signal. (Wi-Fi cards, which are found universally in PDAs, laptops, and even some televisions and gaming consoles, are not interoperable with carrier-grade network architectures.)

The incumbent national carriers have partnerships and relationships with device manufacturers to develop, market, and sell end user equipment. The USPS would need to develop similar relationships and incent manufacturers to provide such devices. Absent the scale of a large carrier, this might be a burdensome and costly requirement. The potential market for this ISP service to be offered by the USPS—already small because of rural nature of the community—would be even smaller if the cost or availability of the appropriate consumer device were a hurdle for potential customers.

In a small rural community of a few hundred or a few thousand residents, the revenues associated with the services USPS would provide will be modest. Take, for example, the Maine case study offered below. The town has 570 residents or approximately 250 households. Assuming that the project achieves 50% penetration of the potential market (125 customers) at a monthly fee of $60 per household, the total revenues per month are $7,500—sufficient only to cover the approximate cost of monthly operations.

As a result, the ISP model would require USPS not only to make an unrecoverable investment in the capital costs for the network, but also to subsidize operations for an indefinite period.

4.2 Model 2: Post offices serve as Wi-Fi hotspots

In this model, USPS sites in unserved areas could provide free Wi-Fi connections, similar to what many public libraries and coffee shops offer. The goal would be to turn these post office locations into 21st century "community connectivity centers" where residents could access a basic level of Internet connectivity. This model would demonstrate the relevance and importance of the USPS in these communities, and would likely increase the use of the facilities. In providing a critical public service to residents who lack broadband access, it would also generate substantial good will.

With sufficient space and funding, the public Wi-Fi model could be expanded to include the installation of public computer terminals at post offices in unserved areas—a concept similar to the Public Computer Centers envisioned under the Broadband Technology Opportunities Program.[14] In areas where there is no public library offering Internet access, the availability of public computers at the post office would represent a tremendous community asset.

Another variation on this wireless "hot spot" model would be to enable the USPS Wi-Fi networks to grow into community "hot zones." This is a well-supported vision—it was first embraced by the Clinton administration, which sought to bring high-capacity broadband connections to schools and libraries, and to make that bandwidth available to residents of the surrounding communities. In this case, the USPS would bring the capacity to its sites, and encourage local community groups to develop mesh networks with inexpensive, off-the-shelf equipment. This would be similar to residents connecting to their neighbor's DSL or cable modem service through an unsecured wireless router—but it would be sanctioned, higher bandwidth, and available community-wide.

Because each post office facility is different, a Wi-Fi network would need to be individually engineered for each site. A public Wi-Fi signal would certainly cover the post office facility itself, and could conceivably provide Internet access to a fairly wide area surrounding the building. Wi-Fi is a line-of-sight technology, so obstructions such as buildings, hills, and broad-leaf foliage would limit the signal propagation. (Signal reception is also influenced by the end user's device.) In areas with no visual obstructions, a Wi-Fi signal could reach a mobile device one-half mile away, and a fixed wireless device as far as 1½ miles away.

While offering free publicly available connectivity would naturally exclude the possibility of earning revenue from users, it might enable the USPS to sell local or national sponsorships based on the potential good will to be created in the target communities. More significantly, in terms of economic feasibility, this model would require only limited USPS investment.

Simple wireless networks with short-range coverage are relatively inexpensive to design and operate, and could be built with widely available off-the-shelf technologies. These networks

[14] The Broadband Technology Opportunities Program (BTOP), the initiative that distributed over $4 billion in stimulus grants to broadband projects, specifically listed "Public Computer Centers" as one of its funding categories: http://www2.ntia.doc.gov/about

would operate on wireless spectrum already designated for general unlicensed use, eliminating both the need to seek approval before installation and the cost of purchasing spectrum.

Further limiting the financial exposure inherent in this model, the USPS would commit only to a "best effort" for maintaining a connection. Just as with library and coffee shop wireless networks, there would be no contractual relationship between the USPS and its end users, and thus no required quality of service. This sort of best-effort availability would require much lower levels of investment and staffing than would a fee-based offering. (As discussed above in the ISP model, if the USPS were to charge a subscription fee, end users would expect a higher quality product with greater levels of reliability, security, and customer support. Each of these aspects of private Internet service would require substantially higher levels of investment from the USPS compared to offering a free network.)

The major cost with the public Wi-Fi network approach would be providing each participating USPS site with the necessary "backhaul" connectivity to accommodate bandwidth demands. Accessing backhaul transport and commodity Internet bandwidth is frequently one of the most costly elements of broadband deployment. (That problem is the basis for NTIA's focus on "middle mile" projects in the BTOP stimulus program).

The optimal backhaul solution is fiber optics, which is extraordinarily costly to build and seldom available in rural areas (particularly unserved areas). Among the alternatives are satellite and DSL, which would bring the Internet connectivity to the postal facility over satellite or telephone company wiring, respectively, and return the network traffic generated at the postal facility to the public Internet (hence the term, "backhaul").

The bandwidth delivered to that facility would be shared among the users of the WiFi network; as a result, the higher the bandwidth, the more use the community could make of the WiFi—but at a higher the cost to the USPS. And, of course, both of these options usually entail higher downstream speeds than upstream speeds, which makes the provision of service that much more complex (or, put another way, lower quality) for the USPS.

We believe that USPS could get competitively priced bulk pricing from the commercial sector as the result of a competitive bidding process. For reference, the following table shows sample pricing (assuming one facility only) for commodity business service from HughesNet (a satellite option, which will be available almost everywhere) and InfoWest, a DSL option, which will be available in very few unserved areas because the town in which the postal facility is located would likely be considered "served" if any customer can access DSL.

Table 4: Sample Backhaul Pricing

Provider	Type of Service	Monthly Cost	Capacity	Notes
HughesNet[15]	Satellite	$350	5 Mbps down/ 1 Mbps up	Two-year commitment; unlimited users; 800 MB daily data cap
InfoWest[16]	DSL	$75 and up	7 Mbps down/ No guaranteed upload speed	Requires copper circuits of appropriate length and availability of DSL service

4.3 Model 3: Public–private partnership/universal lease access agreement

As described above, becoming a retail Internet service provider with a carrier-grade network would require the USPS to make a substantial long-term investment. Deploying public Wi-Fi, too, would require a financial commitment. As an alternative to these business models, the USPS could seek the cooperation of one or more incumbent providers and establish some level of public–private partnership to expand wireless broadband coverage around post office facilities in unserved areas.

In a public–private partnership, the capital and operational costs required for network deployment would be divided between the partners in some fashion. Thus, the USPS would not shoulder all of the expense itself. That said, in such arrangements the public partner typically assumes much of the financial burden; this is the primary model not just in the United States, but in broadband deployments in New Zealand, Japan, and Singapore.

Reducing the financial risk of a project presents private carriers with scenarios where they can be reasonably certain of a return on their investment, which is the incentive they need to enter a market they had previously passed over. In essence, the partnership arrangement significantly alters the economics of serving a currently unserved area by reducing the private sector's risk.

The partnership model would address one of the underlying reasons that many unserved areas are unserved. These unserved areas have not attracted private investment because carriers do not believe the communities can support profitable business operations. If it were easy to operate a profitable telecommunications service in areas with low population density and challenging topography, private carriers would likely already be investing in infrastructure and launching services there. (A 2006 U.S. Government Accountability Office (GAO) report attributed "the decision to deploy broadband service" to variety of factors, including an area's population and

[15] "Express Services Plans," HughesNet, http://business.hughesnet.com/explore-our-services/business-internet/business-internet-high-speed/express-service-plans (accessed August 25, 2011)
[16] "Business DSL Internet Services," InfoWest, http://www.infowest.com/business-services/dsl-broadband-internet-services/ (accessed August 25, 2011)

population density; "the percentage of the population residing in an urban area"; and the area's proximity to a metropolitan area.[17])

The challenge for a USPS partnership with the private sector is that the key asset USPS brings to the table is its rural postal facilities, and these structures are unfortunately insufficient to noticeably change the economics of broadband construction. Many post offices in rural areas are one- or two-story structures. These are not usable for carrier-grade wireless technologies, which still require construction of a tower. Given that limitation—and the fact that land in rural areas is typically inexpensive—USPS's asset has some value in lowering costs to carriers at the margins but not in such a significant way that carriers would choose to invest where they otherwise would not.

Altering the economic reality of the U.S. rural broadband market to the point of gaining carrier interest would thus likely require the USPS to assume a relatively large amount of financial risk in the partnership. Given that, the USPS may choose to establish a more conservative public-private partnership that would expose it to a lower level of financial risk, while still offering an incentive to the private sector.

The USPS could offer wireless carriers a comprehensive lease access agreement that authorizes the installation of network equipment at a large number of post offices and other USPS-owned sites. This model would leverage the USPS's greatest non-cash asset, in terms of expanding broadband availability: the physical "bricks and mortar" presence of post offices in unserved areas. Also, because the USPS would not be designing, installing, or operating any networks, this approach would require little to no investment. It might even create a modest revenue stream.

In essence, this model would enable private carriers to sign one document and get authority to place equipment at as many USPS-owned sites as they wished. (Real estate that USPS rents rather than owns may not be eligible if construction of towers and subleasing is limited by lease agreement.) This approach is not going to fundamentally transform the economics of broadband investment, but potentially delivers benefits at the margins of the broadband market. A carrier that signed such a master lease would avoid the cost and effort of negotiating individual leases for potentially hundreds of sites, and would presumably receive highly preferred lease rates.

Such streamlined leasing would have high-level benefits beyond reducing carriers' transaction costs. First, it would directly address a recommendation made by both the private sector and the federal government to reduce the complexity of federal facility licensing. In a recent FCC proceeding on local rights-of-way issues, for example, several major carriers specifically articulated their desire to see federal entities adopt "one-stop shopping" practices for leased

[17] U.S. GAO, GAO-06-426, May 2006, Telecommunications: Broadband Deployment Is Extensive throughout the United States, but It Is Difficult to Assess the Extent of Deployment Gaps in Rural Areas," at 4 (http://www.gao.gov/new.items/d06426.pdf).

access to facilities.[18] Similarly, the National Broadband Plan recommended that leasing practices be equalized across all federal agencies.[19]

This model would also have symbolic effects. It would demonstrate that the USPS and the federal government are trying to facilitate private sector investment, and attempting to make it easier for the private sector to enter broadband markets in areas where it was previously cost-prohibitive to do so. It would also show that not only is the USPS taking action on current policy goals, it is attempting to implement them in a manner recommended by the present administration.

The carrier would still need to perform site-by-site engineering and analysis, and it would be required to comply with local zoning requirements.

To determine carrier interest in a master lease arrangement, then, we would recommend that the USPS put out a Request for Information (RFI) to as wide a range of local, regional, and national carriers as is feasible. The goal of the RFI would be to determine a general level of interest, the types of price points that would attract the carriers, and the importance of various technical parameters. Based on the response to the RFI, the USPS could then proceed to a Request for Proposal to solicit concrete plans for executing master leases.

We are cautious about estimating potential lease revenue because we do not have a sense of the demand the USPS would see from private carriers, given that the rural real estate market is not competitive. Our concern is with assuming a certain level of leasing activity. Rather, we offer below a range of information about lease costs in rural and metropolitan areas, based on our own experience with lease negotiations, to offer a sense of what the revenues per site might be if the relationships do materialize. We would recommend a negotiation with potential customers that starts in the middle of this range and floats down strategically from there:

1. In rural North Carolina (near a small town), five- to 10-year lease rates range from $400 to $700 per month for at least one acre. This is for the real estate only; the carrier provides the tower and shelter.[20]

2. In metropolitan areas of Maryland, five-year leases from state and local entities are $700 per month and up for access to tower facilities (e.g., water towers, rooftops, low towers) in strategic locations.[21]

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[18] See FCC Docket WC 11-59. AT&T comments at 20 http://fjallfoss.fcc.gov/ecfs/comment/view?id=6016829005; Verizon comments at 14 http://fjallfoss.fcc.gov/ecfs/comment/view?id=6016828937; CTIA comments at 44 http://fjallfoss.fcc.gov/ecfs/comment/view?id=6016828961.

[19] See National Broadband Plan, Recommendation 6.10: http://www.broadband.gov/plan/6-infrastructure/

[20] Source: CTC Media Group, a tower owner in eastern North Carolina

[21] Source: Leases negotiated between communications carriers and both the State of Maryland and metro-area counties in the state.

5. Case Studies

In the brief case studies below, we apply our engineering and financial feasibility analysis to three post office sites representing the type of communities and facilities a USPS wireless broadband initiative might target.

5.1 Unalaska-Dutch Harbor, Alaska

The town of Unalaska (population 4,376) is the largest settlement in Alaska’s Aleutian Islands chain. The settlement is also known as Dutch Harbor, the name of its port facilities. A majority of the residents are White or Native Alaskan. There is a large gender gap: 68.5 percent of the population is male. The imbalance may be explained by the area’s dominant industry, commercial fishing. (Dutch Harbor is featured prominently on the Discovery Channel show “Deadliest Catch,” which chronicles the Alaskan crab fishing trade.)

According to 2000 Census data, 12 percent of the population lived below the federal poverty line and median household income was $69,539. Though the commercial fishing operations are temporary and seasonal in nature, the industry can be lucrative for those involved.

The USPS actually has two facilities in the area. One is located at 82 Airport Beach Road, Unalaska, AK 99685. The other is at 1745 Airport Beach Road, Dutch Harbor, AK 99692. These two sites are just over a mile apart and are close to many of the town’s community anchor institutions.

The Unalaska Post Office is located less than one-third of a mile from many of the local municipal departments, including the City of Unalaska office, the public library, and the court magistrate, as well as the National Marine Fisheries Department office.

The Dutch Harbor Post Office is located closer to the harbor facilities and the commercial fishing operations. It is also across the street from the Grand Aleutian, the area’s only large hotel.

Figure 4: Unalaska-Dutch Harbor Regional Overview

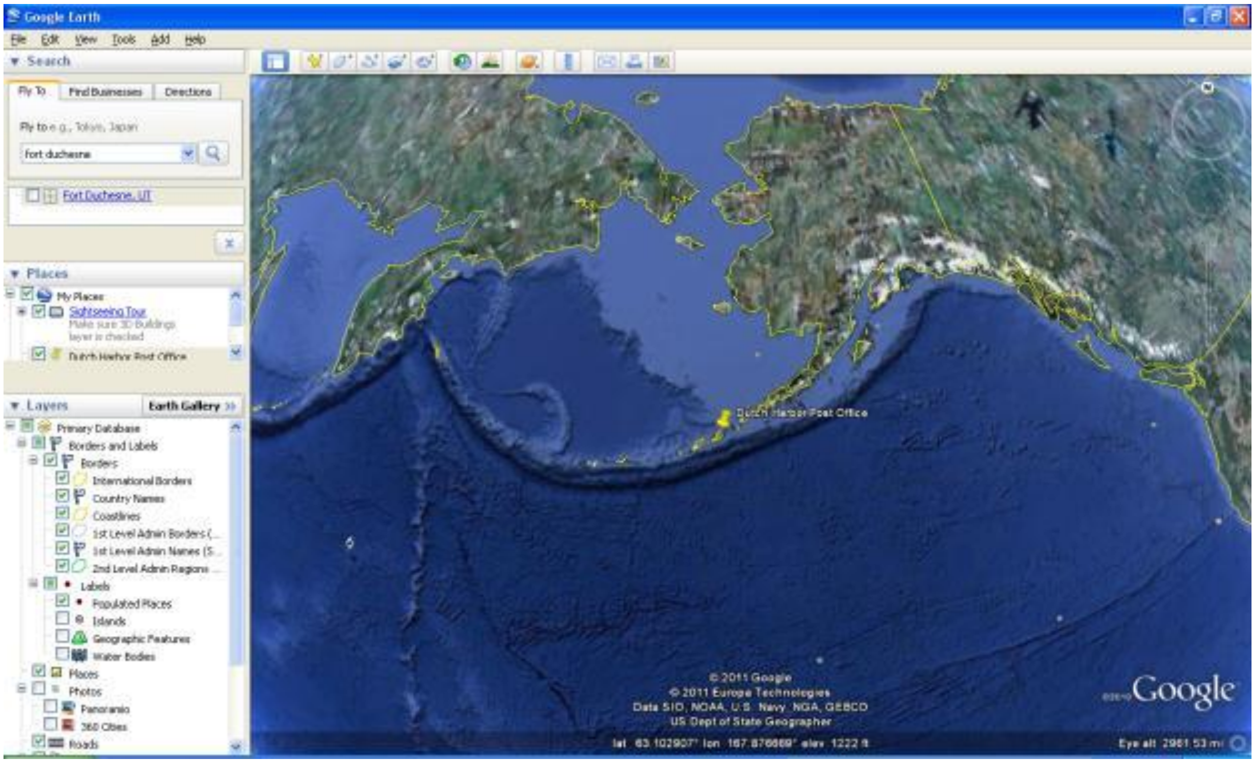


Figure 5: Unalaska-Dutch Harbor Local Overview

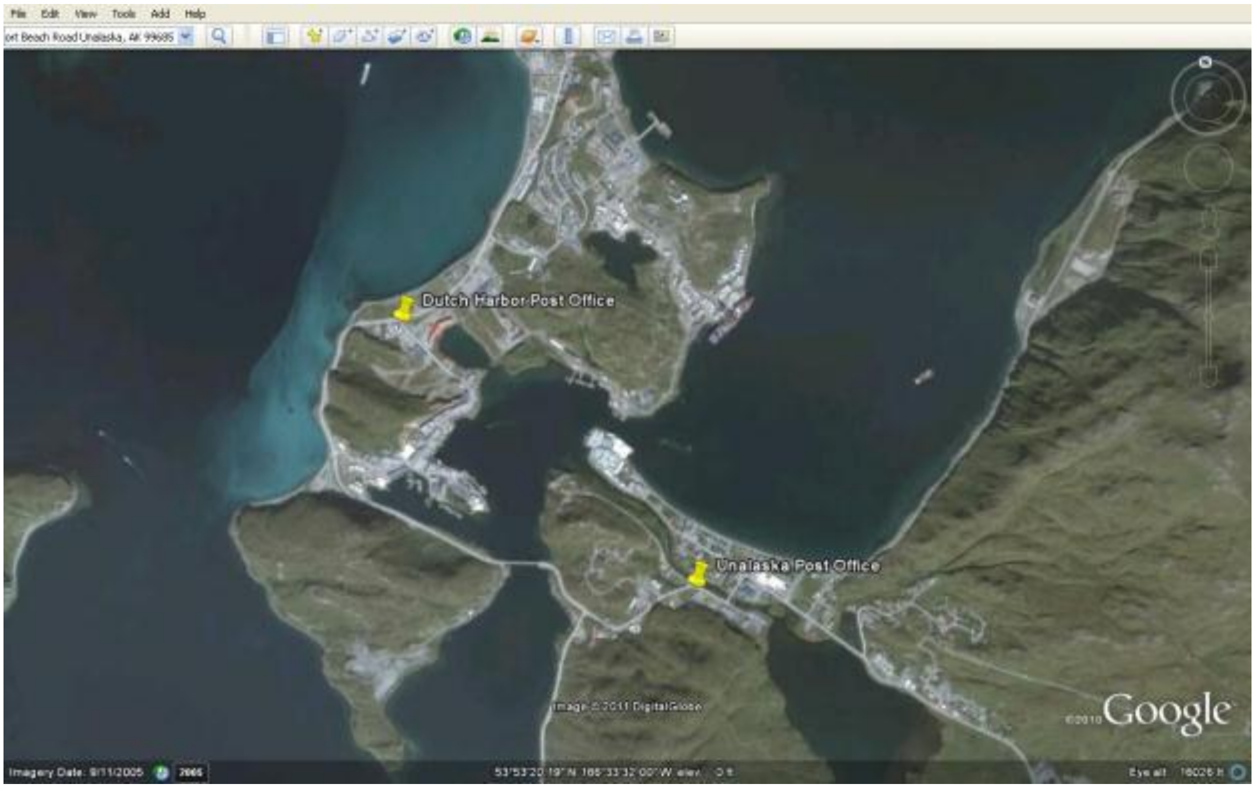


Figure 6: Unalaska-Dutch Harbor Topography

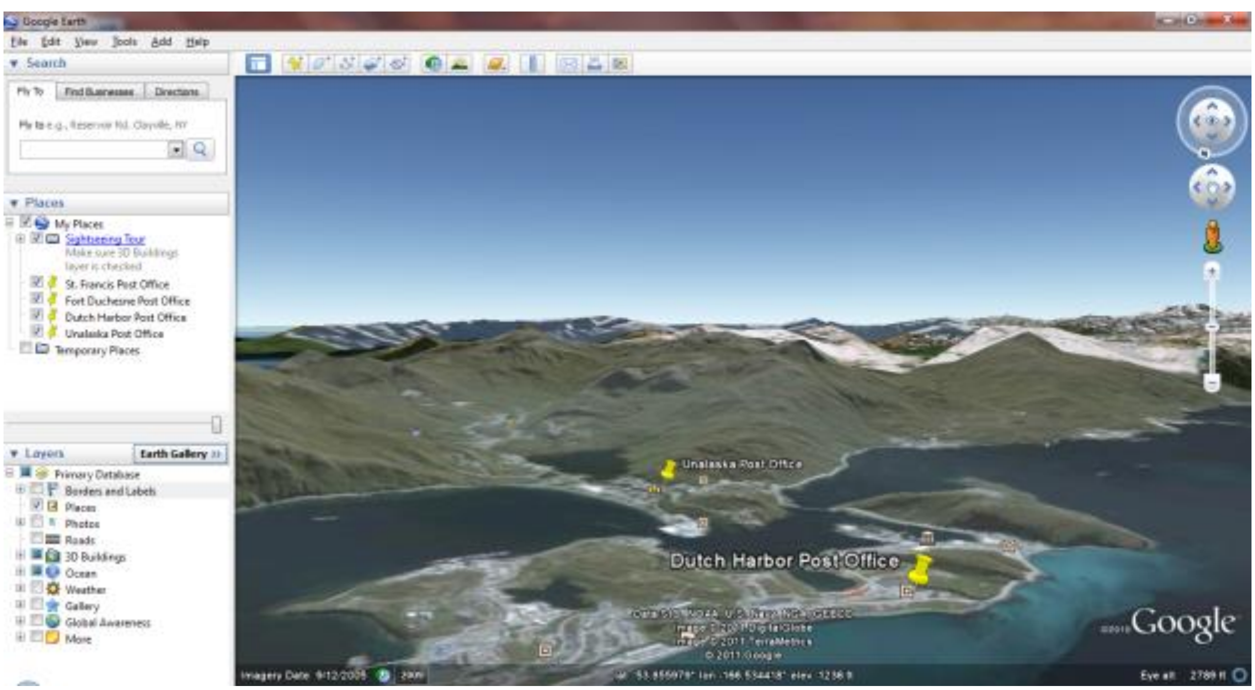


Figure 7: View of Dutch Harbor

Source: Panoramio

Figure 8: View of Unalaska in the Foreground, Dutch Harbor in the Background

Source: City of Unalaska

Figure 9: Dutch Harbor Post Office

Figure 10: Dutch Harbor Post Office Topography

Figure 11: Dutch Harbor Post Office Street View

Source: Panoramio

Figure 12: Unalaska Post Office

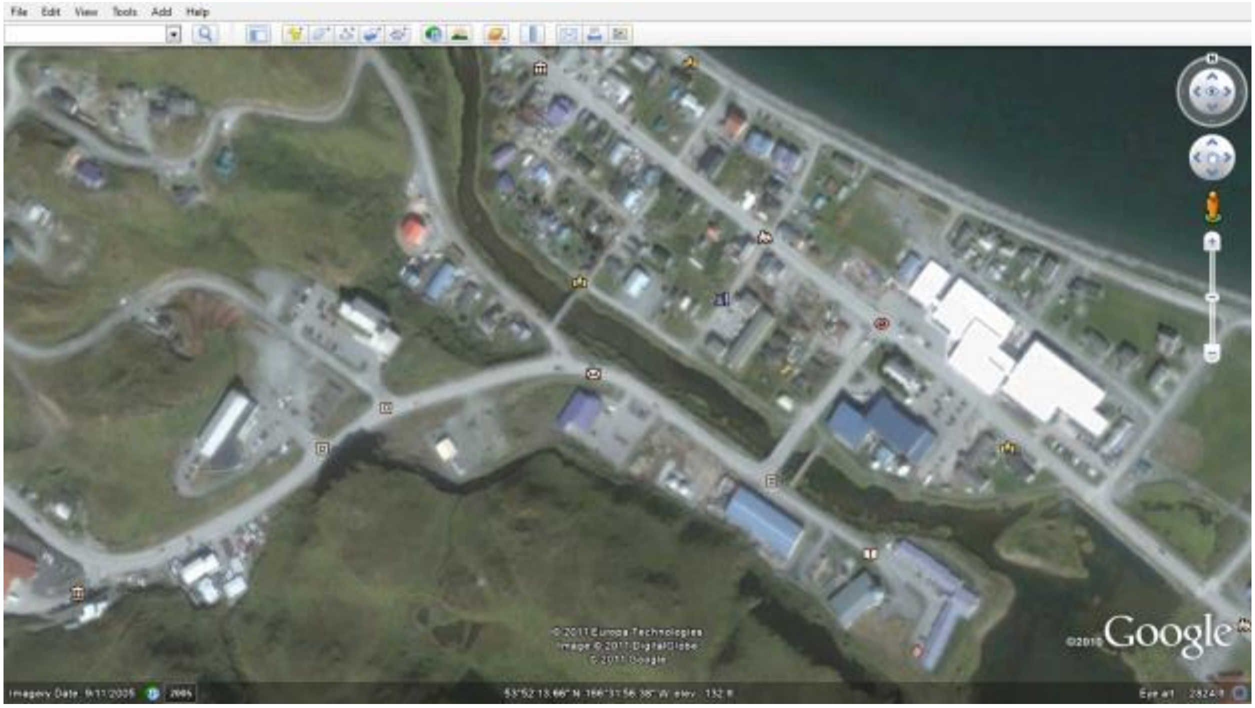


Figure 13: Unalaska Post Office Topography

The terrain around Unalaska-Dutch Harbor has no tree cover. However, is it quite hilly, and hills can significantly impact the propagation of wireless signals in the spectrum band used for Wi-Fi technology. A Wi-Fi device, with an optimal range of one-half mile, placed on the Unalaska site would provide coverage for a great many of the local anchor institutions described above without interference from terrain. The hill located between Unalaska and the harbor would impede the signal traveling to the west. A Wi-Fi device placed on the Dutch Harbor site would have effectiveness to the north and east, but the hill located behind it would impact the signal traveling toward the south and some of the harbor facilities.

Figure 14 and Figure 15 illustrate the possible range of Wi-Fi signal propagation around the area's post offices.

Figure 14: Unalaska-Dutch Harbor Wi-Fi Maximum Signal Reach

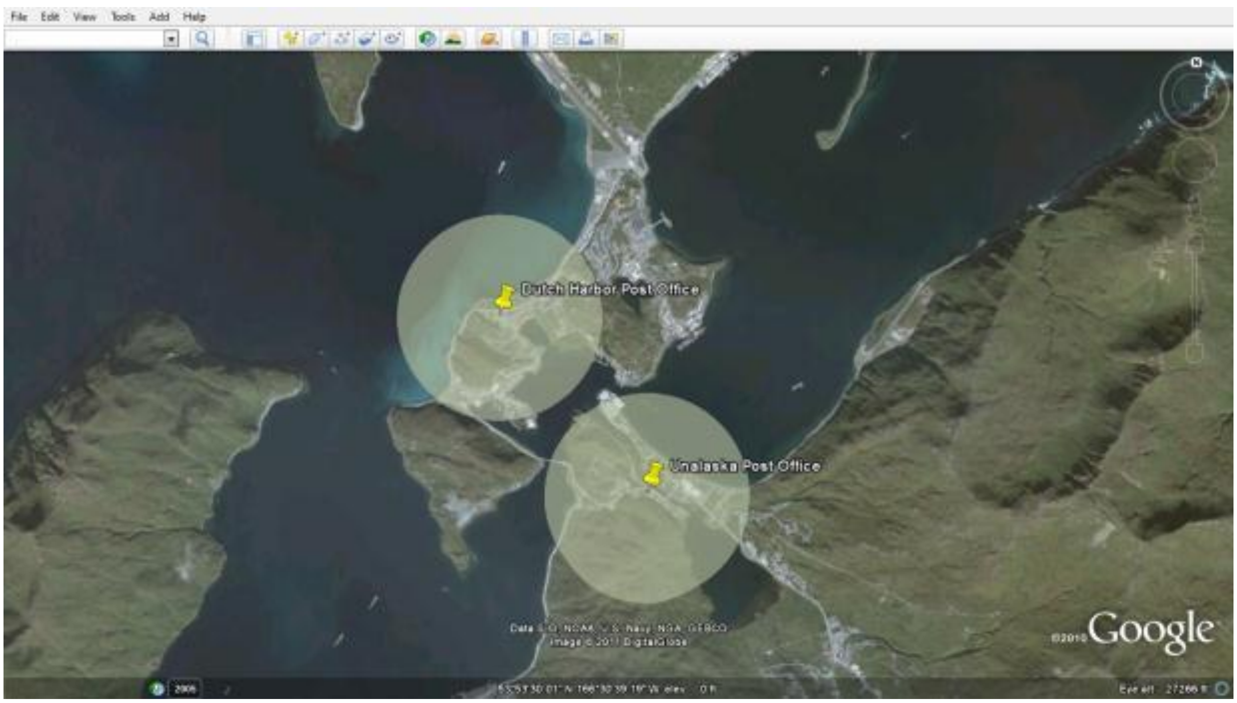
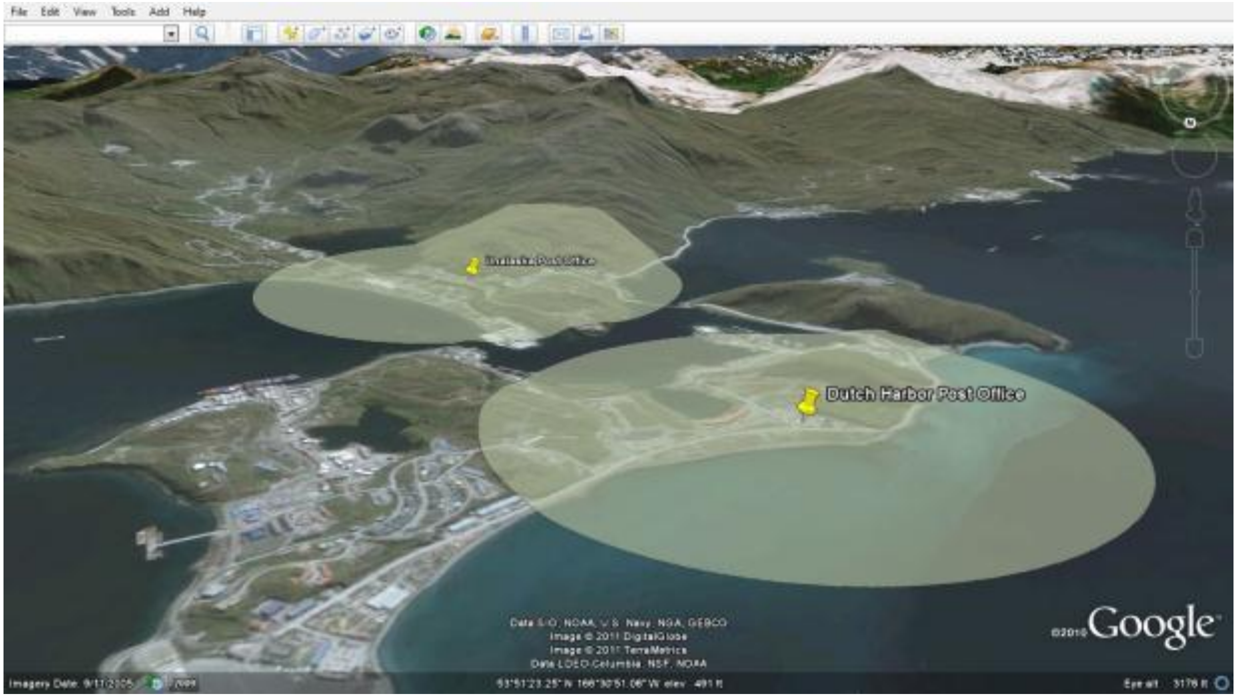


Figure 15: Unalaska-Dutch Harbor Wi-Fi Maximum Signal Reach with Topography



Publicly available photos demonstrate that one of the main hills near Unalaska already holds several tower facilities, perhaps for public safety communications. Ideally, a WiMAX station and equipment could be co-located here, allowing a single tower to serve the area and utilizing local topography to maximize line-of-sight connectivity. Technology placed at this site might cover all of the area's commercial and residential development. In contrast, siting the WiMAX equipment at either of the post office locations would risk its signal being impacted by the hilly terrain.

Figure 16 and Figure 17 illustrate the possible range of WiMAX signal propagation, using the spectrum and design proposed above, around the area's post offices. The red circle indicates the optimal range of 10 km. The pink circle indicates the maximum range of 16 km. These figures were generated using the aforementioned hill location as the site of the WiMAX technology.

Figure 16: Unalaska-Dutch Harbor WiMAX Optimal and Maximum Signal Reach

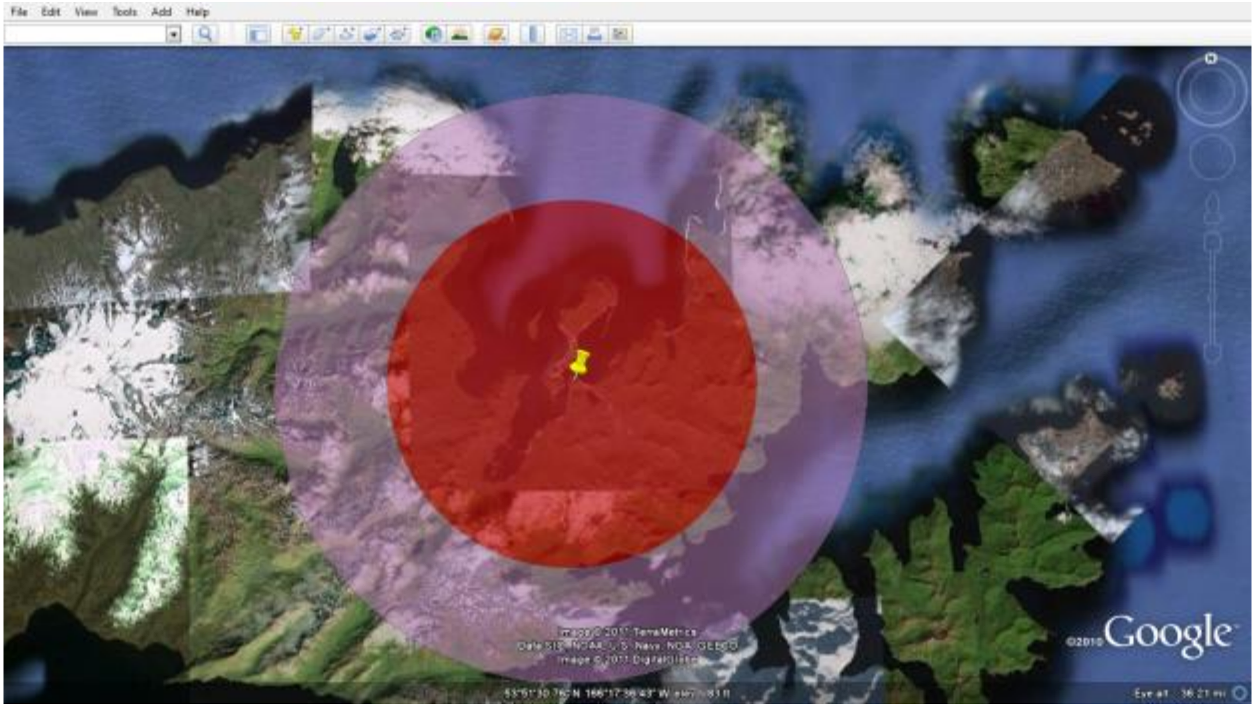
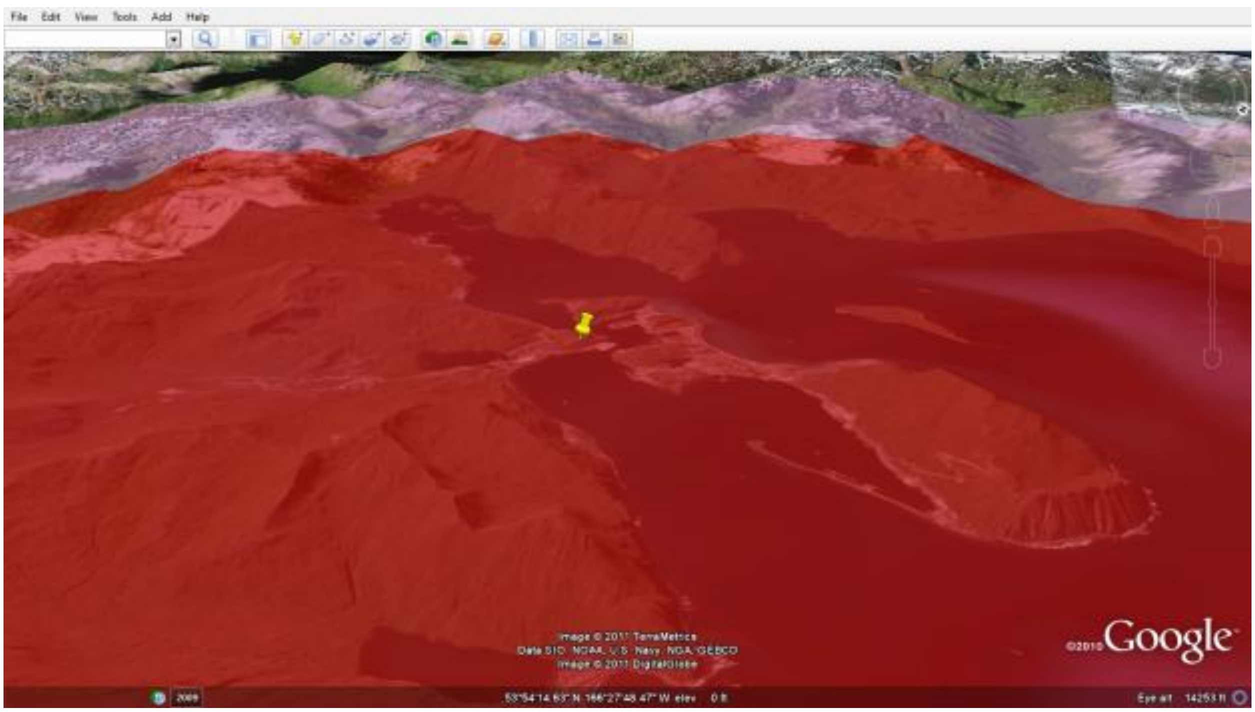


Figure 17: Unalaska-Dutch Harbor WiMAX Optimal and Maximum Signal Reach with Topography



5.2 Fort Duchesne, Utah

The town of Fort Duchesne, Utah is located 150 miles east of Salt Lake City and is not far from the borders of both Wyoming and Colorado. There are only 714 residents, most of whom are Native American and members of the Ute nation. Fort Duchesne is located within the Uintah and Ouray Indian Reservation and hosts the Ute tribal headquarters.

According to 2000 Census data the median household income for Fort Duchesne was $18,750. More than 50 percent of the population lived below the federal poverty line.

The local post office facility is located at 7299 U.S. 40, Fort Duchesne, UT 84026. It is located within one of the residential developments, one mile north of the area's larger residential development (which houses the Ute tribal offices). Large commercial developments in the vicinity are limited, but smaller retail businesses, like a restaurant and the Ute Plaza Supermarket, are close.

Figure 18: Fort Duchesne Regional Overview

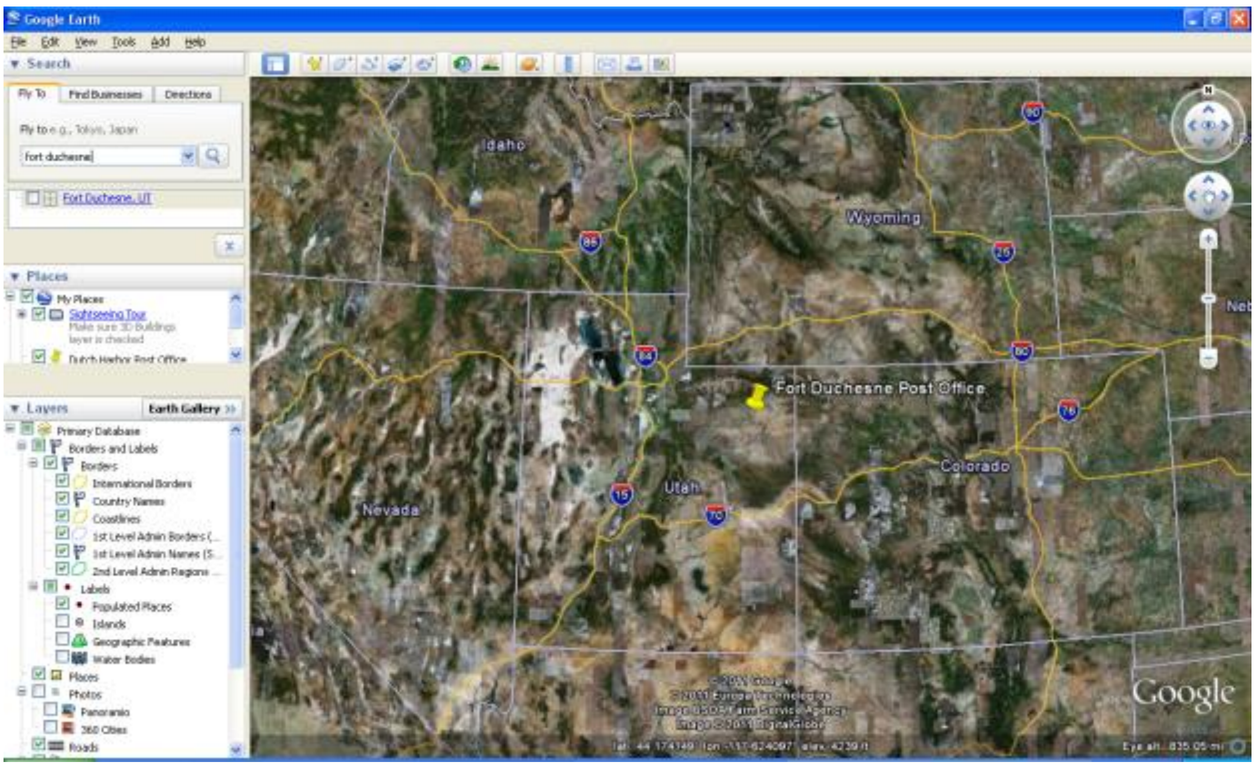


Figure 19: Fort Duchesne Local Overview

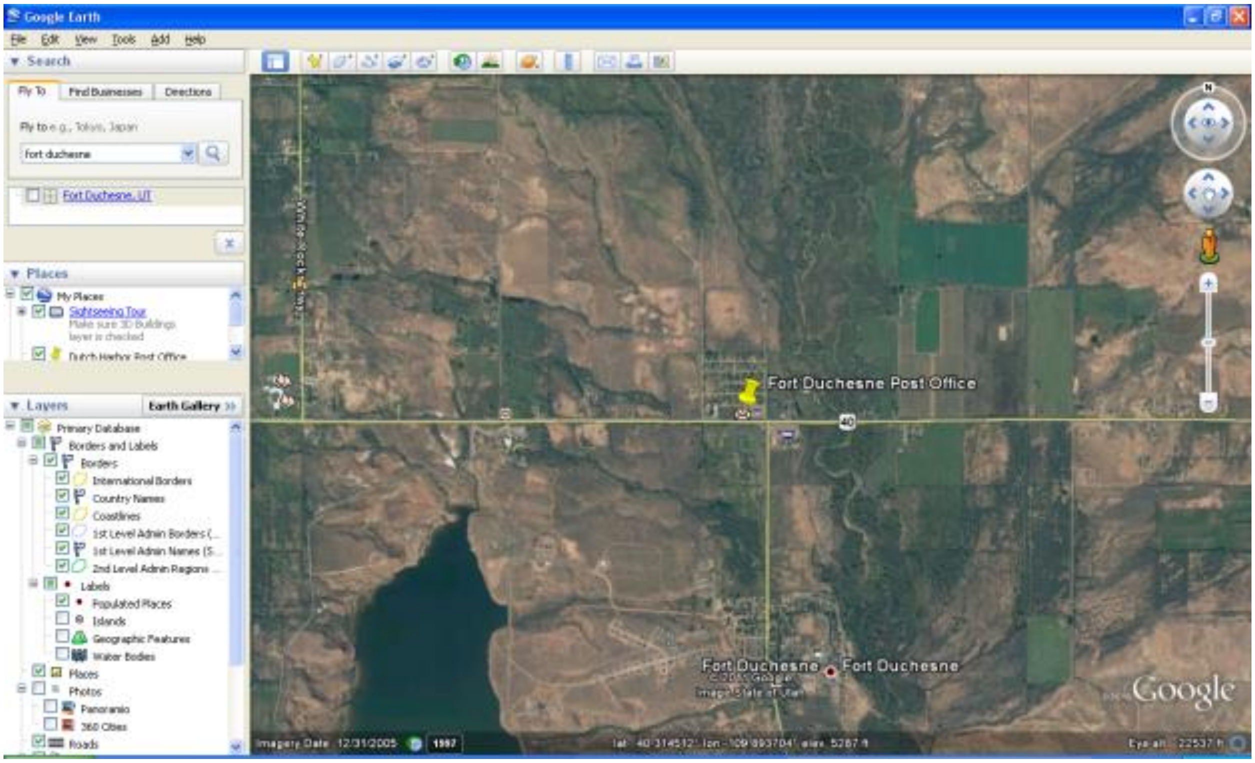


Figure 20: Fort Duchesne Topography

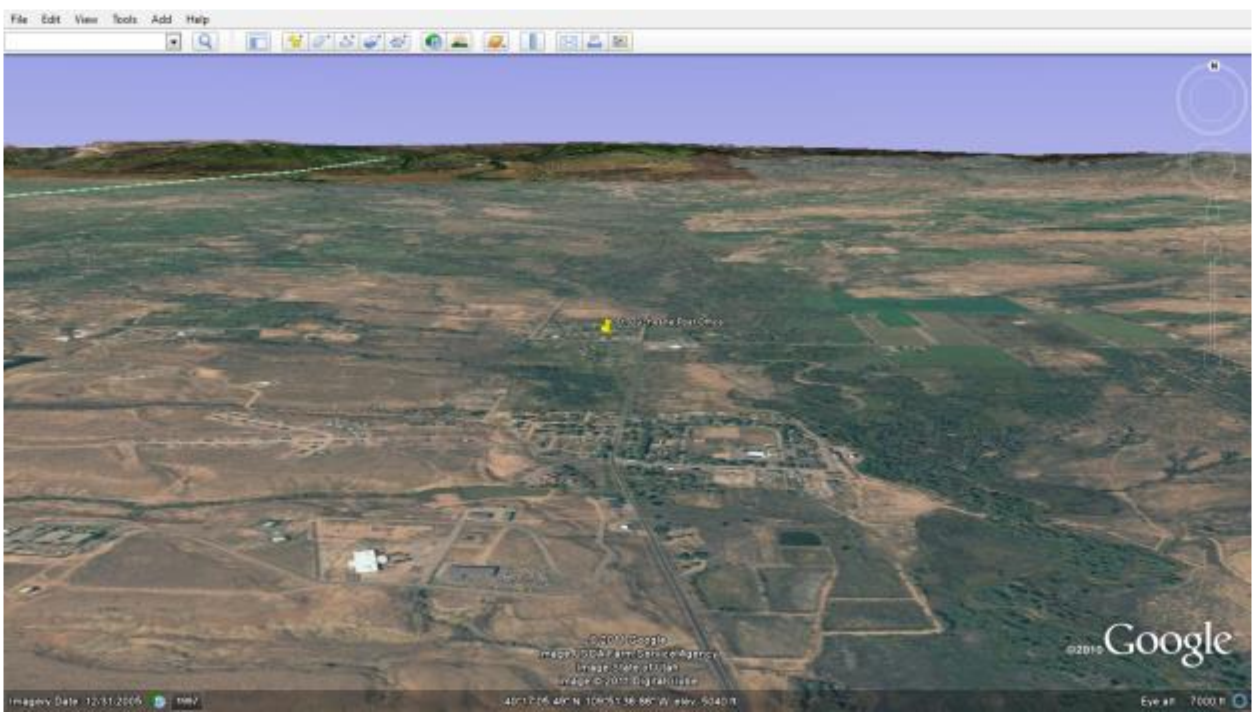


Figure 21: Fort Duchesne Post Office Overview

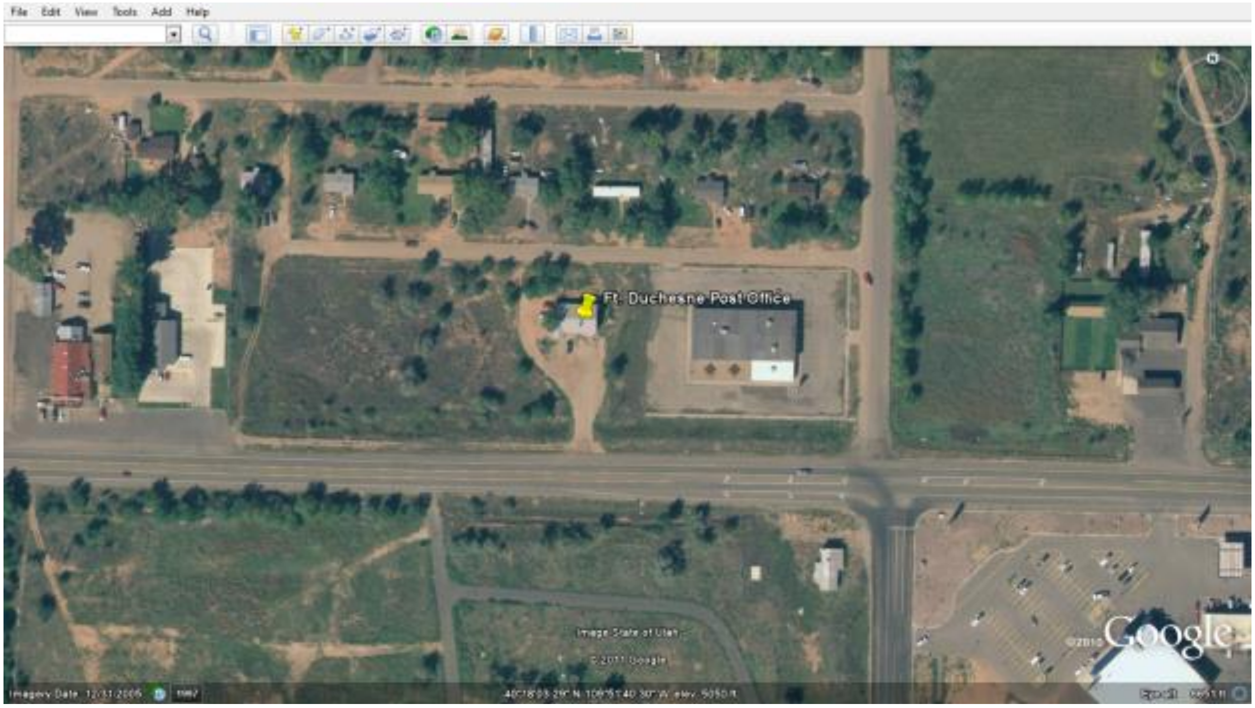


Figure 22: Fort Duchesne Post Office Street View

The terrain surrounding the post office is quite flat. A Wi-Fi device would provide coverage for the smaller residential area and the supermarket. The larger residential development and tribal offices are out of the half-mile range. There are some point-to-point Wi-Fi devices with ranges of up to 1.5 miles that might effectively reach that far; however, the signal would be impacted by the moderate tree cover that exists between the two developments.

Figure 23 and Figure 24 illustrate the possible range of Wi-Fi signal propagation around the town's post office.

Figure 23: Fort Duchesne Wi-Fi Maximum Signal Reach

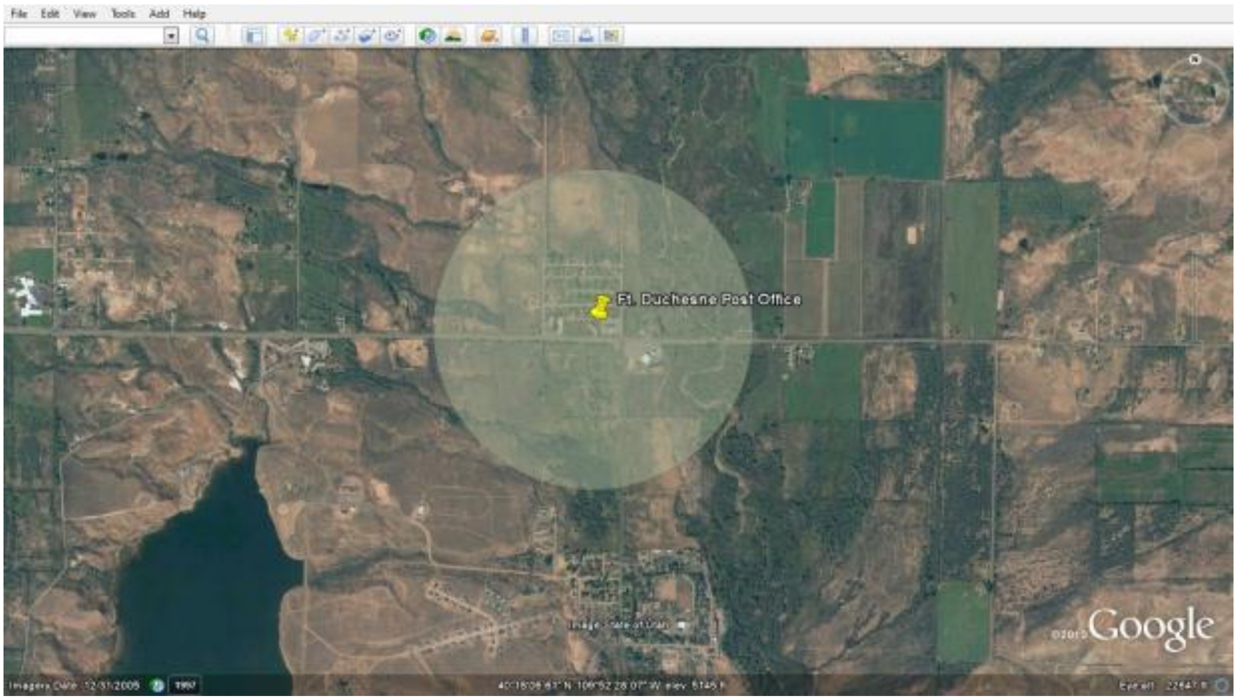
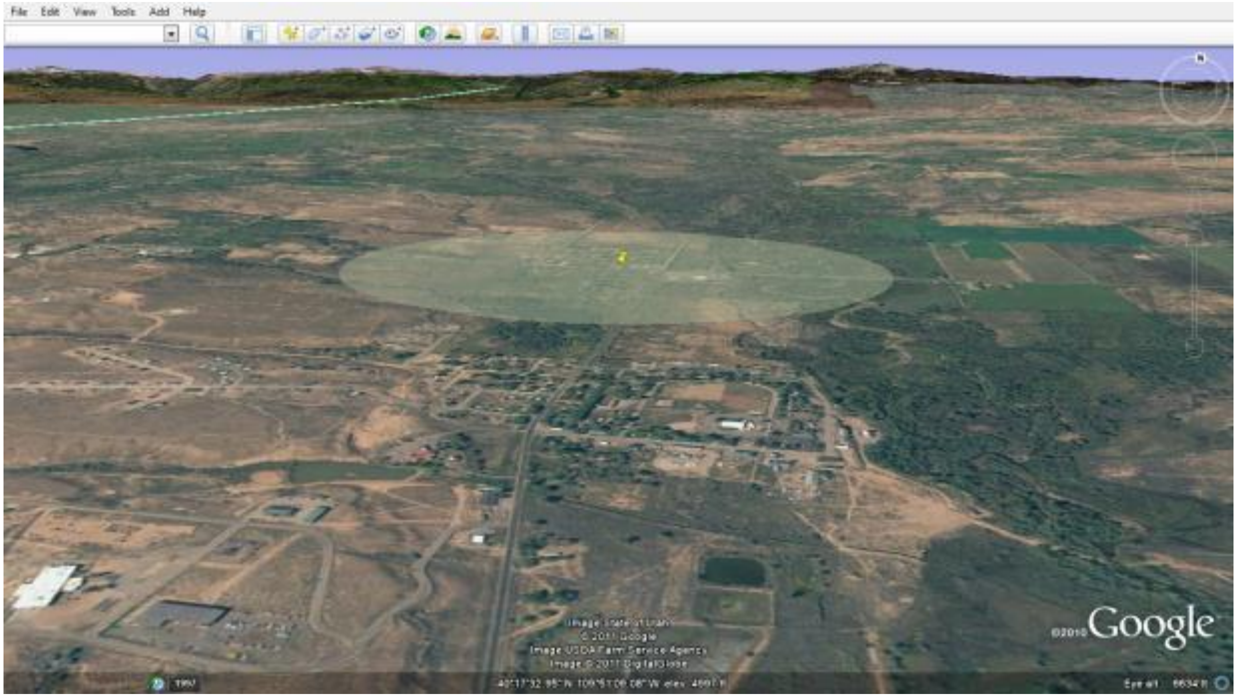


Figure 24: Fort Duchesne Wi-Fi Maximum Signal Reach with Topography



Signals from WiMAX equipment on a tower placed on or near the Fort Duchesne post office would likely be able to reach its full range thanks to the flat topography. The only limiting agent would be the height and density of the aforementioned tree cover.

Figure 25 and Figure 26 illustrate the possible range of WiMAX signal propagation, using the spectrum and design proposed above, around the town's post office. The red circle indicates the optimal range of 10 km. The pink circle indicates the maximum range of 16 km.

Figure 25: Fort Duchesne WiMAX Optimal and Maximum Signal Reach

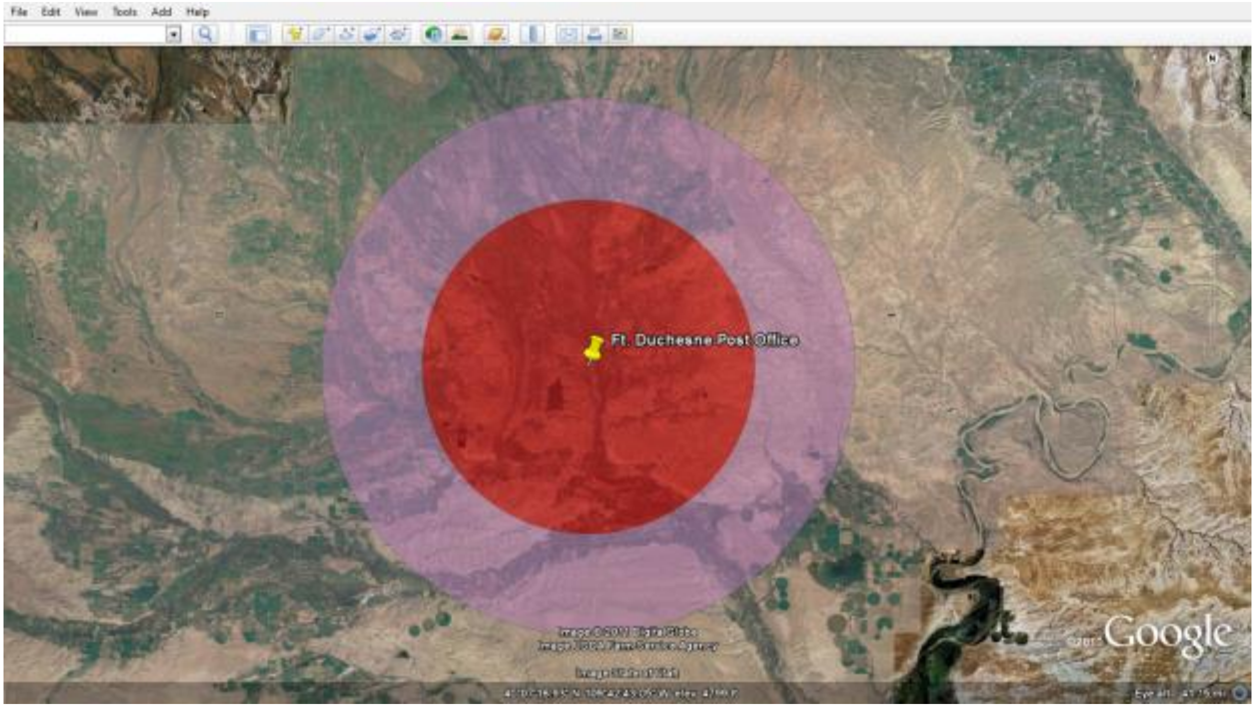
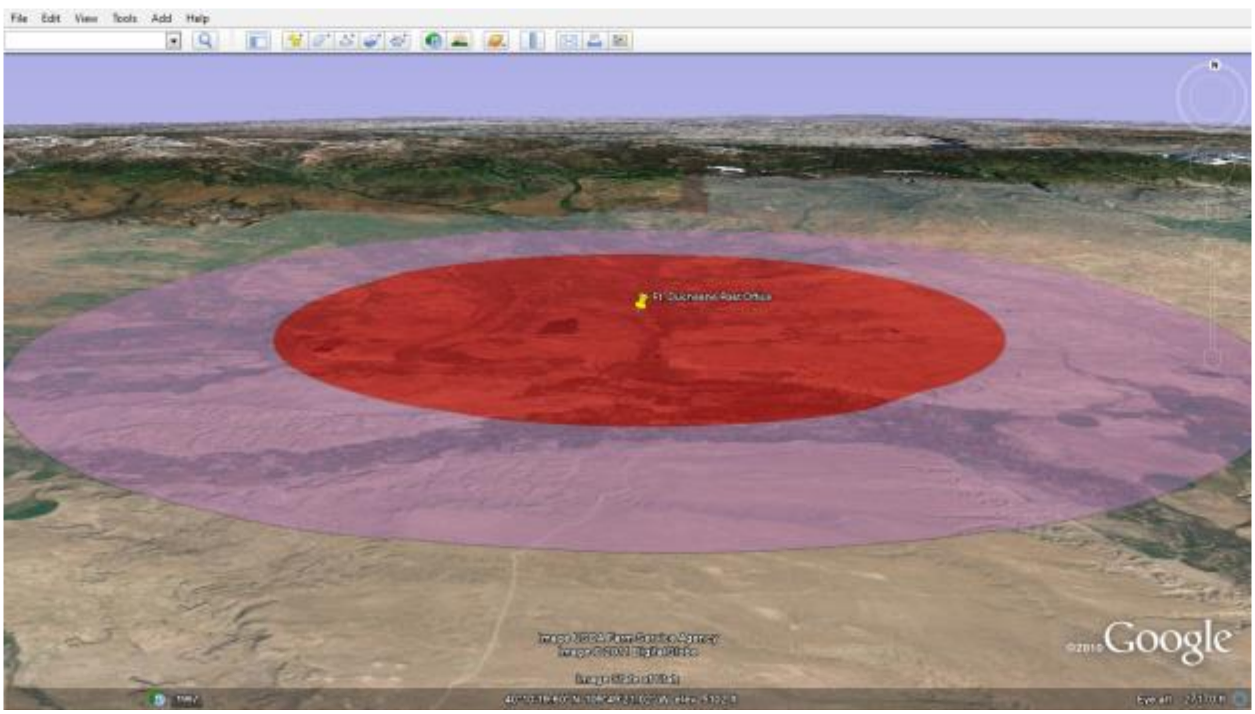


Figure 26: Fort Duchesne WiMAX Optimal and Maximum Signal Reach with Topography



5.3 St. Francis, Maine

The town of St. Francis (population 577) is located in the far north of Maine, directly on the border with Canada. Across the St. Francis and St. John rivers is the Canadian province of New Brunswick.

According to 2000 Census data, households are nearly evenly split between native English and native French speakers. The median household income was $25,125, and 7 percent of the population was below the federal poverty line. There appear to be limited commercial developments in the vicinity, with perhaps only a few very small local businesses.

The post office facility is located at 890 Main Street, St. Francis, ME 04774. It is located in the mostly densely settled (relatively speaking) section of the municipality. Again, the postal facility is located close—less than one-half mile—to several community anchor institutions, including an elementary school, town office, fire station, and church.

Figure 27: St. Francis Regional Overview

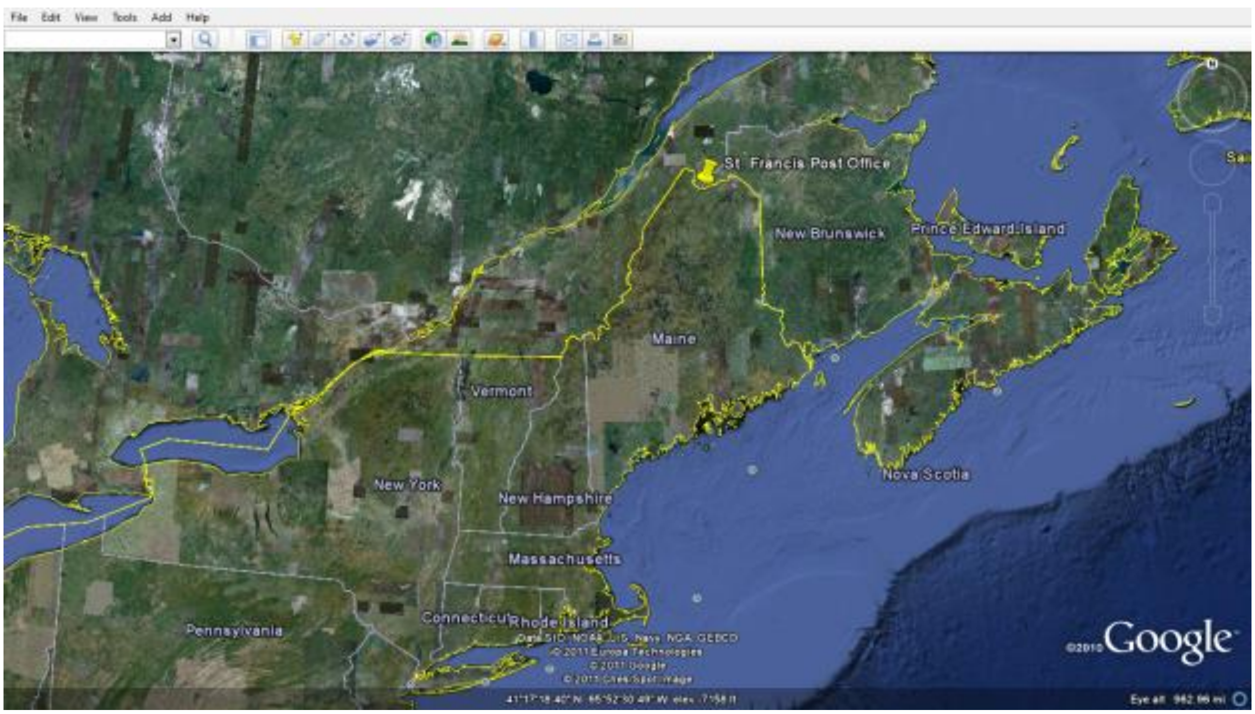


Figure 28: St. Francis Local Overview

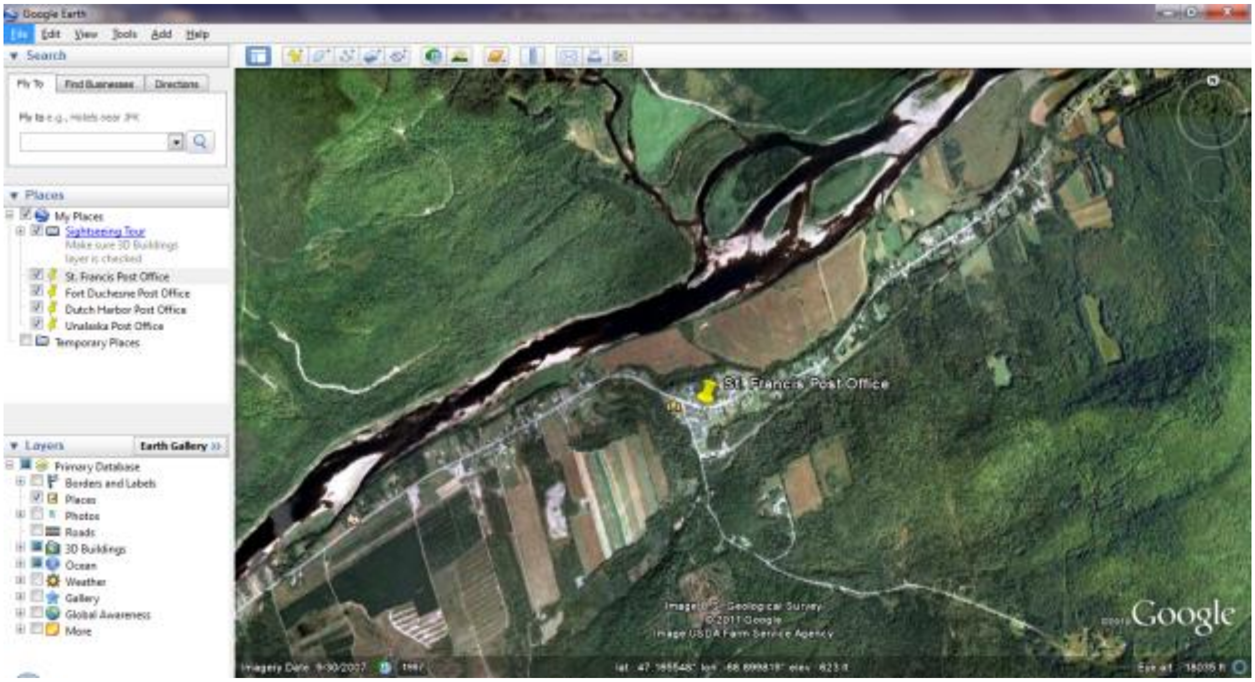


Figure 29: St. Francis Topography

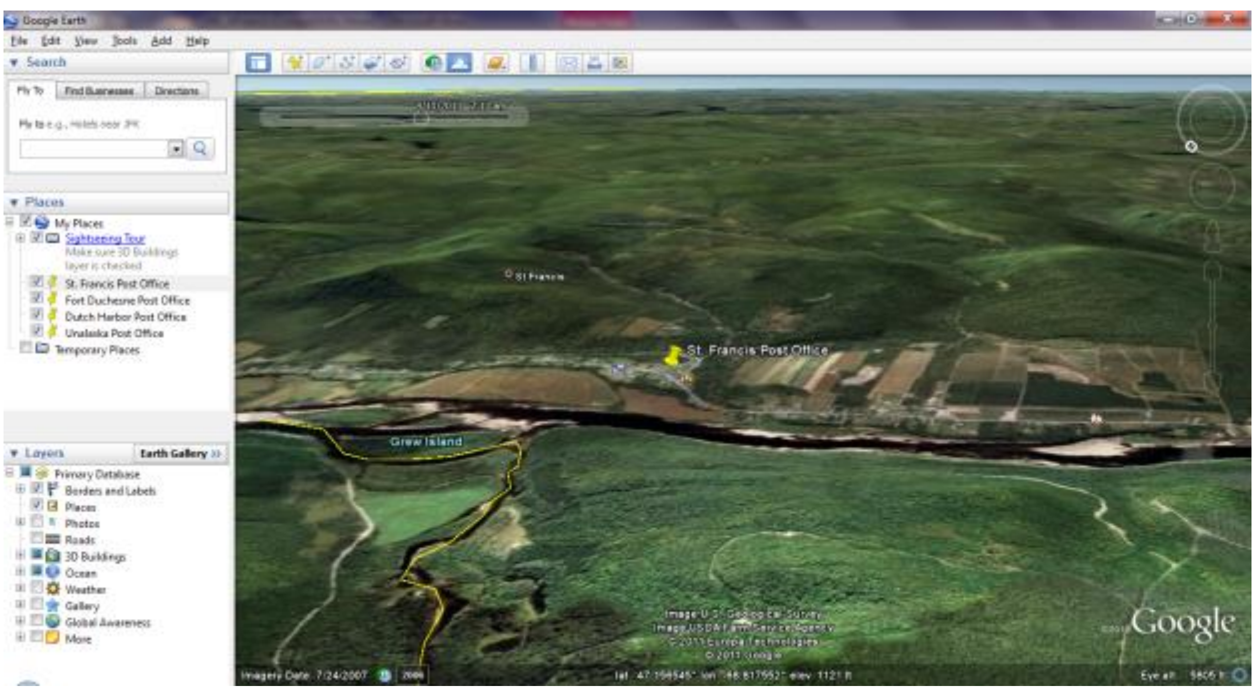


Figure 30: St. Francis Topography, Looking East Along St. John River Valley

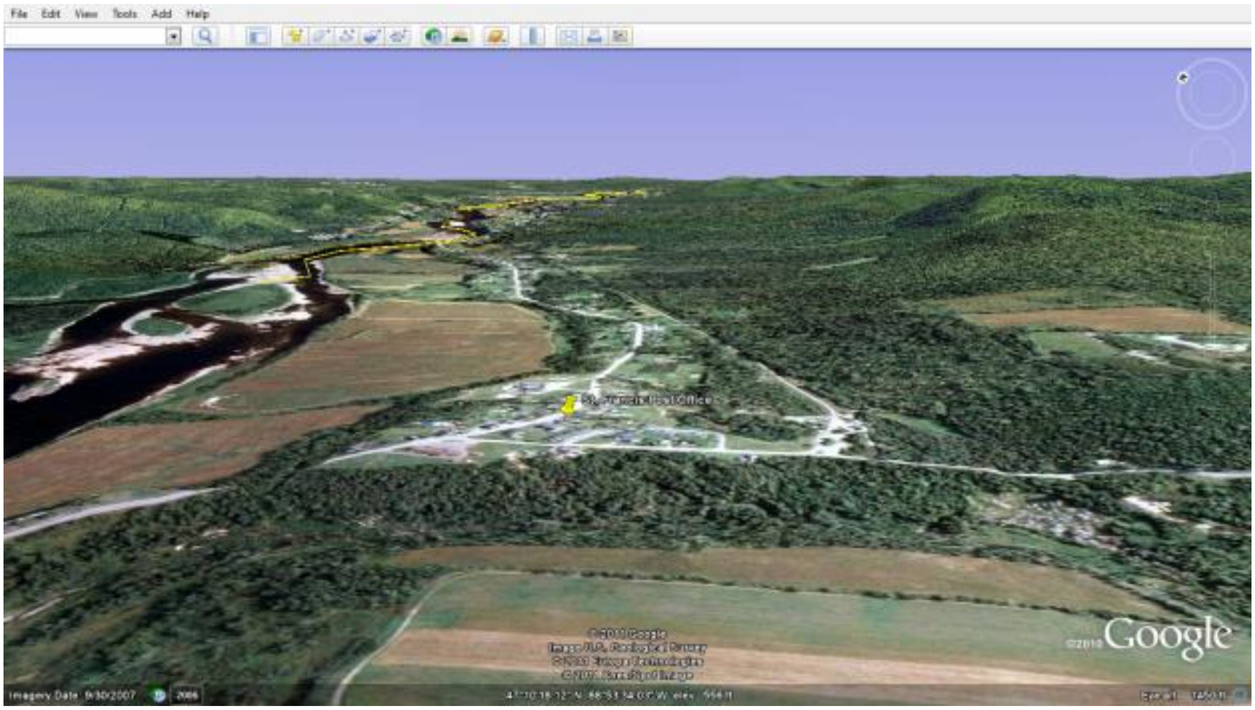


Figure 31: St. Francis Post Office Close View

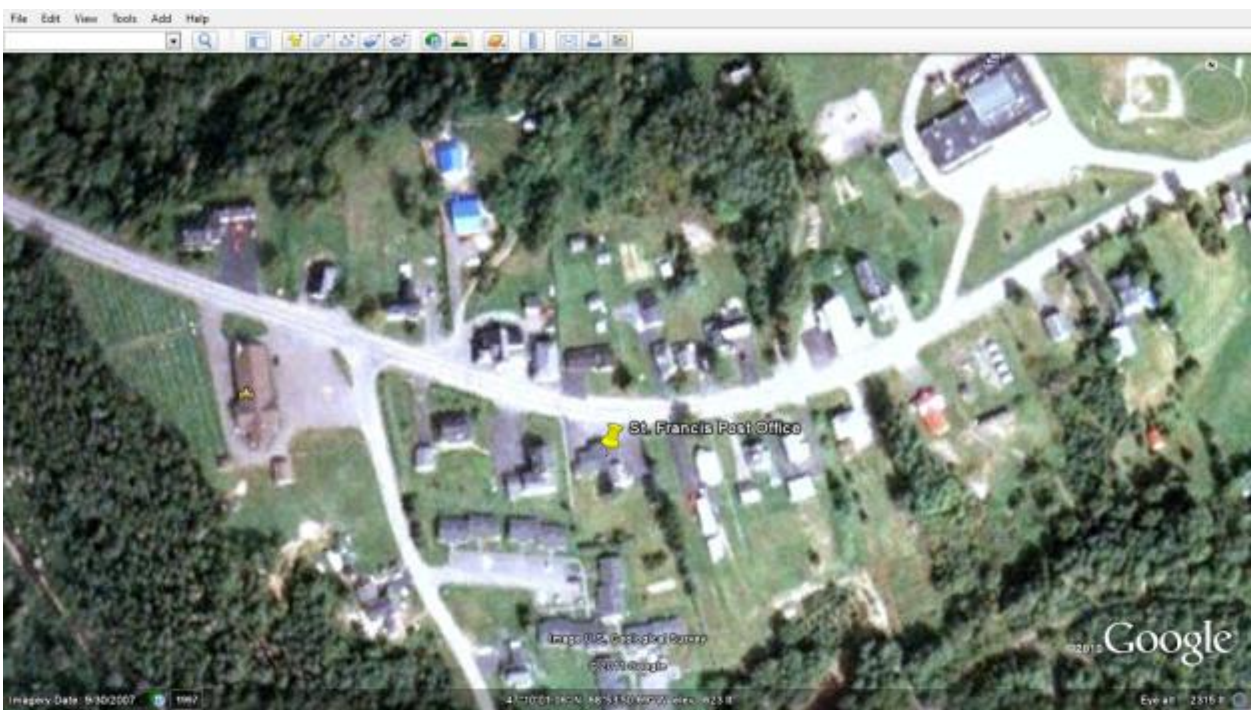


Figure 32: St. Francis Post Office Street View

The terrain around St. Francis has moderately sized hills and dense tree cover, both factors that would negatively impact the effectiveness of either Wi-Fi or WiMAX technologies. A Wi-Fi device placed on the post office would, however, still provide connectivity to the local anchor institutions because of their close proximity and sight lines along the main road. The signal would degrade quickly as the tree cover began.

Figure 33 and Figure 34 illustrate the possible range of Wi-Fi signal propagation around the town's post office.

Figure 33: St. Francis Maximum Wi-Fi Signal Reach

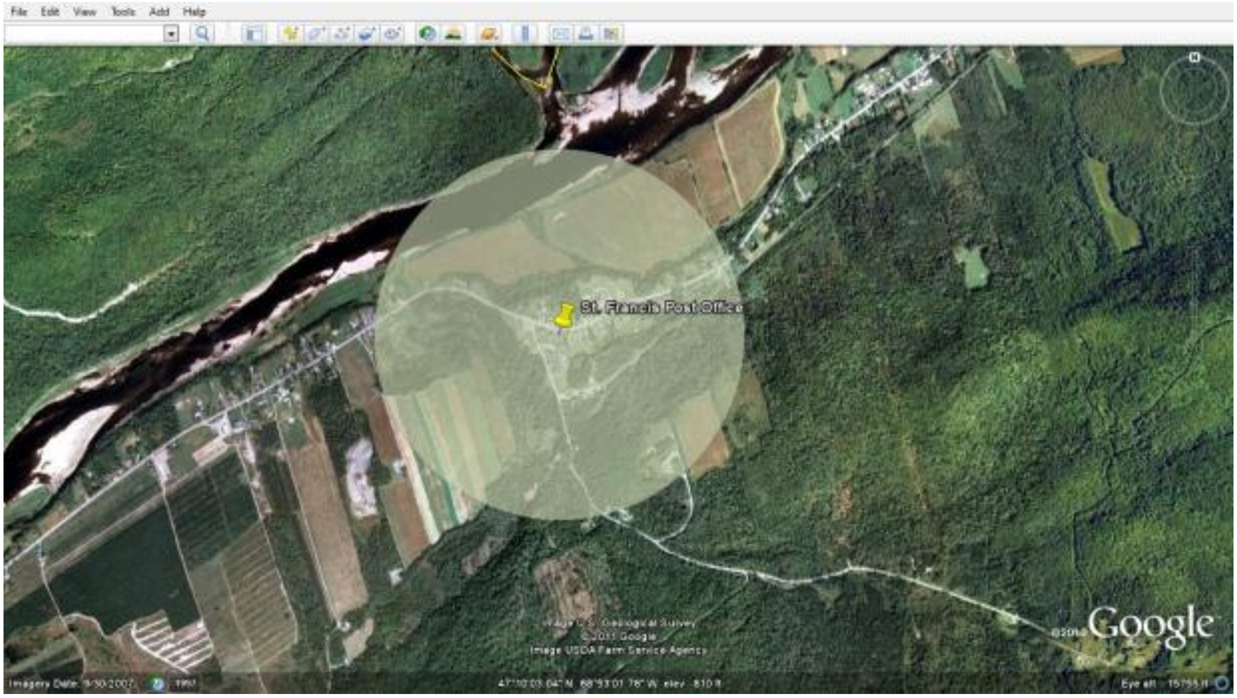
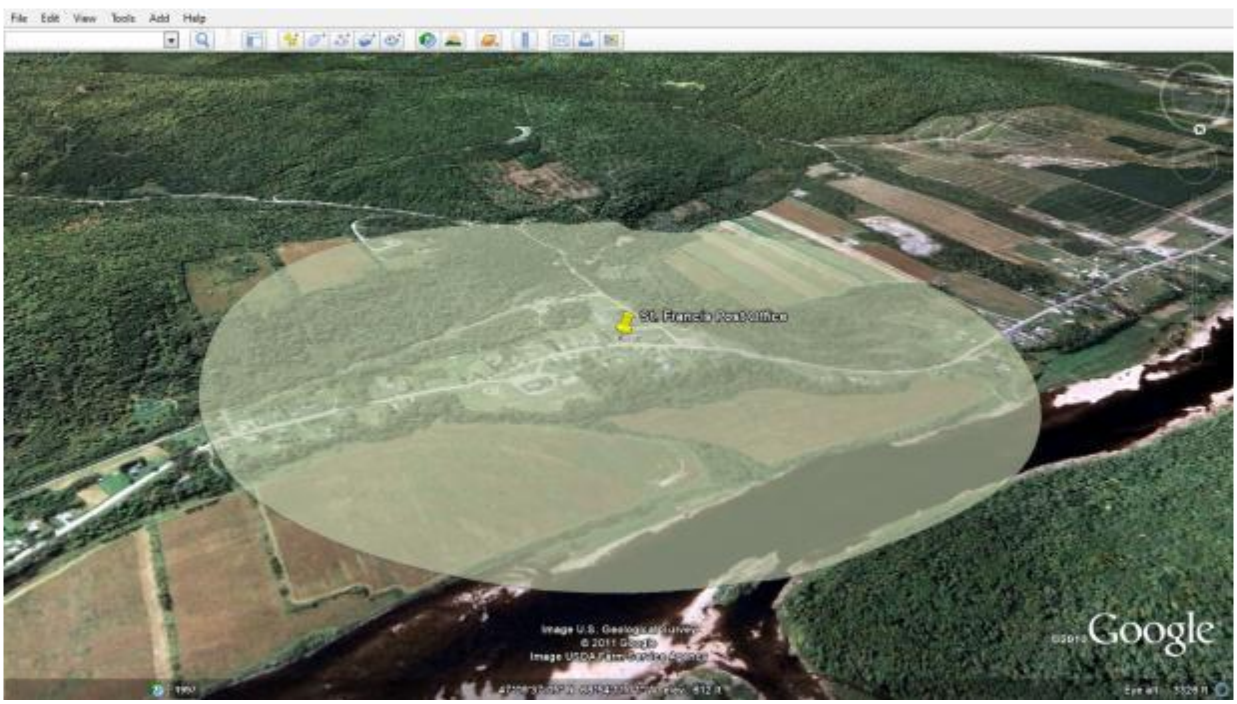


Figure 34: St. Francis Maximum Wi-Fi Signal Reach with Topography



A WiMAX tower would be impacted similarly. Connectivity to the immediate anchors and housing could be established. Signal strength would be strongest along the St. John River valley, which is where most of the area's residential development is located.

Figure 35 and Figure 36 illustrate the possible range of WiMAX signal propagation, using the spectrum and design proposed above, around the town's post office. The red circle indicates the optimal range of 10 km. The pink circle indicates the maximum range of 16 km. Approximately one-quarter of the WiMAX signal would extend into Canada.

Figure 35: St. Francis Optimal and Maximum WiMAX Signal Reach

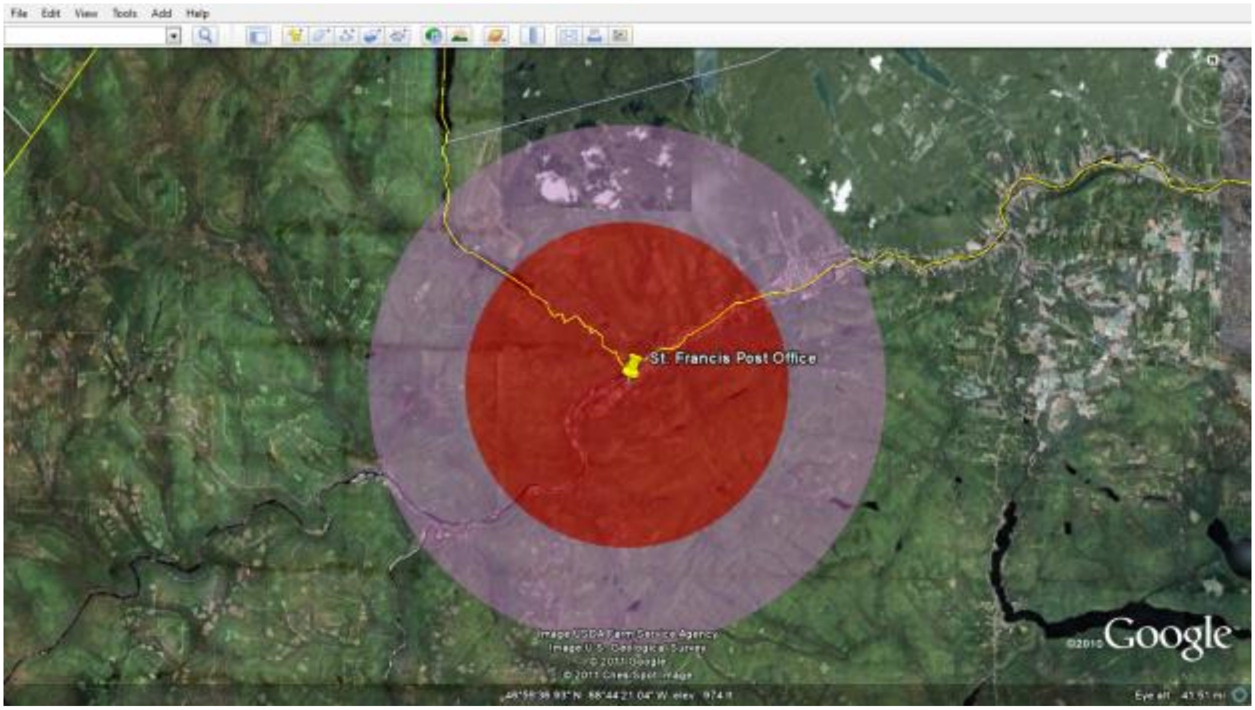
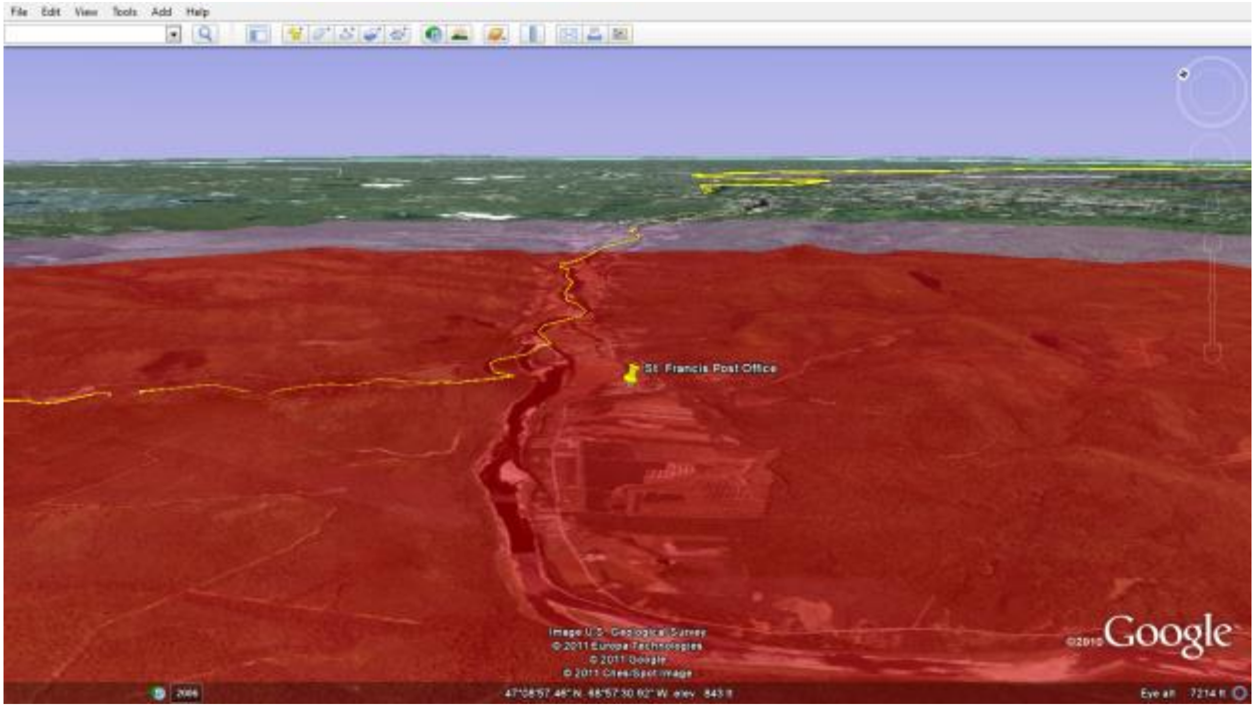


Figure 36: St. Francis Optimal and Maximum WiMAX Signal Reach with Topography



Appendix A: Benefits of Rural Broadband

Broadband provides extensive benefits to rural communities.[22] FCC Commissioner Copps recently noted that broadband is "the great enabler that restores America's economic well-being and opens doors of opportunity for all Americans to pass through, no matter who they are, where they live, or the particular circumstances of their individual lives."[23] Thus, broadband functions as an equalizer that reduces the physical distance between rural towns and urban areas. The need for rural broadband has been amplified in recent years as the digital divide between urban and rural communities has grown. Rural broadband investment is essential to avoid the economic and social isolation of these communities.

Economic Benefits

Rural broadband investment confers significant economic benefits to both the receiving area and the nation's economy. Locally, it allows small businesses to thrive. Local craftsman can advertise and sell their wares online, dramatically expanding their customer base. Thus, broadband allows rural businesses to increase their market presence by making it more cost-effective to reach larger markets. Retailers can track and manage their inventory online, preventing costly and inefficient travel to urban centers to maintain their stock. The FCC reports that high-speed Internet access attracts retail development, noting that communities with access to broadband experience disproportionate growth in employment and the number of businesses overall.[24] Broadband allows rural residents to save money by enabling price discovery and consumer information gathering, which is particularly beneficial for large purchases like real estate and automobiles.[25] Broadband also allows local tourism authorities to better promote rural communities, increasing their potential customer base.

Rural broadband also stimulates broader economic development outside the community. E-commerce allows rural residents to purchase goods online, giving rural customers access to goods that may not otherwise be available locally. In fact, "connected" residents are likely to demand additional goods and services—from Internet Protocol (IP)-enabled phones, smart meters, telehealth, distance learning, video relay services, online music, streaming movies, and interactive gaming. While these goods and services may not originate locally, this growing demand nonetheless stimulates broad economic development.

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[22] The U.S. Federal Communications Commission elaborates on the myriad benefits of rural broadband access in "Bringing Broadband to Rural America: Report on a Rural Broadband Strategy," May 22, 2009 (available online at http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-291012A1.pdf). Unless otherwise noted, the discussion in this section is based on this report.

[23] FCC Commissioner Michael Copps April 8, 2009 (available online at http://wireless.fcc.gov/outreach/index.htm?job=broadband_home).

[24] *Id.* at 8.

[25] Andrew Feinberg, BroadbandCensus.com, "Internet Use Vital to Rural Economy, USDA Report Finds," Mar. 3, 2009 (available online at http://www.benton.org/outgoingframe/22760/3).

Farmers

Farmers are particularly likely to benefit from rural broadband investment. The Internet facilitates comparison shopping, enabling farmers to purchase inputs from the best-priced source. Relatedly, farmers can also consider detailed online marketing information when making pricing and sales decisions. This enables farmers to access a larger market and allows them to sell their crops at a higher price. Farmers can also use the Internet to access real-time information about weather and insect infestation, allowing them to respond in a timely manner. By facilitating communications between farmers, for example, broadband connectivity has enabled farmers in rural Carroll County, Maryland to identify state-of-the-art techniques to allow their farms to flourish.

Broadband is already making tremendous inroads among farmers in rural communities. In 2005, 30 percent of farmers used the Internet for business purposes. By 2007, that number had more than doubled to 63 percent of farmers.[26] Additional investment in broadband can expand this growth area and allow farmers to refine their online business practices.

Education

Broadband greatly expands educational opportunities for rural residents. Children in rural schools are not limited by the resources in their community. They can take virtual fieldtrips and interface with students around the country. Students can participate remotely in advanced courses that match their personal interests, despite limited demand since distance learning does not require as many resources as a traditional classroom. Rural students can also readily access materials from distant libraries. And, as bandwidth increases, this research can include more intensive activities, like complex simulations and video streaming. Even outside the classroom setting, broadband is necessary for rural residents to use a wide array of content-rich applications. Notably, even basic features—like computer virus protection—may be out-of-reach absent high-speed Internet access.

Telemedicine

Telemedicine holds tremendous potential for rural communities. Indeed, rural residents are often subject to limited health care services. High-speed Internet access, however, enables rural residents to readily access distant information and expertise. Rural residents are no longer limited to a single service provider, but can become better-informed patients. Moreover, rural healthcare providers can work with their patients to access off-site specialists, helping patients avoid travel and potentially emergency transfers to urban hospitals.[27] This also allows rural residents to save time and money by avoiding costly trips to distant physicians and associated time away from work. This also increases local lab and pharmacy work and allows local health facilities to avoid

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[26] Andrew Feinberg**,** BroadbandCensus.com, "Internet Use Vital to Rural Economy, USDA Report Finds," Mar. 3, 2009 (available online at http://www.benton.org/outgoingframe/22760/3**).**

[27] U.S. Department of Agriculture, Peter Stenberg, Sarah Low, "Rural Broadband At A Glance," March 2009.

outsourcing specialized medical procedures. In fact, the USDA notes that one study of 24 rural hospitals placed the annual cost of not having telemedicine at $370,000 per hospital.[28]

Notably, the FCC has already authorized over $400 million to 25 states to use telemedicine networks to provide medical care to rural areas.[29] This allows rural doctors to provide timely medical care while avoiding costly—and potentially risky—transfers to urban hospitals. In Georgia, for instance, telemedicine allows doctors at academic centers to participate remotely in the examination of patients at rural hospitals, cutting transports by 60 percent to 80 percent.[30] This program enables doctors at the Medical College of Georgia's neurology department to use videoconferencing to examine, diagnose, and treat stroke patients at 10 rural hospitals.[31] Broadband also improves the quality of medical care in rural areas by providing access to in-service training without requiring costly participation in distant conferences.[32]

Environmental Benefits

Internet communications technology confers significant environmental benefits. In fact, one analysis holds that the Internet could reduce global greenhouse gas (GHG) emissions by 15 percent by 2020 (an amount at least five times larger than the sector's carbon footprint), representing about $946.5 billion in savings to the economy.[33] Another study finds that widespread adoption of broadband could support a net reduction of 1 billion tons of GHG emissions over 10 years.[34] These environmental benefits include increased opportunities for and access to telework, teleconferencing, telemedicine, and e-commerce. Each of these applications reduces vehicle travel and associated emissions. Because rural residents typically have to drive

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[28] USDA, Economic Research Service, Peter Stenberg et al., "Broadband Internet's Value for Rural America," August 2009.

[29] Robert LaRose *et. al*., "Closing the Rural Broadband Gap," Department of Telecommunication, Information Studies, and Media, Michigan State University, Nov 30, 2008 (available online at https://www.msu.edu/~larose/ruralbb/).

[30] Dr. Jay Sanders, President and CEO, the Global Telemedicine Group and Professor of Medicine (Adjunct) at Johns Hopkins School of Medicine (cited in the Broadband Factbook) (available online at http://internetinnovation.org/factbook/entry/application-of-telemedicine-to-rural-healthcare/).

[31] Jonathan Rintels, "An Action Plan for America: Using Technology and Innovation to Address Our Nation's Critical Challenges," The Benton Foundation, 2008, 16 (available online at http://www.benton.org/initiatives/broadband_benefits/action_plan).

[32] Joseph Fuhr and Stephen Pociask, "Broadband Services: Economic and Environmental Benefits," The American Consumer Institute. Oct. 31, 2007, 39 (available online at http://www.theamericanconsumer.org/2007/10/31/broadband-services-economic-and-environmental-benefits/).

[33] SMART 2020: Enabling the low carbon economy in the information age," Global e-Sustainability Initiative & BCG, June 2008. Chapter 3, Figure 8. http://www.gesi.org/files/smart2020report_lo_res.pdf.

[34] Joseph Fuhr and Stephen Pociask, "Broadband Services: Economic and Environmental Benefits," The American Consumer Institute, Oct 31, 2007. 2. *See also* Michael Render, "U.S. Fiber to the Home Market Update," Render Vanderslice and Assoc., June 2008. 35-36. (Finding that universal FTTH could lead to a 5 percent reduction in gas use, a 4 percent reduction in carbon emissions, a $5 billion reduction in road expenditures and 1.5 billion fewer hours spent commuting). These analyses consider the net environmental benefits associated with ICT, as the direct impacts associated with installation and operation can be recovered in four to six years. *See* Steven S. Ross and Masha Zager, "Fiber to the Home Is Green Technology," Broadband Properties, Jan/ Feb 2009. 28-35. http://www.bbpmag.com/2009issues/jan09/BBP_JanFeb09_CoverStory.pdf. (Modeling the projected environmental benefits of FTTP against the direct environmental costs associated with installation).

further for basic goods and services, the potential benefits are particularly great in these communities. Broadband can also reduce home energy use by enabling smart-grid technologies. Connectivity is “the backbone” of each of these solutions.[35]

These varied benefits can be conferred through development of better broadband networking in rural communities. As the FCC noted in its Report on a Rural Broadband Strategy, “[b]roadband is the interstate highway of the 21^{st} century for small towns and rural communities, the vital connection to the broader national and, increasingly, the global economy.”[36]

[35] “Report Addendum: SMART 2020: Enabling the low carbon economy in the information age.” 1.
[36] U.S. Federal Communications Commission, May 22, 2009, at 11-12.

Appendix B: Detailed Pricing for Sample Carrier-Grade Network

Network Equipment and Installation Costs			
Description	**Unit Price**	**Quantity**	**Total**
Tower	$60,000	1	$60,000
Base Station	$15,000	1	$15,000
User devices w/external antennas	$500	0	$0
Base station site installation	$8,000	1	$8,000
Detailed engineering	$15,000	1	$15,000
Site router	$3,000	1	$3,000
Enhancement to power/site prep	$25,000	1	$25,000
Software	$30,000	1	$30,000
Backhaul between base stations	$12,500	2	$25,000
Total:			**$181,000**

Notes:

- Non line-of-sight technology solution at 2.5 GHz will not necessarily require a pre-site survey.
- Assuming use of 7 MHz channels to increase the S/N ratio
- 802.16e enables use by mobile user
- Channel bandwidth can be reduced or increased based on future needs of network
- Can use local labor for construction
- Aggregate capacity per sector per base station approximately 20 Mbps symmetrical
- Motorola PMP36320 base station antennas, cables, and mounting hardware; four sectors
- Cisco 2950 site router
- WiMAX-compliant user devices are not included in this estimate
- Backhaul between base stations: 5.8 GHz Motorola PTP58600, 150 Mbps point-to-point, both ends connectorized, plus antennas
- Software: network-wide provisioning; can reuse over multiple sites

Assumptions:

- Use of WiMAX technology in 3.6 GHz spectrum band
- Core base station (BS) also to serve as network operations center and ISP meet point
- Three 45 Mbps sectors
- 5.8 GHZ point-to-point backhaul
- Tower installation of base station antennas
- Internet capacity and tower construction/lease at far end not included

Appendix C: Detailed Pricing for Sample Best-Effort Network

Network Equipment and Installation Costs			
Description	**Unit Price**	**Quantity**	**Total**
Tower	$60,000	1	$60,000
Base Station	$250	1	$250
User devices w/external antennas	$500	0	$0
Base station site installation	$8,000	1	$8,000
Detailed engineering	$15,000	1	$15,000
Site router	$3,000	1	$3,000
Enhancement to power/site prep	$25,000	1	$25,000
Software	$30,000	1	$30,000
Backhaul between base stations	$250	2	$500
Total:			**$141,750**

Notes:

- Use of line-of-sight technology solution at 5 GHz will require a pre-site survey.
- Assuming use of 5 MHz channels to increase the S/N ratio
- Channel bandwidth can be reduced or increased based on future needs of network
- Can use local labor for construction
- Aggregate capacity per sector per base station approximately 40 Mbps symmetrical
- Ubiquiti Networks Rocket M base station antennas, cables, and mounting hardware; four sectors
- Cisco 2950 site router
- 802.11-compliant user devices are not included in this estimate
- Backhaul between base stations: 5.8 GHz Ubiquiti Networks Rocket M, 300 Mbps point-to-point, both ends connectorized, plus antennas
- Software: network-wide provisioning; can reuse over multiple sites

Assumptions:

- Use of 802.11n technology in 5 GHz U-NII band
- Core base station (BS) also to serve as network operations center and ISP meet point
- Three 100 Mbps sectors
- 5.8 GHz point-to-point backhaul
- Tower installation of base station antennas
- Internet capacity and tower construction/lease at far end not included

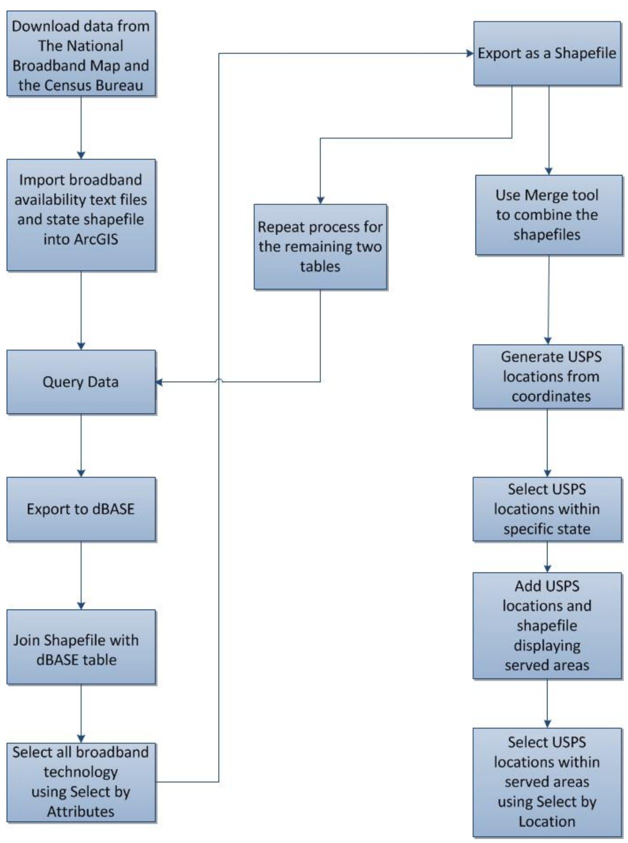
Appendix D: Mapping Methodology

To determine, for purposes of this study, how many USPS facilities lie in areas defined as unserved by broadband under NTIA and FCC definition, we adopted a sampling technique and analyzed the following representative states:

- Idaho and Wyoming: Selected as representative of largely rural, northwestern states
- Utah: Selected as representative of largely rural, southwestern states
- Maine: Selected as representative of largely rural, eastern states
- Maryland: Selected as representative of (relatively) more densely populated eastern states
- Alaska: Alaska is singular and not representative of any other states, but very significant to understand the totality of rural areas in the United States

NTIA does not provide broadband map data with spatial reference (e.g., shapefiles) already included. Data is available in a text file format (.txt) that includes a block FIPS code column that is unique for each census block in the United States, so much of the Geographic Information Systems (GIS) work required for this project involved rebuilding the geospatial reference associated with the broadband availability data. We used ESRI ArcView 9.2 and Microsoft Excel 2007 software. Figure 37 illustrates our GIS workflow.

Figure 37: GIS Workflow Diagram



Data for this project was downloaded from two sources, NTIA's National Broadband Map and the U.S. Census Bureau website. Data on broadband availability by FIPS code is available from the Broadband Map website (http://www.broadbandmap.gov/data-download). We obtained shapefiles containing the census blocks by state from the Census Bureau's website (http://www.census.gov/cgi-bin/geo/shapefiles2010/main). We selected 2000 census block data because the broadband availability data is based on 2000 census block FIPS codes. Data was compiled by state in an effort to make the file size more manageable.

An additional data set of all USPS locations in the United States was supplied by the USPS Office of Inspector General (OIG). The data was received in an Excel file with latitude and longitude coordinates listed in columns. We used the "Create Feature Class From XY Table" tool in ArcCatalog to generate points at each USPS location. In order to get only the locations in a given state, the "Select By Location" tool was used to select post offices that fall within the state boundary. After completing the selection, the post offices could then be exported as a shapefile displaying only USPS locations in a specific state.

NTIA's broadband availability data by state is broken down into three separate groups:

1. Census blocks smaller than two square miles,
2. Wireless data, and
3. Census blocks larger than two square miles.

These data sets are very large; in the case of Utah, for example, which has one of the smaller data sets, the total number of records is more than 800,000, making the data slow and difficult to use.

We imported the text files into ArcMap. Included in each table is the broadband technology that is available in each census block. For purposes of this project, we excluded "other copper wire," "satellite," and "all other" from the study. This was done using a definition query within ArcMap. After excluding these records, we exported the text file to a dBASE (.dbf) file to speed up performance. The census block shapefile for the respective state was imported to ArcMap as well. We then joined the table and the shapefile based on the FIPS code. Using the "Select By Attributes" tool, all of the broadband technology types were selected. After the join was completed and all types of broadband technology were selected, the census block shapefile was exported as a shapefile. The join was then removed and the process was repeated for the other two tables.

Using the merge tool, all three shapefiles were compiled into one final shapefile, representing the served areas. The shapefiles displaying all served census blocks and the USPS locations were loaded into ArcMap. With the "Select By Location" tool, post offices that are within served areas were selected. Displayed at the bottom of the USPS locations attribute table is the number of selected post offices (post offices in served areas) out of the total number of post offices.

This methodology was used for the states of Idaho, Wyoming, Utah, and Alaska. When applied to the remaining representative states selected for analysis (all of which have more population and, correspondingly, more census blocks), the NTIA data sets proved to be significantly larger and more difficult to work with using this set of hardware and software tools. As a result, we used a mix of methodologies for the remaining selected states.

For Maine, we used a modified version of the methodology described above. In that state, due to its distinct geographic population patterns, it was possible to isolate the large swath of less populated areas in the west and along the border with Canada. Census data demonstrated that the state's population is far more concentrated in the eastern part of the state, so we excluded that region in order to reduce the relevant portion of the NTIA data set to a workable size. We then applied the methodology described above to the less populated area of the state to arrive at a number of served and unserved locations.

In Maryland, the population patterns are not as distinct as in Maine; rural and more populated areas are more mixed together, making the task of removing the population centers from the data set more challenging and less methodologically appropriate. We have substantial in-house knowledge of broadband deployment patterns in the state, however, as a result of our long-time work there and our role analyzing the levels of broadband service for purposes of the State's application to NTIA for stimulus funds to build fiber optics (the One Maryland Broadband Network).

So although the National Broadband Map indicates that there are large areas that are unserved by broadband , we know that the small towns where the USPS facilities are located do tend to have some level of broadband. In rural western Maryland, for example, the great majority of the geography of rural Allegany and Garrett counties is unserved—but even small towns like Accident, in Garrett County, are served with very basic levels of DSL and cable modem service.

The Maryland finding was consistent with our more quantitative analysis of the rural western states and Maine—that even in rural areas, few postal facilities are located outside even the smallest population centers, and they are therefore likely to be located in small areas defined as "served." In Maine, which is the most rural of the east coast or Midwestern states, only nine of 438 post offices (2 percent) are located in unserved areas.

Having determined that even the least populated northeastern and Midwestern states (other than Maine) have no postal facilities in unserved areas under these data sets, one can reasonably assume that the same would hold true for the remaining states in those regions of the country, all of which are more populated.

Even in large rural western states, the quantitative analysis demonstrates that relatively few post offices are in unserved areas—even though these states include enormous unserved areas. Postal facilities tend to be sited in towns—and rural towns are far more likely to have some minimum form of broadband than are the less populated areas near and around them. As a result, a surprisingly high percentage of post offices are located in areas that are considered served. Thus, for example, only 4 percent of post offices in Wyoming are in unserved areas (seven out of 162); in Utah, the number is 7 percent (14 out of 198); and in Idaho, no post offices are in unserved areas—even though large unserved areas certainly exist in that state.

Accordingly, we extrapolated the low percentage of postal facilities located in unserved areas to the remaining rural western states to establish a 4 percent to 7 percent range.

We then incorporated Alaska, which is the most rural state in the country, and is the only outlier in our analysis: 64 percent of its post offices (136 of 212) are located in unserved areas.

Based on these assumptions regarding the locations of postal facilities in unserved areas (few or none in the east and Midwest, 4 percent to 7 percent in the rural west, and 64 percent in Alaska), we estimate that no more than 2 to 3 percent of all post offices nationally (about 975 to 1,600 out of roughly 32,500) lie in wholly unserved areas. The great majority of these are located in rural western states and Alaska.

Appendix E: Post Offices in Unserved Areas

The following tables list the post office facilities located in unserved areas in the representative states analyzed for this report.

ALASKA			
LATITUDE	**LONGITUDE**	**ADDRESS**	**CITY**
62.693289	-164.676681	500 ANDERSON ST	ALAKANUK
59.358906	-158.801174	123 MAIN ST	ALEKNAGIK
67.08372	-157.867269	9998 AMBLER AVE	AMBLER
63.408573	-160.104238	9998 MAIN ST	ANVIK
68.162829	-145.468263	9998 BRIDGE ST	ARCTIC VILLAGE
67.371818	-150.597789	1 FRONT ST	BETTLES FIELD
65.460642	-166.940123	9998 KUGSHI RD	BREVIG MISSION
62.77614	-164.539819	9998 KWIGUK ST	EMMONAK
55.057923	-162.3039	38 WINDY WALKWAY	KING COVE
58.110882	-135.443238	310 HILL ST	HOONAH
64.929479	-161.166332	200 BIRCH ST	KOYUK
64.726766	-162.185437	1 MAIN ST	ELIM
58.903046	-158.921713	300 C ST	MANOKOTAK
57.126203	-170.276698	2000 POLOVINA TPKE	SAINT PAUL ISLAND
61.719577	-157.220436	40 RIVER RD	RED DEVIL
64.737626	-155.490131	9998 WILDBERRY RD	RUBY
66.780556	-157.395535	9998 SHUNGNAK RD	SHUNGNAK
61.820964	-165.089606	102 JOHNSON RD	SCAMMON BAY
60.656991	-164.685041	100 AIRPORT WAY	TUNUNAK
63.383145	-170.139835	9769 SAVOONGA WAY	SAVOONGA
61.553248	-157.054012	100 POST OFFICE DR	SLEETMUTE
66.256312	-166.072881	123 MAIN ST	SHISHMAREF
55.281311	-160.707876	9998 MAIN ST	SAND POINT
64.890178	-157.683168	149 MAIN ST	KOYUKUK
70.603747	-159.263319	9998 WAINWRIGHT RD	WAINWRIGHT
57.56202	-157.563369	600 AIRPLANE LAKE RD	PILOT POINT
61.735642	-163.311517	4 BUILDING AIRPORT RD	PILOT STATION
66.550645	-152.740583	21 ALLAKAKET RD	ALLAKAKET
57.537841	-153.990057	500 3RD ST	LARSEN BAY
60.679756	-161.743415	50 MARAQ RD	NAPAKIAK
60.043776	-151.6664	15700 KINGSLEY RD	NINILCHIK
61.873857	-162.079583	200 YUKON AVE	MARSHALL
65.398214	-145.976196	128 STEESE HWY	CENTRAL

ALASKA			
LATITUDE	LONGITUDE	ADDRESS	CITY
62.654937	-159.536075	500 MAIN ST	SHAGELUK
64.786482	-141.201826	200 JEFFERSON ST	EAGLE
60.883371	-161.194759	250 OFF DOOPS ST	AKIAK
66.368504	-147.341292	400 C ST	BEAVER
55.459931	-161.224307	1 LETTY AVE	COLD BAY
58.21601	-157.356479	1 SCHOOL RD	EGEGIK
59.101634	-156.874241	100 MAIN ST	LEVELOCK
59.147813	-161.52071	9998 GOODNEWS BAY ST	GOODNEWS BAY
60.488578	-149.794854	38741 SNUG HARBOR RD	COOPER LANDING
58.70273	-156.713677	13 ALASKA HWY	KING SALMON
59.060099	-160.391884	9998 AIRPORT WAY	TOGIAK
61.509965	-160.360616	100 E ST	LOWER KALSKAG
66.342816	-159.546662	78 SELAWIK RD	SELAWIK
56.276637	-133.401135	9998 STATE FLOAT	POINT BAKER
60.963918	-149.134788	118 LINDBLAD AVE	GIRDWOOD
53.238777	-168.475331	9998 NIKOLSKI RD	NIKOLSKI
70.122547	-143.681239	2041 BARTER AVE	KAKTOVIK
57.867603	-152.879605	520 MAIN ST	PORT LIONS
60.122774	-166.517417	1 MAIN ST	MEKORYUK
55.945004	-159.209442	16 N BROOK ACCESS RD	PERRYVILLE
61.535729	-160.346942	9998 KALSKAG RD	KALSKAG
66.908246	-156.884869	9998 AIRPORT RD	KOBUK
57.796467	-134.441469	705 AANDEINATT ST	ANGOON
65.817964	-144.080054	161 STEESE HWY	CIRCLE
57.921213	-152.508275	200 2ND AND E ST	OUZINKIE
63.641831	-160.52368	100 MAIN ST	UNALAKLEET
53.871067	-166.53391	82 AIRPORT BEACH RD	UNALASKA
55.923649	-130.039261	100 HYDER AVE	HYDER
59.547921	-139.728007	477 MALLOTTS AVE	YAKUTAT
66.563301	-145.253398	9998 E 3RD AVE	FORT YUKON
66.03584	-149.27153	9774 STEVENS VILLAGE	STEVENS VILLAGE
66.749622	-159.888335	9998 FIREWEED LN	NOORVIK
67.66719	-160.435106	9998 TAYLOR AND KOZAK	KIANA
64.796953	-160.352447	123 MAIN ST	SHAKTOOLIK
65.696653	-167.114525	500 AIRPORT JUNCTION	WALES
63.429283	-148.738858	210 GEORGE PARKS HWY	CANTWELL
58.711848	-157.004192	500 7TH ST	SOUTH NAKNEK

ALASKA			
LATITUDE	LONGITUDE	ADDRESS	CITY
63.479628	-162.230025	100 MAIN ST	STEBBINS
61.101855	-147.103219	221 TATITLEK ST	VALDEZ
63.831704	-152.318409	123 AIRPORT WAY	LAKE MINCHUMINA
64.728869	-158.113087	250 NIKAGHUN ST	NULATO
56.311259	-158.505632	100 AIRPORT DR	CHIGNIK LAGOON
65.702492	-160.708914	17 BETTY AVE	BUCKLAND
68.146198	-151.72962	1104 SUMMER ST	ANAKTUVUK PASS
60.340739	-154.605362	1 LANG RD	PORT ALSWORTH
62.089363	-163.718856	9998 AIRPORT RD	MOUNTAIN VILLAGE
59.36226	-157.484368	1 POSTAL WAY	EKWOK
56.953157	-133.900613	272 KEKU RD	KAKE
65.69961	-156.392863	34 DAKLI ST	HUSLIA
62.304234	-160.507697	100 4TH ST	HOLY CROSS
65.197666	-166.268361	100 MAIN ST	TELLER
60.174411	-164.211476	500 BOARDWALK ST	CHEFORNAK
60.900316	-161.413066	500 PHILLIPS ST	AKIACHAK
63.756442	-171.690165	9998 SAINT LAWRENCE IS	GAMBELL
57.777567	-135.212119	108 E TENAKEE AVE	TENAKEE SPRINGS
61.21904	-156.762254	101 BOUNDARY AVE	ANIAK
60.880201	-162.044189	19 NAYAGAAM AND MISVIGMUIT RDS	KASIGLUK
54.141571	-165.921182	101 SALMON BERRY RD	AKUTAN
61.529711	-165.319866	1 UNIAQ AVE	HOOPER BAY
63.091373	-163.963868	500 USPS BOARDWALK	KOTLIK
58.189353	-136.308992	1 MAIN ST	ELFIN COVE
54.848174	-163.410104	170 UMIAK DR	FALSE PASS
61.868332	-158.134575	500 AIRPORT RD	CROOKED CREEK
60.047683	-154.529588	101 MAIN ST	NONDALTON
67.72261	-163.650964	1 POSTAL WAY	KIVALINA
57.960637	-136.230555	171 A SALMON WAY	PELICAN
58.729197	-157.00829	1/2 SCHOOL RD	NAKNEK
62.04634	-163.1908	101 ALSTROM ST	SAINT MARYS
63.321372	-161.862397	1 POSTAL WAY	SAINT MICHAEL
64.075528	-159.688334	1 POSTAL WAY	GRAYLING
60.545266	-145.762876	502 RAILROAD AVE	CORDOVA
67.258157	-162.822749	9998 NOATAK RD	NOATAK
59.414422	-135.931146	55 HAINES HWY	HAINES
59.780923	-155.39097	9998 ILIAMNA AIRPORT	ILIAMNA

ALASKA			
LATITUDE	LONGITUDE	ADDRESS	CITY
64.07321	-141.938419	66 TAYLOR HWY	CHICKEN
61.766924	-160.946291	500 AYAK LOOP	RUSSIAN MISSION
64.32221	-158.727809	100 6TH AVE	KALTAG
58.970398	-161.409378	1 MAIN ST	PLATINUM
59.449755	-157.320143	100 WALLACE ST	NEW STUYAHOK
59.91039	-164.067223	9998 KIPNUK WAY	KIPNUK
56.292271	-158.408889	101 MAIN ST	CHIGNIK
66.125022	-154.403379	511 GALENA RD	GALENA
59.040504	-158.472888	9998 D ST	DILLINGHAM
61.408482	-164.422734	9998 CHEVAK RD	CHEVAK
67.020255	-146.399572	100 MAIN ST	VENETIE
57.195444	-153.309306	9998 THREE SAINTS AVE	OLD HARBOR
66.045942	-154.260109	110 FRONT ST	HUGHES
59.066363	-136.389753	123 POSTMARK DR	GUSTAVUS
59.866574	-163.008325	100 MAIN ST	KWIGILLINGOK
65.257287	-151.855063	100 FRONT ST	TANANA
65.193275	-150.745991	100 LANDING RD	MANLEY HOT SPRINGS
65.792357	-163.054811	59B B ST	DEERING
64.04011	-145.734449	266 RICHARDSON HWY	DELTA JUNCTION
58.747878	-157.990663	11 MAIN ST	CLARKS POINT
68.279591	-165.997298	655 TIKIGAQ AVE	POINT HOPE
59.751711	-161.889034	9998 1ST ST	EEK
55.156564	-132.384844	1 POSTAL WAY	HYDABURG
59.731343	-161.070354	101 QANIRTUUQ RD	QUINHAGAK
53.887536	-166.545967	1745 AIRPORT BEACH RD	DUTCH HARBOR
61.588048	-152.133776	100 MAIN ST	SKWENTNA
60.809236	-161.442531	500 AIRPORT RD	KWETHLUK
61.011136	-162.061975	9998 NUNAPITCHUK RD	NUNAPITCHUK
64.679371	-163.403424	100 MAIN ST	WHITE MOUNTAIN

MAINE			
LATITUDE	LONGITUDE	ADDRESS	CITY
44.2601	-68.2267	61 MAIN ST	ISLESFORD
47.12304	-69.0185	890 MAIN ST	SAINT FRANCIS
44.60703	-68.8736	48B MAIN RD S	FRANKFORT
45.87839	-68.1067	751 MAIN ST	WYTOPITLOCK
44.65841	-70.36	6 MUNSON RD	DRYDEN
46.1827	-69.9987	62 VILLAGE RD	ROCKWOOD
45.4847	-68.3751	986 ROUTE 2	WINN
45.33949	-69.9711	2933 US RTE 201	WEST FORKS
0	0	79 POSTAL SERVICE WAY	SCARBOROUGH

UTAH			
LATITUDE	LONGITUDE	ADDRESS	CITY
37.26189	-109.306	50 CENTER ST	MONTEZUMA CREEK
37.2817	-109.567	55 N 500 E	BLUFF
37.56253	-111.994	25 STATE HIGHWAY 12	HENRIEVILLE
37.62343	-112.082	31 N STATE HIGHWAY 12	TROPIC
37.77038	-111.605	230 W MAIN ST	ESCALANTE
38.17174	-112.276	143 W MAIN ST	CIRCLEVILLE
39.12327	-113.494	2 S HIGHWAY 21	GARRISON
39.92587	-112.127	482 E MAIN ST	EUREKA
40.31052	-109.849	7299 E HIGHWAY 40	FORT DUCHESNE
40.33673	-110.334	11978 W 4000 N	BLUEBELL
40.36795	-110.724	38060 W STATE HWY 35	TABIONA
40.40469	-110.458	15537 W 4000 N	ALTAMONT
40.51904	-109.909	11444 N WHTRCKS HWY	WHITEROCKS
40.93129	-109.388	690 SOUTH BLVD	DUTCH JOHN

WYOMING			
LATITUDE	LONGITUDE	ADDRESS	CITY
41.10138	-107.245	1132 STATE HWY 70	SAVERY
42.75991	-105.384	129 N 3RD ST	DOUGLAS
42.96923	-111.044	5740 COUNTY RD 125	FREEDOM
43.15967	-110.364	13884 HIGHWAY 191	BONDURANT
43.29906	-104.596	1805 HIGHWAY 270	LANCE CREEK
44.64629	-104.84	56 STATE HWY 110	DEVILS TOWER
44.09925	-104.627	622 PINE ST	UPTON