ASR ANALYTICS

National Telecommunications and Information Administration

Broadband Technology Opportunities Program Evaluation Study

Order Number D10PD18645

Case Study Report

Executive Office of the State of West Virginia

Comprehensive Community Infrastructure

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Executive Summary

About BTOP

The American Recovery and Reinvestment Act of 2009 (Recovery Act) appropriated $4.4 billion in federal funding to the National Telecommunications and Information Administration (NTIA) to implement the Broadband Technology Opportunities Program (BTOP) in order to spur job creation, stimulate economic growth, and increase access to broadband services.[1] BTOP projects are intended to support increased broadband access and adoption, provide broadband training and support through community organizations, and stimulate the demand for broadband. NTIA distributed grant funding to 233 projects, benefiting all 50 states, 5 territories, and the District of Columbia. The types of projects BTOP funded include Public Computer Centers (PCC), Sustainable Broadband Adoption (SBA), and

> Comprehensive Community Infrastructure projects deploy new or improved broadband Internet facilities to connect households, businesses, and community anchor institutions such as schools, libraries, hospitals, and public safety facilities.

Comprehensive Community Infrastructure (CCI). CCI projects deploy new or improved broadband Internet facilities to connect households, businesses, and community anchor institutions (CAI) such as schools, libraries, hospitals, and public safety facilities.[2] CCI projects funded by BTOP are predominantly middle mile projects, although a small number of last mile projects were awarded.[3]

About the Evaluation Study

This case study report is one of twelve case studies performed by ASR Analytics, LLC (ASR) on CCI projects. It is part of a larger mixed-methods evaluation of the social and economic impacts of the BTOP program.

The purpose of this case study is to:[4]

- Identify how the grantee maximized the impact of the BTOP investment.
- Identify successful techniques, tools, materials, and strategies used to implement the project.
- Identify any best practices, and gather evidence from third parties, such as consumers and anchor institutions, as to the impact of the project in the community.

> The information presented in this report intends to capture the social and economic impacts of the grant, and is not an evaluation of the Executive Office of the State of West Virginia, its partners, or its subgrantees.

This case study is primarily qualitative. Social and economic impacts are categorized by the five focus areas described in *Interim Report 1*, with the addition of the Government Services focus area.[5] Section 2 includes the presentation of these impacts by focus area.

The evaluation study team collected information to evaluate the social and economic impacts of the Executive Office of the State of West Virginia project during field visits. From November 18 to November 21, 2013, the evaluation study team met with representatives of Executive Office of the State of West Virginia, the West Virginia Office of Technology (WVOT), Frontier Communications, and CAIs connected by the project. In total, the evaluation study team performed fifteen site visit interviews and focus groups. ASR transcribed these discussions and used this information, along with other information and reports provided by the grantee, to supplement Quarterly Performance

Progress Reports (PPR), Annual Performance Progress Reports (APR), and other publicly available information. The information presented here is intended to capture the social and economic impacts of the grant, and is not an evaluation of the Executive Office of the State of West Virginia, its partners, or its subgrantees.

About the Grantee

The Executive Office of the State of West Virginia is composed of the Governor, the Governor's Senior Staff, and the Governor's Cabinet. On February 1, 2010, NTIA awarded the Executive Office of the State of West Virginia a BTOP CCI grant for $126,323,296 to implement the West Virginia Statewide Broadband Infrastructure Project. Matching funds totaled $33,500,000. Altogether, the project proposed to invest a total of $159,823,296 in West Virginia. Representatives of various state agencies including the Executive Office, WVOT, and the Division of Homeland Security and Emergency Management made up the grant implementation team. The project ended on September 23, 2013 after spending $124,063,560, 78 percent of the total budget.[6]

> The West Virginia Statewide Broadband Infrastructure Project ended on September 23, 2013 after spending $124,063,560 on infrastructure throughout West Virginia.

Project Proposal and Status

The project planned to expand the state's microwave public safety network and existing broadband infrastructure by adding 900 miles of fiber.[7] The project intended to directly connect over 1,000 CAIs, including public safety agencies, public libraries, schools, government offices, and other agencies, with broadband speeds up to 45 Mbps.[8] The Executive Office proposed the following, with results shown:

- As of September 23, 2013, the project added 675.2 miles of new fiber to the network.[9] Actual miles constructed were fewer than planned due to an overlap in service area with Hardy Telecommunications, another BTOP grant recipient. Hardy assumed some of the planned construction in the eastern part of the state.[10]

- Expand the state's existing microwave public safety network.[11] As of September 23, 2013, the project constructed twelve new microwave towers and rebuilt five existing towers.[12] Eighty-four existing towers, including those that were rebuilt, were fitted with equipment to support Internet protocol (IP) based communications. The new fiber that was installed through the grant serves selected towers.

> The Executive Office of the State of West Virginia accomplished the following from its proposed goals:
> - Deployed 675 miles of new fiber
> - Provided fiber connections, routers, or both to 1,097 CAIs
> - Constructed twelve new microwave towers and upgraded five existing towers
> - Enhanced broadband capabilities for every 911 center in the state

- Upgrade Internet access at 985 sites, including 471 schools, 176 public libraries, 53 public safety answering points, 184 telemedicine sites, 34 jails, 11 planning and development councils, 55 county courthouses, and the Green Bank National Radio Astronomy Observatory.[13] As of September 23, 2013, the project improved broadband service at 1,097 CAIs by providing fiber connections and routers. [14] Of these, 632 CAIs were directly connected to the statewide network.[15]

- Enhance broadband capabilities for public safety agencies throughout West Virginia. Through the grant-funded project, every 911 center in the state now has some form of broadband service

available to them, although not all are connected.[16] Among the remaining unconnected 911 centers, cost was the most common reason for not obtaining broadband service.[17]

As shown in Table 1, nearly half of the CAIs served as of September 23, 2013 are educational institutions (52 percent), followed by libraries as the second most frequent CAI type (15 percent). The grant connected nearly every library in the State of West Virginia.[18]

Table 1. Community Anchor Institutions Located in West Virginia

Type	Served by Grantee		West Virginia
	#	%	#
School (K-12)	511	47%	764
Library	170	15%	172
Medical/Healthcare	96	9%	1,824
Public Safety	160	15%	788
University, College, or Other Postsecondary	54	5%	109
Other Community Support	106	10%	106
All	**1,097**		**3,763**

There is a significant opportunity for more end users to connect to the grant-funded network. While West Virginia's mountainous terrain makes infrastructure projects expensive, the cost of expanding middle mile infrastructure has been incurred by the BTOP-funded project. Last mile providers are now in a position to better serve end users in previously underserved, predominantly rural communities.

Major Outcomes and Impacts

Through interviews and data collection from a number of sources, the evaluation study team observed qualitative and quantitative outcomes and impacts of the project. The list below highlights these outcomes and impacts, with additional detail provided in Section 2.

- Most K-12 schools were broadband subscribers prior to the grant, albeit at slower speeds than they receive since connecting to the grant-funded network. The grant improved broadband speeds at 511 schools by providing fiber connections and/or routers.[19] The upgraded connections have enabled teachers to incorporate more multimedia into instruction, including educational videos and interactive software. The connections also support the use of mobile devices such as tablets and laptops in the classroom. The ability to use more technology for instruction has led to greater student engagement.[20]

- Participation in the BTOP project enabled the West Virginia Network for Educational Telecomputing (WVNET), the broadband provider for the state's higher education institutions, to increase network reliability and lower customers' cost for service by more than 50 percent.[21] In addition, the grant enabled WVNET to become the state's access point to Internet2, which was not accessible by West Virginia's higher education institutions prior to BTOP.[22]

> Through BTOP, the project achieved the following community impacts:
>
> - Faster broadband service for K-12 schools
> - Decreased costs and improved services for higher education institutions
> - More robust public safety communications system
> - More efficient healthcare practices and improved patient-provider communications

- The National Research Astronomy Observatory (NRAO) in Green Bank, WV has been able to expand research activities and cut costs by approximately $250,000 per year due to the direct fiber connection to West Virginia University (WVU) put in place by the grant.[23] Before the grant, broadband speeds between NRAO and WVU were so limited that large datasets collected by NRAO's telescopes had to be copied to disk drives and transported 120 miles by car from Green Bank to WVU on a near-weekly basis.[24] The fiber connection between the institutions provided by the grant has adequate capacity to facilitate the transport of data sets, eliminating travel costs and reducing delays in data collection.

- The 911 centers connected through the grant now have direct connectivity to the state Emergency Operations Center (EOC) and to other public safety agencies in the state through the expanded public safety radio network. Interconnectivity enables independent public safety entities to communicate more easily. Connecting to the statewide public safety radio network also improves network reliability because communications can be rerouted remotely if a center loses power or connectivity. Before the grant, 911 centers relied on their own T1 or telephone lines and rerouting traffic required physically switching T1 and telephone lines on-site.

- Interconnectivity provided through the grant enabled the Department of Military and Public Safety (DMAPS) facilities to consolidate inmate records into a single system, which will result in improved communications and data sharing.[25] Prior to BTOP, DMAPS divisions, including Juvenile Services, Corrections, and the Regional Jail and Correctional Facilities Authority, used separate systems to track intake and other inmate data. Limited bandwidth made it difficult for them to consider integrating their recordkeeping systems. After connecting through the grant, DMAPS facilities had adequate bandwidth to support the consolidation of data and implementation of a unified recordkeeping system.[26]

- New River Health, a healthcare system visited by the evaluation study team, leveraged enhanced connectivity to improve internal efficiency and patient experiences by implementing a centralized patient-provider communications center. The communications center was too expensive for New River Health prior to the grant because network upgrades were necessary to implement the system. Increased bandwidth and routing equipment obtained through the grant reduced the cost of installation by more than 50 percent, making it possible to implement centralized communications. Before the grant, every site had its own telephone system operated by the staff at each site. Patients had difficulty reaching office staff to schedule appointments or obtain health information. The new IP-based telephone system routes calls for all sites to the central communications center. The call center has improved the ability of patients to reach an appointment scheduler or triage nurse and has resulted in more scheduled appointments and more patients seen.[27]

Conclusions

Without the BTOP grant, many of the 1,097 CAIs would have slower and more expensive broadband connections. West Virginia's mountainous terrain made it too expensive for private sector telecommunications providers to build or to expand fiber infrastructure to many parts of the state. CAIs in rural communities, including schools and libraries, would not have fiber-based services available to them. Existing broadband subscribers would likely face higher monthly charges for connectivity. Communications between public safety entities would be disjointed and many 911 centers would continue to rely on T1 or telephone service as their primary means of connectivity. Many CAIs would lack the equipment necessary to support increased network capacity.

> Community anchor institutions interviewed by the evaluation study team reported that the average price of broadband per megabit per month dropped by an average of 86 percent while average speeds increased more than 2,200 percent.

Frontier Communications, the middle and last mile provider and network operator, deployed multiple interconnection points to give other last mile providers opportunities to access the middle

mile network. The Executive Office and Frontier have received interconnection requests from seven last mile providers; however, no last mile agreements were signed as of September 23, 2013, the date of the project's completion.[28]

Price and capacity data from CAIs interviewed by the evaluation study team provided evidence that on average, connecting to the grant-funded network resulted in connection speeds up to twenty-two times faster and reduced monthly costs by as much as 86 percent.[29]

Section 1. Introduction

The goal of the West Virginia Statewide Broadband Infrastructure Project was to expand the state's existing microwave public safety network and deploy approximately 900 miles of fiber.[30] The expanded statewide network directly connects more than 1,000 CAIs and provides last mile interconnectivity opportunities in each of the state's 55 counties.[31] Figure 1 shows the infrastructure deployed by the project, which includes new and upgraded microwave towers, depicted by the triangular icons, and new fiber, shown in gray.[32]

Figure 1. West Virginia Project Service Area Map
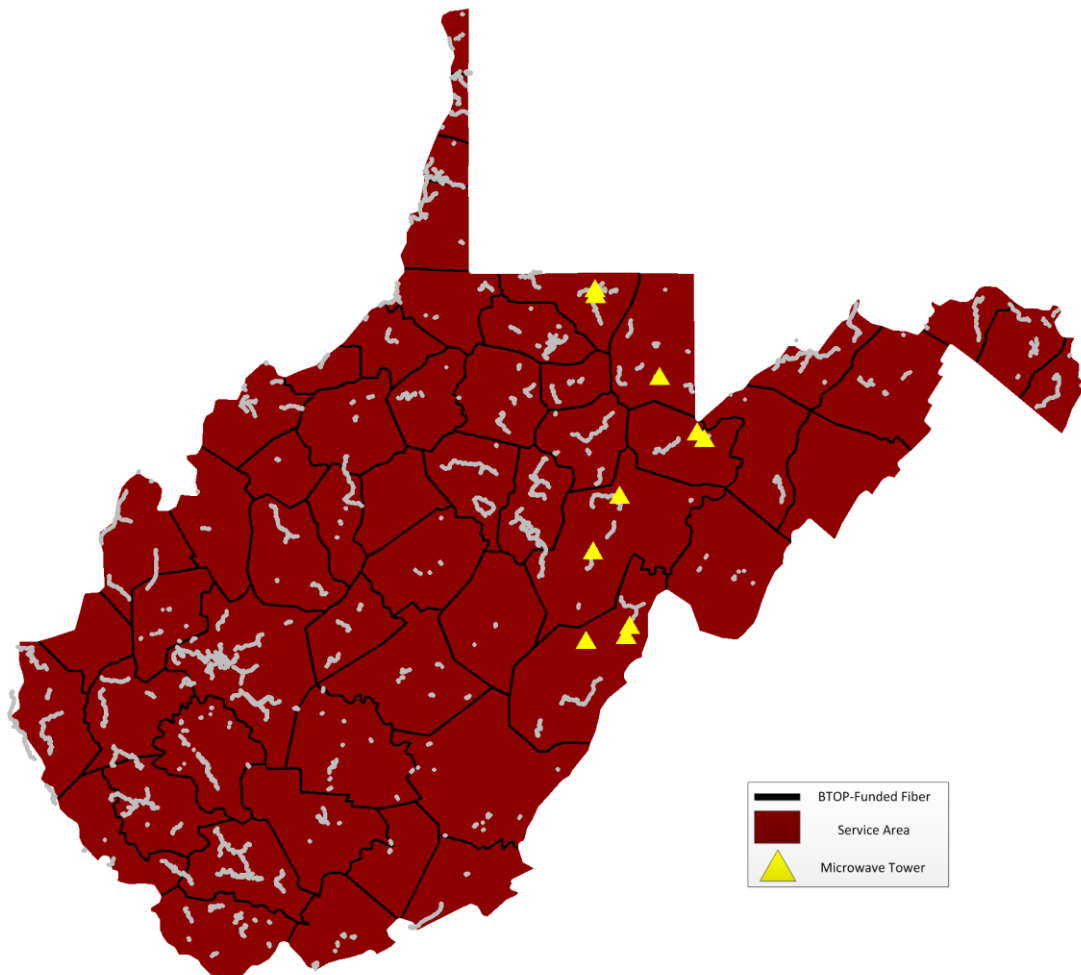
Using publicly available data, the evaluation study team identified 3,763 CAIs in the service area, including 1,824 medical/healthcare facilities, 764 K-12 schools, 788 public safety institutions, 109 postsecondary institutions, and 172 libraries.[33]

The State of West Virginia has a population of nearly 1.9 million people and is predominantly rural.[34] The American Community Survey (ACS) Five Year Summary for 2007 to 2011 shows that more than 94 percent of the service area residents are White and more than 60 percent of service area residents have a household income of less than $60,000 per year. Service area residents

have a high level of poverty, with nearly 17 percent of the population living in poverty in the last 12 months.[35]

Table 2 shows the percentages of the populations in the service area by the number of broadband providers available according to data and speed thresholds defined by the National Broadband Map (NBM).[36] More than one-half of the service area population (55 percent) does not have access to any broadband providers. A combined 45 percent of the service area population has access to two or one broadband providers. All provider statistics use the June 2011 release of the NBM and 2010 population data from GeoLytics.

Table 2. Number of Broadband Providers Available in West Virginia

Number of Providers	Service Area
0	54.78%
1	42.06%
2	3.14%
3	0.02%

Figure 2 shows the percentages of the service area population with respect to the fastest download and upload speed range available to them.[37] According to the NBM, there are twelve broadband providers across the State of West Virginia. Just two of the service area providers deliver service in the fastest download speed ranges of at least 100 Mbps. Maximum available download speeds range from 3 Mbps to 1 Gbps, while maximum upload speeds range from 768 kbps to 1 Gbps.

Figure 2. Maximum Speed Ranges Available for the Service Area Population
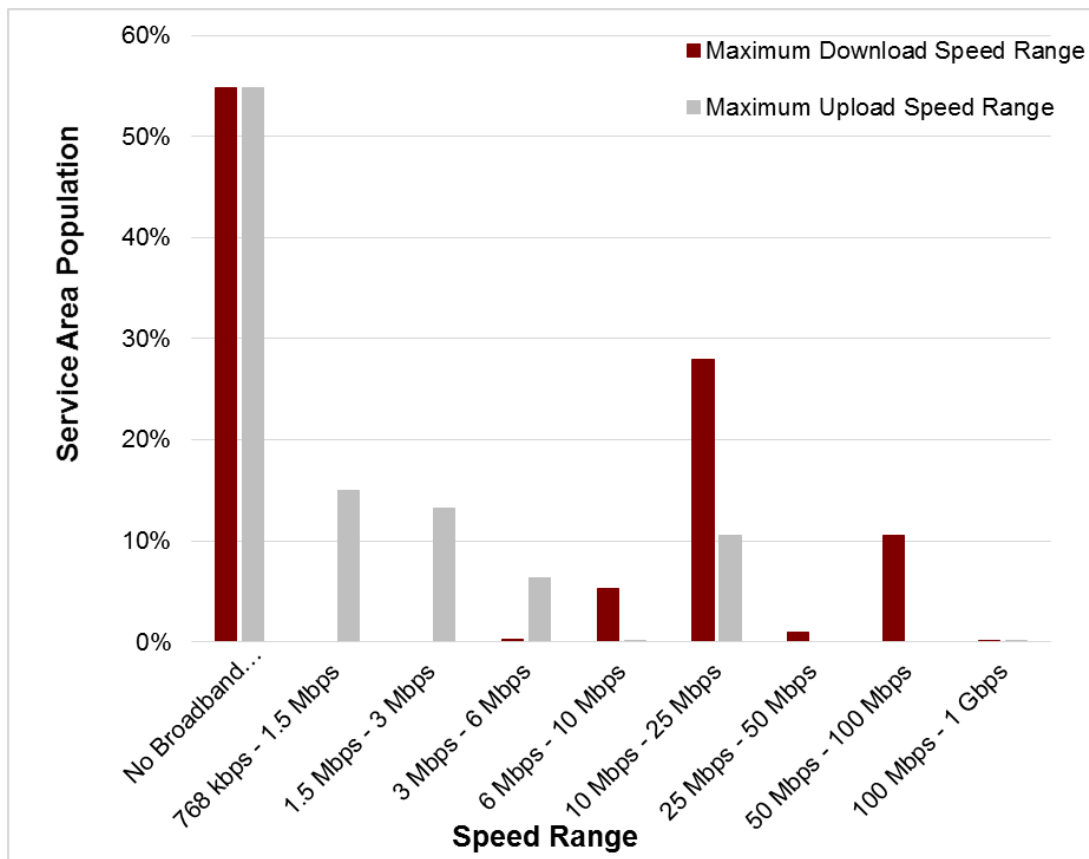
Federal Communications Commission (FCC) data from June 2012 show that more than 56 percent of the service area households subscribe to an Internet service that had at least 768 kbps download speeds and 200 kbps upload speeds.[38]

Figure 3 presents a summary of CAI subscriptions at different speed tiers since West Virginia first reported serving CAIs in the third quarter of 2013.[39] While the grant served 1,097 CAIs, Figure 3 reports connection speeds for only 1,092 CAIs.[40] The grant implementation team reports these figures as estimates in the PPRs, and states that it will report actual values as the grant nears its close. Most subscribers have service in the 10 to 50 Mbps range. The next largest group of CAIs has service over 50 Mbps.

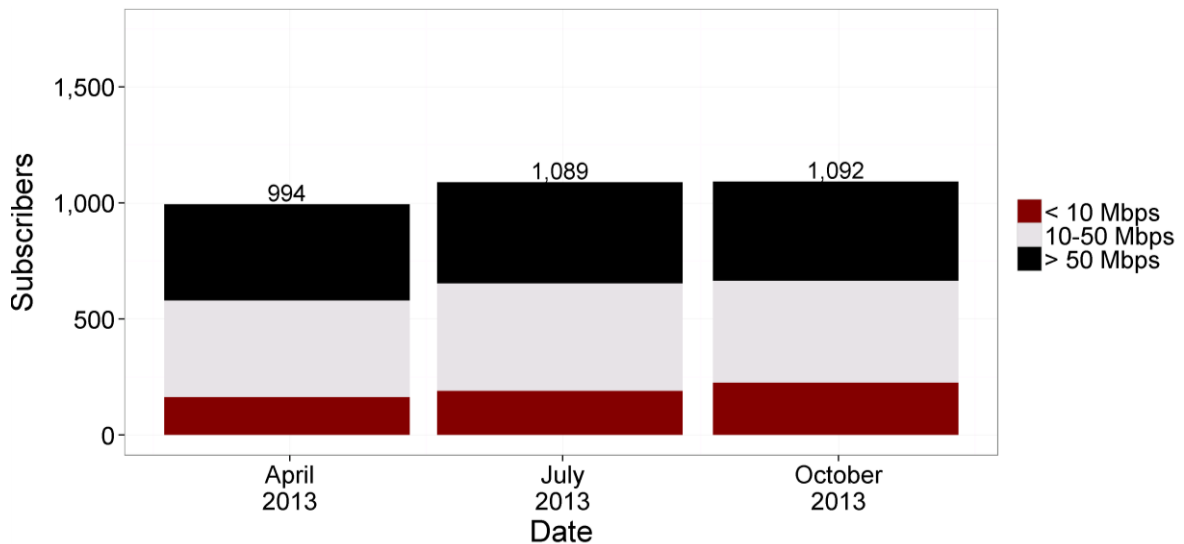## Figure 3. CAI Subscribers by Connection Speed

Figure 4 displays maps of the project's service area and the locations of the CAIs served as of the project's completion on September 23, 2013.[41] The grant funded fiber-optic connections and equipment to serve the 1,097 CAIs across the state. The grant focused on strategic routing of the middle mile infrastructure to reach as many of the CAIs as possible.

Figure 4. Map of CAIs in the Service Area
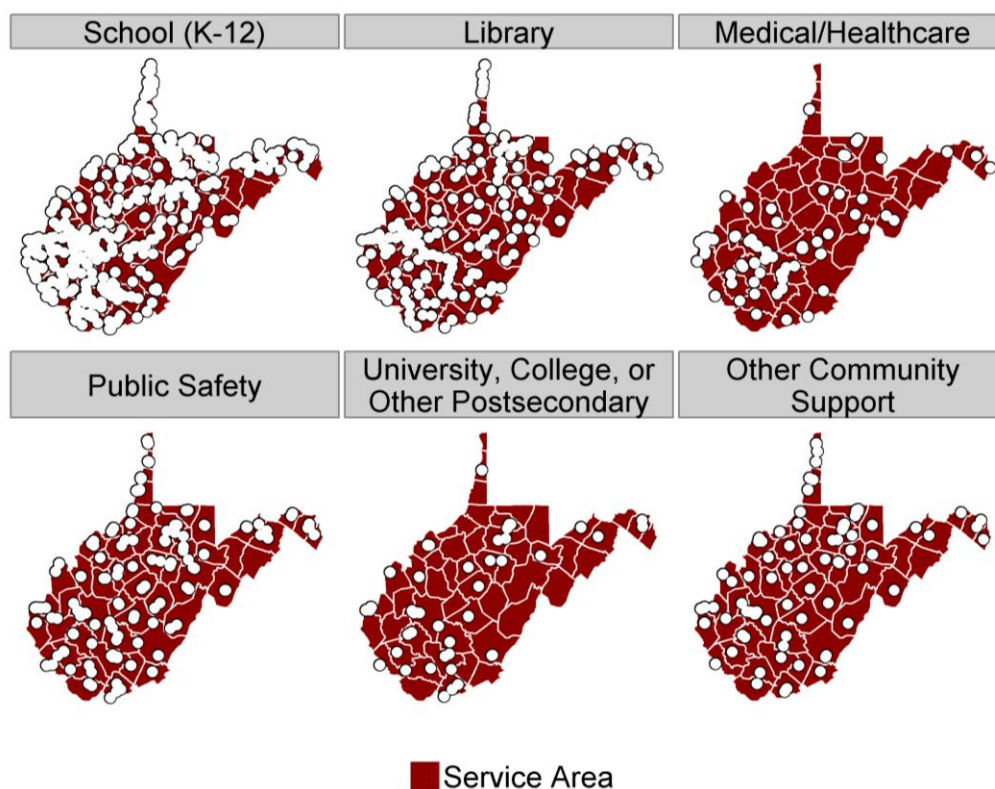
The evaluation study team met with grant implementation staff, project partners, and government agencies. These interviews helped the team understand the grantee's approach to project implementation and the strategies used to create demand for the broadband service. Additional interviews with key CAIs and partners throughout West Virginia focused on describing the impact on CAIs in relation to several factors, including the quality of service of the upgraded network, especially speed, reliability, flexibility, and cost. The analysis in this report focuses on outcomes and impacts to CAIs. Interviews conducted include the following:

- K-12 Schools
  - **Southside K-8 School** in War had four bonded T1 lines, totaling 6 Mbps, prior to BTOP.[42] Connectivity to the expanded network provides the school with 100 Mbps over a fiber-optic connection. The four bonded T1s cost $1,920 total per month.[43] Southside K-8 School now pays $1,505 per month for its 100 Mbps service. Southside K-8 School staff use the school's improved connectivity to deploy iPads and additional SMART Tables. Teachers and students benefit from faster load time for web pages, which translates into more time for learning and engagement in the classroom. The connectivity will allow the school to administer the WESTEST 2 state assessment in an online environment.[44]
  - **Woodrow Wilson High School** (WWHS) in Beckley is the largest of four high schools in the Raleigh County Schools system with over 1,400 students.[45] Prior to BTOP, the school paid $800 per month for 3 Mbps of bandwidth over two T1 lines.[46] The new fiber connection provides 500 Mbps through a local provider for $2,500 per month.[47] With the increased bandwidth, teachers are able to use iPads, Apple TV streaming media devices, and MacBooks in the classroom and for administrative tasks. School officials also have implemented a one-to-one iPad program for students. This program allows students to access textbooks online and facilitates online student research, creation of presentations, and alternative instruction methods such as virtual labs.[48]

- Higher Education
  - **West Virginia Network for Educational Telecomputing** (WVNET) provides cloud-based administrative services, broadband technologies and services, and research and collaboration opportunities to state universities, K-12 schools, government units, and nonprofit organizations.[49] WVNET provides online and distance learning services, such as the Blackboard learning management system, Banner, and DegreeWorks, and provides e-mail, data backup, and disaster recovery services to its clients. WVNET is the E-Rate provider for its eligible clients and hosts the BTOP-funded network's access point to Internet2, which was not available to state higher education institutions prior to BTOP. WVNET's participation in the project has allowed it to provide increased network reliability and to lower recurring subscribership fees by over 50 percent.[50] Prior to BTOP, the cost for WVNET clients was $50 per Mbps, per month.[51] Because of the project, the cost decreased to approximately $25 per Mbps, per month at the time of the site visit. As of March 2014, the grantee reported that WVNET further reduced monthly fees to $19.95 per month.
  - **National Radio Astronomy Observatory** (NRAO) in Green Bank is a National Science Foundation (NSF) funded radio astronomy research facility providing research opportunities to scientists around the world since 1956.[52] NRAO also provides both formal and informal programs in education and public outreach for teachers, students, the general public, and the media. Prior to BTOP, NRAO was connected at 45 Mbps at a cost of $5,000 per month.[53] The BTOP connection allowed NRAO to use the grant-funded BTOP backbone to purchase 10 Gbps of bandwidth for the same price.[54] NRAO has established a high-speed broadband link with West Virginia University (WVU) in Morgantown and to the regional Internet access point. The connection to the university also provides a path to connect with WVNET, its commodity Internet provider, and to Internet2. These connections allow for cost-effective transmission of large datasets collected from NRAO telescopes to WVU and other research entities, facilitating research by scientists around the world. NRAO also provides opportunities for K-12 science, technology, engineering, and mathematics (STEM) programs, such as the Pulsar Search Collaboratory, that are supported by the upgraded connections.[55]
  - **West Virginia University** (WVU), founded in 1867, is a public land grant research university in Morgantown with a fall 2013 semester enrollment of 29,466 students, including 22,757 undergraduates and 5,077 graduates.[56] The BTOP grant funded a fiber-based 10 Gbps connection between WVU and NRAO in Green Bank.[57] The monthly cost of this connection paid by NRAO did not change. Prior to BTOP, NRAO had a 45 Mbps connection to WVU.[58] The improved connection between WVU and NRAO improves on-campus research opportunities for WVU faculty and students through remote observation and the transmission of data from the telescope and other instruments to WVU.[59] The increased bandwidth also supports expansion of the university's videoconferencing capabilities.[60]
- Government and Public Safety
  - **Office of Emergency Medical Services** (OEMS) operates and maintains the state's 350 Mbps microwave public safety network. The network serves the State Interoperable Radio Network (SIRN), the National Guard, local police and fire departments, West Virginia State Police, other public safety-related state agencies, local 911 call centers, ambulance services, county jail facilities, and courthouses. The state microwave network also serves federal agencies such as the National Park Service, Federal Bureau of Investigation, and the United States Marshal Service.[61] BTOP-funded hardware supports the deployment of multi-protocol label switching (MPLS) virtual private networks (VPN) for each agency to provide them secure and private communication channels. The same technology supports interoperability that allows these agencies to communicate with each other in times of emergency. The BTOP grant enabled OEMS to install additional towers and fiber that provided backhaul capabilities and redundancy to support the bandwidth-intensive data transfer needs of each agency.[62] The BTOP grant also provided upgraded routers to support the increased bandwidth and end user equipment, such as radios, to facilitate interagency communication.[63] The fiber infrastructure supports the bandwidth-intensive data transfer

needs of each agency and increases network resiliency that was not possible prior to the grant.[64]

- o The **Glen Jean Armed Forces Center** houses four Army National Guard units and a military entrance processing station (MEPS), including administrative and instructional space. The primary purpose of the facility's grant-funded fiber connection was to serve the Glen Jean microwave tower to enable the use of advanced communications technologies needed to support public safety operations.[65] The 2013 National Scout Jamboree (NSJ) in nearby Mount Hope served as a pilot program to test interagency collaboration processes for future large-scale emergency and disaster scenarios.[66] The fiber connection is used for day-to-day armory operations and serves the microwave tower for public safety communications.

- o The **West Virginia Department of Education** (WVDE) is the state agency responsible for administering educational policy, providing web-based resources to support teacher certification and professional development, and student assessments for West Virginia K-12 schools.[67] The WVDE has committed to establishing a technology integration component in every classroom. West Virginia considers all schools in the state CAIs. The increased capacity allows schools to offer more online content in the classroom, to offer more online courses, and to support online professional development activities.[68]

- Healthcare

  - o **New River Health** is a private, nonprofit organization comprised of seventeen clinics located in Fayette and Raleigh Counties, West Virginia.[69] Nine of those clinics are in local elementary, middle, and high schools. The services offered include family practice, dental, mental health, behavioral services, a breathing center, and a women's health center.[70] New River Health sites, which include a second location in Scarbro and locations in Sophia and Fayetteville, are connected to each other through a redundant metro Ethernet deployment made possible by BTOP-funded networking equipment.[71] Prior to BTOP, New River Health paid between $500 and $600 per site per month for a 1.5 Mbps T1 connection.[72] Due to BTOP, New River Health pays approximately $200 per site per month for 10 Mbps of Internet bandwidth and a secure 5 Mbps channel.[73]

- Public Libraries

  - o **Kanawha County Public Library (KCPL)** KCPL is a system of eleven facilities, including the main library in Charleston, nine branch libraries, and a bookmobile.[74] The BTOP grant provided a fiber-optic connection to each library facility and routers to support the connections. Each facility now subscribes to 20 Mbps of Internet service at a cost of $1,200 per month.[75] The connectivity has allowed for the expansion of existing public-use computer facilities and wireless access for patrons to bring and use their own device. The library offers live homework help for K-12 students, Mango language software, digital downloads, and an increased portfolio of commercial databases. The libraries also offer webinars and one-on-one digital literacy training for organizations and individuals.[76] Because of the BTOP grant, KCPL offers physical and digital book and media collections and access to an expanded portfolio of commercial databases to its patrons throughout Kanawha County.

  - o **Bridgeport Public Library (BPL)** provides physical and digital materials, resources, and services that help its approximately 25,000 patrons meet their personal, educational, cultural, and professional needs. The library is a department of the City of Bridgeport and is served by a 100 Mbps fiber-optic connection as a part of the city's network connection with CityNet, a local Internet service provider (ISP) not involved with the BTOP grant. Prior to BTOP and its fiber-optic connection through CityNet, the library received Internet service over a T1 connection provided by the WVNET. Since the library already had an existing connection through CityNet at the time of the BTOP grant award, it requested only a router and declined a BTOP-funded connection. The BTOP-funded router is located in CityNet's data center and serves as an enterprise network hub for the municipal government. The enhanced connectivity supported by the BTOP-provided router has enabled the library to offer access to more databases and downloadable content, and supports citywide scalability to meet the city's broadband needs into the future. The city has converted to a Voice over Internet Protocol (VoIP) system for telephony. The city representatives interviewed by the

evaluation study team stated that the router has the capacity to reduce operational costs and facilitate partnerships with organizations to enhance municipal services and library programming, such as a potential partnership with the National Chess Federation.[77]

The evaluation study team also met with the following groups that provided information on the social and economic impacts of the grant, although they did not directly receive broadband service because of it.

- **Frontier Communications** provides both data and voice services to all fifty-five counties in West Virginia.[78] In July 2010, Frontier acquired Verizon's assets in West Virginia. This acquisition allowed Frontier to expand its service area within the state. Due to this expansion, Frontier is now able to provide fiber-based broadband to remote areas of the state. Frontier representatives worked closely with the grant implementation team to engineer the state's middle mile network, to build the fiber portion of that network, and to connect CAIs. Frontier also serves as the network operator and is responsible for handling maintenance, billing, and network support. The backbone connects to Internet exchange points in Ashburn, Virginia and Chicago, Illinois, and its ringed configuration provides network redundancy. The Verizon acquisition included compliance with the terms and conditions of the BTOP grant and the assumption of the negotiated rates of the state's MPLS contract, which applies to CAIs that Frontier serves. As part of the state MPLS contract, Frontier provides virtual private network VPN services and tiered Ethernet speeds up to 1 Gbps.[79] Under the contract, 10 Mbps is offered at $575 per month, 100 Mbps is offered for $1,505 per month, and 1 Gbps is available for $2,500 per month.[80] Frontier representatives stated that Frontier is committed to upholding the open access requirements of the grant and maintains openness and transparency in all negotiations.[81]
- **Alexander Utility Engineering** (AUE) is a San Antonio, Texas-based professional engineering and design firm that has worked with the agencies of the State of West Virginia since 1998. As the engineer of record for the project, AUE provided planning, design, and construction supervision for the microwave network. AUE ensured that the installed equipment would meet the performance specifications of the grant implementation team and developed the training specifications for network operators.[82]

Section 2 provides a summary of the outcomes and impacts the evaluation study team observed.

Section 2. Impacts

This section describes the outcomes and impacts of the West Virginia project in relation to the five focus areas described in *Interim Report 1*, with the addition of the Government Services focus area.[83] These outcomes and impacts focus on understanding the effect on CAIs. The grantee anticipates that the infrastructure put in place by the grant will foster innovative uses such as telehealth and public safety applications.

2.1 Education and Training

Impacts within the Education and Training focus area are measured as changes to elements of educational content distribution and instruction. These impacts occur at K-12 institutions, community colleges, four-year institutions, universities, and other education providers. This focus area includes how the broadband Internet connections help the educational CAIs to perform activities that lead to helping students earn a certificate or diploma or receive training that is recognized as valuable for career advancement. Examples of certificates or diplomas include community college degrees, four-year college degrees, advanced degrees, high school diploma, general equivalency degrees, certifications in advanced software technologies such as network engineering, and other licenses or certifications that reflect knowledge of a particular subject at a level that would typically be taught at an educational institution.

When assessing impacts it is important to understand the characteristics and composition of education providers within the service area. Table 3 identifies all public schools in the service area.[84] The Executive Office connected more primary schools (54 percent) than schools of any other kind. The project also connected a large proportion of middle and high schools, accounting for 19 percent of connections each. As of the grant's completion on September 23, 2013, 67 percent of the K-12 schools in the state were served on the grant-funded network. The grantee reported that every K-12 school in the state now has fiber connectivity.

Table 3. West Virginia Public Schools (K-12) by School Level

School Level	Served by Grantee	Others in West Virginia
Primary	278	170
Middle	95	25
High	98	34
Other	34	22
Undefined	6	2
All	**511**	**253**

West Virginia connected schools that serve nearly 188,000 students, 67 percent of all primary and secondary school students in the state. Approximately 13,000 of these students are minorities and more than 98,000 qualify for free or reduced lunch. The schools connected by the West Virginia grant serve nearly 68 percent of the students that qualify for free or reduced lunch in the state. These schools employ more than 13,600 full-time equivalent teachers, representing 67 percent of all teachers in the service area.

In addition to K-12 schools, the grant served public postsecondary institutions, connecting nineteen two-year community colleges and twenty-six four-year institutions in the service area.[85]

This section summarizes the activities observed by the evaluation study team during site visits. The literature review presented in *Interim Report 1* provides evidence that these activities and situations lead to economic and social impacts. This report lists these impacts from the literature along with the evaluation study team's observational evidence supporting either the realization of impacts or their potential to occur.

- **Distance learning opportunities allow schools to broaden the variety of courses offered. They also represent an educational resource for nontraditional or disabled students, or those living in geographically remote or poor areas.[86]**
  - WVDE reported that enrollment in its Virtual Academy increased by 23 percent during the BTOP award period. [87] The Virtual Academy is an alternative to the traditional classroom and enables students to take classes online that are not available at their school. For example, in 2012 a new school, the Union Education Complex, was nearing the completion of construction but did not have enough teachers available to teach required courses. Once the grant-funded fiber connection was established, students were able to take required courses online to graduate on time.[88]
  - WVDE leveraged increased bandwidth obtained through the grant by reshaping Virtual Academy curricula to promote greater interaction between teachers and students.[89] Because many schools had limited bandwidth, the Virtual Academy was initially delivered through self-guided online modules. Now, WVDE has developed a blended model under which teachers deliver content via live audio or video and students can respond in real time. Two-way video and audio capabilities are particularly helpful for classes that require student-teacher interaction. Foreign language teachers, for example, can use audio to assess students' pronunciation and conversational abilities.
  - Increased capacity for higher education institutions allows WVNET to provide more efficient learning management systems (LMS) to its member institutions.[90] The new connections enable higher education institutions to expand their catalog of online courses. It also allows them to improve the quality of online instruction through interactive features such as two-way video and audio.
  - Improved broadband connections among higher education institutions enabled the deployment of the West Virginia Remote Online Collaborative Knowledge System (WVROCKS).[91] WVROCKS is an online degree program for college dropouts who want to finish their degrees through distance education. WVNET invites every higher education institution to have its online courses hosted through the WVROCKS portal. WVNET leadership stated that they would not have offered the WVROCKS service prior to the BTOP grant.[92]

- **Broadband gives teachers a wide range of media through which to facilitate lessons. The integration of technology into classroom activities creates the opportunity for interactive and personalized educational experiences for students.[93]**
  - New and improved connections have made it easier for schools to access and use TechSteps, a web-based tool provided by WVDE. TechSteps modules have the dual goal of delivering instructional content and developing students' technology skills. All K-12 schools in the state are required to administer a minimum amount of training to students to comply with the No Child Left Behind Act and Children's Internet Protection Act.[94] WVDE uses TechSteps to deliver this training and other instructional content. Because it is a bandwidth-intensive application, TechSteps content often loaded slowly or malfunctioned at schools with slow connection speeds. Schools that received fiber connections now have adequate bandwidth to support the use of TechSteps, which functions faster and more smoothly than before.[95]
  - Prior to the grant, Southside K-8 School received broadband speeds between 6 and 7 Mbps, which was shared among teachers, students, and administrators. Users often experienced

slow service and frequent instances of network time-outs. Southside received a fiber connection through the grant and average speeds now measure between 30 and 40 Mbps. The faster connection enables the school to use more instructional software in classrooms, such as Carnegie MATHia, Lexia, Headsprout, and WV Writes. WV Writes is preparatory software for WVDE's writing assessment. Teachers and administrators reported that increased use of interactive software has led to greater student engagement.[96]

- o Southside K-8 School accelerated deployment of mobile computing devices after receiving a fiber connection. The new connection has adequate bandwidth to support simultaneous use of many devices. This capability was limited prior to the grant. Teachers at Southside now have access to 120 iPads to check out for their classrooms.[97] The school also purchased SMART Tables for all kindergarten and first grade classes. Teachers reported that student engagement has increased with greater use of broadband-enabled tools. The school plans to expand the use of mobile devices further by creating a volume purchasing account to receive discounts for applications.[98]

- o The grant enabled WWHS to deploy a one-to-one computing initiative. WWHS administration was interested in pursuing a one-to-one initiative before the grant, but did not have an adequate wireless network to support a large number of devices. Routers provided by the grant allowed WWHS to reallocate money that was budgeted for routing equipment to upgrade their wireless infrastructure.[99] Now, the district has provided every WWHS student with an iPad. Teachers stated that students appear more engaged and participate in more peer-to-peer learning and collaboration.[100]

- **Research has shown that computer use among students leads to improved academic performance, greater levels of educational attainment, improved school enrollment, graduation rates, and increased earning potential for students.[101]**
  - o Administrators at WWHS reported that school attendance has increased since implementing its one-to-one iPad initiative in the 2013-2014 school year. They believe that the iPad initiative has contributed to the increase, stating that students are more motivated in classrooms that incorporate technology into instruction.[102]

- **School administrations leverage broadband infrastructure to carry out internal operations. Broadband represents a rapid, reliable channel of communication to improve interactions among administrators, teachers, parents, and students.[103] Broadband infrastructure may also give school districts or higher education institutions a competitive edge over similar institutions that are not connected, boosting enrollment rates.[104]**
  - o WESTEST 2, an annual statewide K-12 assessment, will migrate online in spring 2014 because of widespread improvements in connection speeds.[105] Online testing is cheaper and allows WVDE to collect and compute scoring data faster than traditional paper-based exams. For many of the schools connected by the grant, shifting to online testing would have been difficult using their old broadband connections. Bandwidth at WWHS, for example, could only support testing in three computer labs at a time before the grant.[106] Now the school can operate sixteen full labs at a time. This will reduce the school's WESTEST testing schedule from two weeks to three days, leaving more time for regular instruction. [107]

- **School districts may realize cost savings by conducting staff training activities online rather than using hardcopy training materials or hosting in-person training sessions.[108]**
  - o WVDE is deploying more online technology training for teachers in lieu of in-person training sessions.[109] Faster connection speeds at schools support greater use of video sessions, and interactive training content. WVDE offers seventy-seven online courses that focus on instructional technology integration.[110] Training developers customized courses for different grade levels and subjects. School districts save money by leveraging online training capabilities, reducing the need for technology specialists and travel time for teachers attending training sessions.

In addition to K-12 and higher education institutions, the BTOP grant also benefited NRAO, a federally funded research and development center. The grant improved the connection between

NRAO's Green Bank facility and WVU in Morgantown from 45 Mbps to 10 Gbps. Frontier, NRAO's provider, did not raise the monthly fee of $5,000 for the faster connection. The connection has improved NRAO's data-sharing capabilities and reduced research costs. Before the grant, the broadband connection serving NRAO was so limited that it could not support transmission of datasets collected by NRAO telescopes to WVU. NRAO had to save datasets on disk drives and physically transport the disk drives from Green Bank to the university in Morgantown. This resulted in data collection delays of a week or more and required weekly travel of nearly 250 miles round trip. NRAO's new fiber connection allows it to transmit datasets digitally, saving an estimated $250,000 per year in travel and data storage costs.

The BTOP improvements have also allowed NRAO to access Internet2 for the first time via their connection to WVU, improving NRAO's ability to collaborate with researchers across the United States and abroad.[111] Researchers rely on this connectivity to access projects and operate telescope equipment at NRAO remotely from their home university. Remote access capabilities reduce the need to travel to NRAO's facility in Green Bank, West Virginia, which reduces the cost of research. The increased bandwidth and Internet2 access enables NRAO to host more remote access research activities.[112]

2.2 Government Services

One of the five core purposes established by the Recovery Act was to "improve access to, and use of, broadband service by public safety agencies."[113] The Government Services focus area identifies how broadband improves services provided by government organizations to the public and includes both the provision and administration of public safety activities. Examples of public safety agencies include law enforcement agencies, fire departments, and emergency medical services (EMS). Some potential government service impacts include enhanced government efficiency, improved ability to save lives and reduce injuries, prevention of criminal activity, and improved information sharing between citizens and public safety entities.

The project connected 160 public safety institutions across the State of West Virginia.[114] Figure 5 identifies all agency types in the service area.[115]

Figure 5. West Virginia Public Safety Institutions by Type
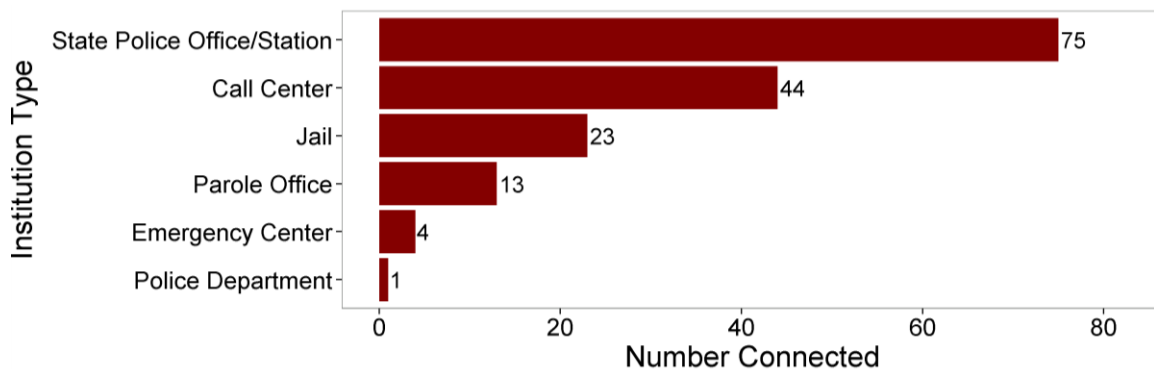
The grant funded the construction of twelve new microwave towers and the replacement of five existing towers on the SIRN network, the state's existing system of public safety communications microwave towers.[116] The BTOP-funded project built fiber infrastructure to selected towers to provide backhaul and adds redundancy to those towers that had only a single link to the network prior to the grant. The fiber infrastructure supports the bandwidth-intensive data transfer needs of each agency and increases network resiliency that was not possible prior to the grant.[117] New equipment to support Internet protocol (IP) based communications were installed on all existing tower or rooftop sites. The completed SIRN network has ninety-six integrated towers or rooftop

sites. Funding from other grants was used to purchase interoperable handheld radio units to link multiple public safety agencies on SIRN. The project ensured that every 911 center in the state has connectivity into the system and tie-ins to the state EOC through SIRN. In addition, all fifty-five county courthouses received fiber connections. The grant implementation team and stakeholders in the public safety sector stated that the grant-funded infrastructure and enhancements leave West Virginia well positioned to participate in another NTIA program, the First Responder Network Authority (FirstNet).[118] SIRN representatives stated that the tower infrastructure, broadband-class backhaul, and network capacity can be leveraged by the FirstNet program.[119]

This section summarizes the activities observed by the evaluation study team during site visits. This report lists impacts from the literature along with the evaluation study team's observational evidence supporting either the realization of impacts or their potential to occur.

- **The use of broadband at all levels of government allows government entities to deliver services more efficiently. Intranet systems enable the secure and rapid exchange of information among government agencies. Governments are also able to store and safeguard massive quantities of data. By streamlining in-house operations with the use of broadband-supported tools, governments realize greater internal efficiency and productivity.[120]**
  - Federal agencies and departments rely on SIRN for day-to-operations or temporarily for emergency operations, such as during Federal Emergency Management Agency (FEMA) responses. Thirteen federal agencies and departments are day-to-day users of the SIRN network.[121] These organizations also benefit from enhanced communications capabilities resulting from improvements to the network's capacity, reliability, and statewide connectivity.
  - SIRN provides adequate connectivity for the West Virginia National Guard to train and plan for deployments.[122] The fiber connections enable rapid communications and data sharing channels between National Guard units and other military and government entities. SIRN has also increased capacity at training sites, allowing for enhanced interactive training activities that would not have been possible prior to the grant, such as the Center for National Response, discussed below.
  - Increased bandwidth has allowed for integration of recordkeeping among DMAPS correctional facilities. Prior to the BTOP award, the Division of Juvenile Services, Division of Corrections, and Regional Jail and Correctional Facilities Authority used separate systems for intake and other inmate data. While they wanted to integrate their systems to work on a single platform, the bandwidth at most sites was not adequate to do so. Increased bandwidth obtained through fiber and/or routers provided by the BTOP-funded project allows these entities to consolidate their records into a single system, implemented as of March 2014.
- **Public safety entities, including police, fire, and emergency medical personnel, can reduce response times and improve the quality of services they provide with the use of broadband-supported applications and equipment.[123]**
  - Connecting 911 centers through SIRN has improved interagency communications and made the public safety network more robust. Prior to the grant, many 911 centers relied on T1 or telephone lines for communications, which were frequently operating at or near capacity.[124] The 911 centers connected through the grant now have greater capacity through fiber and microwave radio connections. They also have direct connectivity to the state EOC and to other public safety agencies in the state. Interconnectivity enables public safety entities from different counties and different levels of government to communicate easily and coordinate joint efforts. It also improves the public safety network's reliability, allowing network operators to reroute traffic if a center loses power or connectivity.[125] Without the grant, rerouting traffic required physically switching T1 or telephone lines on-site. Manual reroutes require more workers and take longer to resolve than remote rerouting.
  - The capacity and interconnectivity provided to 911 centers and EOCs by the project's fiber and SIRN connections will allow for the future development of next generation 911

services.[126] Before the grant, most 911 centers and county EOCs were using copper circuits, which cannot support next generation applications.

o Connections to local health departments have improved the West Virginia Bureau of Public Health's disease monitoring and surveillance capabilities. Direct links to local health departments allow the Bureau to access local records to identify trends. The new fiber connections are more reliable than pre-grant communication channels. They increase the amount of disease trend information available to the state health officer, which facilitates decision-making.[127]

o Coordination between public health and public safety agencies is greatly improved by the communications system and interoperable handheld radios distributed through the project. The Bureau of Public Health works closely with the Centers for Disease Control and Prevention (CDC), communicating primarily through the Internet. The Bureau of Public Health has connections to CDC databases for administration and disease tracking. West Virginia's Center for Threat Preparedness also works with the CDC to help local health units respond to incidents that may cause a surge of patients. The reliability of the grant-funded connections can lead to greater response capabilities and improved communications with CDC's EOC during states of emergency.

o The 2013 NSJ, held July 15 to 24, 2013, gave West Virginia the opportunity to test and showcase the capabilities of the interoperable network and BTOP-funded enhancements. With 45,000 Scouts, leaders, and volunteers attending, the NSJ at the Summit Bechtel Family National Scout Reserve made Mount Hope the fourth largest city in the state during the event.[128] The NSJ required a temporary joint interagency operations center. The operations center was located at the nearby Glen Jean Armed Forces Reserve Center, the site of a BTOP-funded SIRN tower and fiber connection. Federal, state, and local partners staffed the operations center. The operations center could not have functioned without the tower and fiber connections constructed through the grant. The high-bandwidth connections enabled the use of full-motion surveillance video at the reserve and on highways. It also allowed each agency to remotely access proprietary tools.

o The Center for National Response, operated by the West Virginia National Guard, received connectivity as a result of the project. The site was formerly the Memorial Tunnel, which allowed turnpike traffic to pass through Paint Creek Mountain. Since a new turnpike route bypassed the tunnel, the National Guard converted the site to a multi-scenario anti-terrorism training complex. The site has hosted military and public safety trainees from across the United States and abroad. Located in a rural, mountainous area, the site had a limited amount of copper-based services before the grant and it was cost-prohibitive to build fiber there. After SIRN was completed, the National Guard added microwave capabilities at the site using a passive reflector to connect to the network. The Center for National Response can now hold training exercises that would not have been possible prior to the grant. For example, while military personnel or first responders participate in training exercises on the ground, staff at the training agency's home EOC can observe and participate in the exercise using video and audio communications. Previous broadband capacity was not sufficient to support this integrated approach to training.[129]

- **Broadband connectivity also helps to preserve continuity of government operations in the wake of disasters or epidemics.[130]**

West Virginia is establishing agreements with neighboring states. These agreements will enable interagency communications across state lines.[131] The capability to communicate with public safety entities in neighboring states allows West Virginia to coordinate joint emergency response efforts for events that occur near or traverse state lines. In addition, tying into neighboring states' public safety networks could improve SIRN's resiliency. The completed SIRN network has some towers that have a single link into the network, making them susceptible to outages.[132] Tying into a neighboring state's network would provide an alternate route for that traffic in the case of a fiber cut or power outage. The northeastern portion of SIRN is working to tie into Maryland's Washington-Allegheny-Garrett Interoperability Network (WAGIN), which serves the western part of Maryland bordering

West Virginia. The two states are developing a memorandum of understanding (MOU) which would provide redundant paths for both states. In West Virginia's northern panhandle, SIRN has tie-ins to the Pennsylvania public safety network where officials are working on an MOU to facilitate network sharing for redundancy during day-to-day operations. Three counties in western West Virginia tie into Ohio's Multi-Agency Radio Communications System (MARCS). There has also been some resource sharing with the Virginia State Police in southeastern West Virginia and the eastern panhandle region.

- o Directly connecting county and local public safety sites increases emergency response capabilities. Prior to the grant, law enforcement agencies dispatched officers to rural counties during states of emergency only to discover that the local EOC had a dial-up connection. These low-bandwidth connections were not conducive to supporting emergency response operations. Wireless communication services were also scarce. Officers often drove as long as thirty minutes away from the site to access a cellular signal. The grant has improved communication capabilities by adding microwave towers and distributing handheld radios. Having adequate connectivity in rural areas allows state and federal agencies to set up satellite offices closer to the disaster area. Disaster response workers can transmit information about the affected area, including data, pictures, and video, in real time to their home agencies.[133]

- o Prior to the grant, if time-division multiplexing (TDM) microwave communications were severed, the site remained down until a tower crew made repairs, taking up to eighteen hours in severe cases.[134] The new IP-based system reroutes traffic during outages so there is no downtime during repairs, resulting in more robust communication during a disaster. In addition, many public safety agencies are eliminating aerial telephone lines because of the SIRN connections.[135] Aerial lines are susceptible to outages resulting from ice, fallen trees, or other damage due to inclement weather. The SIRN connections have proved more reliable during storms. Each site has two dishes for redundancy in case one falls out of alignment. SIRN was vital for response efforts following a severe land storm in July 2012 and the after-effects of Hurricane Sandy in October 2012. SIRN representatives reported that the network functioned smoothly through both storms and no tower outages occurred.[136]

- **Online tools allow government entities to offer better customer service and support.[137]**
  - o Participating in the project has increased network capacity for many local and county government entities in rural areas. As a result, there has been greater use of online permitting and licensing services, saving citizens travel time and expenses.[138]

2.3 Healthcare

This focus area includes activities intended to increase elements of the provision and administration of healthcare services, including health information technology, e-Care, electronic health records (EHR), telehealth, and mobile health. Impacts in the Healthcare focus area include broadband-enabled activities aimed at improving personal health or that of someone else. This definition includes not only sophisticated tasks, such as viewing medical records online, but also more common activities that might not involve a medical provider at all. Healthcare impacts might be observed at primary care physicians' offices, hospitals, or in areas served by nurse practitioners.

When assessing impacts it is important to understand the characteristics and composition of healthcare providers within the service area. West Virginia had connected ninety-six healthcare institutions as of September 23, 2013.[139] Table 3 identifies the taxonomy groups of these connected institutions and the taxonomy groups of all healthcare institutions in the service area according to the National Plan and Provider Enumeration System (NPPES).[140] Connecting healthcare CAIs was not the primary focus of this grant. The majority of healthcare institutions connected by West Virginia fall in the ambulatory health care facilities taxonomy groups.

Table 4. West Virginia Healthcare Institutions by Taxonomy Group

Taxonomy Group	Served by Grantee	All of West Virginia
Agency	3	675
Ambulatory Health Care Facilities	71	534
Hospital Units	0	37
Hospitals	18	159
Managed Care Organizations	0	16
Nursing & Custodial Care Facilities	2	267
Residential Treatment Facilities	0	40
Other	2	0
All	**96**	**1,728**

This section summarizes the activities observed by the evaluation study team during site visits. The literature review presented in *Interim Report 1* provides evidence that these activities and situations lead to economic and social impacts. This report lists these impacts from the literature along with the evaluation study team's observational evidence supporting either the realization of impacts or their potential to occur.

- **Patients obtain improved ongoing care.[141]**
  - o Improved network capacity has enabled New River Health to take advantage of EHR applications. While an EHR system existed prior to the grant, bandwidth limitations prevented New River Health from using all of its features. Since participating in the grant-funded project, New River Health is able to generate thorough and up-to-date patient profiles when patients arrive for their appointments. The reports notify the physician if scheduled tests are overdue and allow doctors to follow-up on referrals to ensure that they have received results from tests performed at other locations.[142]
  - o Following a disaster or emergency, victims and first responders often require mental and behavioral health support that may not be readily available in rural, isolated areas. The fiber and radio networks are used to identify the need for and improve the delivery of mental and behavioral healthcare services in rural communities.[143]

- **Broadband connectivity enables providers to adopt new technologies and practices that enhance productivity, achieving outcomes such as improved appointment and treatment scheduling and more complete medical records at lower costs.[144]**
  - o Improved connection speeds provided through the BTOP grant enabled New River Health to implement a communications center to improve appointment scheduling and patient-provider communications.[145] Since connecting to the network, New River Health has installed an IP-based telephone system that links all of its sites. This would have been too expensive before the grant, since New River Health's existing infrastructure required extensive upgrades to implement the system. The new system accepts calls for all New River Health sites in one centralized communications center. Communications center operators schedule appointments and provide triage consultation for emergency calls. Before the communications center opened, each site had its own telephone system operated by its office staff. Phone lines were often busy and patients could not easily reach office staff.[146] Since establishing the call center, the New River Health system has scheduled more appointments and seen more patients.[147]
  - o New River Health now conducts management meetings via teleconference. Teleconferencing eliminates the need for staff at all New River Health sites to meet in a

central location. As a result, they are not absent from work and physicians are able to see more patients.[148]

- **Broadband access enables providers to rapidly share patient information with other healthcare providers.[149]**
  - Enhancements to the state's public safety network have increased the ability of local health departments to communicate with one another and with state agencies. West Virginia has forty-nine local health departments. In addition to clinical responsibilities, they are responsible for submitting registration data for federally funded program enrollees, such as the Supplemental Nutrition Assistance Program (SNAP). The network gives them greater data transmission capabilities to report this information to the state.[150]
  - Data-sharing capabilities have improved the quality and speed of patient care in cases of trauma. Because much of West Virginia is rural, a large portion of the state relies on small critical access hospitals. First responders transport trauma patients to critical access facilities to stabilize them. The critical access hospital can run tests or capture images and send these results to a larger facility where the patient is transferred. The public safety network has improved the ability of these small, rural hospitals to transmit patient files to the transfer facility. In addition, the SIRN network is used to coordinate the patients' transfers.[151]
  - New River Health is using the increased communications capabilities by making connections to local hospitals for EHR-sharing. This will allow hospitals to have access to New River Health's patient records to better serve those admitted to emergency rooms. New River Health will also have access to its patients' hospital records, allowing it to better care for recovering patients. The grant project greatly improved New River Health's ability to make these connections.[152]
  - The benefits of the BTOP grant enhance another grant awarded to the West Virginia Bureau of Public Health. The grant, administered through the United States Department of Health and Human Services' Hospital Preparedness Program (HPP), places digital radios in hospital ERs. The radios will facilitate direct communications between hospitals and medics caring for trauma patients in the field. The BTOP grant supports this goal of the HPP grant by providing network infrastructure in areas that were previously inaccessible via radio communications due to surrounding mountainous terrain.[153]

- **Broadband enables providers to improve the range of health services offered.[154]**
  - Bandwidth increases obtained through the project have enabled the use of x-ray technology at New River Health sites. They employ a roving technician who takes dental x-ray images using mobile technology and transmits them to the New River Health database. Doctors at any New River Health site can retrieve patients' x-rays from the database. Prior to the grant, New River Health only offered x-rays at one location. The patient had to travel to that site for the x-ray and then travel back to their local clinic with a compact disc containing the x-ray images for interpretation.[155]
  - The state trauma network includes five medical command centers, located in Beckley, Charleston, Flatwoods, Huntington, and Morgantown. When a trauma incident occurs, medics relay information about trauma patients to a doctor at the medical command center. The doctor gives the medic directions for stabilizing the patient, including any drugs to administer. The command center also relies on feedback from medics to determine where to transport the patient. Before, these communications traveled on the old microwave system. The new network, which is a dual microwave and fiber system, can accommodate more data, which has resulted in faster, clearer communications between command centers and those in the field.[156] In the future, telemetry can be passed over the new network to support improved patient outcomes.

2.4 Workforce and Economic Development

Impacts within the Workforce and Economic Development focus area can occur through activities intended to increase overall employment of the target population, or to assist employed members

of that population in finding jobs that offer increased salaries, better benefits, or a more attractive career path, including self-employment. This focus area also includes activities to attract new businesses to locate along the fiber path or to expand the economic activity of existing businesses connected to the network. While this focus area primarily describes jobs, it also includes other economic impacts such as wages, property values, and the number of firms in a region.

This section summarizes the activities observed by the evaluation study team during site visits. The literature review presented in *Interim Report 1* provides evidence that these activities and situations lead to economic and social impacts. This report lists these impacts from the literature along with the evaluation study team's observational evidence supporting either the realization of impacts or their potential to occur.

- **Access to computers and broadband helps to reduce unemployment by enabling job seekers to engage in training programs, facilitating job seekers' ability to search and apply for open positions online, and reducing geographic limitations associated with employment search.[157]**
  - o Since receiving connectivity through the grant, KCPL has expanded the number of online job-focused applications. Library staff members stated that these applications would not have functioned without the increased speeds obtained through the grant. New offerings include Career Cruising, a web-based career planning tool, and ProQuest Entrepreneurship, which provides research resources, videos, and how-to content for aspiring and practicing entrepreneurs.
  - o KCPL provides access to online résumé and cover letter writing tutorials, including an application that allows job seekers to distribute their application materials to a nationwide database to reach employers across the country. Library staff members are developing YouTube presentations and other tutorials to guide patrons in the use of these resources if a librarian is unavailable to assist them.[158]
  - o BPL's service offerings have grown because of improved network speeds. Patrons now have access to a wider variety of job-related resources, such as the State Library Commission's Learning Express Library. Learning Express offers self-guided online training in several subjects, including workforce skills improvement and occupation-specific practice tests. BPL's staff also provides support for job seekers, most of which is focused on word processing. Most job seekers who come to the library to assemble résumés and cover letters have the content prepared, but need assistance from BPL's staff using Microsoft Word to draft and format the documents.[159]
- **Access to computers with broadband connectivity enables additional employment options and increased earning potential for workers.[160]**
  - o Connecting to the state's education network provides teachers with opportunities to engage in online professional development activities during the day. WVDE provides online professional development courses.[161] Teachers are allotted time during the school day to complete training. Prior to the grant, limited bandwidth restricted their ability to complete online courses while instructional activities were taking place. After participating in the grant, schools now have the capacity to support instructional activities as well as teachers' professional development training.[162]

As required by the Recovery Act, the Executive Office of West Virginia reported quarterly on the number of jobs created as a direct result of the project. For three consecutive quarters starting in quarter 4, 2011 and ending in quarter 2, 2012, West Virginia created work for more than 100 full-time equivalents (FTE).[163] The jobs created by through the grant include program management, administrative, and project implementation positions.

Figure 6. Direct Jobs Created by West Virginia
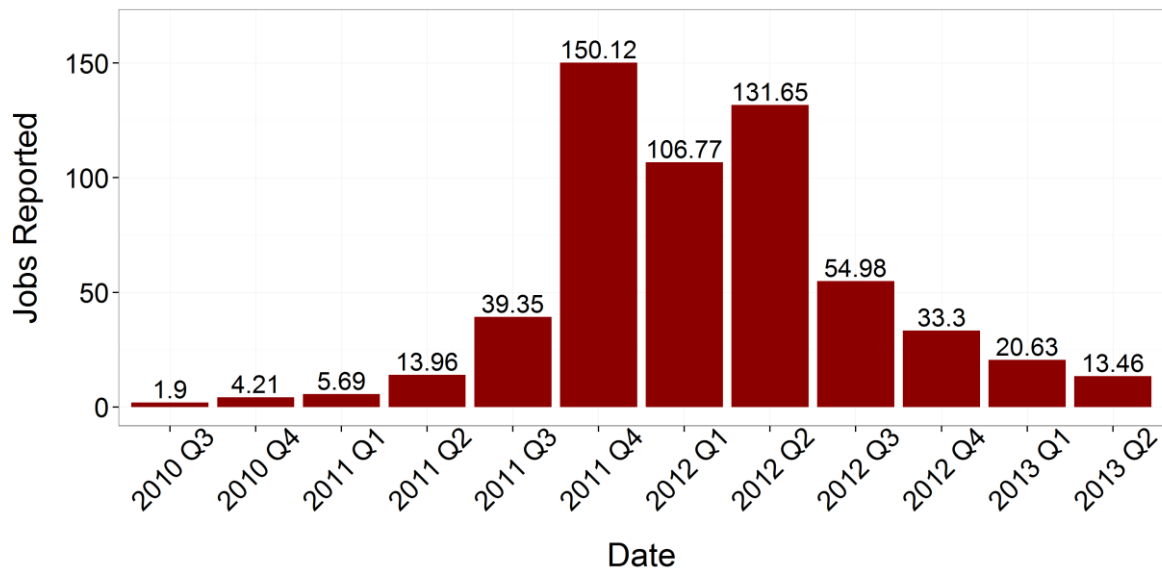
2.5 Digital Literacy

This focus area is fundamental to all of the others. "Digital Literacy" defines a set of skills and abilities that enable an individual to interact with the digital aspects of culture, and to maintain a digital identity. In the National Broadband Plan, the Federal Communications Commission (FCC) defines digital literacy as "the skills needed to use information and communications technology to find, evaluate, create, and communicate information."[164] Impacts within this focus area include the attainment of skills needed to obtain an education, search for employment, learn job-related skills, accessing government information, and more.[165]

Access to broadband enables users to engage in a wide range of digital literacy activities, generating benefits to individuals, businesses, and communities. Digital Literacy is fundamental to all other focus areas, and includes the set of skills and abilities that enable an individual to interact with the digital aspects of culture, and to maintain a digital identity. Possessing the skills necessary to complete basic digital functions, such as using a computer with a modern operating system, use e-mail, and obtain information using Internet search tools, enhances an individual's ability to realize the benefits of broadband connectivity.

The grant implementation team and other project stakeholders agree that now that the infrastructure is complete, the next step is to educate the public on how they can best use these resources.[166] While school-age children are proficient using common operating systems and mobile devices, other demographic groups require varying degrees of training to make use of the technology.[167] BPL and the KCPL offer one-on-one training ranging from device usage, including iPad, Kindle, and Nook, to software usage, such as Microsoft Word, Excel, and Publisher. BPL stated that its wireless network has improved so significantly because of the grant that it is considering purchasing laptops to hold group training sessions.[168]

As schools' connections have created more opportunities for technology use, districts are providing more technology training for teachers. At WWHS, teachers participate in two-and-a-half-hour training sessions six times per school year.[169] WVDE also manages the statewide Technology Integration Specialist program, which focuses on building teachers' digital literacy skills and helping them integrate technology into their instructional activities.

Improved library connections have led to an expansion of services. Both libraries the evaluation study team visited are members of the West Virginia Digital Entertainment Library Initiative (WVDELI), a consortium of ten libraries that share digital materials for circulation.[170] Each library contributed $10,000 worth of content, totaling 35,000 items available for checkout.[171] BPL has doubled the number of online research databases and added Zinio, an online magazine subscription service, and Freegal, a free music download service.[172] KCPL also purchased a license for Freegal that was implemented in October 2013.[173] Use of these services would have been limited prior to the BTOP grant.

Section 3. Grant Implementation

This section presents the Executive Office of the State of West Virginia's strategy to maximize the social and economic impacts of the BTOP grant. The following subsections describe the Executive Office of the State of West Virginia's implementation strategies; the approach to open access; major results of the implementation strategy; an overview of sustainability efforts; and successful tools, techniques, and strategies identified during interviews with the grantee.

3.1 Implementation

The project expanded existing fiber and microwave infrastructure to build a comprehensive network for the state. The grantee formed an implementation team to administer and manage the grant. The implementation team is comprised of representatives from the Executive Office of the State of West Virginia, the West Virginia Office of Technology (WVOT), and the Division of Homeland Security and Emergency Management. The team's strategy was to build out a middle mile network to reach CAIs, and eventually, homes and businesses. The network's fiber backbone provides reliable pathways for public safety, education, and government traffic. It is designed to support expansion to additional subscribers as more last mile providers interconnect.

In 2007, Verizon won the statewide bid put forth by WVOT to provide fiber construction, broadband solutions, and other telecommunications services. Frontier later acquired all Verizon assets in West Virginia and assumed most of its responsibilities under the contract. Frontier provided engineering and construction services for the middle mile network and facility build-outs. They filled many roles throughout the project. Because the statewide network operates on Frontier-owned fiber, Frontier functions as the network operator. Frontier also signed an MOU to provide middle and last mile services on the network. As of November 2013, Frontier's footprint for all services offered covers approximately 95 percent of the state.[174] Frontier's largest single customer is the State of West Virginia.

The implementation team identified CAIs in unserved and underserved areas, including K-12 schools, higher education institutions, libraries, healthcare providers, and public safety entities. They recorded existing fiber assets to minimize instances of duplicative fiber. The grantee did not provide new fiber connections to CAIs with existing fiber connections. Rather, it provided those CAIs with routers, giving them increased accessibility and functionality on the BTOP network. The grantee intended to construct 900 miles of new fiber.[175] Because the grant's environmental assessment took longer than expected (one year), providers and other grant recipients installed many new fiber assets in the intervening months.[176] One grant recipient that installed fiber during this time was Hardy Telecommunications, another BTOP recipient. Discussions between the Executive Office, Hardy Telecommunications, and NTIA concluded that Hardy Telecommunications would construct portions of the fiber build originally planned by the Executive Office. [177] The Executive Office supplied equipment to support CAIs in the area where Hardy Telecommunications took over construction. Hardy Telecommunications constructed 107 miles of new fiber and contributed 16 miles of upgraded fiber by December 31, 2012.[178] Because of this change, and the Executive Office's desire to avoid duplicating fiber, the project constructed 675.2 miles of new fiber as of its conclusion on September 23, 2013.[179]

The middle mile network follows a mesh topology, comprising multiple interconnected rings. The portions of the rings near the state's borders form a larger ring around the state. The mesh architecture facilitates network resiliency by providing a number of alternate routes for traffic in the case of a fault. In addition, the network has more than 150 Ethernet switches throughout.[180] The switches reroute traffic across the mesh network when necessary.

Alexander Utility Engineering, based in San Antonio, TX, provided engineering services for microwave tower construction and upgrades. Twelve new microwave towers were constructed to serve the public safety network. [181] Eighty-four existing towers were fitted with additional microwave radios to provide IP connectivity on all towers.[182] Five of the existing towers were entirely rebuilt.[183]

3.2 Open Access Policies

CCI projects funded by BTOP are predominantly middle mile projects, although a small number of last mile projects were awarded. These grants are intended to improve available broadband capabilities for CAIs, to facilitate the development of last mile services in unserved and underserved areas, and to promote economic growth. This investment through the BTOP grant is intended to "lay the foundation for the ultimate provision of reasonably priced end-user broadband services" through open and nondiscriminatory interconnection strategies to enable last mile providers to have open access to the network.[184]

There is considerable debate on the impact of open access policies on the competiveness of the broadband market.[185] Open access is implemented through a wide variety of strategies. "These can range from commercial or voluntary arrangements, between communication operators and third-parties, through to regulatory intervention aimed at promoting certain policy objectives, such as expanding broadband availability, increasing competition, or promoting investment that may otherwise not be economic, such as in the case of enabling the establishment and treatment of shared facilities."[186] The impact of open access will be dependent upon how well the practices and policies help to reduce the time, cost, and difficulty for last mile providers to interconnect to the network.[187] The impact also depends on how well the policy mechanisms ensure competitive pricing for wholesale services in the event of the presence of a middle mile provider that may also be a last mile provider.[188]

As of September 23, 2013, no last mile providers other than Frontier have signed agreements with the state to provide last mile services on the network.[189] Frontier stated on November 21, 2013 that seven providers had submitted interconnection requests that were in negotiations.[190] The network has over 1,000 access points, providing many opportunities to connect third party providers.[191] The middle mile expansion funded by the grant reduces the costs that providers would have faced to expand their footprint. Frontier considers this reduction in cost to be an incentive for other last mile providers to interconnect to the network.[192]

3.3 Results

There were three major results of the Executive Office of the State of West Virginia project observed by the evaluation study team:

- The grant project extended fiber connections to CAIs in all fifty-five counties in West Virginia to provide faster and more reliable broadband service. Fiber-based services were limited in many parts of the state because the mountainous terrain made fiber construction expensive. The technologies in place prior to the grant could not have supported the quality and speed of service to which these CAIs now subscribe. Section 2, above, provides descriptions of early impacts observed by the evaluation study team.

- Tower construction and upgrades have enhanced the capabilities and reliability of the state's public safety communications infrastructure. IP-based technologies installed through the grant give network managers greater agility in directing network traffic. This capability makes the network more resilient by enabling managers to reroute traffic quickly and easily in the event of an outage to preserve continuity of communications. Interconnectivity among the state's public safety entities and with neighboring states' networks improves the ability of multiple agencies to coordinate joint emergency response efforts. Section 2.2 discusses these capabilities and the associated impacts in detail.

- The expansion of middle mile fiber across West Virginia has reduced the cost of high-quality broadband service to last mile providers and to end users. Incurring the cost of the middle mile build-out reduces expenses for last mile providers, making it cheaper for them to interconnect to the network to serve new subscribers. CAIs that directly connected to the network through the grant project reported that the price of broadband service per megabit dropped by 86 percent on average.[193] They also stated that their broadband speeds had increased by an average of 2,200 percent.[194]

The longer-term impact of the network will depend on several factors related to the results listed above:

- The middle mile fiber expansion has given Frontier, in collaboration with the State of West Virginia, 95 percent coverage in the state.[195] However, the impact of open access will depend on the implementation of practices and policies aimed at encouraging last mile providers to connect to the network.
- Frontier must maintain the reliability of the network over time. The grant-funded network operates on portions of Frontier's proprietary network, and is thus monitored and managed by Frontier at all times. Frontier's experience as a commercial Internet provider suggests that future network maintenance is well within its capabilities.

3.4 Sustainability

The sustainability of the Executive Office of the State of West Virginia broadband project will depend on the development of last mile connections to CAIs and the ability of CAIs to continue to pay for connectivity. Recent funding cuts for school districts and libraries have led the Executive Office to consider where it might reallocate equipment in the event of CAI closures. NTIA has approved a list of CAIs where the implementation team can relocate routers if necessary.[196] To promote the benefits of the BTOP program further, NTIA is also allowing CAIs to share grant-provided resources, including fiber connections and routing equipment, with municipal institutions.[197] The implementation team and Frontier hope that the middle mile network will ultimately reach homes and businesses, either through Frontier or through third party providers.

Sustainability of SIRN depends on tower maintenance and agencies' ability to purchase radio communications equipment. SIRN leadership is preparing for increases in tower utility costs and maintaining land lease agreements.[198] SIRN does not charge a user fee. Sustained use of the SIRN will depend on agencies' ability to budget for radio equipment or to secure funding through a different grant. As mentioned in Section 2, West Virginia plans to participate in NTIA's FirstNet program as part of a nationwide public safety network.[199] The grantee is doubtful the state could have participated in FirstNet without the enhancements made possible through the BTOP grant.[200]

3.5 Successful Tools, Techniques, and Strategies

This subsection describes successful techniques, tools, and strategies identified by the grantee and interviewees. Successes and challenges described in earlier sections are not repeated here.

- The grant implementation team created a three-step approval process to ensure efficient grant management and compliance with the environmental assessment: (1) environmental assessment review; (2) financial review and completion of the local construction requests (LCR) for the fiber build; and (3) a technical review. An engineer from Frontier visited each site to conduct an assessment, to document any environmental assessment impact, and to assess whether fiber was present at the site. The engineer documented all locations with preexisting fiber and created LCRs for all sites. The three-step approval process for the fiber build helped the grantee identify the average cost per location. These estimates were useful for determining monthly costs and establishing a reasonable baseline for future construction costs.

- The grantee established a quality control process to monitor the installation of routers. A staff member visited each site that received routers for inspection. The staff member used a standard checklist to confirm that equipment was properly installed and tagged, and to document equipment serial numbers.

Section 4. Conclusions

The American Recovery and Reinvestment Act of 2009 (Recovery Act) instructed NTIA to implement BTOP to promote five core purposes:[201]

1. Provide access to broadband service to consumers residing in unserved areas of the country.
2. Provide improved access to broadband service to consumers residing in underserved areas of the country.
3. Provide broadband education, awareness, training, access, equipment, and support to:
   a. Schools, libraries, medical and healthcare providers, community colleges and other institutions of higher learning, and other community support organizations.
   b. Organizations and agencies that provide outreach, access, equipment, and support services to facilitate greater use of broadband services by vulnerable populations (e.g., low-income, unemployed, seniors).
   c. Job-creating strategic facilities located in state- or federally designated economic development zones.
4. Improve access to, and use of, broadband service by public safety agencies.
5. Stimulate the demand for broadband, economic growth, and job creation.

This section summarizes how the West Virginia Statewide Broadband Infrastructure Project has encouraged the fulfillment of the Recovery Act's goals. The grant implementation team supported Recovery Act goals to improve access in unserved and underserved areas. With these connections, CAIs are beginning to transform their services for public safety, education, and healthcare.

4.1 Improve Access to Unserved and Underserved Areas of the Country

The first two goals of the Recovery Act encourage improved access for unserved and underserved areas:

- Provide access to broadband service to consumers residing in unserved areas of the country.
- Provide improved access to broadband service to consumers residing in underserved areas of the country.

According to the June 2011 release of the NBM, more than one-half (55 percent) of the service area population has no broadband availability.[202] The West Virginia Statewide Broadband Infrastructure Project improved access to broadband by upgrading existing middle mile facilities and expanding the state's middle mile footprint to areas of the state that have historically been unserved or underserved. The backbone passed strategic locations throughout the state to facilitate the direct connections to 1,097 CAIs. The network provides a technology-neutral backbone based on fiber and wireless microwave technologies. This allows the network to accommodate multiple, disparate technologies ranging from legacy network implementations to newer, fiber-based technologies. The backbone incorporates points of presence along its route to facilitate future network growth. These characteristics support future expansion by facilitating the process of interconnection by third-party providers to expand the reach of affordable broadband availability to households and businesses in remote areas of the state.

4.2 Broadband Education, Awareness, Training, Access, Equipment, and Support

Most closely aligned with PCC and SBA grants, the next Recovery Act goal is for grantees to provide broadband education, awareness, training, access, equipment, and support to:

1. Schools, libraries, medical and healthcare providers, community colleges and other institutions of higher learning, and other community support organizations.
2. Organizations and agencies that provide outreach, access, equipment, and support services to facilitate greater use of broadband services by vulnerable populations (e.g., low-income, unemployed, seniors).
3. Job-creating strategic facilities located in state- or federally designated economic development zones.

The project focused on providing an interoperable, technology-neutral middle mile broadband network and last mile connections to CAIs. The grant funded an expanded and upgraded microwave tower system to enhance the state's public safety network. The remaining middle mile and last mile infrastructure consists of fiber designed, deployed, and operated in collaboration with Frontier Communications.

The BTOP grant also provided equipment and support to institutions as part of the upgrades to broadband access at the CAIs. Upgraded routers and switches support the immediate and long-term bandwidth demand while radios and IP-based video units support CAI-specific activities such as emergency communications and telemedicine implementations. Frontier provides ongoing support to its connected institutions while the state Office of Technology, OEMS, and WVNET provide support to state agencies connected to their respective networks.[203]

4.3 Public Safety Agencies

The fourth goal of the Recovery Act is to improve access to, and use of, broadband service by public safety agencies. As described in Section 2.2 of this report, the grant funded upgrades and expansion of the state's public safety communications infrastructure. The design of the network reflected the grant's objective of facilitating network access by 911 centers and other public safety agencies around the state. The state public safety network provides the infrastructure upon which various agencies can collaborate in times of disaster preparedness and emergency communications and training.

The network operators that share space on the network backbone provide broadband services for their CAIs, including metro Ethernet service and encrypted VPN over the public safety network. The public safety agencies on the microwave network have separate, encrypted VPN services. These capabilities also help to support the emergency preparedness and trauma response needs of the state and local healthcare providers, law enforcement, and public safety agencies.

4.4 Demand for Broadband, Economic Growth, and Job Creation

The final Recovery Act goal is to stimulate the demand for broadband, economic growth, and job creation. The CAIs that benefitted from the BTOP grant were organizations that already subscribed to broadband services. The project provided fiber-based capacity to meet the demand for bandwidth of these existing users, rather than increasing broadband adoption at CAIs that had no broadband connection.[204] Frontier Communications acquired Verizon's West Virginia assets, including the MPLS state contract. This investment allowed state agencies and Frontier to mutually benefit from the expanded middle mile infrastructure to grow the broadband presence throughout

the state. The network was designed specifically to reach into remote areas of the state to facilitate investment in last mile connections to CAIs and interconnection with other private third-party providers. The project was completed on September 23, 2013. No additional third-party providers had signed agreements to offer services over the network at that time.

Several of the CAIs reported increases in operational efficiency or decreases in operational costs because of the improved quality and cost of broadband access. Southside K-8 School and New River Health were able to re-invest these savings into other projects or activities supported by enhanced broadband connectivity. Southside K-8 School is now able to use the enhanced connectivity to deploy equipment and software that it could not use prior to BTOP, such as SMART Tables, and the use of educational software and streaming content on school-provided laptops and iPads. The enhanced connectivity has reduced instructional time lost to long wait times for software to load. Their monthly per-Mbps rate for bandwidth decreased from $320.00 to $15.05.[205] New River Health installed a phone system and hired employees to staff its call and scheduling center. This would not have been possible prior to BTOP. Their involvement in BTOP resulted in a decrease in their monthly per-Mbps bandwidth rate from $400.00 to $20.00.

There are no studies available that illustrate the effect of the project on economic growth or job creation in the service area. However, AUE created approximately eight new engineering and technician positions in support of the BTOP project.[206] Two multinational corporations built or expanded facilities in West Virginia during the BTOP award period. While these developments are not directly attributable to the BTOP project, both corporations worked with Frontier to access the Frontier infrastructure.[207] Representatives from Frontier stated that it plans to partner with economic development organizations throughout the state to market broadband assets to expanding or relocating businesses that rely on broadband services. Frontier also indicated a willingness to work with state economic development officials to explore opportunities for the construction of large-scale data centers in West Virginia.[208]

Section 5. Next Steps for the Evaluation Study

In early 2014, ASR will deliver *Interim Report 2* to NTIA. This report will include a summary of the site visits to twelve CCI projects. It will also include a summary of the second round of site visits to the fifteen PCC and SBA grants.

For the CCI projects, *Interim Report 2* will summarize the activities underway by twelve CCI grantees and the social and economic impacts of these projects. For the PCC and SBA projects, *Interim Report 2* will provide an update to and refinement of the analysis presented in *Interim Report 1*.

In September 2014, ASR will deliver a *Final Report* that quantitatively and qualitatively assesses the economic and social impact of BTOP grants (including CCI, PCC, and SBA grants). The centerpiece of the *Final Report* will be an assessment of how and to what extent BTOP grant awards have achieved economic and social benefits in areas served by the grantees. To the extent that such information is available, ASR will use results from studies performed by the grantees to round out the conclusions presented.

Notes

[1] National Telecommunications and Information Administration, *Broadband Technology Opportunities Program (BTOP) 16th Quarterly Program Status Report*, 2013, http://www.ntia.doc.gov/files/ntia/publications/ntia_btop_16th_quarterly_report.pdf.

[2] National Telecommunications and Information Administration, "About," *BroadbandUSA: Connecting America's Communities* (Washington, DC, June 11, 2012), http://www2.ntia.doc.gov/about.

[3] The Notice of Funds Availability (NOFA) includes the following definitions:

- Last mile project – any infrastructure project the predominant purpose of which is to provide broadband service to end users or enduser devices (including households, businesses, community anchor institutions, public safety entities, and critical community facilities).
- Middle mile project – a broadband infrastructure project that does not predominantly provide broadband service to end users or to end-user devices, and may include interoffice transport, backhaul, Internet connectivity, or special access.

National Telecommunications and Information Administration, "Broadband Initiatives Program; Broadband Technology Opportunities Program Notice" (Washington, D.C., 2009), http://www.ntia.doc.gov/files/ntia/publications/fr_bbnofa_090709.pdf.

[4] National Telecommunications and Information Administration, "Statement of Work for Broadband Technology Opportunities Program (BTOP) Evaluation Study," July 26, 2010, 6.

[5] ASR Analytics, *Progress towards BTOP Goals: Interim Report on PCC and SBA Case Studies*, *Broadband Technology Opportunities Program Evaluation Study (Order Number D10PD18645)* (Potomac, MD, 2012), http://www.ntia.doc.gov/report/2012/progress-towards-btop-goals-interim-report-pcc-and-sba-case-studies.

[6] National Telecommunications and Information Administration, "Post-Award Monitoring (PAM) Database 2013-09-12" (Washington, DC: Distributed by National Telecommunications and Information Administration, 2013).

[7] National Telecommunications and Information Administration, *Executive Office of the State of West Virginia Statewide Broadband Infrastructure Project Fact Sheet*, *BroadbandUSA: Connecting America's Communities*, January 16, 2012, http://www2.ntia.doc.gov/files/grantees/WV_ExecOfcWestVA_FINAL.pdf.

At the request of the grantee, the evaluation study team revised this sentence to include 900 miles of fiber.

[8] National Telecommunications and Information Administration, *Executive Office of the State of West Virginia Statewide Broadband Infrastructure Project Fact Sheet*.

[9] National Telecommunications and Information Administration, "Post-Award Monitoring (PAM) Database 2013-09-12."

[10] Grant Implementation Team, "Interview with Author" (Charleston, WV, November 21, 2013).

[11] National Telecommunications and Information Administration, *Executive Office of the State of West Virginia Statewide Broadband Infrastructure Project Fact Sheet*.

[12] National Telecommunications and Information Administration, "Post-Award Monitoring (PAM) Database 2013-09-12."

[13] National Telecommunications and Information Administration, *Executive Office of the State of West Virginia Statewide Broadband Infrastructure Project Fact Sheet*.

[14] The evaluation study team made several adjustments to the list of institutions reported by Executive Office of the State of West Virginia:

- Many of the reported institutions represent locations, subentities, etc. of institutions found in public data rather than separate institutions, including twenty-eight Postsecondary institutions, seventy-five Library institutions, and seventy-two Public Safety institutions. The evaluation study team treats these all of these institutions as separate entities and adds them to the public data totals for the purposes of this report.

- Several reported institutions could not be matched to any institution in public data, including four Postsecondary institutions and five Schools (K-12) institutions. The evaluation study team added these institutions to the count of existing institutions in the public data.

- One reported institution falls within both the Library and Healthcare groups. To accurately reflect the services provided by this location and the reach of the grant, this institution is counted twice - once as a Library institution and once as healthcare institution.

- The evaluation study team reclassified many of the reported institutions. From Schools (K-12), one institution was reclassified as Healthcare and three as Other Community Support. From Library, one was reclassified as Other Community Support. From Healthcare, one was reclassified as Postsecondary and one as Schools (K-12). From Postsecondary, twelve were reclassified as Healthcare, one as Other Community Support, and two as Schools (K-12). From Other Community Support, 113 were reclassified as Public Safety and twenty-seven as Schools (K-12). From Public Safety, one was reclassified as Healthcare.

- Two reported Schools (K-12) institutions were removed: one institution was closed and one was a duplicated entry.

- Six reported Schools (K-12) institutions each represent two institutions in the public data set. The evaluation study team treats the six reported institutions as twelve actual institutions

National Telecommunications and Information Administration, "Post-Award Monitoring (PAM) Database 2013-09-12."

[15] National Telecommunications and Information Administration, "Post-Award Monitoring (PAM) Database 2013-09-12."

[16] Representatives of the West Virginia Office of Emergency Management Services, "Interview with Author" (Flatwoods, WV, November 20, 2013).

Representative of West Virginia State Police and Representative of West Virginia National Guard, "Interview with Author" (Charleston, WV, November 18, 2013).

[17] Representatives of the West Virginia Office of Emergency Management Services, "Interview with Author."

Representative of West Virginia State Police and Representative of West Virginia National Guard, "Interview with Author."

[18] Institute of Museum and Library Services, "Public Libraries in the United States Survey (FY2011)" (Washington, DC, June 2013), http://www.imls.gov/research/public_libraries_in_the_united_states_survey.aspx; Centers for Medicare & Medicaid Studies, "National Plan and Provider Enumeration System (NPPES)" (Washington, DC, July 2013), http://nppes.viva-it.com/NPI_Files.html.

United States Fire Administration, "National Fire Department Census Database", August 8, 2013, http://apps.usfa.fema.gov/census/.

United States Department of Justice. Office of Justice Programs. Bureau of Justice Statistics, "Census of State and Local Law Enforcement Agencies (CSLLEA), 2008," *Directory of Law Enforcement Agencies Series* (Ann Arbor, MI: Inter-university Consortium for Political and Social Research, August 3, 2011)

National Center for Education Statistics, "Elementary/Secondary Information System (ELSi)" (Washington, DC, August 15, 2013), https://nces.ed.gov/ccd/elsi/

National Center for Education Statistics, "Integrated Postsecondary Education Data System (IPEDS)" (Washington, DC, August 15, 2013), https://nces.ed.gov/ipeds/

National Telecommunications and Information Administration, "Post-Award Monitoring (PAM) Database 2013-09-12."

[19] National Telecommunications and Information Administration, "Post-Award Monitoring (PAM) Database 2013-09-12."

[20] Representatives of Southside K-8 School, "Interview with Author" (War, WV, November 19, 2013).

Representatives of West Virginia Department of Education, "Interview with Author" (Charleston, WV, November 18, 2013).

Representatives of Woodrow Wilson High School and Raleigh County Public Schools, "Interview with Author" (Beckley, WV, November 19, 2013).

[21] Representative of the West Virginia Network for Educational Telecomputing, "Phone Interview with Author," 2013.

[22] Representative of the West Virginia Network for Educational Telecomputing, "Phone Interview with Author."

[23] Representative of the National Radio Astronomy Observatory, "Interview with Author" (Green Bank, WV, November 20, 2013).

[24] Representative of the National Radio Astronomy Observatory, "Interview with Author."

[25] Representative of West Virginia State Police and Representative of West Virginia National Guard, "Interview with Author."

[26] Representative of West Virginia State Police and Representative of West Virginia National Guard, "Interview with Author."

[27] Representatives of New River Health, "Interview with Author" (Scarbro, WV, November 19, 2013).

[28] National Telecommunications and Information Administration, "Post-Award Monitoring (PAM) Database 2013-09-12."

Representatives of Frontier Communications, "Interview with Author" (Charleston, WV, 2013).

[29] This calculation omits connection speed and pricing data for NRAO and WWHS, both of which exhibited speed increases that were significantly larger than the other CAIs included in this report. NRAO's connection speed increased by more 22,000 percent while WWHS experienced a more than 16,000 percent speed increase.

[30] National Telecommunications and Information Administration, *Executive Office of the State of West Virginia Statewide Broadband Infrastructure Project Fact Sheet.*

[31] National Telecommunications and Information Administration, "Post-Award Monitoring (PAM) Database 2013-09-12."

[32] National Telecommunications and Information Administration, *Executive Office of the State of West Virginia Statewide Broadband Infrastructure Project Fact Sheet*.

[33] National Telecommunications and Information Administration, "Post-Award Monitoring (PAM) Database 2013-09-12."

[34] United States Census Bureau, "2007-2011 ACS 5-Year Summary File," *American Community Survey* (Washington, DC, December 06, 2012), http://www.census.gov/acs/www/data_documentation/2011_release/.

[35] United States Census Bureau, "2007-2011 ACS 5-Year Summary File."

[36] National Telecommunications and Information Administration, "State Broadband Initiative June 30, 2011" (Washington, D.C.: United States Department of Commerce, 2011), http://www2.ntia.doc.gov/Jun-2011-datasets.

[37] National Telecommunications and Information Administration, "State Broadband Initiative June 30, 2011."

[38] FCC Form 477 data includes information at the census tract level on the population that subscribes to broadband using the following speed thresholds: at least 768 kbps download speed and at least 200 kbps upload speed. Because of this limitation, ASR is not able to filter for subscribers with download speeds of at least 3 Mbps and upload speeds of at least 768 kbps.

[39] National Telecommunications and Information Administration, "Post-Award Monitoring (PAM) Database 2013-09-12."

[40] The grantee reported speed data for 1,092 CAIs in the third quarter PPR for 2013.

[41] National Telecommunications and Information Administration, "Post-Award Monitoring (PAM) Database 2013-09-12."

[42] Representatives of Southside K-8 School, "Interview with Author."

[43] Representatives of Southside K-8 School, "Interview with Author."

[44] Representatives of Southside K-8 School, "Interview with Author."

[45] Representatives of Woodrow Wilson High School and Raleigh County Public Schools, "Interview with Author."

[46] Representatives of Woodrow Wilson High School and Raleigh County Public Schools, "Interview with Author."

[47] Representatives of Woodrow Wilson High School and Raleigh County Public Schools, "Interview with Author."

[48] Representatives of Woodrow Wilson High School and Raleigh County Public Schools, "Interview with Author."

[49] West Virginia Network for Educational Telecomputing, "About WVNET," 2013, http://www.wvnet.edu.

[50] Representative of the West Virginia Network for Educational Telecomputing, "Phone Interview with Author."

[51] Representative of the West Virginia Network for Educational Telecomputing, "Phone Interview with Author."

[52] National Radio Astronomy Observatory, "The NRAO Enables Forefront Research Into the Invisible Universe," 2013, http://www.nrao.edu/index.php/about.

[53] National Radio Astronomy Observatory, "The NRAO Enables Forefront Research Into the Invisible Universe."

[54] National Radio Astronomy Observatory, "The NRAO Enables Forefront Research Into the Invisible Universe."

[55] Representative of the National Radio Astronomy Observatory, "Interview with Author."

[56] West Virginia University, "WVU Facts," 2014, http://about.wvu.edu/wvu-facts.

[57] Representative of the National Radio Astronomy Observatory, "Interview with Author."

Representative of West Virginia University, "Phone Interview with Author," 2013.

[58] Representative of the National Radio Astronomy Observatory, "Interview with Author."

[59] Representative of the National Radio Astronomy Observatory, "Interview with Author."

Representative of West Virginia University, "Phone Interview with Author."

[60] Representative of West Virginia University, "Phone Interview with Author."

[61] West Virginia Statewide Interoperable Network, "Details: Federal Agencies," January 14, 2014, http://www.sirn.wv.gov/information/participation/Pages/county-details.aspx?County=Federal Agencies.

[62] Representative of West Virginia State Police and Representative of West Virginia National Guard, "Interview with Author."

Representatives of the West Virginia Office of Emergency Management Services, "Interview with Author."

[63] Representatives of the West Virginia Office of Emergency Management Services, "Interview with Author."

[64] Representative of West Virginia State Police and Representative of West Virginia National Guard, "Interview with Author."

Representatives of the West Virginia Office of Emergency Management Services, "Interview with Author."

[65] Representatives of the West Virginia National Guard and West Virginia Division of Homeland Security, "Interview with Author" (Glen Jean, WV, November 18, 2013).

[66] Representatives of the West Virginia National Guard and West Virginia Department of Homeland Security, "Interview with Author" (Charleston, WV, November 18, 2013).

[67] West Virginia Department of Education, "Mission and Goals," 2013, http://wvde.state.wv.us/.

[68] Representatives of West Virginia Department of Education, "Interview with Author."

[69] New River Health, "New River Health," 2013, http://nrhawv.org/.

[70] New River Health, "New River Health."

[71] Representatives of New River Health, "Interview with Author."

[72] Representatives of New River Health, "Interview with Author."

[73] Representatives of New River Health, "Interview with Author."

[74] Kanawha County Public Library, "Kanawha County Public Library," January 14, 2014, http://kanawhalibrary.org/.

[75] Representatives of the Kanawha County Public Library System, "Interview with Author" (Charleston, WV, November 18, 2013).

[76] Representatives of the Kanawha County Public Library System, "Interview with Author."

[77] Representatives of Bridgeport Public Library, "Interview with Author" (Bridgeport, WV, November 20, 2013).

[78] Representatives of Frontier Communications, "Interview with Author."

[79] Representatives of Frontier Communications, "Interview with Author."

[80] Representatives of Frontier Communications, "Interview with Author."

[81] Representatives of Frontier Communications, "Interview with Author."

[82] Representative of Alexander Utility Engineering, "Phone Interview with Author," 2013.

[83] ASR Analytics, *Progress towards BTOP Goals: Interim Report on PCC and SBA Case Studies*.

[84] National Center for Education Statistics, "Elementary/Secondary Information System (ELSi)."

NCES provides definitions for the following school levels:

- Primary: lowest grade offered is in pre-kindergarten through third grade and highest grade offered is in pre-kindergarten through eighth grade
- Middle: lowest grade offered is in fourth through seventh grades and highest grade offered is in fourth through ninth grades
- High: lowest graded offered is in seventh through twelfth grades and highest grade offered is twelfth grade
- Other: grades offered do not follow the primary, middle, or high school level configurations, or the school does not have a grade system
- Undefined: missing value

Five reported Schools (K-12) institutions could not be matched to any institution in the public data set. Characteristics are unavailable for these institutions. Six reported Schools (K-12) institutions each represent two institutions in the public data set. One reported Healthcare institution, two reported Postsecondary institutions, and twenty-seven reported Other Community Support institutions were reclassified as Schools (K-12) institutions. One reported Schools (K-12) institution was closed and one was a duplicate entry. One reported Schools (K-12) institution was reclassified as a Healthcare institution, and three others were reclassified as Other Community Support institutions.

[85] National Center for Education Statistics, "Integrated Postsecondary Education Data System (IPEDS)."

Four reported Postsecondary institutions could not be matched to any institution in the public data set. Twenty-eight reported Postsecondary institutions represent individual buildings, locations, satellites, or separate campuses of institutions in the public data set rather than separate institutions. One reported Healthcare institution and was reclassified as a Postsecondary institution. Twelve reported Postsecondary institutions were reclassified as Healthcare institutions, one as Other Community Support, and two as Schools (K-12).

[86] Scott M. Andes and Daniel D. Castro, *Opportunities and Innovations in the Mobile Broadband Economy*, *The Information Technology and Innovation Foundation*, 2010, http://www.itif.org/files/2010-mobile-innovations.pdf.

Communications Workers of America, *Speed Matters: Benefits of Broadband* (Washington, DC, 2009), http://files.cwa-union.org/speedmatters/CWA_Benefits_of_Broadbandr_2010.pdf.

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Carly Shuler, *Pockets of Potential: Using Mobile Technologies to Promote Children's Learning* (New York, NY: The Joan Gans Cooney Center, January 2009), http://joanganzcooneycenter.org/Reports-23.html.

[87] Representative of West Virginia Department of Education, "E-Mail Communication," December 09, 2013.

[88] Representatives of West Virginia Department of Education, "Interview with Author."

[89] Representatives of West Virginia Department of Education, "Interview with Author."

[90] Representative of the West Virginia Network for Educational Telecomputing, "Phone Interview with Author."

[91] Representatives of West Virginia Department of Education, "Interview with Author."

[92] Representative of the West Virginia Network for Educational Telecomputing, "Phone Interview with Author."

[93] Ruth H. Moody and Michael P. Bobic, "Teaching the Net Generation without Leaving the Rest of Us Behind: How Technology in the Classroom Influences Student Composition," *Politics & Policy* 39, no. 2 (April 29, 2011): 169–194, doi:10.1111/j.1747-1346.2011.00287.x.

[94] Representatives of West Virginia Department of Education, "Interview with Author."

[95] Representatives of West Virginia Department of Education, "Interview with Author."

[96] Representatives of Southside K-8 School, "Interview with Author."

[97] Representatives of Southside K-8 School, "Interview with Author."

[98] Representatives of Southside K-8 School, "Interview with Author."

[99] Representatives of Woodrow Wilson High School and Raleigh County Public Schools, "Interview with Author."

[100] Representatives of Woodrow Wilson High School and Raleigh County Public Schools, "Interview with Author."

[101] British Educational Communications and Technology Agency, *Extending Opportunity: Final Report of the Minister's Taskforce on Home Access to Technology* (Coventry, UK, July 2008), http://dera.ioe.ac.uk/8285/.

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[194] This calculation omits connection speed data for NRAO and WWHS, both of which exhibited speed increases that were significantly larger than the other CAIs included in this report. NRAO's connection speed increased by more 22,000 percent while WWHS experienced a more than 16,000 percent speed increase.

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Glossary

Acronym	Definition
APR	Annual Performance Progress Report
ASR	ASR Analytics, LLC
AUE	Alexander Utilities Engineering
BPL	Bridgeport Public Library
BTOP	Broadband Technology Opportunities Program
CAI	Community Anchor Institution
CCI	Comprehensive Community Infrastructure
CDC	Centers for Disease Control and Prevention
DMAPS	West Virginia Department of Military and Public Safety
EHR	Electronic Health Records
EMS	Emergency Medical Services
EOC	Emergency Operations Center
FCC	Federal Communications Commission
FEMA	Federal Emergency Management Agency
FirstNet	First Responder Network Authority
FTE	Full Time Equivalent
HPP	Hospital Preparedness Program
IP	Internet Protocol
ISP	Internet Service Provider
KCPL	Kanawha County Public Library
LCR	Local Construction Request
LMS	Learning Management System
MARCS	Multi-Agency Radio Communications System
MEPS	Military Entrance Processing Station
MOU	Memorandum Of Understanding
MPLS	Multi-Protocol Label Switching
NBM	National Broadband Map
NPPES	National Plan and Provider Enumeration System
NRAO	National Radio Astronomy Observatory
NSF	National Science Foundation
NSJ	2013 National Boy Scout Jamboree

Acronym	Definition
NTIA	National Telecommunications and Information Administration
OEMS	West Virginia Office of Emergency Medical Services
PCC	Public Computer Centers
PPR	Quarterly Performance Progress Report
SBA	Sustainable Broadband Adoption
SIRN	State Interoperable Radio Network
SNAP	Supplemental Nutrition Assistance Program
STEM	Science, Technology, Engineering, and Mathematics
TDM	Time-Division Multiplexing
VPN	Virtual Private Network
WAGIN	Washington-Allegheny-Garrett Interoperability Network
WVDE	West Virginia Department of Education
WVDELI	West Virginia Digital Entertainment Library Initiative
WVNET	West Virginia Network for Educational Telecomputing
WVROCKS	West Virginia Remote Online Collaborative Knowledge System
WVU	West Virginia University
WWHS	Woodrow Wilson High School

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