Report for

State of West Virginia Broadband Field Testing Region 3

Prepared for

State of West Virginia Geological and Economic Survey And Office of GIS Coordination

September 2013 ©

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EXECUTIVE SUMMARY

L.R. Kimball respectfully submits this Findings Report for Broadband Field Testing (Findings Report) to the State of West Virginia Geological and Economic Survey and the Office of GIS Coordination (State). The State contracted with L.R. Kimball to provide broadband data verification tasks including statewide wireless broadband field testing. In June 2013, L.R. Kimball performed testing in the Region 3 Regional Intergovernmental Council area consisting of Boone, Clay, Kanawha and Putnam Counties, West Virginia.

The broadband field testing consisted of drive-testing the four county area while using specific app-enabled smartphones provided by the State. The purpose of this testing was to assess the spatial and attribute accuracy of the service area polygons that four providers, AT&T, nTelos, US Cellular and Verizon, submitted to West Virginia in March 2013 as part of the National Telecommunications Information Agency (NTIA) State Broadband Data and Development Program (SBDD). Comparisons between the field data collected and the provider-supplied service area polygons facilitated the identification of possible coverage and speed inaccuracies reported to the State by the providers. This findings report will discuss the methodology associated with the field collection and the results of said field collection.

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1. METHODOLOGY

The drive-testing phase of this project was initiated June 17, 2013 in Huntington, West Virginia. It continued through June 26, 2013, with 6 days of field data collection, where L.R. Kimball field specialists spent a minimum of 10 hours each day driving through Boone, Clay, Kanawha and Putnam Counties. L.R. Kimball field specialists consisted of one two-person team, where one member served as the driver and the other as the navigator and data collector.

1.1 Initial Data Collection

Prior to drive-testing, L.R. Kimball prepared geographic information system (GIS) data layers to make the drive-testing more efficient and improve the quality of the data collected. These layers include the following:

- West Virginia Statewide Addressing and Mapping Board (WVSAMB) 2011 Centerlines, with pre-determined "Drive Centerlines" chosen prior to field work
- West Virginia Statewide Addressing and Mapping Board 2011 Structures
- West Virginia Statewide Addressing and Mapping Board 2011 Imagery
- NTIA Round 7 Wireless Data Coverage Submission
- Speed Test Point Locations

In addition, the State provided four smartphones for use during the drive-testing:

- AT&T Samsung Galaxy S III
- West Virginia PCS Alliance (nTelos) Samsung Galaxy S
- US Cellular Samsung Galaxy S III
- Verizon Samsung Galaxy S III

All of these phones were updated with the QoS Solutions Android Applications that measure carrier connectivity, also provided by the State.

The State asked L.R. Kimball to visit each planning and development council regional office during the initial stages of the fieldwork collection to discuss the objectives of the project and gain feedback from the region regarding specific areas of broadband concern within the region. L.R. Kimball field team met with Mr. Mark Felton, Region 3 Executive Director, on June 17, 2013. Mr. Felton did not have any additional areas of concern for the field crew to focus on.

1.1.1 West Virginia Statewide Addressing and Mapping Board 2011 Centerlines

The WVSAMB 2011 Centerlines were downloaded from the West Virginia GIS Technical Center Website. The centerlines were then evaluated for potential use. Removed from the dataset were named driveways and dead-end streets. The centerlines were further reviewed and potential "Drive Centerlines" for the region were chosen. These potential "Drive Centerlines" were chosen based on several factors. They are a good representation within the submitted coverage areas. Also, they have residents living on them and did not appear to be "fade-away" roads (dirt roads that ultimately lead to nothing). In general, interstates were not included in the potential "Drive Centerlines" coverage because it is anticipated that they will be traveled/measured during normal travel to various locations and did not need to be formally routed.

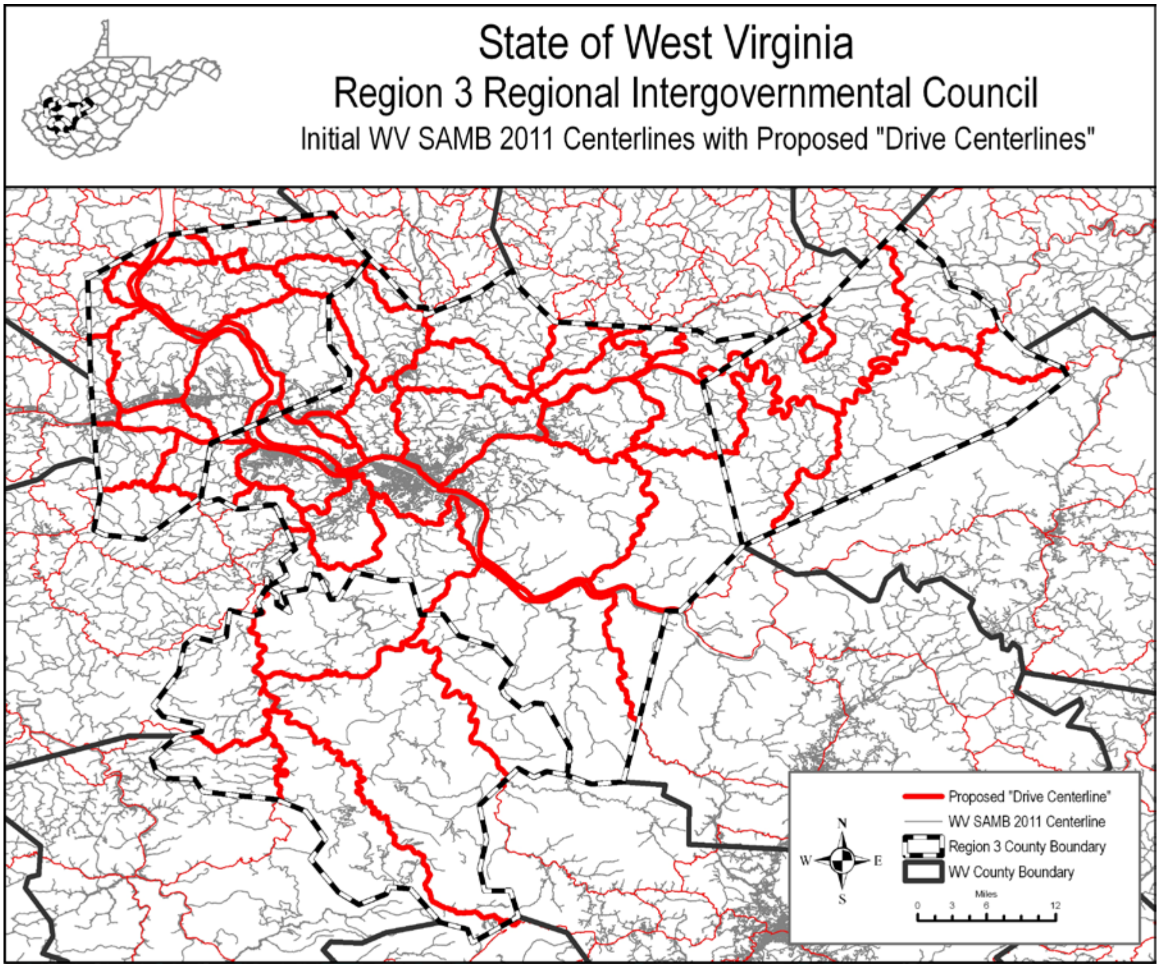

Figure 1—Initial WV SAMB 2011 Centerlines with Proposed "Drive Centerlines"

1.1.2 West Virginia Statewide Addressing and Mapping Board 2011 Structures

The WVSAMB 2011 Structures were downloaded from the West Virginia GIS Technical Center Website to use as reference only. There were no changes made to this layer prior to or during drive-testing.

1.1.3 Speed Test Points

The QoS applications allow for a carrier broadband speed test to occur every five minutes, or at user-selected points. As the application requires remaining in the same location until the test completes, and does not produce accurate results if traveling above 25 mph, QoS recommended selecting random test point locations to run the application throughout the region. L.R. Kimball chose random points in populated areas as a test of the broadband speeds in submitted coverage areas. The initial speed test point layer contained 26 speed test locations in Region 3.

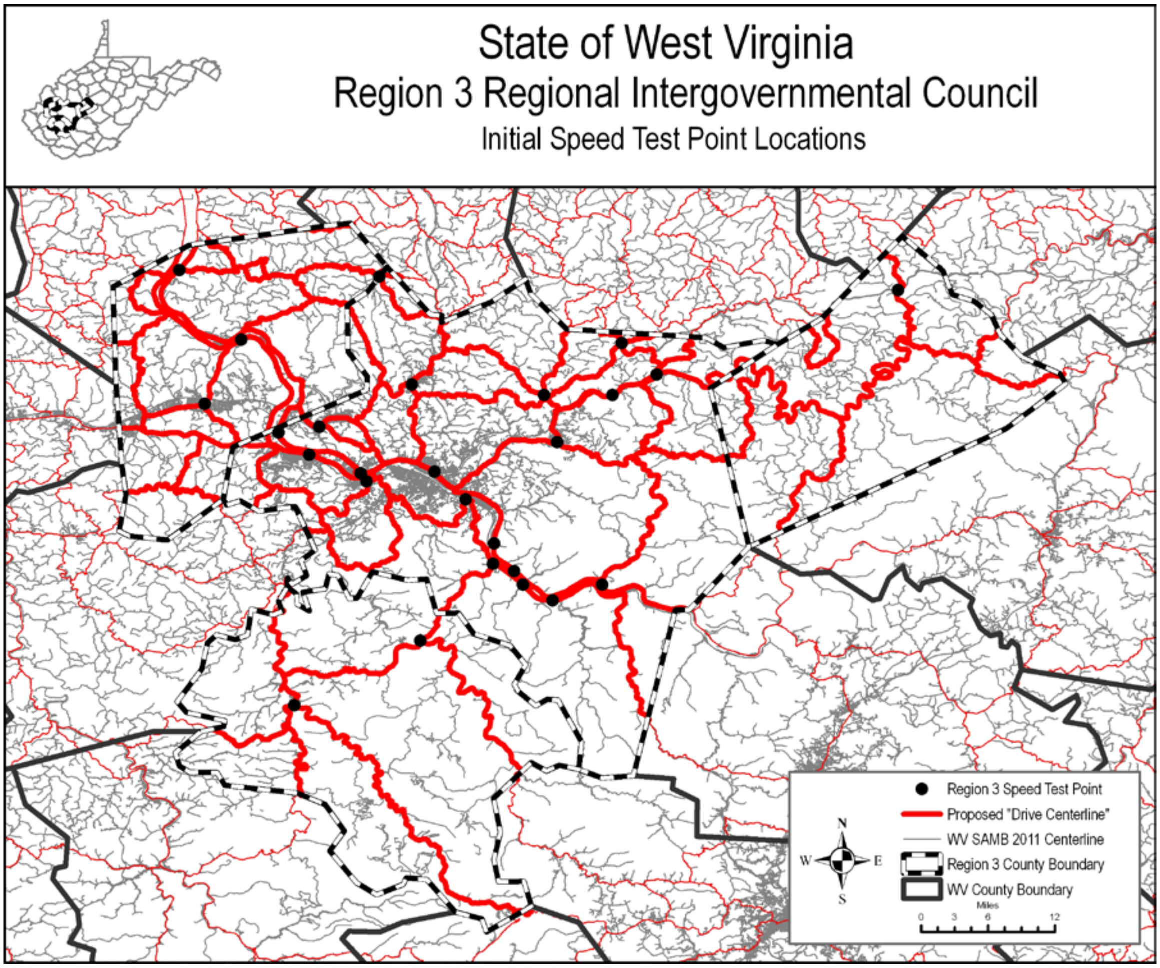

Figure 2—Initial Speed Test Point Locations

1.1.4 West Virginia Statewide Addressing and Mapping Board 2011 Imagery

The WVSAMB 2011 Imagery was downloaded from the West Virginia GIS Technical Center Website for Region 3 counties to use as reference only. There were no changes made to these layers prior to or during drive-testing.

1.1.5 QoS Solutions Android Applications

The QoS Solutions software that was provided by the State consisted of four Android Applications for use with smartphones. QCarrier measures carrier signal strength while driving with collected data stored directly on the phone. Rate of vehicle speed is not a factor in measuring signal strength. QWiFi locates and records Wi-Fi services with collected data stored directly on the phone. Rate of vehicle speed is not a factor in measuring Wi-Fi services. QPerf measures carrier connectivity at specific locations or during specific intervals with collected data stored on the QoS Website. Rate of vehicle speed is a factor in measuring signal strength. QMapper is a mapping device used in urban areas where you want a more accurate reading of your location. It does not store any data, and is to be used as a physical location reference tool. Please see Appendix A; QoS Applications.

1.1.6 AT&T Samsung Galaxy S III Phone

The State provided a Samsung Galaxy S III smartphone for L.R. Kimball field technicians to use with the AT&T network.

1.1.7 nTelos Samsung Galaxy S Phone

The State provided a Samsung Galaxy S smartphone for L.R. Kimball field technicians to use with the West Virginia PCS Alliance (nTelos) network.

1.1.8 US Cellular Samsung Galaxy S III Phone

The State provided a Samsung Galaxy S III smartphone for L.R. Kimball field technicians to use with the US Cellular network.

1.1.9 Verizon Samsung Galaxy S III Phone

The State provided a Samsung Galaxy S III smartphone for L.R. Kimball field technicians to use with the Verizon network.

1.2 Field Data Collection

L.R. Kimball field technicians spent six days drive-testing in Boone, Clay, Kanawha and Putnam Counties for the State. Equipment included a laptop computer pre-loaded with Environmental System Research Institute's (ESRI) ArcMap 10.1 software and the WV SAMB 2011 centerline, drive centerline, speed test point, and orthophotography layers, a GPS to use for reference and four smartphones provided by the State. In addition, a power inverter was used in the vehicle to keep all of the equipment charged while testing.

The L.R. Kimball field technician team consisted of a driver and a navigator. The navigator was responsible for mapping the route taken, as well as keeping track of the roads that were traveled and the points where speed tests were taken.

1.2.1 Roads Traveled

Approximately 780 miles of roads were tested in Region 3 for carrier connectivity. The goal was to drive-test the carrier submitted NTIA wireless polygons using a good representation of roads without "back-tracking" a great deal. The terrain was what was expected for this section of Appalachia, with numerous mountainous and valley areas. In some instances, anticipated road and/or weather conditions prevented the driver from traveling certain roadways and the initial drive centerlines and speed test locations in those areas were adjusted accordingly.

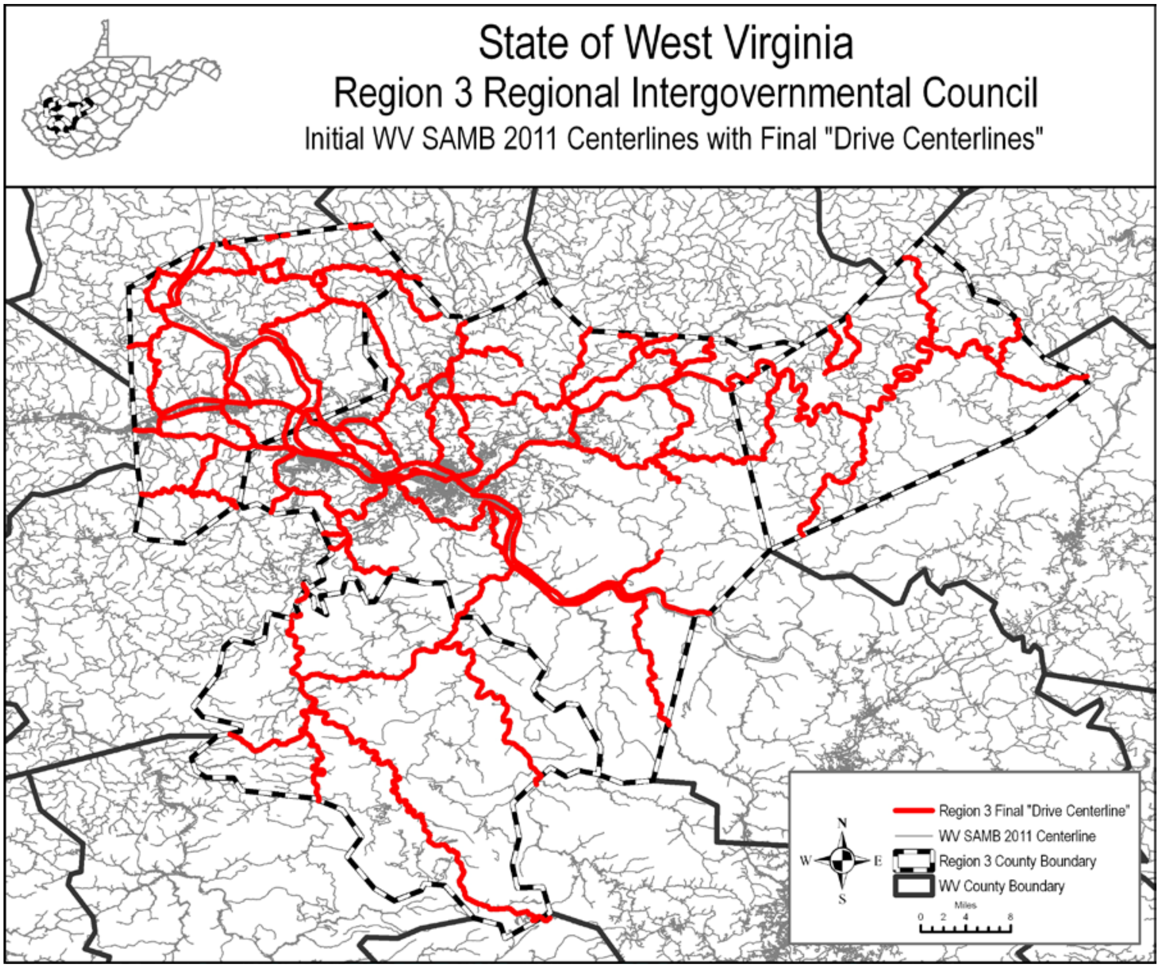

Figure 3—Roads Traveled During Drive-Testing

1.2.2 Speed Test Point Validation

There were a total of 26 speed test locations verified within Region 3.

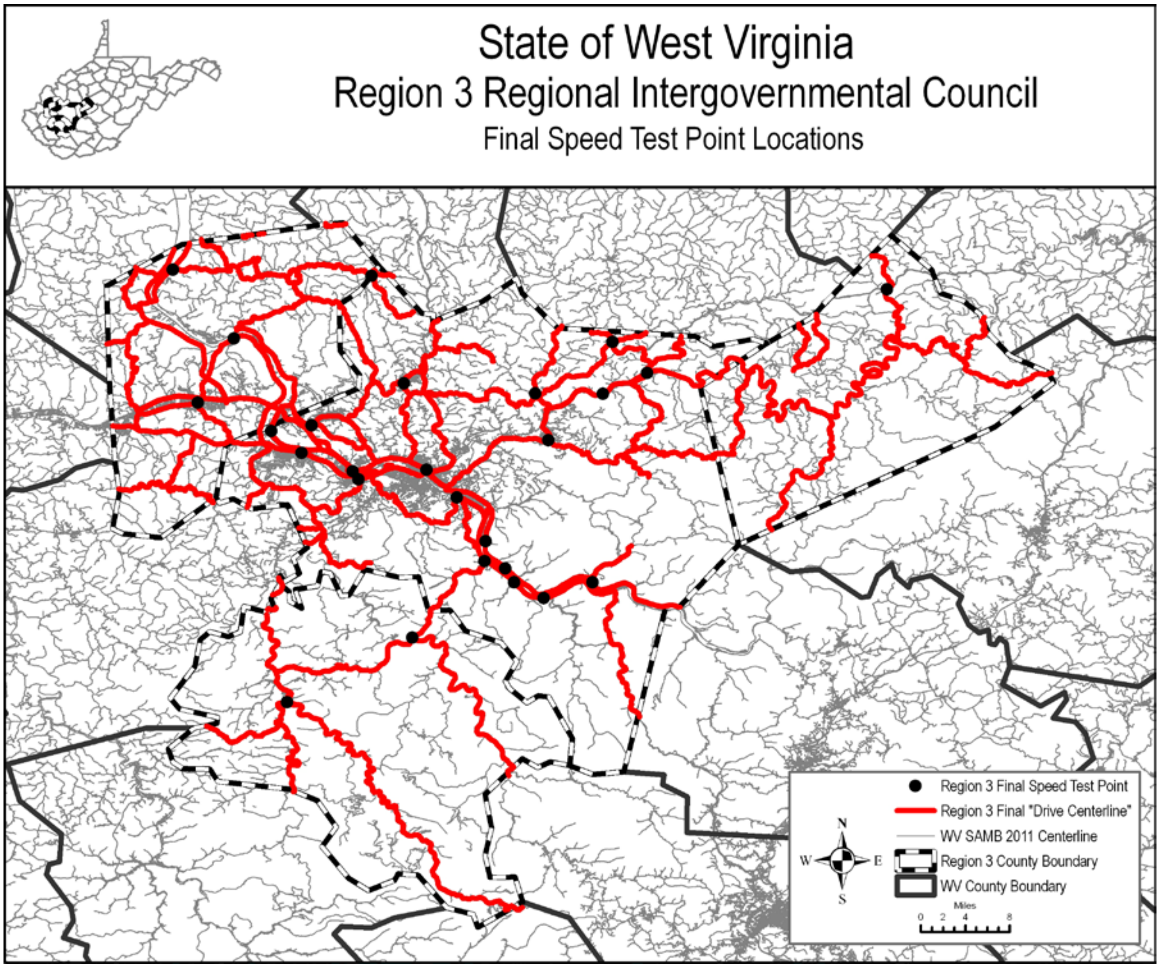

Figure 4—Final Speed Test Point Locations

2. TEST RESULTS

The drive-testing in Region 3 using smartphones was expected to show that good service exists in the urban areas and poor service in the rural areas of the region. In addition, it was expected that each of the providers being tested would have the service advertised in their NTIA submitted round 7 wireless coverage boundaries within the region. The QoS Software applications were user-friendly. It was easy to install the apps on the smartphones, and touching their icons on the screen opened them as expected. Analysis of the QoS Software application results involved the converting of .xml and .csv files into geodatabases and then making the appropriate comparisons.

2.1 QPerf Test Results

The QPerf application is a measure of carrier connectivity at specific locations, or speed test points. Data was uploaded to the QoS Website during the test. The data from the Website was downloaded as .csv files and converted into a geodatabase. The downstream and upstream speeds were then converted to the appropriate NTIA tier to match the Round 7 Wireless Coverage Polygons submitted by wireless providers as part of NTIA's Round 7 data collection effort. Analysis consisted of a location comparison, whereby the plotted locations of the test points were compared against their respective R7 coverage layer, as well as a comparison of the downstream and upstream speeds of the test points against the maximum speeds reported to the NTIA.

Reference Chart #2: Speed Tiers	
Code	Speed Tiers
1	Less than or equal to 200kbps
2	Greater than 200kbps and less than 768 kbps
3	Greater than or equal to 768kbps and less than 1.5 mbps
4	Greater than or equal to 1.5 mbps and less than 3 mbps
5	Greater than or equal to 3 mbps and less than 6 mbps
6	Greater than or equal to 6 mbps and less than 10 mbps
7	Greater than or equal to 10 mbps and less than 25 mbps
8	Greater than or equal to 25 mbps and less than 50 mbps
9	Greater than or equal to 50 mbps and less than 100 mbps
10	Greater than or equal to 100 mbps and less than 1 gbps
11	Greater than or equal to 1 gbps

Figure 5—NTIA Speed Tiers

2.1.1 AT&T QPerf Results

Of the 26 speed test point locations within Region 3, 24 were located within the Round 7 wireless coverage polygon submitted by AT&T and should have obtained QPerf speed test results. However, only 21 test points obtained results using the AT&T mobile network within Region 3, and all but one were within the AT&T submitted coverage polygon. Maximum advertised downstream values for the entire area are a value of four on the NTIA Speed Tier and maximum advertised upstream values for the entire area are a value of three on the NTIA Speed Tier. Of the 20 test points obtaining results within the submitted coverage polygon, 12 met or exceeded the maximum advertised value for downstream coverage and 14 met or exceeded the maximum advertised value for upstream coverage.

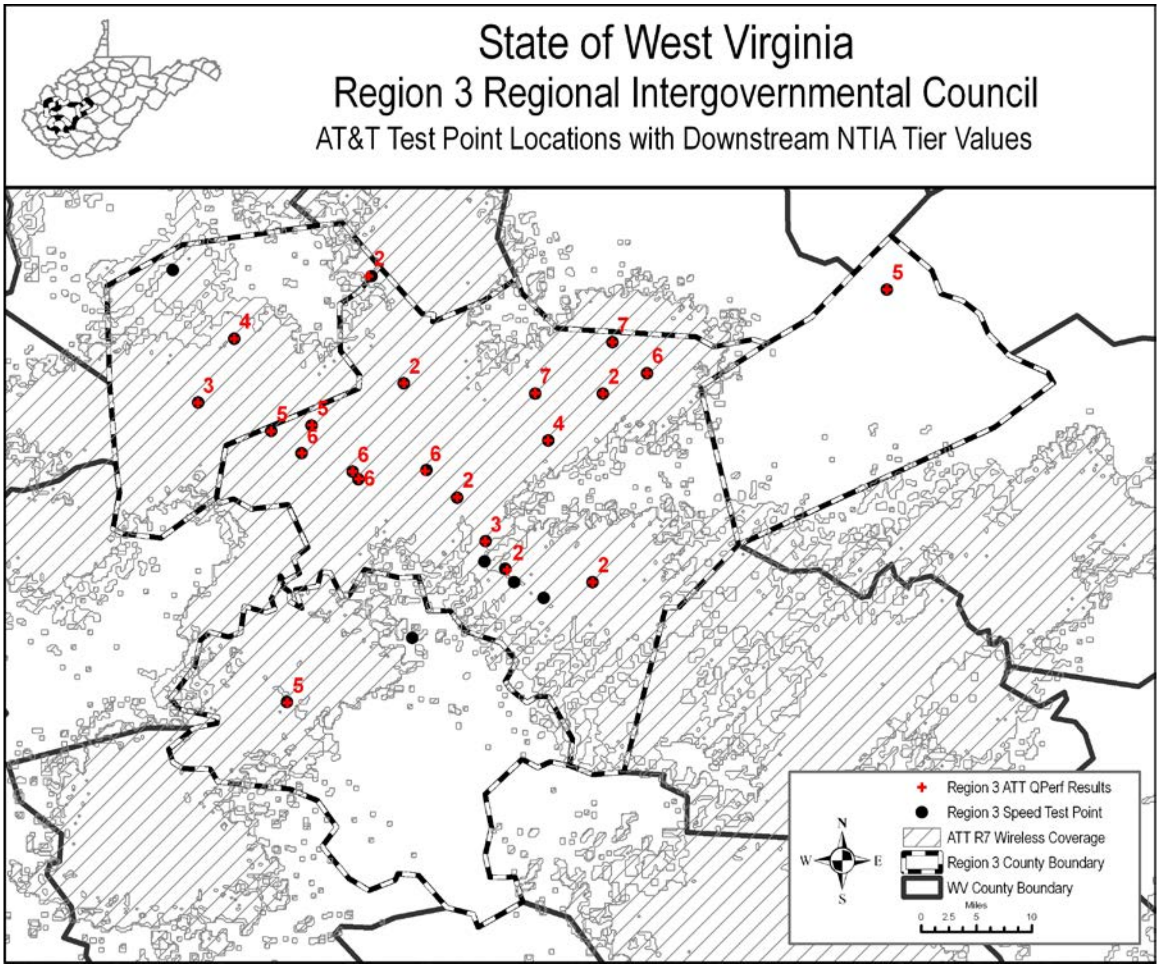

Figure 6—AT&T Downstream Speed Values

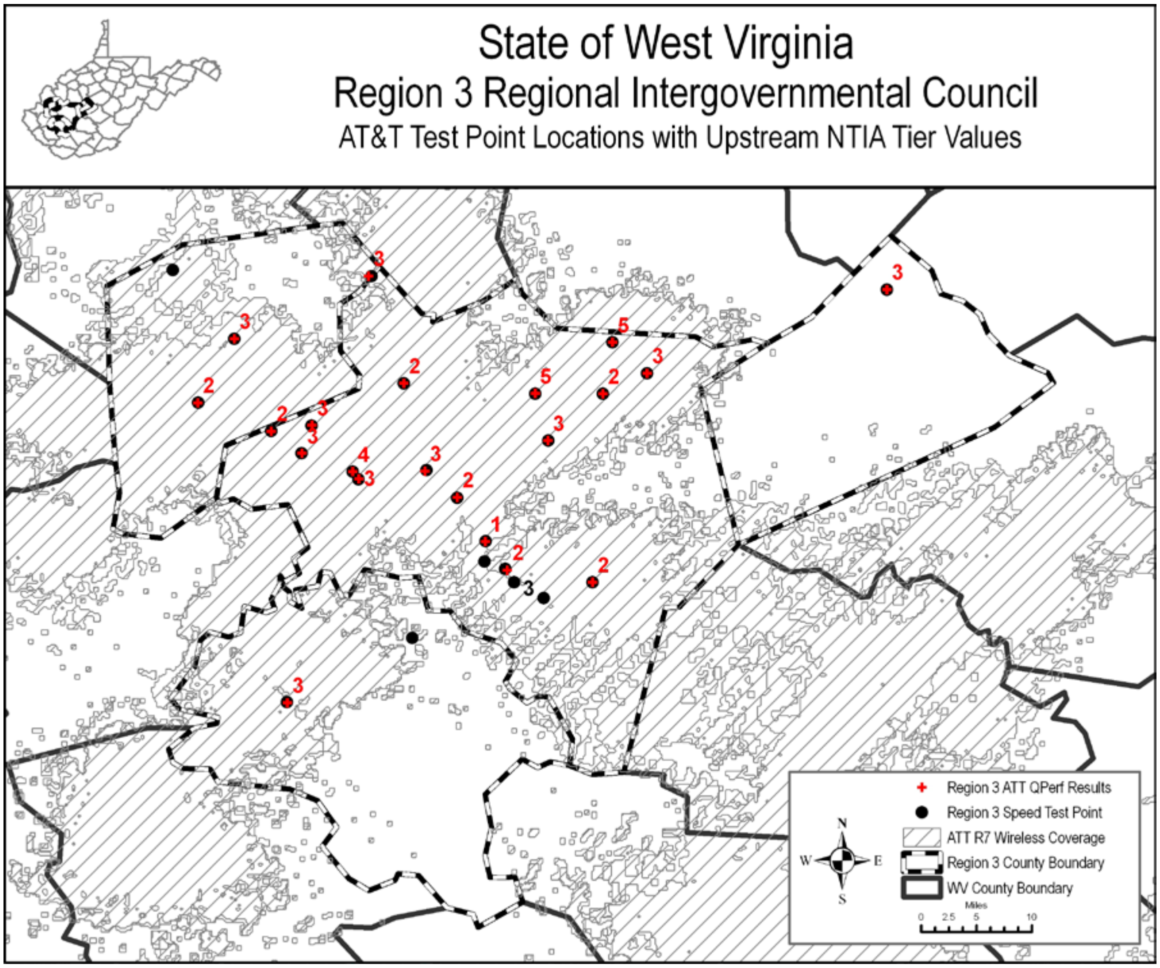

Figure 7—AT&T Upstream Speed Values

2.1.2 nTelos QPerf Results

Of the 26 speed test point locations within Region 3, 21 were located within the Round 7 wireless coverage polygon submitted by nTelos and should have obtained QPerf speed test results. However, only 17 test points obtained results using the nTelos mobile network within Region 3, and all but one were within the nTelos submitted coverage polygon. Maximum advertised downstream values for the entire area are a value of three on the NTIA Speed Tier and maximum advertised upstream values for the entire area are a value of two on the NTIA Speed Tier. Of the 16 test points obtaining results within the submitted coverage polygon, 13 met or exceeded the maximum advertised value for downstream coverage and 15 met or exceeded the maximum advertised value for upstream coverage.

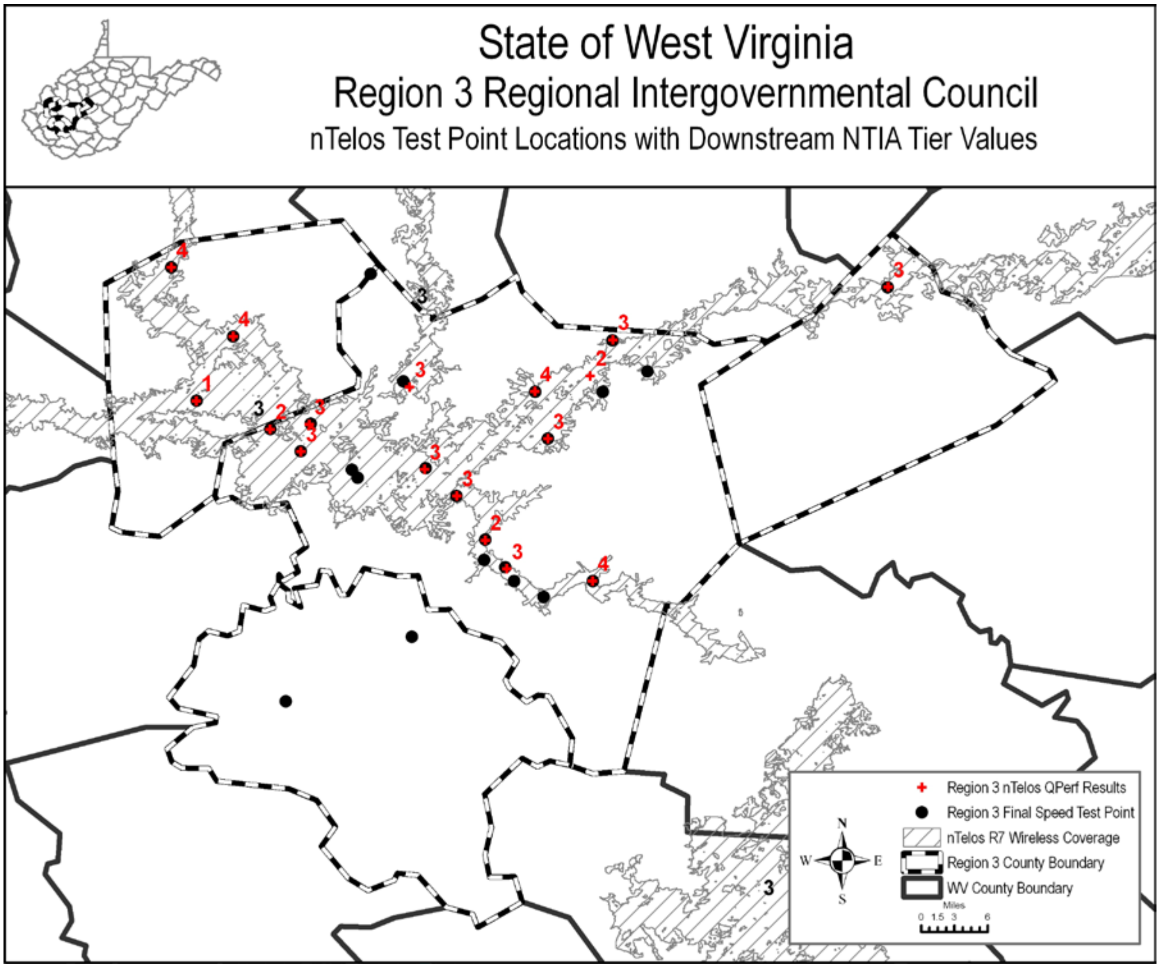

Figure 8—nTelos Downstream Speed Values

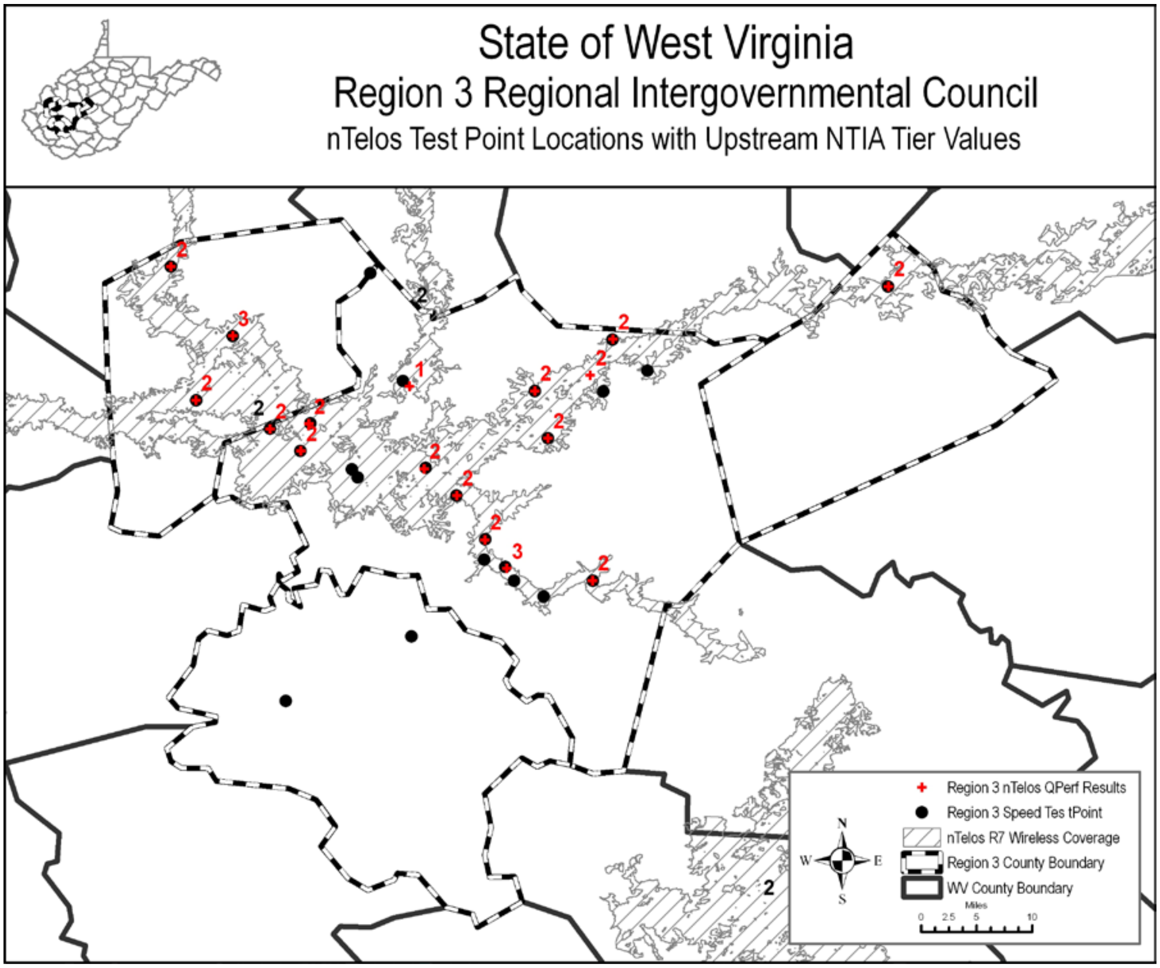

Figure 9—nTelos Upstream Speed Values

2.1.3 US Cellular QPerf Results

Of the 26 speed test point locations within Region 3, zero were located within the Round 7 wireless coverage polygon submitted by US Cellular. However, 22 test points obtained results using the US Cellular mobile network outside of the submitted US Cellular coverage polygon.

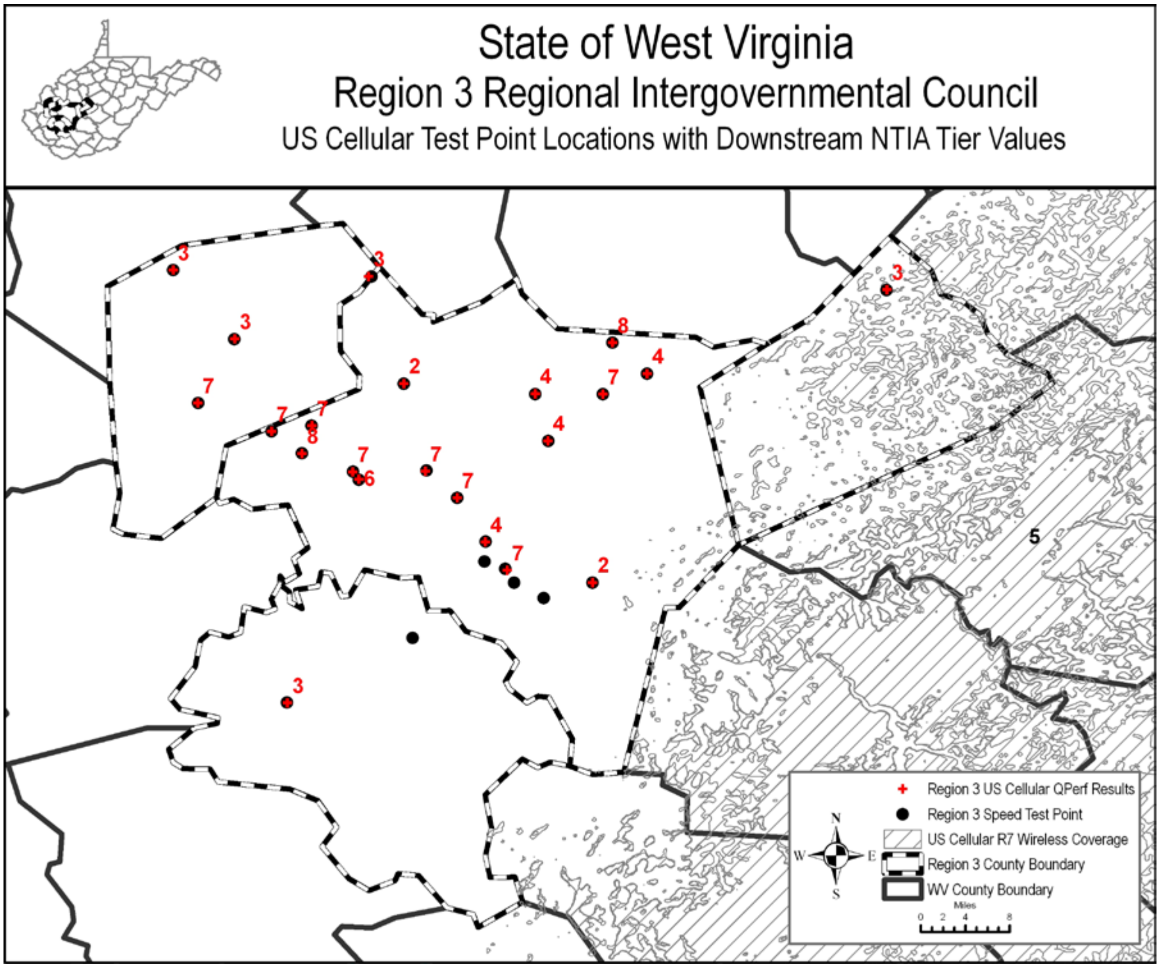

Figure 10—US Cellular Downstream Speed Values

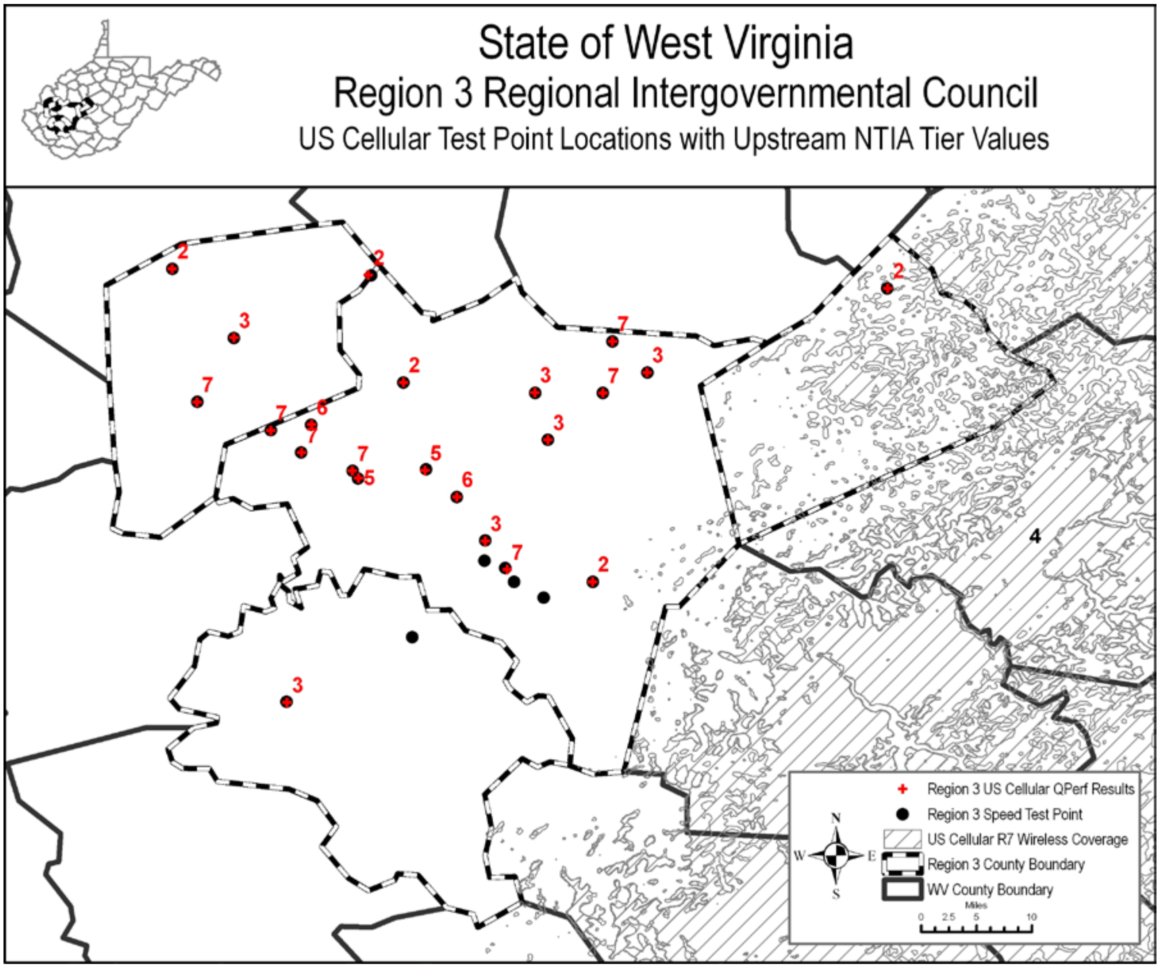

Figure 11—US Cellular Upstream Speed Values

2.1.4 Verizon QPerf Results

Of the 26 speed test point locations within Region 3, all were located within the Round 7 wireless coverage polygon submitted by Verizon and should have obtained QPerf speed test results. However, only 20 test points obtained results using the Verizon mobile network within Region 3, and all were within the Verizon submitted coverage polygon. Maximum advertised downstream values for the entire area are a value of three on the NTIA Speed Tier and maximum advertised upstream values for the entire area are a value of two on the NTIA Speed Tier. Of the 20 test points obtaining results within the submitted coverage polygon, 14 met or exceeded the maximum advertised value for downstream coverage and 19 met or exceeded the maximum advertised value for upstream coverage.

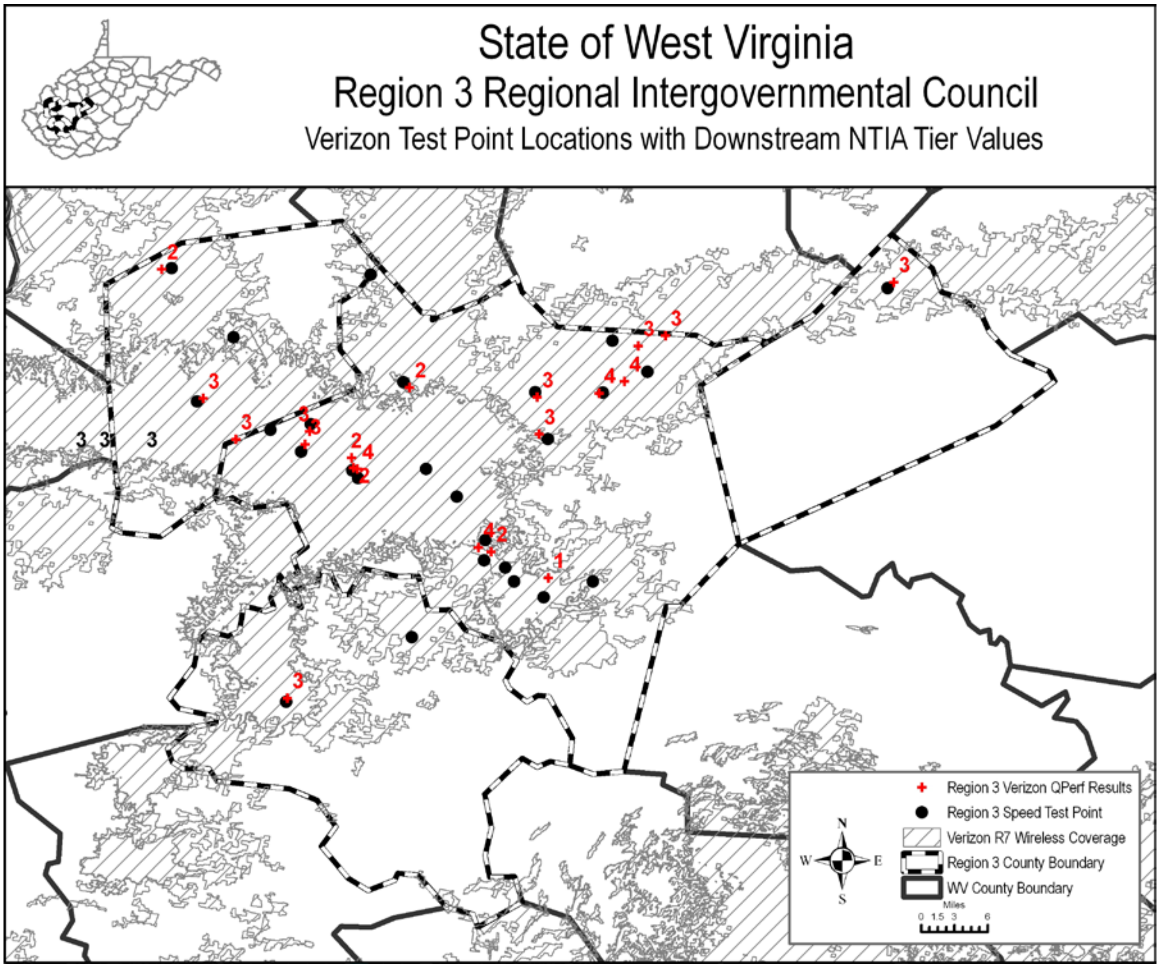

Figure 12—Verizon Downstream Speed Values

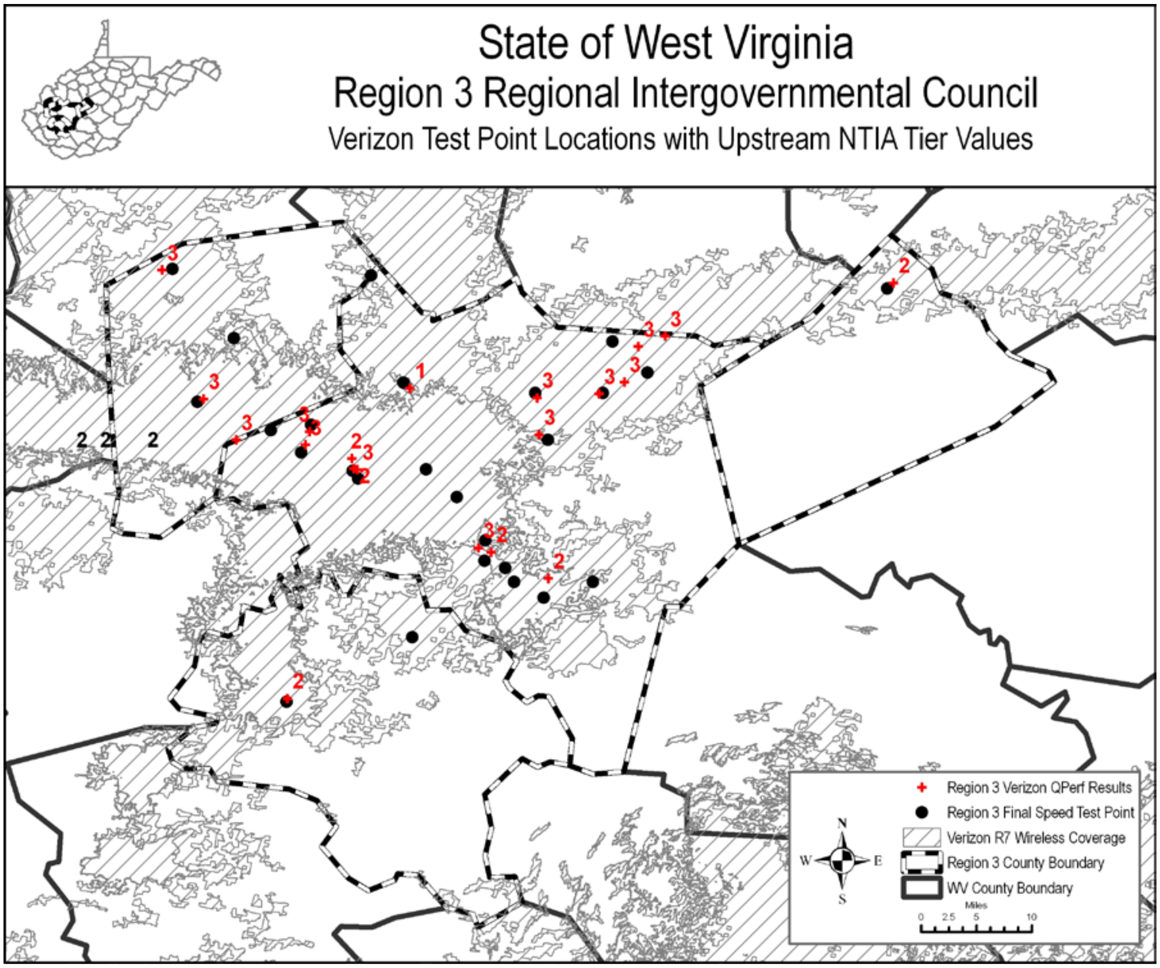

Figure 13—Verizon Upstream Speed Values

2.2 QCarrier Test Results

The QCarrier application is a measure of signal strength along the roads that were traveled during drive-testing. A record is created every 10 seconds or whenever the signal strength changes, and is stored in an .xml file directly on each phone. In general, it was found that there is acceptable coverage within the urban areas of the region and very limited coverage in the rural parts of the region for all carriers. Attributes used for analysis include the RSSI_DM field which is Received Signal Strength Indication, measured in DBm, and the EC/IO field, which is the signal strength relative to interference, measured in dB*10.

2.2.1 AT&T QCarrier Results

There were 19,015 points plotted within the AT&T network in Region 3. There were 3366 points that obtained no data, indicating no signal strength. The signal strength ranged from -51 to -113 DBm. There was no EC/IO data collected for these points, as AT&T uses a Global System for Mobile Communication (GSM), which does not measure this value. The final drive centerlines shown with no phone data overlaid indicate areas where the phone was not able to connect to a GPS satellite, had no cellular service, and was not able to track the location of the phone.

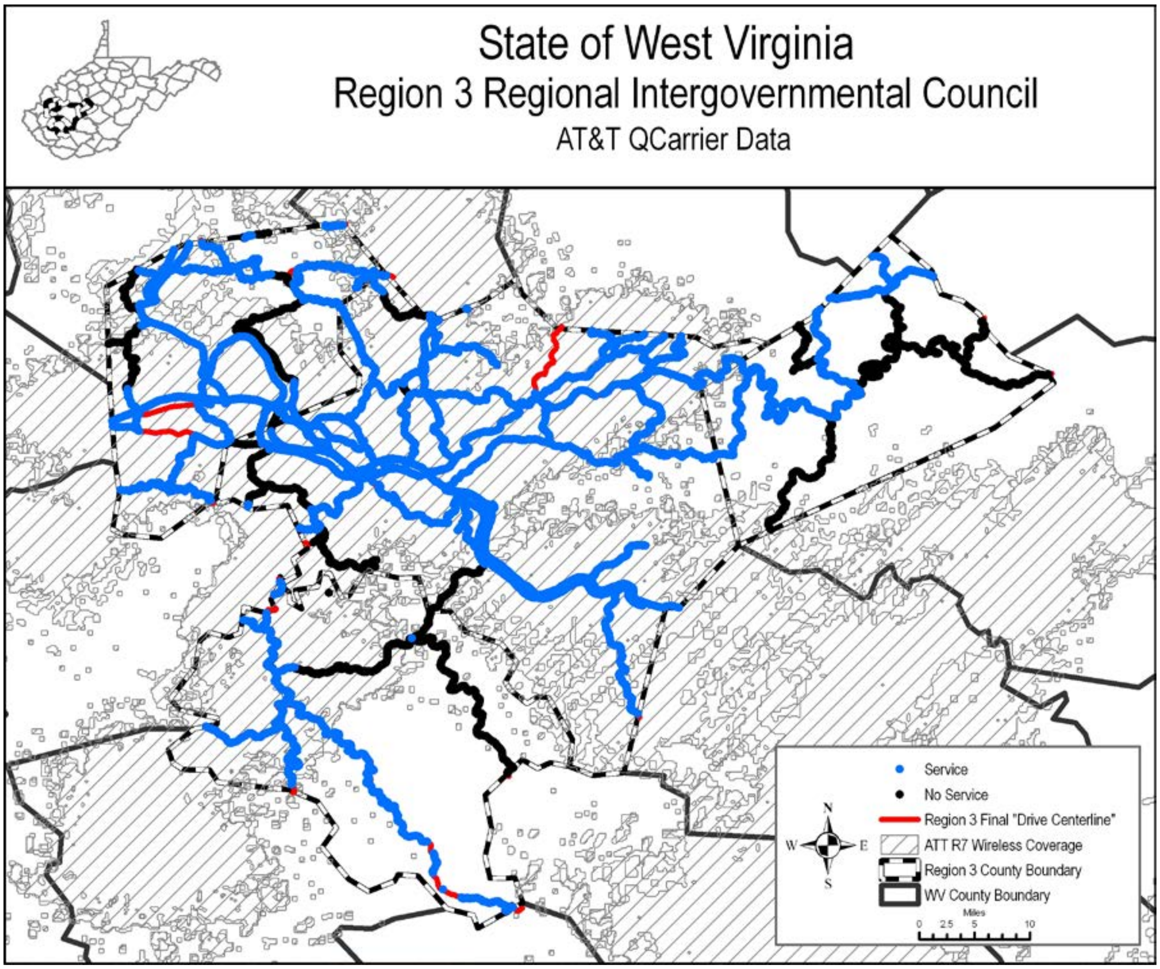

Figure 14—AT&T QCarrier Results, Based on RSSI_DM

2.2.2 nTelos QCarrier Results

There were 31,888 points plotted within the nTelos network in Region 3. The signal strength ranged from -53 to -105 DBm. The EC/IO data ranged from -90 to -160, with the majority of points falling at -160. This indicates areas where calls cannot connect, or calls are dropped constantly.[1] The final drive centerlines shown with no phone data overlaid

[1] http://www.telecomhall.com/what-is-ecio-and-ebno.aspx

indicate areas where the phone was not able to connect to a GPS satellite, had no cellular service, and was not able to track the location of the phone.

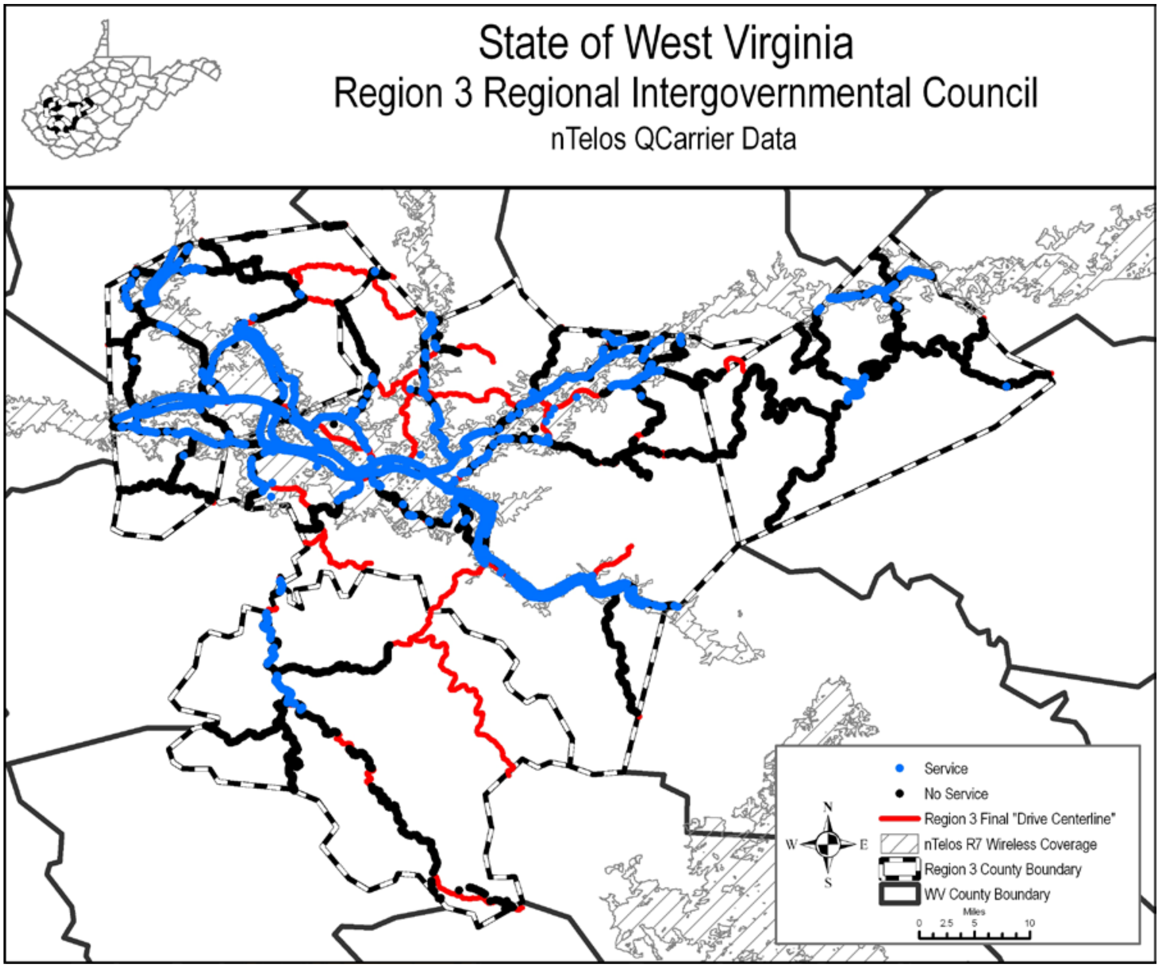

Figure 15—nTelos QCarrier Results, Based on EC/IO

2.2.3 US Cellular QCarrier Results

There were 14505 points plotted within the US Cellular network in Region 3. The signal strength ranged from -52 to -125 DBm. The EC/IO data ranged from -5 to -315. EC/IO data of -160 indicates areas where calls cannot connect, or calls are dropped constantly.[2] The final drive centerlines shown with no phone data overlaid indicate areas where

[2] http://www.telecomhall.com/what-is-ecio-and-ebno.aspx

the phone was not able to connect to a GPS satellite, had no cellular service, and was not able to track the location of the phone.

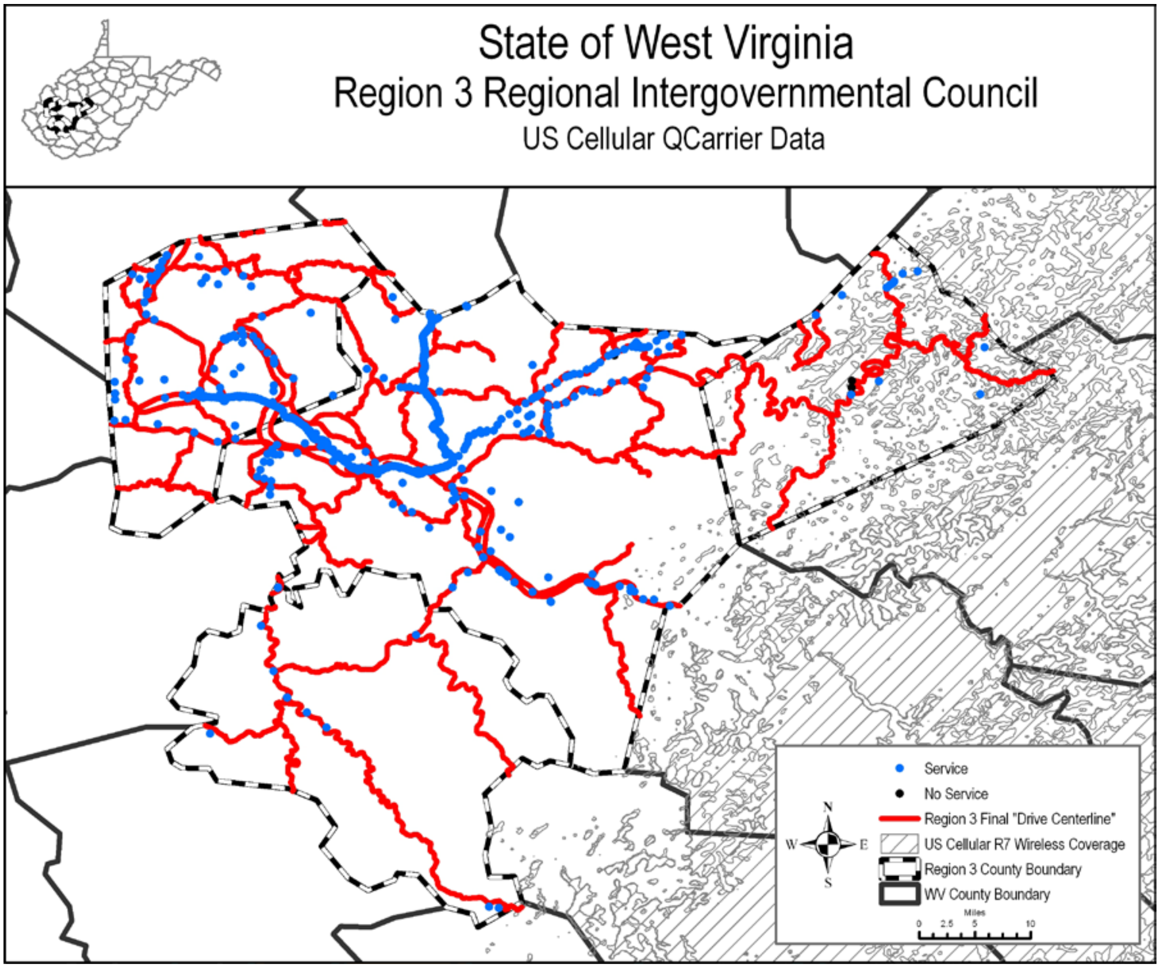

Figure 16—US Cellular QCarrier Results, Based on EC/IO

2.2.4 Verizon QCarrier Results

There were 20,606 points plotted within the Verizon network in Region 3. The signal strength ranged from -48 to -125 DBm. The EC/IO data ranged from -10 to -160. EC/IO data of -160 indicates areas where calls cannot connect, or calls are dropped constantly.[3] The final drive centerlines shown with no phone data overlaid indicate areas where the phone was not able to connect to a GPS satellite, had no cellular service, and was not able to track the location of the phone.

[3] http://www.telecomhall.com/what-is-ecio-and-ebno.aspx

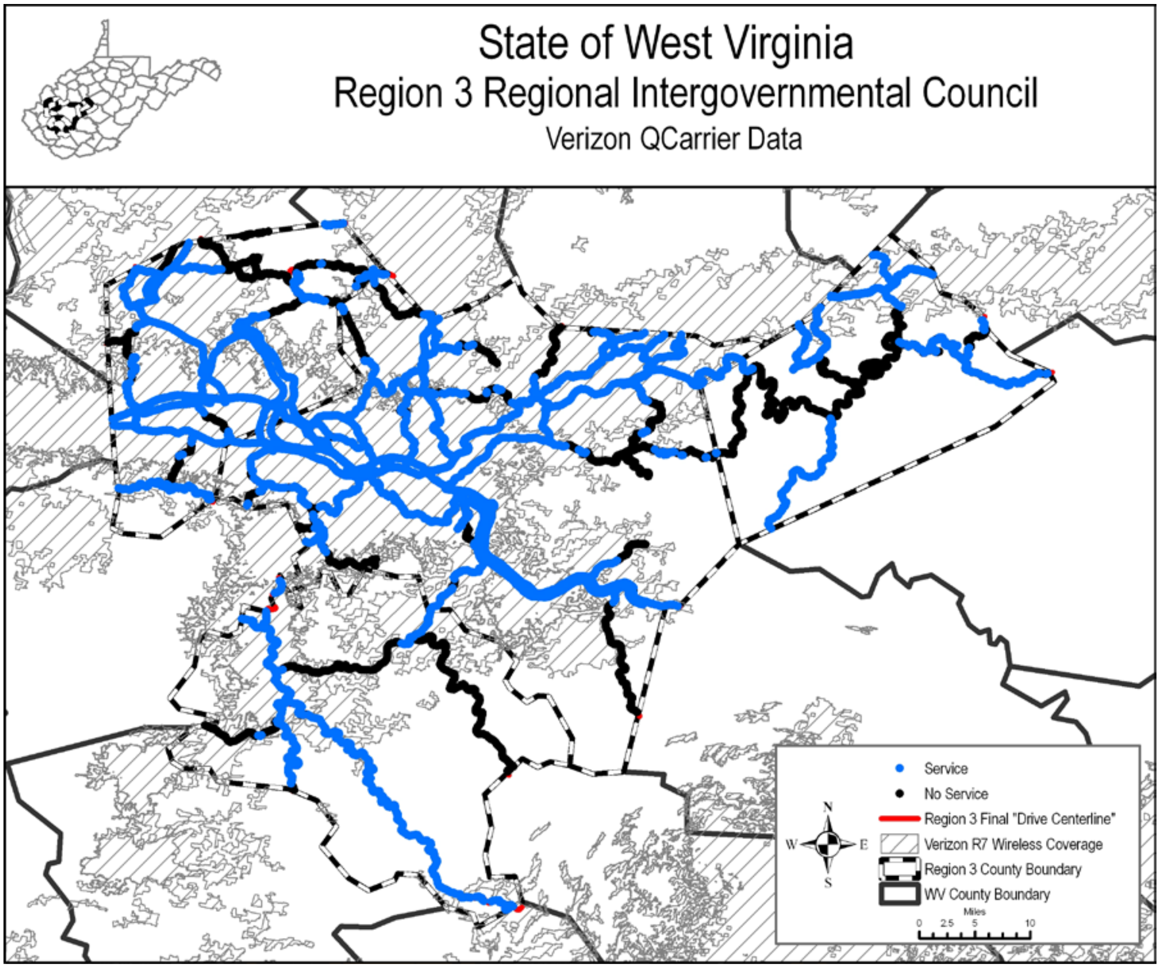

Figure 17—Verizon QCarrier Results, Based on EC/IO

2.3 West Virginia Broadband Mapping Survey Results

As requested by the Region, LR Kimball is providing a summary of participation results for the West Virginia Broadband Mapping Program's Broadband Survey program. Residents of West Virginia have been asked to provide feedback to the State regarding their broadband access. There are two surveys available. One is for broadband feedback, and one is to measure broadband speed at a specific location. The surveys are located at http://gis2.kimballdata.com/westvirginiaonline/WVBroadbandSurvey and http://gis2.kimballdata.com/westvirginiaonline/wvspeedtest. As of June 1, 2013, 272 residents participated in the survey by taking the broadband survey, 283 residents participated by taking the speed test and 142 residents provided user feedback through the broadband survey website. These results are on a statewide basis.

Region 3 had a total of 92 participants: 22 provided user feedback, 41 took the broadband survey and 29 took the speed test. Of the 22 residents providing user feedback, 15 indicated that the map shows that broadband is available, but in reality it is not available at their residence and two reported that they have broadband at their location even though the map does not indicate that broadband is available. The remaining five participants indicated "other." Providers listed for the broadband survey and speed test include AT&T, Citynet, Comcast, Frontier, Lumos, Suddenlink, Verizon and Wild Blue. The majority of residents indicated that they had poor broadband service at their residence/business. Comments include the following:

- I have been disappointed that the speed doesn't seem to be as high as advertised.
- Advertised speed of 3 mbps but seems to max out at 1.5 mbps. Have no other broadband provider (save HughesNet which is an inferior and expensive product). Would like to see cable expand or higher speed fiber lines in the area.
- All residents of Valley Grove and Hope Lane in Charleston would use Broadband if we were offered services.
- Although Frontier guarantees 75% of their advertised speed, I am not getting that speed and they refuse to deal with me on it. I plan to switch to another provider in July when my contract is up.
- Broadband technology and TV cable is not available in this area.
- Dial-up is my only choice.
- Frontier is the internet service we would use if it was available, it is less than three miles from me to the east and two miles to the west, they tell me there is a gap, I would love to know why they can't close the gap, this is a populated area.
- I'm very disappointed that Frontier is advertising high speed internet with speeds up to 12 Mbps and I'm receiving less than .5 Mbps.
- I currently have Hughes Net satellite service and it is very slow and expensive. I would like DSL or some other wired high speed provider.
- I have internet service (DSL) but according to prior statements by your council it doesn't fall into the Broadband arena because it is not able to achieve 4MBPS download speed. I think this effort is focused on businesses, schools and other areas.
- I mainly use my internet to work extra hours from home.
- I need to be able to work from home because I primarily telecommute. I must travel to another site that offers broadband in order to do my job. I pay for broadband at a relative's home in order to do my job.
- If the state government had not given the federal grant to Frontier, instead of having competition for the grant and providing requirements of state ownership of any facilities built with our tax dollars we would have been much better off.
- My family would use the service for all mentioned uses above, especially small business, entertainment, education and work from home.
- My neighbors and I have tried to get service at our locations but no one will provide us any help or information on when we might be provided with this much needed service. We have wide ranging reasons why we need this service.
- My service is bad. It goes on and off while I am trying to use it. It is so slow that you cannot watch video, but have to pay full price. Suddenlink will not run service because I am too far from their line.
- Please upgrade services so I can get high speed internet at a more affordable price. Satellite service is both expensive and slow.

- The only broadband available in my neighborhood is satellite. We hear that Frontier is planning to upgrade lines and offer broadband, but I don't think that will happen anytime soon.
- We're homeschoolers so while we use the internet for all kinds of things, education is the primary use here. After 4 long years of cellular and dial-up connections we are so happy to finally have broadband available in our current home.
- We are a community with several small businesses trying to keep up websites with dial-up connections....a virtual horror for our small businesses.
- We live in Kanawha County about 30 minutes drive from the state capital and have no affordable broadband connection available. This is a huge problem since almost everything is conducted over the internet these days.
- Without Broadband we are unable to take visa or debit card payments. This is something our customers ask about continuously.

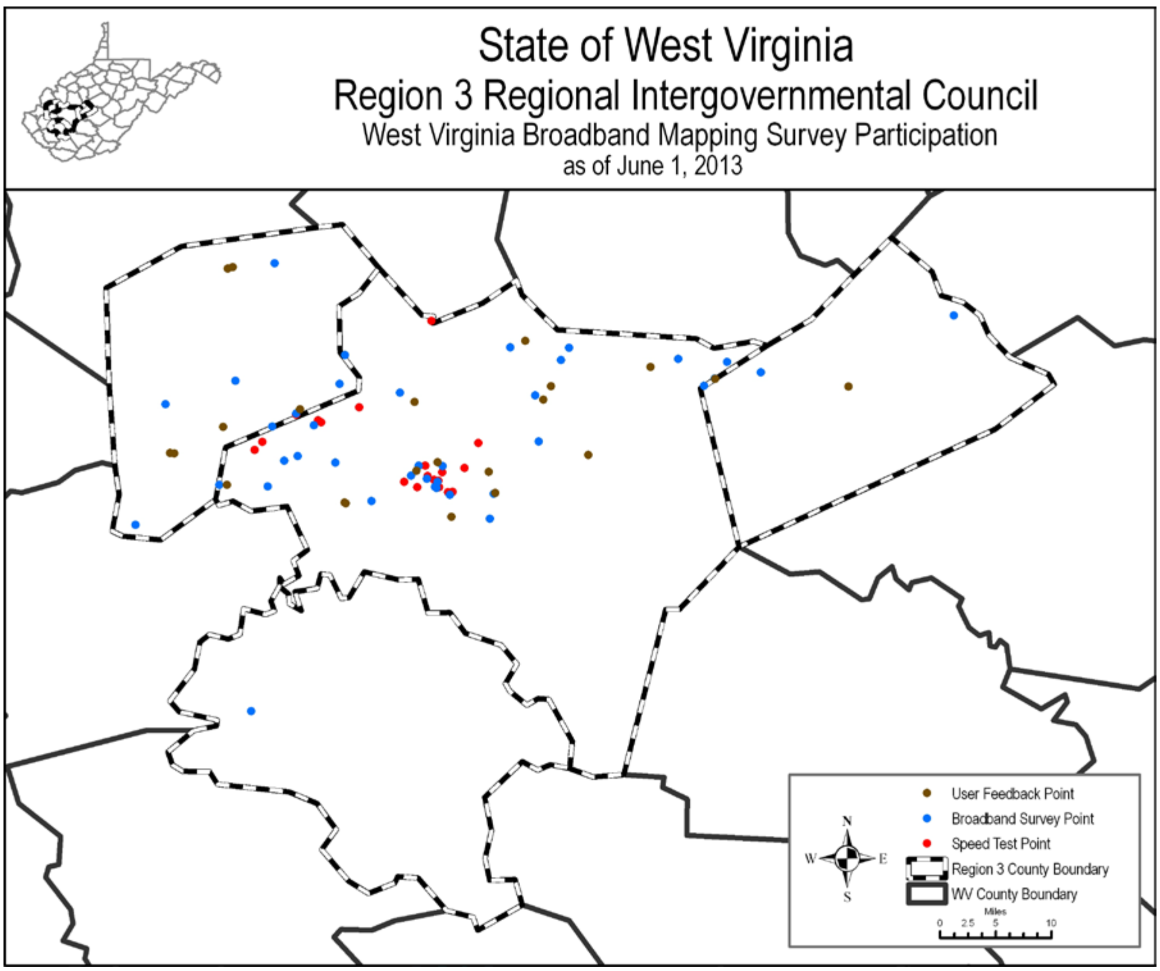

Figure 18—Broadband Survey Participant Locations

3. CONCLUSION

3.1 Carrier Connectivity

Carrier connectivity for the AT&T, nTelos and Verizon networks proved to exist as anticipated with good coverage in the urban areas and poor to non-existent coverage in the rural areas of Region 3, and the US Cellular network performed better than expected. AT&T, nTelos, and Verizon submitted acceptable designations of their coverage areas to the NTIA. US Cellular showed significant discrepancies in reported coverage boundaries for both the urban and rural areas of Region 3.

3.2 Recommendations

There are several areas within Region 3 having very limited cell carrier connectivity. Unfortunately, the topography and demographics of this area of West Virginia is not conducive to the efficient construction of additional cell towers, as it would be difficult to reach a large number of potential customers with one tower. However, it is recommended that the region continue to look at other possible broadband technologies to build out last mile capabilities for residents within the region. Broadband technologies are described in more detail in the following section.

One of the most noted comments by L.R. Kimball field technicians throughout their drive-testing within the State is the lack of appropriate road name signage. It is highly recommended that the regional councils encourage their participating counties to erect street signs at each intersection according to addressing standards once county SAMB addressing data has been verified and approved by the United States Postal Service. The “West Virginia E9-1-1 Addressing Reference Guide, Version 2.1” contains guidelines regarding road signage, and should be used for reference.[4]

It should also be noted that several of the roads traveled during the drive-testing were found to not be suitable for non-four-wheel-drive vehicle use. Some SAMB road classification may need to be reviewed in some areas over time to assure road classifications meet the road types for dispatching vehicles as it may be difficult for emergency vehicles to travel some of these rural roads. Travelers unfamiliar with some of these areas following GPS-given directions could find themselves in a challenging, potentially dangerous road situation if assuming a road is a certain road classification.

3.3 Broadband Technologies

This section will give a high level overview of the different types of bandwidth transport mediums and types of service providers available in the industry today.

3.3.1 Cable

The Cable TV providers throughout the country have migrated and grown to be much more than simply video programming providers. The cable providers are now providing cable internet speeds much faster than DSL, satellite

[4] http://www.dhsem.wv.gov/gis/Documents/reference%20guide.pdf

and dial-up. Another advantage is in discounts that can be realized by the end user through bundled service offerings. These bundled services usually offer TV, high speed internet access and phone services.

The transport method to the end user is typically using fiber optic cables from the head end office at the cable company to a common fiber node in the field which is then converted to coaxial cable to the end user's location. This technology, in conjunction with other elements in the network, allows for high speed internet access to be a reality. With this technology the bandwidth speeds realized can be up to 50 Mbps.

The cable providers are improving as time goes by but consumers are more likely to lose cable service before traditional telephone service. One reason for this may be due to the standards followed by cable providers when installing the outside plant facilities. Poor weather conditions can cause outages.

In areas such as West Virginia, high amounts of rock and granite tend to make the installation of such outside plant facilities expensive to construct, making the offering non cost-effective for the provider.

3.3.2 Fiber Optics

Fiber Optic technology is used by nearly all providers to deliver the voice, video, and data included with high speed internet access. A very high level description of fiber optic technology is an electronic signal (traditional) that is converted to an optical signal through an optical transmitter. This optical signal will transmit through the optical fiber to an end point. In some areas of the country, a few of the local exchange carriers such as Verizon and AT&T have optical service to their residents. Optical gear is expensive to purchase for large networks and the cost of construction, like all outside plants, tends to be expensive to deploy.

The following table and scenario is provided by http://www.lageman.com/bandwidth.htm.[5] Using a file size of 1,000,000,000.00 bytes (1,000.00 Megabytes) the following download speeds are projected using standard calculations and demonstrating bandwidth use with a T1 (1.5Mbps) as the standard. Notice the faster OC speeds are ideal for voice, video, applications mirroring, and disaster recovery hot sites because the speeds of mirroring systems are relatively instantaneous.

128 K	128,000 bps	17:21:40	91% slower
256 K	256,000 bps	8:40:50	83% slower
512K	512,000 bps	4:20:25	66% slower
768 K	768,000 bps	2:53:37	50% slower
T1, DS-1	1.544 Mbps	1:26:21	BASELINE
T3, DS-3	44.736 Mbps	2:59	2,748% faster
OC-3	115.520 Mbps	51	9,973% faster
OC-12	622.080 Mbps	13	40,191% faster
OC-48	2.488 Gbps	3	161,040% faster
OC-192	10 Gbps	1	647,569% faster

Figure 19—Typical Download Speeds Using Standard Mediums

[5] http://www.lageman.com/bandwidth.htm

3.3.3 Digital Subscriber Line

Where typically delivered by the Local Exchange Carriers (LEC), which provide very reliable services, there is normally very little downtime using Digital Subscriber Line (DSL). The DSL services provided by the LECs are competitive in price to other service providers in the same market segment. DSL can be purchased at different speeds up to a maximum speed. DSL can use a medium transport for data over the existing twisted pair cabling.

Advertised bandwidth speeds for DSL are good and much better than dial-up services. DSL is typically delivered by the LECs over twisted pair facilities which may limit the through-put speeds desired. Extremely fast speed may require other types of services such as Asymmetrical Digital Subscriber Line (ADSL) and Symmetrical Digital Subscriber Line (SDSL), T-1, T-3 etc.

3.3.4 Wireless

Wireless technology uses radio waves as a medium of communication.

With consideration to the remote locations attempting to be serviced http://www.broadband.gov describes wireless broadband in the following five bullets:[6]

- Wireless broadband connects a home or business to the Internet using a radio link between the customer's location and the service provider's facility. Wireless broadband can be mobile or fixed.

- Wireless technologies using longer-range directional equipment provide broadband service in remote or sparsely populated areas where DSL or cable modem service would be costly to provide. Speeds are generally comparable to DSL and cable modem. An external antenna is usually required.

- Wireless broadband Internet access services offered over fixed networks allow consumers to access the Internet from a fixed point while stationary and often require a direct line-of-sight between the wireless transmitter and receiver. These services have been offered using both licensed spectrum and unlicensed devices. For example, thousands of small Wireless Internet Services Providers (WISPs) provide such wireless broadband at speeds of around one Mbps using unlicensed devices, often in rural areas not served by cable or wireline broadband networks.

- Wireless Local Area Networks (WLANs) provide wireless broadband access over shorter distances and are often used to extend the reach of a "last-mile" wireline or fixed wireless broadband connection within a home, building, or campus environment. Wi-Fi networks use unlicensed devices and can be designed for private access within a home or business, or be used for public Internet access at "hot spots" such as restaurants, coffee shops, hotels, airports, convention centers, and city parks.

- Mobile wireless broadband services are also becoming available from mobile telephone service providers and others. These services are generally appropriate for highly-mobile customers and require a special PC

[6] http://www.broadband.gov/broadband_types.html#wireless

card with a built in antenna that plugs into a user's laptop computer. Generally, they provide lower speeds, in the range of several hundred Kbps.

3.3.4.1 Cellular

Cellular Internet service is based on a cellular architecture that consists of a backbone network with fixed base stations interconnected through the wired public switched telephone network (PSTN).

3.3.4.2 Satellite

Satellite access is another type of wireless transport.

One should consider that satellite communications can be highly affected by atmospheric conditions as well as severe weather. Intermittent and sporadic interruptions are very possible.

Lower orbiting satellites are used today to provide many services to our population such as (but not limited to) communications and video transmission. Satellite broadband is also a key element in providing necessary links for delivering access to the end user. Although faster than dial-up one could realize speeds of 500 Kbps downstream and 80 to 100 Kbps upstream.

3.3.4.3 WiMAX

The network WiMAX is known as Worldwide Interoperability for Microwave Access and known to the technical community as IEEE, 802.16 (WiMAX). WiMAX is thought by many to be the technology that will deliver access to the majority of the population in the near future. WiMAX is an option when considering the last mile connection to the end user.

The data rates are 30 to 70 Mbps. A 30 mile radius for access is possible. WiMAX provides qua broadband access and has a very high penetrability, in that the microwaves it emits can be accessed by nearly every point in its coverage area. Access is from fixed or mobile devices, desktops at home or work, smart phones etc. VoIP is possible as well.

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APPENDIX A—QOS SOLUTIONS ANDROID APPLICATIONS

The QoS Solutions Android Applications can be found on the following pages.

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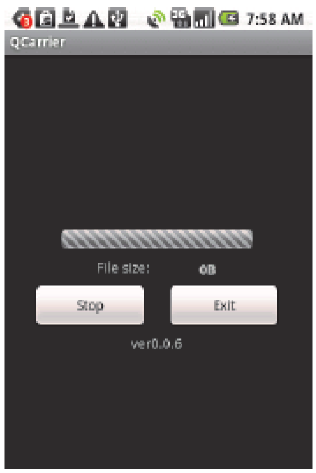
Instructions for Running QoS Solutions Android Applications

The applications will be sent to you as attachments in an email from qos-solutions.com or from your account administrator.

Please review the Download and Installations Document for further information.

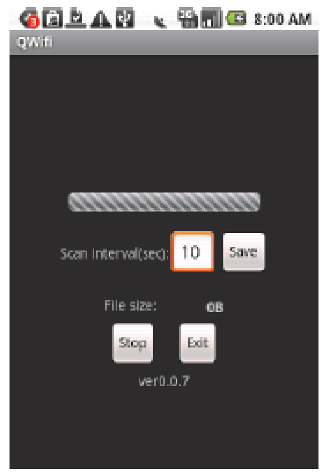
QCarrier

QCarrier will automatically create a file each time it starts on the SD Card of your phone. The app will automatically create records every 10 seconds or whenever the signal changes. The file size will not show up until the file exceeds 1MB.



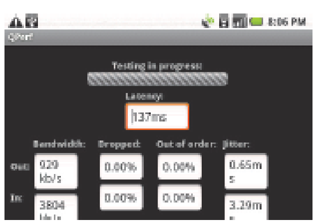
QWiFi

QWiFi is designed for locating and recording WiFi services. It also creates a file on the SD card each time it starts.



QPerf

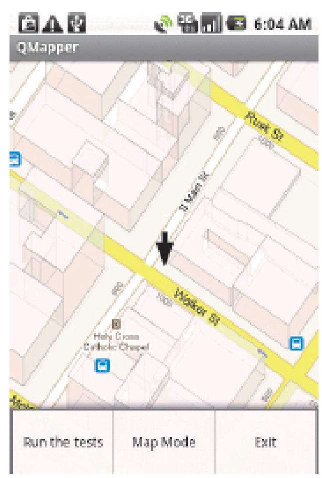
QPerf is designed to measure the carriers connectivity. It is recommended that you hit the Menu Button and turn off WiFi so that you measure the carrier's performance and not WiFi. You should remain in the same location until it completes.



QPerf will run every 5 minutes until you stop or exit the program. QPerf does not record any data locally. All data is sent to the QoS website for downloading.

QMapper

QMapper is designed for those locations such as downtown locations where GPS is unreliable. The application will download a map so that you can pinpoint your exact location and run any or all of the tests such as QCarrier, QWiFi and QPerf.



Q Carrier	
Field	Description
accuracy	accuracy of the fix in meters
carrier_cid	cell id in GSM, UNKNOWN_CID if in UMTS or CDMA
carrier_lac	Location Area Code in GSM, UNKNOWN_CID if in UMTS or CMDA
date_stamp_date	They calendar day of the measurement..
date_stamp_hours	The hour of the measurement.
date_stamp_minutes	The minutes into the hour of the measurement.
date_stamp_month	The numeric month of the measurement.
date_stamp_seconds	The seconds into the minute of the measurement.
date_stamp_time_zone	The time zone (hours +/- GMT) of the measurement.
date_stamp_year	The year of the measurement.
latitude	Phone latitude
longitude	Phone longitude
newtwork_type	The carrier type of network
phone_type	CDMA or GSM
remote_id	The IMEI of the phone
signal_level	The strength of the signal, measured in either RSSI (for GSM phones) or dbm (for CDMA and EVDO) phones
sim_operator_name	Provider name
Phone_Name	MBI Calculated field

Route	MBI Calculated field

Q Perf	
Field	Description
Timestamp	Date and Time from QPerf.
_Location	The phone that data was gathered from.
_Internal_IP	In a NAT environment, this is the IP address of the device which would be different from the External IP
_External_IP	This is the IP address of the device as seen from the internet
_Latitude	Phone Latitude
_Longitude	Phone Longitude
_Inbound_Jitter__msecs	This is a measure of the variance in interarrival packet delays calculated according to RFC 1889
_Inbound_Dropped___	Packets dropped from server to phone.
_Inbound_Out_of_Order___	Packets which arrived at phone not in the order sent from server
_Outbound_Latency__msecs	This is calculated as the average round trip time of a set of UDP packets sent to the server and returned to the device.
_Outbound_Jitter_msecs	This is a measure of the variance in interarrival packet delays calculated according to RFC 1889
_Outbound_Dropped___	Packets dropped from phone to server.
_Outbound_Out_of_Order___	Packets which arrived at server in not in the order sent from phone
_Inbound_Bandwidth_kbps_	This is calculated using the total number of data bytes received * 8 / time to completion
_Outbound_Bandwidth_kbps_	See above
_Target	Qperf.net
_UDP_TOS_	These settings are available in the NetQualtiy Analyzer to enable testing based on TOS Values typically used in carrier MPLS networks for prioritizing traffic
_TCP_TOS	See above
Provider	MBI Calculated field

Route	MBI Calculated field
YEAR	MBI Calculated field
MONTH	MBI Calculated field
DAY	MBI Calculated field
MINUTES	MBI Calculated field
HOUR	MBI Calculated field
Upstream_Req_Met	MBI Calculated field. Value is 1 if the [_Outbound_Bandwidth_kbps_] value greater than 200
Downstream_Req_Met	MBI Calculated field. Value is 1 if the [_Inbound_Bandwidth_kbps_] value greater than 786

Q Wifi	
Field	Description
hours	Timestamp Hours
minutes	Timestamp Minutes
Seconds	Timestamp Seconds
time_zone	Time Zone of Phone
Remote_iD	Phone IMEI
latitude	Latitude in Degrees
longitude	Lontitude in Degrees
accuracy	Accuracy of GPS fix in meters
ssid_name	SSID Name
ssid_id	Numeric ID of SSID
ssid_capabilities	SSID Capabilities
ssid_frequency	SSID Frequency
ssid_level	The detected signal level in dBm