BEAD/CPF

Perspective

State of the States : broadband mapping initiatives at the state level

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Introduction

Congress has launched a number of initiatives aimed at accelerating the rate of broadband deployment in the United States. These include $65 billion in broadband funding in the Infrastructure Investment and Jobs Act (IIJA) and $10 billion in the Capital Projects Fund (CPF) of the American Rescue Plan (ARP). The IIJA includes $42.45 billion in Broadband Equity Access and Deployment (BEAD) funds.

CPF funds can be used by states and territories for broadband planning and deployment or for a small number of other critical needs. The Broadband Deployment Accuracy and Technology Availability (DATA) Act – another initiative – gives the FCC improved tools for measuring broadband deployment and identifying areas of need.

Most of the IIJA/BEAD and CPF funds will go directly to states and territories. Every state and territory will need to produce a strategic plan to guide its use of funds.

A key question for a state or territory is how they will allocate the funds. The BEAD Notice of Funding Opportunity (NOFO) provides detailed guidelines but still allows broad discretion.

The FCC collects broadband deployment data via form 477. The results are sometimes viewed as an overly optimistic perspective of the state of state of broadband deployment (more on that in a few pages). The Broadband DATA Act seeks to address these concerns by capturing deployment data with greater granularity. Its future results will provide a baseline for BEAD decision-making.

A key question is "What are individual states doing in data mapping?" Many have state maps visualizing form 477 data, often alongside other data sources. Many states engage universities or not-for-profit organizations in the effort. Some require broadband providers in their state to submit coverage data directly to the state. The state analyzes the data then sometimes publishes it ahead of the FCC's Form 477 release cycle. A small number of states collect broadband speed test data directly from consumers and businesses. A portion of those states make the data (not just a map) available to the public.

Showcasing Two Exemplary States

This whitepaper examines two noteworthy programs that collect and release data, showing what they collect, how they collect it, and what insights such data can provide. Specifically:

- *North Carolina* collects crowd-sourced speed test data and – importantly – makes it available to the public. North Carolina, a state with a population of 10.6 million, has collected 109,000 speed tests. Each measurement is timestamped and geolocated with a latitude and longitude (many to the rooftop). Each measures download speed, upload speed, latency, and jitter. As the reader will see this basic information enables a robust discussion of broadband service quality. The survey was developed by a team headed by Ray Zeisz at the Friday Institute at NC State University.

  Beyond conducting speed tests North Carolina asks questions about broadband decision-making, as shown in the survey instrument and in the detailed field descriptions. The survey asks about technology options (wired, wireless), service providers, service pricing, device/operating system, and the

Figure 1: North Carolina base map with county boundaries

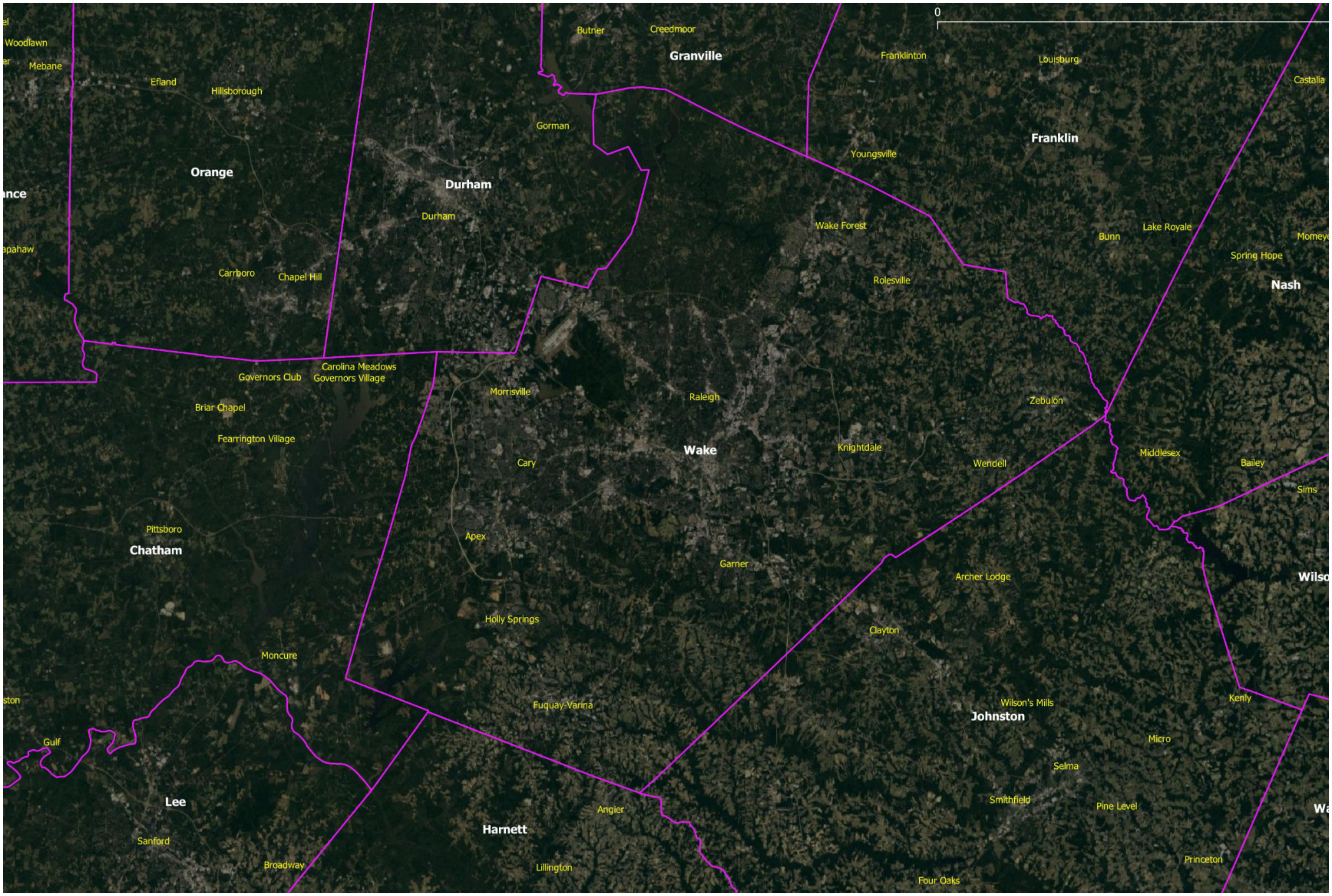
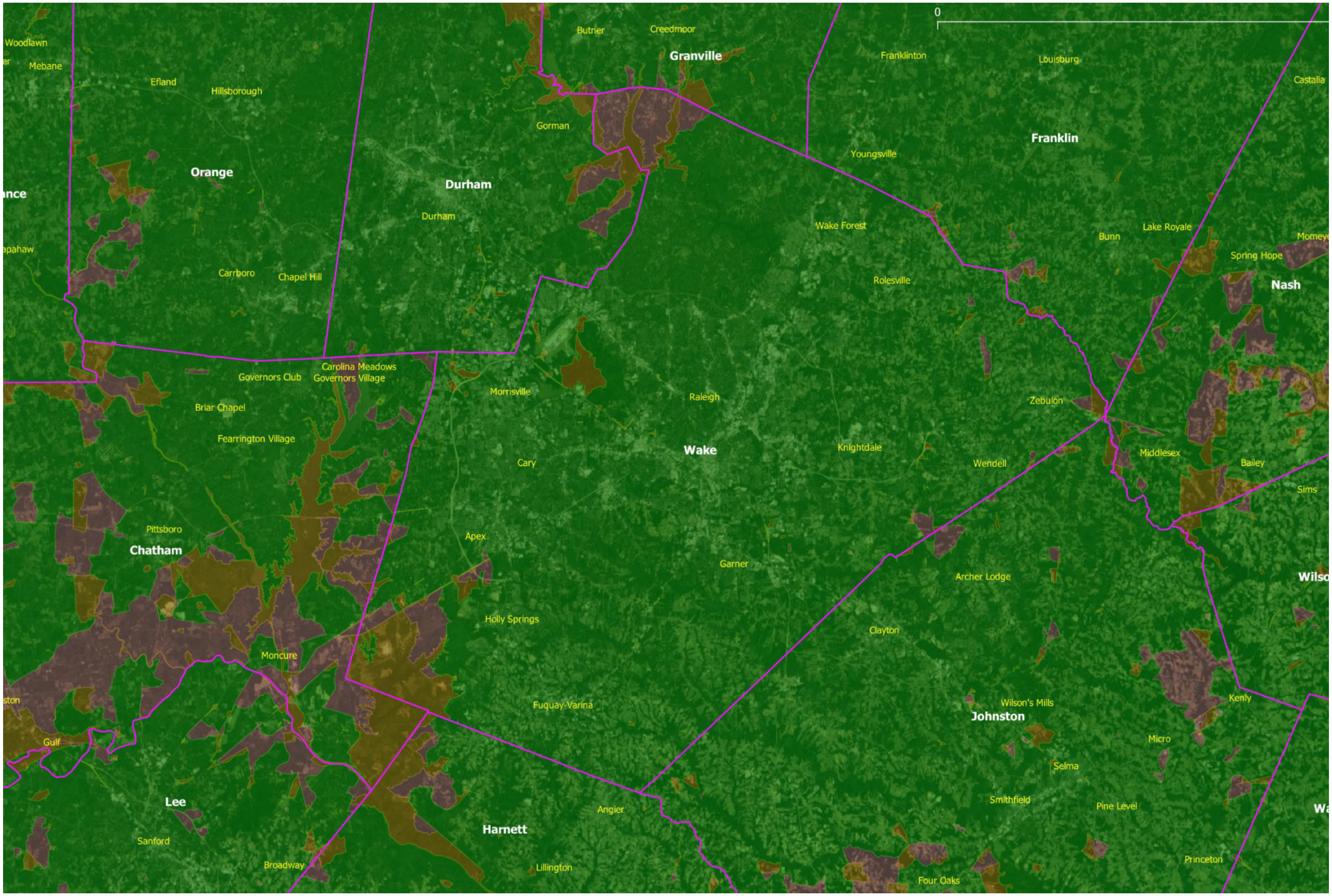


Figure 2: FCC form 477 data: qualifying 100-20 Mbps (bright green), underserved 25-3 Mbps (salmon), and unserved (mustard) blocks



multitude of factors including broadband decision-making. The overall process also includes a phone survey to get feedback from those without internet access.

North Carolina's approach is powerful because it correlates behavioral information (what people decided and why) with measured performance.

- *Georgia* collects detailed coverage data from broadband providers, using a process that mirrors the future process of the FCC under the Broadband DATA Act. Georgia created a "fabric" of locations, using commercial and other sources, invested in "cleaning" the data (a time-consuming task), then asked each broadband provider to map their network coverage against those specific locations. The dialogue with each broadband provider was often iterative. The State then published a set of block-level results, showing each block as "Served", "Unserved", or "No Locations". The data set shows the number of served and unserved locations within each census block, so a user of the published data can calculate an exact ratio. In the June, 2022 release "Served" was defined as 25 Mbps / 3 Mbps service to 80 percent or more of the locations within the census. Future releases will change the performance threshold to 100 Mbps / 20 Mbps, consistent with the BEAD definition. Georgia has an elegant "slider" that lets the user compare coverage based on 477 data to coverage based on the findings of their state study.

  The data used internally by the State of Georgia is more granular than the data released to the public. Eric McRae of the University of Georgia, who spearheads the mapping portion of the program, summarized the effort on a Broadband Breakfast webinar on February 2nd, 2022.

Between North Carolina and Georgia we see the two fundamental approaches to analyzing broadband availability. The first measures the end user experience. The second measures the stated performance of deployed networks based on data reported by ISPs. Each process has its strengths and weaknesses. Using the two in combination is particularly powerful.

Exploring the Data

Before discussing each approach conceptually it may be helpful to see some results.

North Carolina results are visualized in the following figures:

- Figure 1. A Google earth base map with county lines, showing Wake County (with Raleigh, the state capital) and several surrounding counties. This map includes areas with very different qualities of broadband service.

- Figure 2. FCC Form 477 data, visualized as "qualifying" broadband (100 Mbps / 20 Mbps), underserved (25 Mbps / 3 Mbps, but less than qualifying), or unserved (less than 25 Mbps / 3 Mbps).

- Figure 3. Tract level results, showing the percentage of qualifying (100 Mbps / 20 Mbps) speed tests. The summary statistic is shown as a number and as a color (red to yellow to green, representing 0% to 100%).

- Figure 4. Tract level results, showing, as a color, the percentage of qualifying (100 Mbps / 20 Mbps) speed tests and as a number the median download and upload speeds for the tract. The percentage of qualifying speed tests and

Figure 3: Percentage of qualifying (100-20 Mbps) data points, by tract, from red (0%) to green (100%)

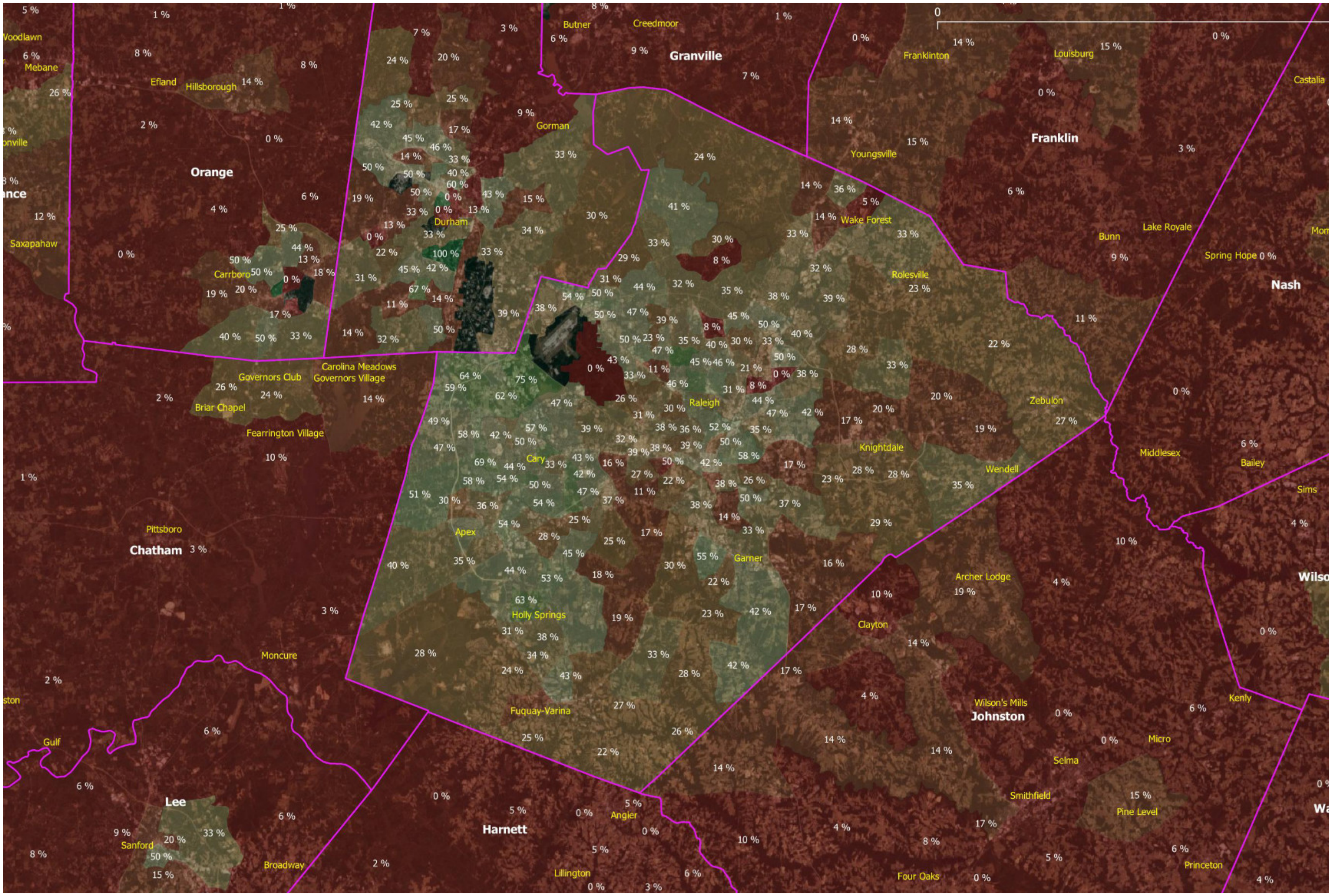


Figure 4: Percentage of qualifying data points, by tract, from red (0%) to green (100%), with download-upload speeds

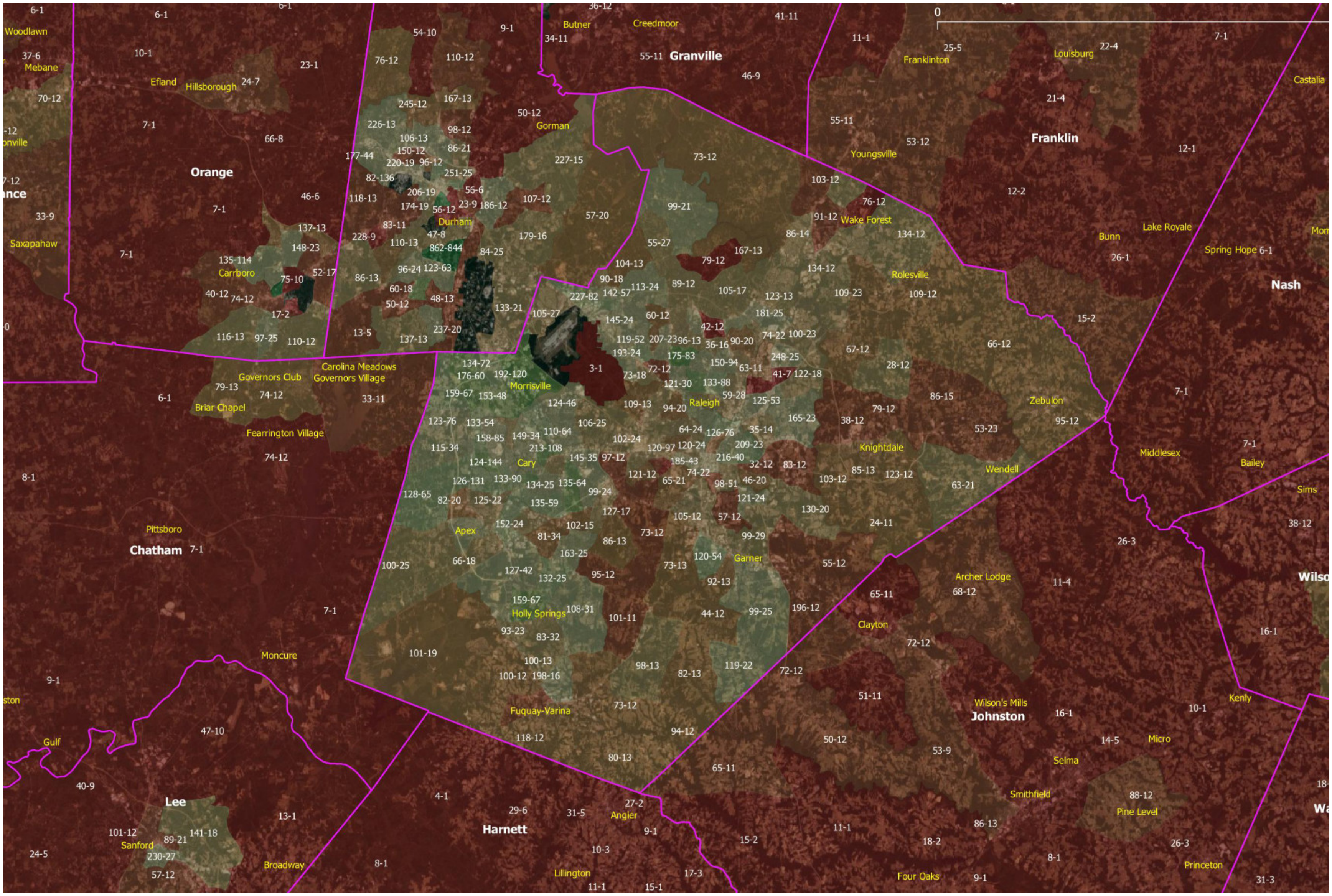


Figure 5: Block-level results (bright green = qualifying, salmon = underserved, mustard = unserved, clear = no data)

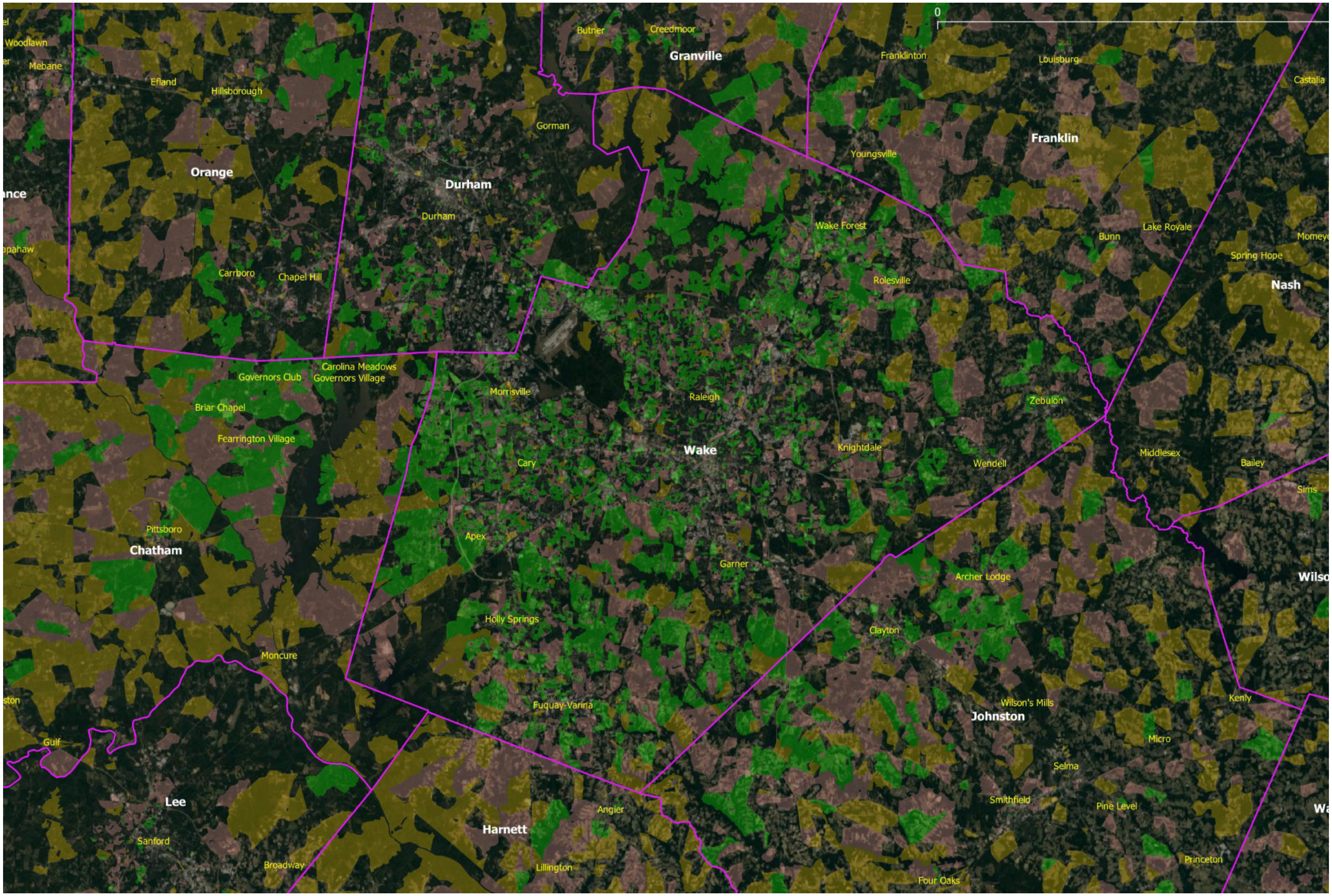


Figure 6: Individual data points, color coded to reflect performance (bright green = qualifying, salmon = underserved, mustard = unserved)

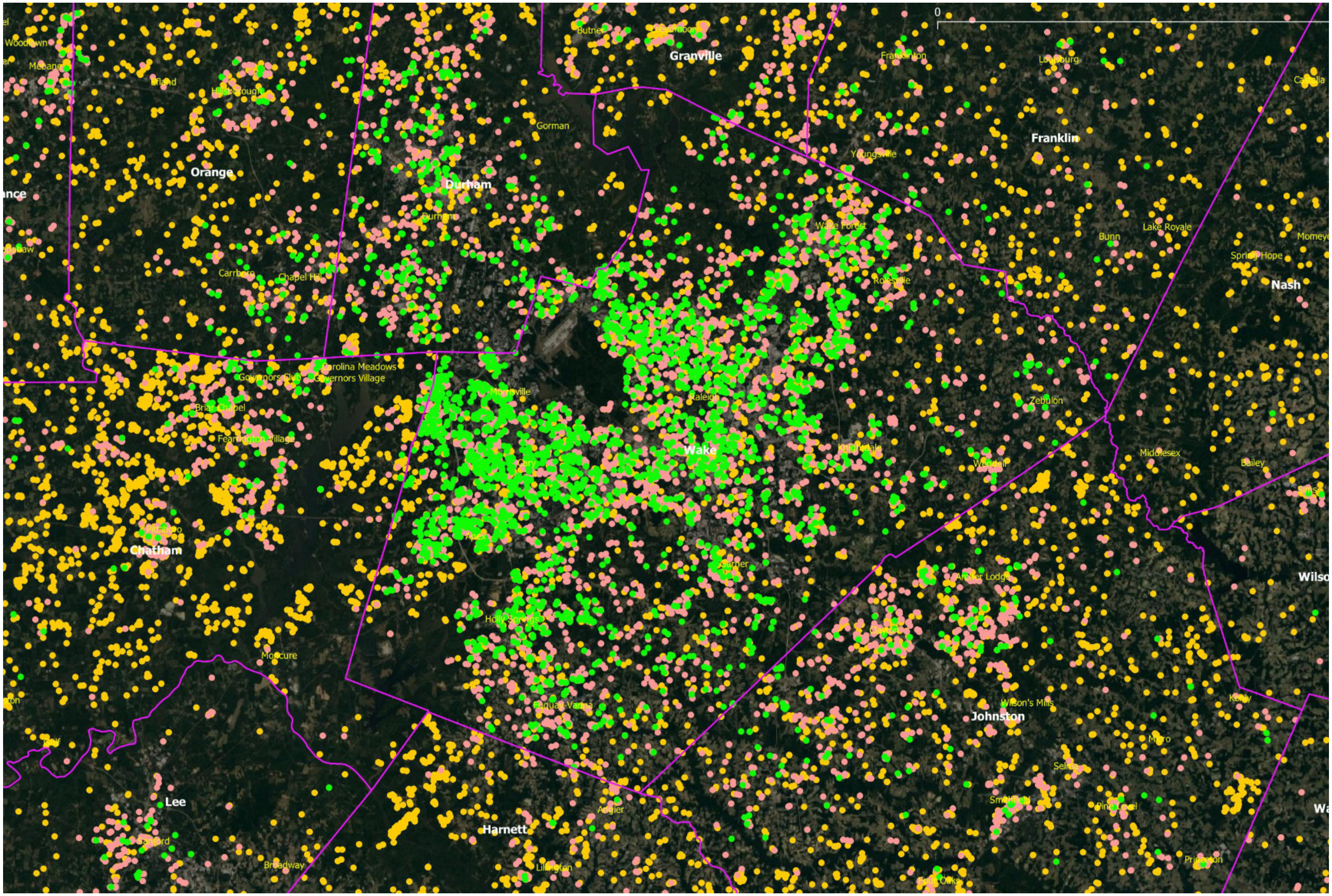


Figure 7: Fiber infrastructure by block

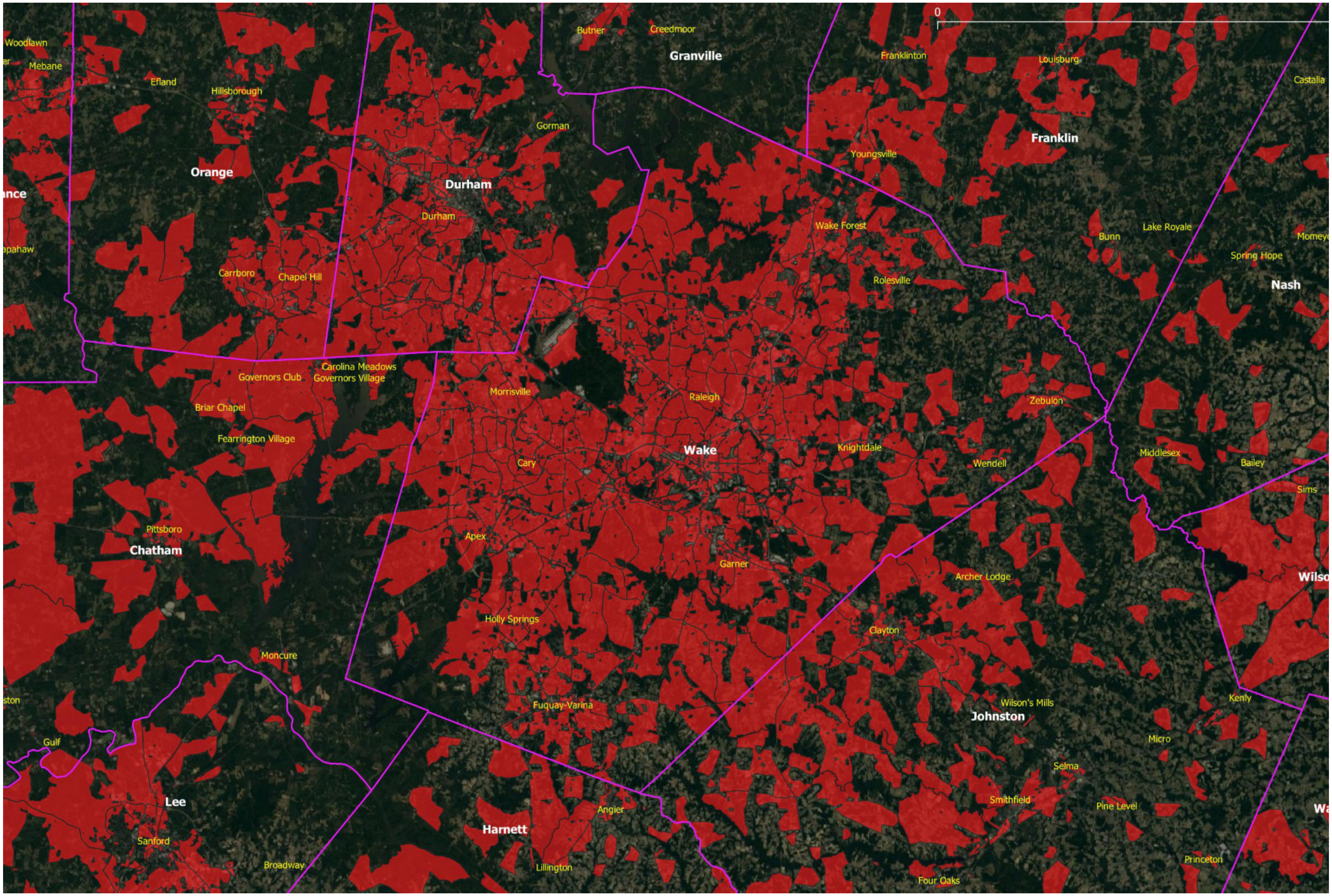
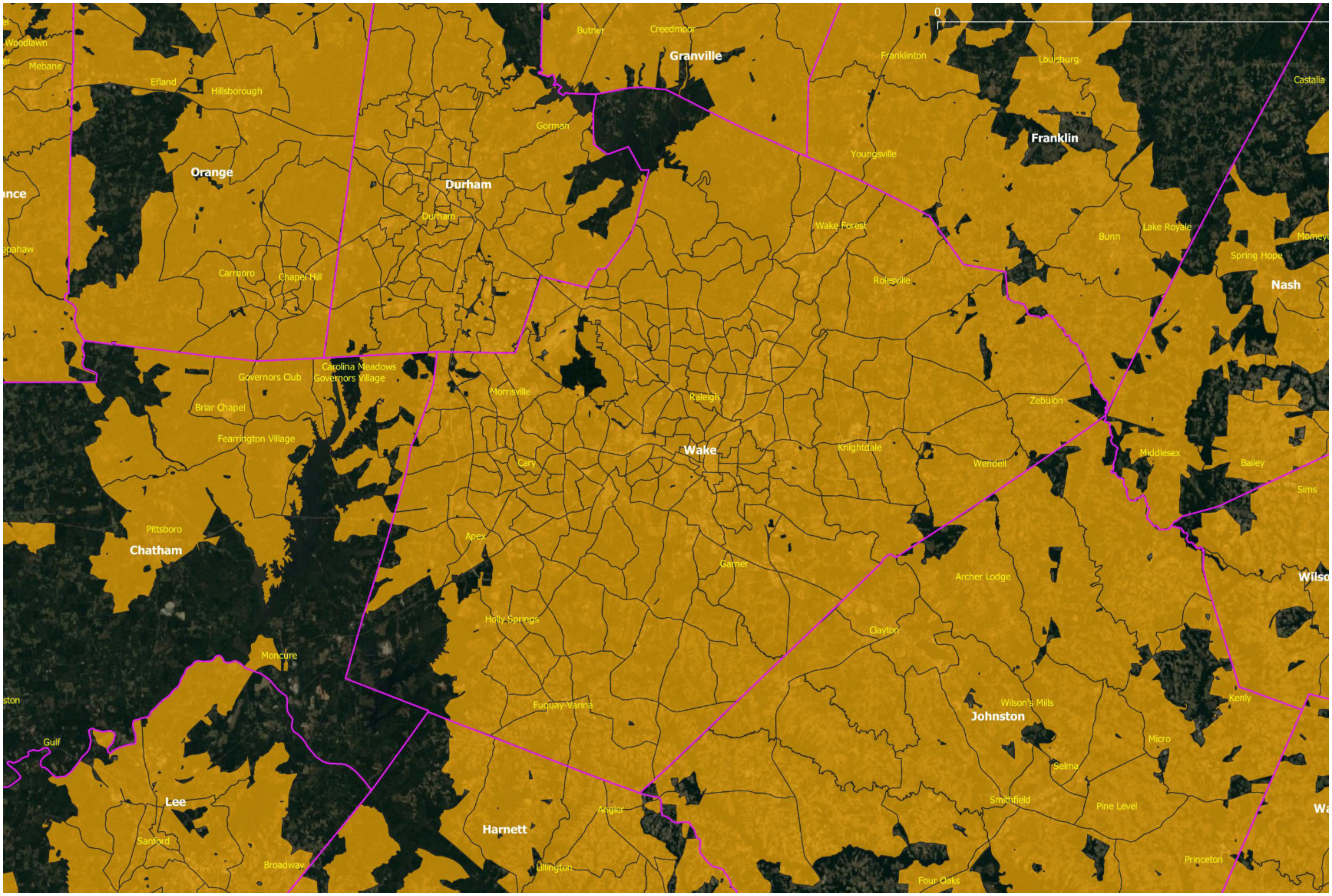


Figure 8: Cable infrastructure by block



the median downlink and uplink speeds are independent but highly correlated metrics, juxtaposed in a single image.

- Figure 5. Block-level results. In this image each block is tagged as either “qualifying” (bright green), “underserved” (salmon), or “unserved” (mustard) based on the fastest speed recorded in the block. This methodology attempts to mirror the conceptual approach of the FCC’s Form 477 data in that a census block is tagged as covered if a single home or business is covered. Blocks without any measurements are transparent.

- Figure 6. The exact location of each measurement, with each point color coded as “qualifying” (bright green), “underserved” (salmon), or “unserved” (mustard).

- Figure 7. The availability of fiber infrastructure, on a block-by-block basis, based on the most recent (12/31/2020) available Form 477 data.

- Figure 8. The availability of cable infrastructure, on a block-by-block basis, based on the most recent (12/31/2020) available Form 477 data.

The process used to visualize the data (one of many possible approaches) is described in the following figures:

- Figure 9. A zoomed-in view (Raleigh, but only a small geographic area) with a set of point representing speed test locations.

- Figure 10. Data speeds (download, dash, upload) associated with each data point.

- Figure 11. Each data point is colored (bright green, salmon, or mustard) to reflect the associated result.

- Figure 12. Each census block is colored to reflect the fastest speed test within the block. As an example, a block with one green, two salmon, and two mustard points will be colored green, because green is the best result within the block.

- Table 1. The results within each block group and within each tract and – potentially – within larger geographic areas are aggregated. In this table the following information is displayed for each block group: number of qualifying, underserved, and unserved locations (shown as counts and percentages) and the median download speed, upload speed, and latency within the geographic boundary.

- Figure 13. The results of the table of Figure 12, shown as a colored image, with the colors and the numbers reflecting the percentage of qualifying (100 Mbps / 20 Mbps) tests.

A quick conclusion for North Carolina is that the state appears to be well-covered based on Form 477 data (Figure 2) yet appears to be poorly covered based on speed test measurements (figures 3, 4, and 15). The contrast in results between these two approaches underscores the value of having both.

North Carolina, like every other state and territory, will need to decide how to spend its BEAD and CFP dollars. Fortunately it is collecting a rich set of data that will facilitate these decisions.

Figure 9: Zoomed-in view of a few data points

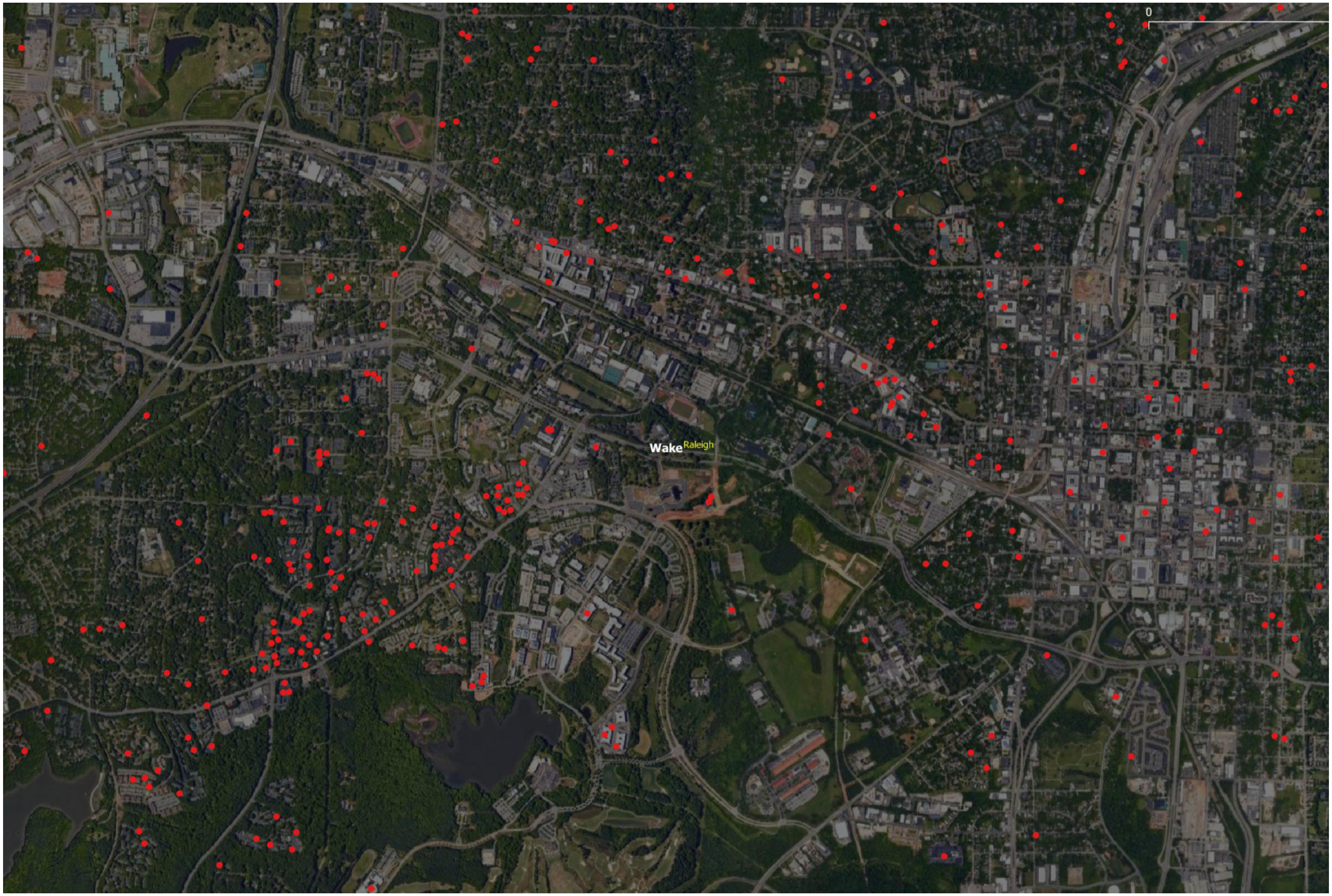


Figure 10: Data points tagged with download-upload speeds

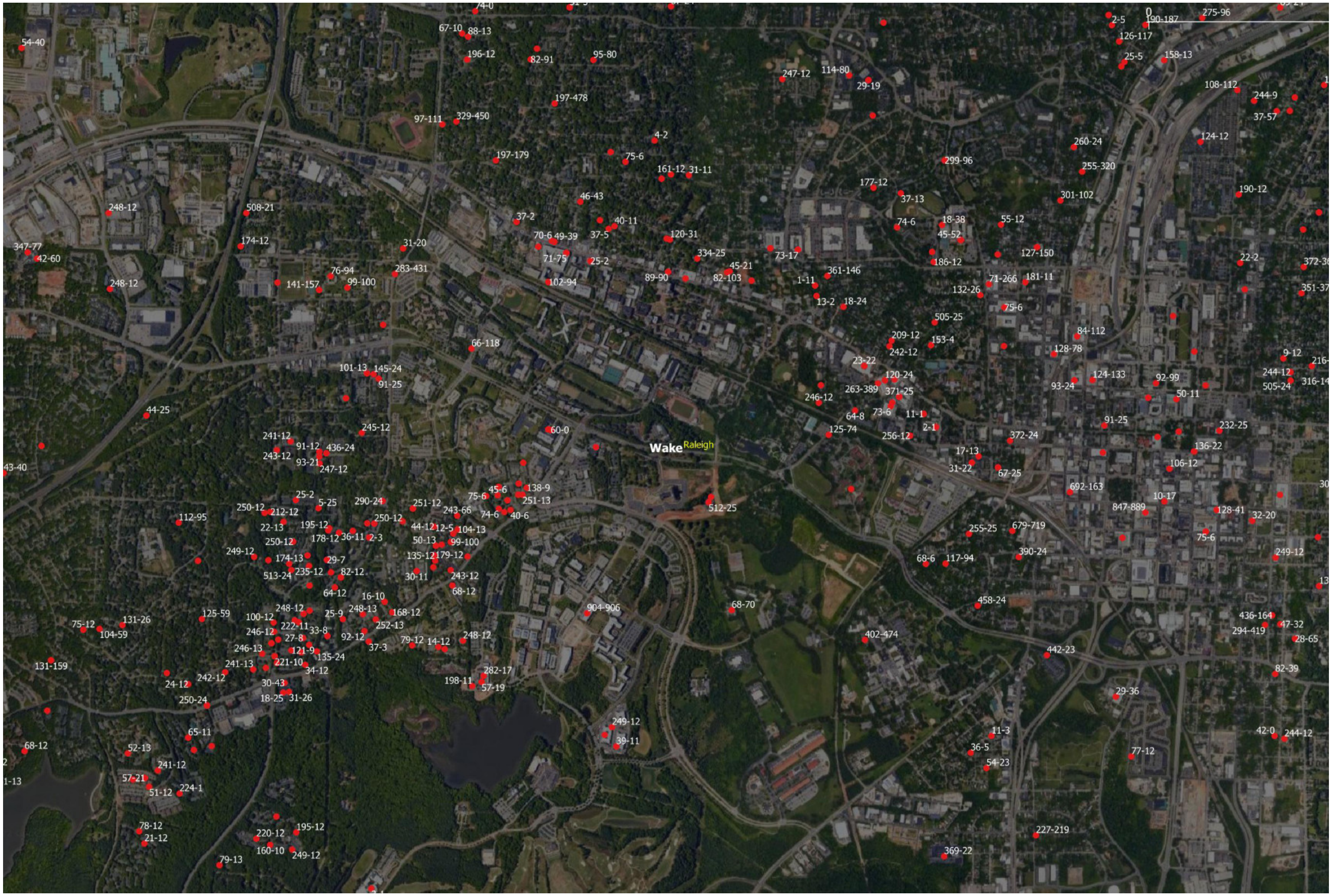


Figure 11: Data points color-coded (bright green = qualifying, salmon = underserved, mustard = unserved) to reflect measured performance

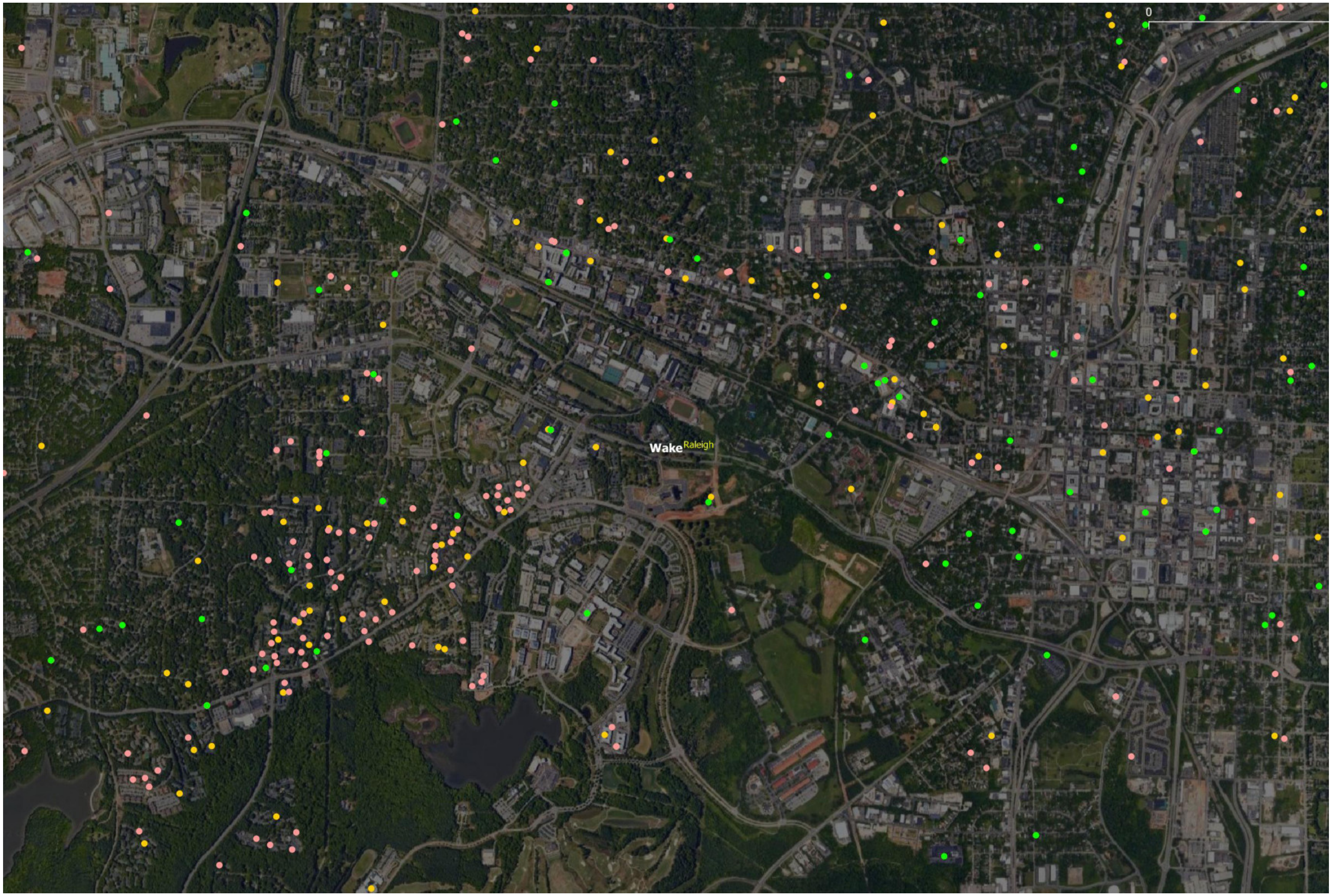


Figure 12: Blocks tagged based on best speed test within block

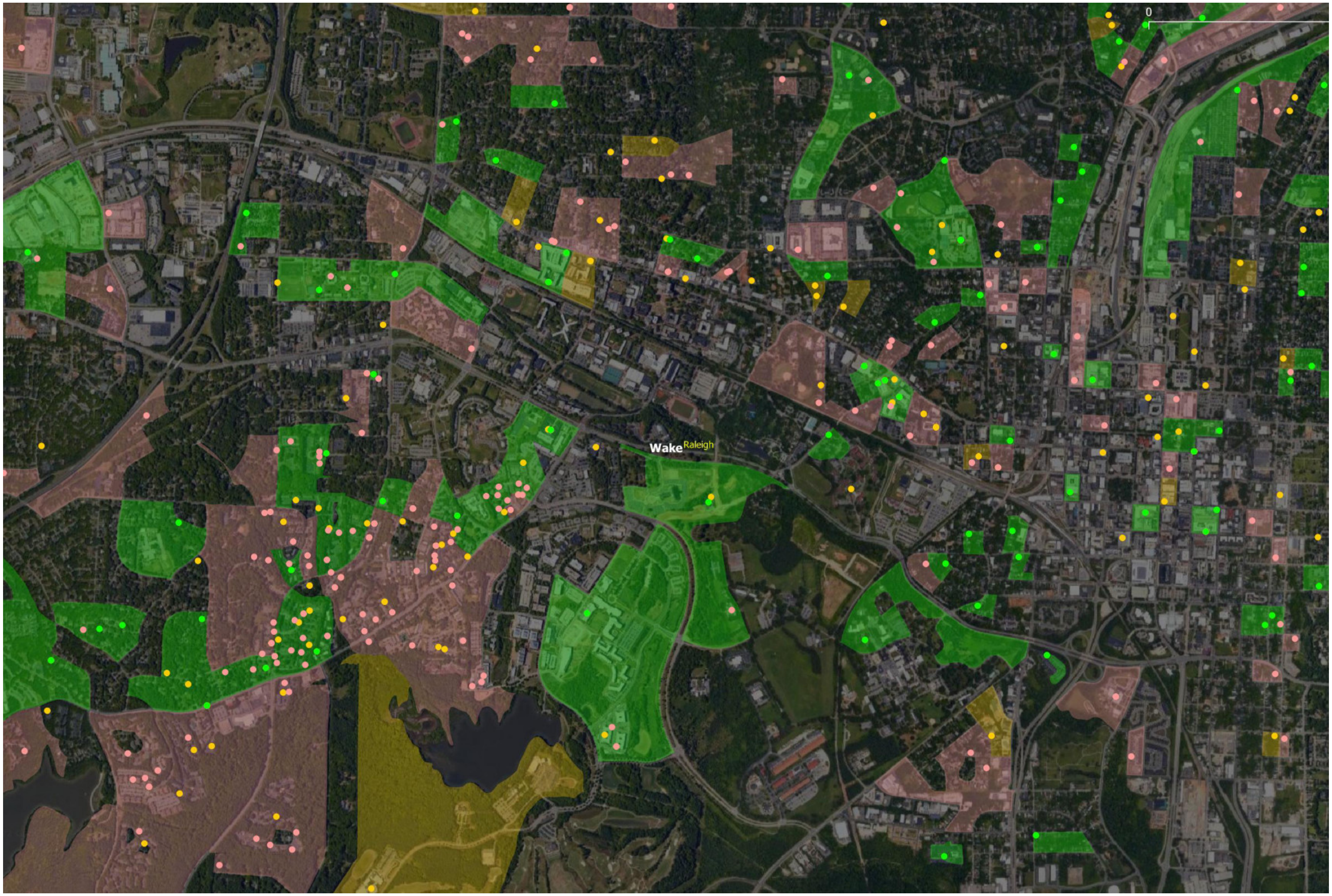
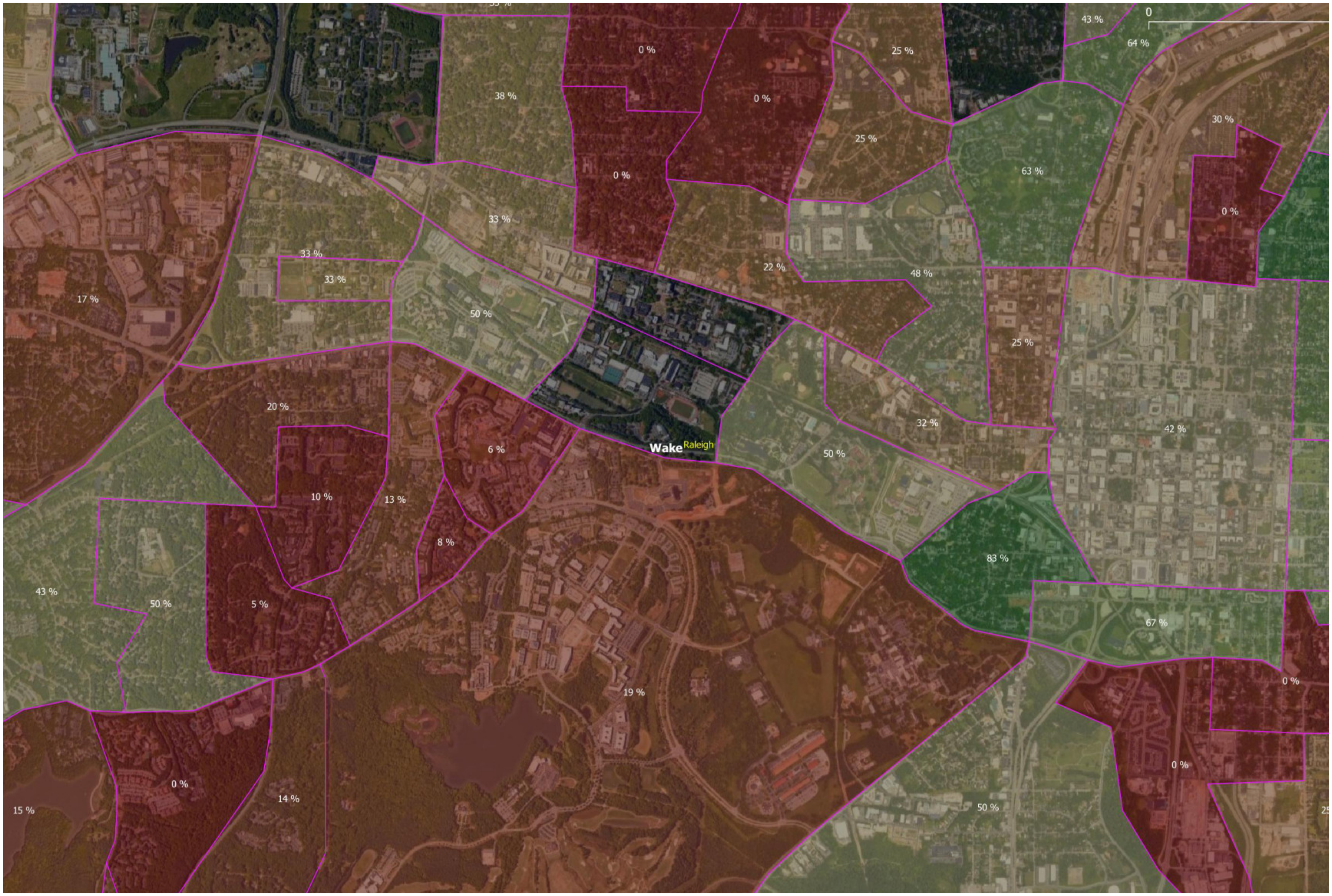


Table 1: Statistics calculated for each block group

	Bgroup	Count	Cqual	Cunder	Cun	Pqual	Punder	Pun	Dmed	Umed	Lmed
1	371719303021	6	0	2	4	0	0.33	0.67	12.2	2.43	29.09
2	371719303012	8	0	5	3	0	0.63	0.38	37.64	8.87	37
3	371719303011	2	0	0	2	0	0	1	3.42	0.51	76.06
4	371719302023	1	0	1	0	0	1	0	124.67	12.01	25
5	371719304002	1	0	1	0	0	1	0	60.27	6.1	22
6	371719303022	4	0	3	1	0	0.75	0.25	49.31	11.17	30.4
7	371719301023	4	0	0	4	0	0	1	6.47	0.69	46.5
8	371719301012	5	0	0	5	0	0	1	10.89	4.33	55.1
9	371719302022	1	0	0	1	0	0	1	24.66	11.46	24.6
10	371719302021	15	0	3	12	0	0.2	0.8	10.38	1.75	32
11	371719302012	4	0	2	2	0	0.5	0.5	19.1	7.84	51.75
12	371719302011	1	0	1	0	0	1	0	65.54	89.72	26
13	371719307002	1	0	0	1	0	0	1	16.46	12.5	25
14	371719307001	5	0	2	3	0	0.4	0.6	10.37	0.82	51.95
15	371719308014	4	0	1	3	0	0.25	0.75	10.58	3.16	21.5
16	371719308013	9	0	1	8	0	0.11	0.89	6.32	0.72	44.6
17	371719308012	2	0	1	1	0	0.5	0.5	27.59	3.42	40.52
18	371719305022	2	0	1	1	0	0.5	0.5	26.42	22.59	22.8
19	371719305012	4	0	2	2	0	0.5	0.5	26.24	15.32	30.5
20	371719305011	2	0	1	1	0	0.5	0.5	19.76	5.84	41.65
21	371719306003	1	0	1	0	0	1	0	34.88	4.64	23
22	371719306002	5	0	2	3	0	0.4	0.6	27.65	4.12	27
23	371719305024	4	0	0	4	0	0	1	1.33	1.03	81.95
24	371719310021	6	0	4	2	0	0.67	0.33	77.74	12.36	21.4
25	371719310012	4	0	1	3	0	0.25	0.75	10.86	7.02	33.3
26	371719310011	8	0	4	4	0	0.5	0.5	22.08	7.11	26.7

Figure 13: Block groups color-coded to reflect percentage of qualifying tests



Next, let's consider the data provided by the State of Georgia:

- Figure 14. This image shows the entire state with each block color coded as "served" (25 Mbps / 3Mbps in over 80% of its locations - forest green), or unserved (fewer than 80% of locations - salmon), or "No Locations" (transparent) within the block.

- As described above, the state of Georgia defines a census block as served not when a single location is served but when 80% of locations are served, thereby overcoming a common criticism of Form 477 data. The June 2022 release, as uses 25 Mbps / 3 Mbps as the qualifying threshold. That threshold will increase in a future release of the data set to 100 Mbps / 20 Mbps.

- Figure 15. Figure 15 is a zoomed-in view of Figure 14. Since each census block is either "served" or "unserved" or transparent the image is fairly simple.

- Figure 16. Figure 16 shows a continuous color scheme (red to yellow to green) reflecting the percentage of served (25-3) locations within the block. The resulting image is much more nuanced.

- Figure 17. Figure 17 shows Form 477 data, visualized as "qualifying" broadband (100 Mbps / 20 Mbps), underserved (25 Mbps / 3 Mbps, but less than qualifying), or unserved (less than 25 Mbps / 3 Mbps).

FCC Form 477 data and the data resulting from the Georgia analysis each reflect ISP coverage data, although the state-level approach is more nuanced. The visual patterns shown in Figures 16 and 17, are not as different as the visual patterns in Figures 2 and 3 for North Carolina, where the figures reflect completely different types of data.

Conceptual Issues

There are a number of concerns commonly associated with FCC Form 477 data:

- If an ISP is able to cover a single residence or business within a block then the entire block is deemed "covered". This might be a reasonable assumption in a urban area where census blocks are small, but it is less reasonable in a rural area where the census block is large and where it may be extremely difficult to cover it.

- The reported speeds are the "advertised downstream speed" and the "advertised upstream speed". If an ISP advertises an "up to ______" speed then the stated number is filed with the FCC. These definitions lead to several possible concerns:

    - The block might or might not contain any actual customers.

    - The promised "up to" speed might be aspirational.

    - ISPs don't always deliver the precise speed cited in their advertising. The FCC's Eleventh Measuring Broadband America Fixed Broadband Report (figures 12.1 and 12.2) discusses this topic

    - The speed may be impacted by congestion in the access network or in the core.

Figure 14: Served (80% at 25-3 Mbps) and Unserved blocks in Georgia

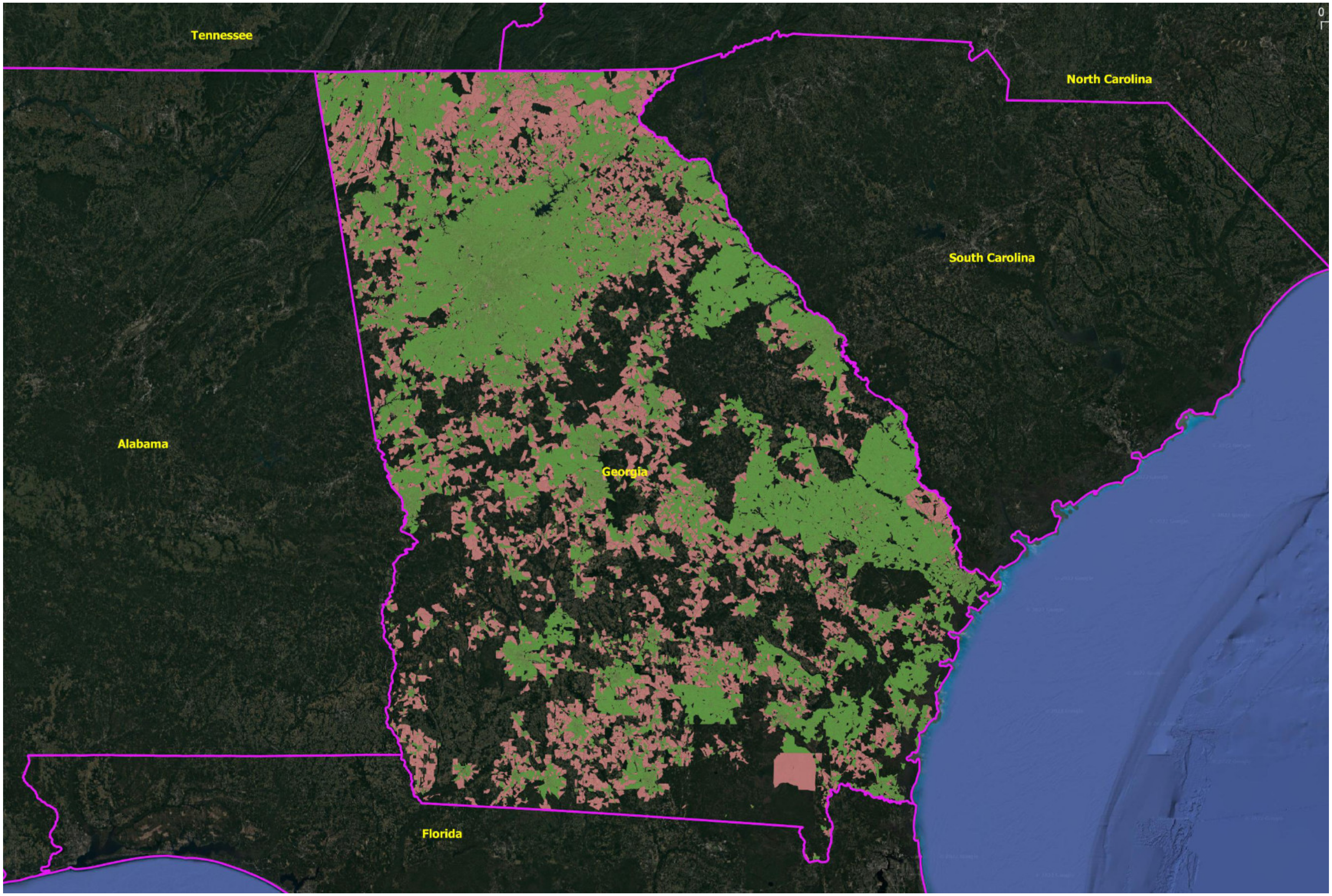


Figure 15: Zoomed-in view of served and unserved blocks in Georgia

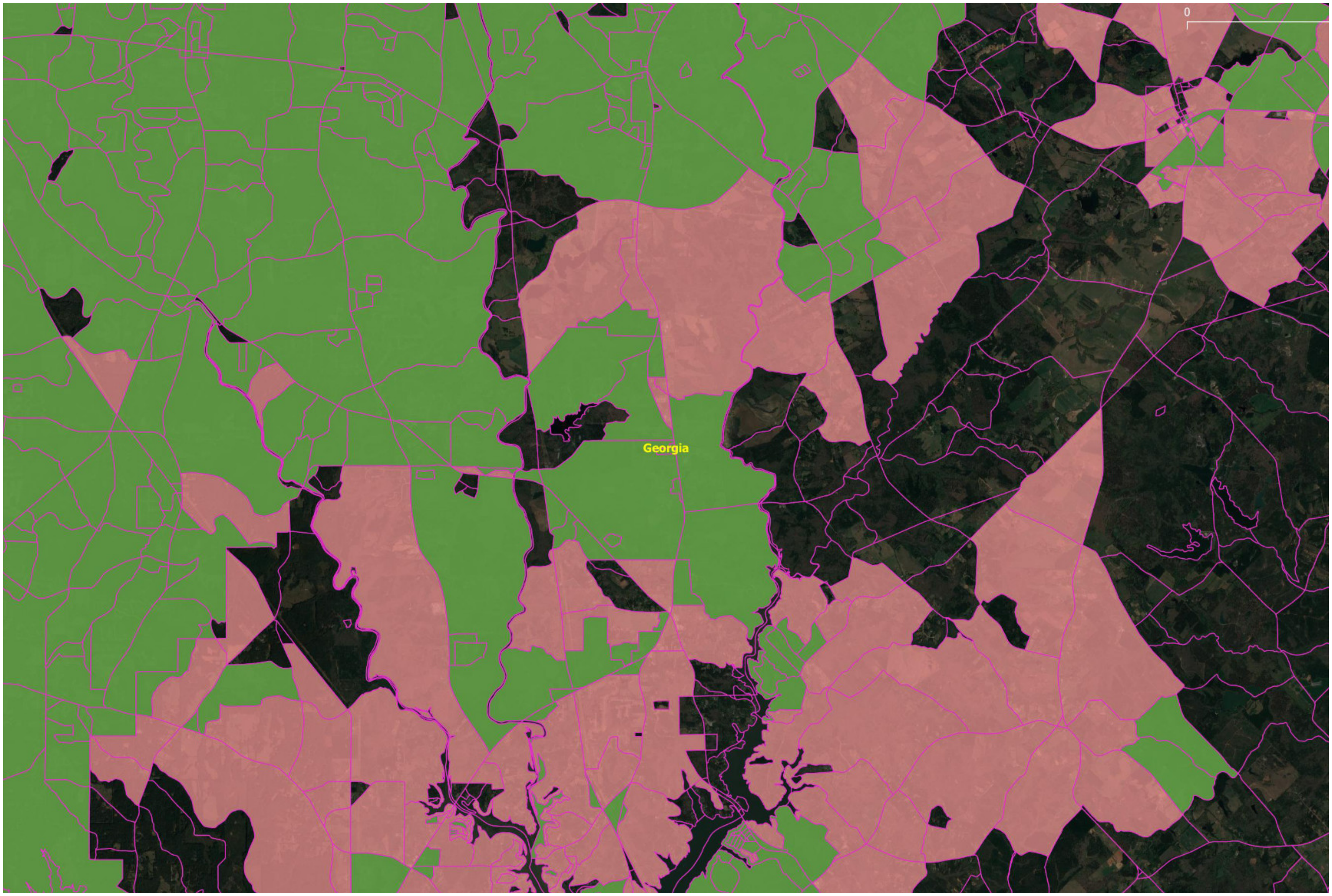


Figure 16: Blocks colored-coded and labeled to reflect percentage of served locations

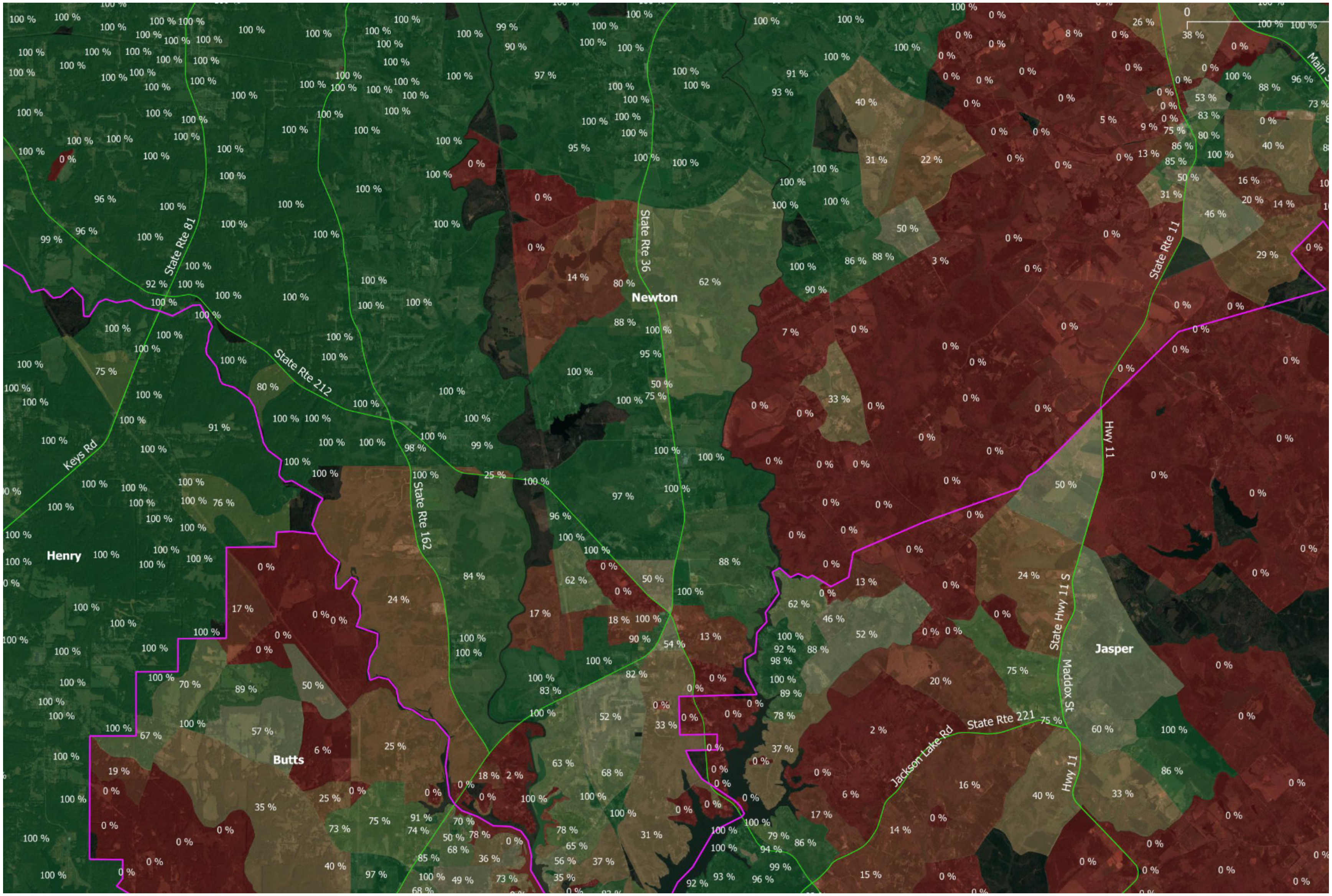
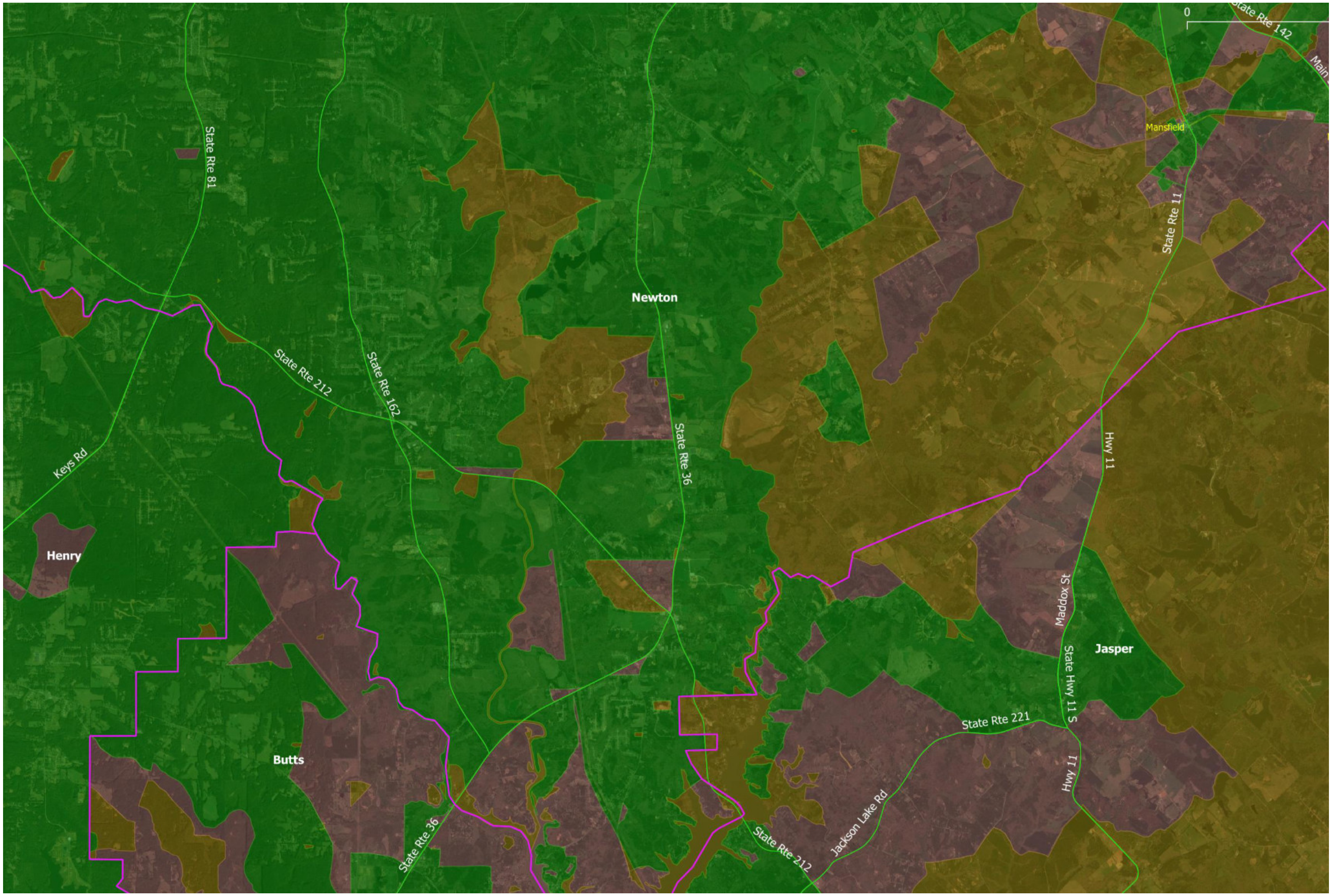


Figure 17: FCC form 477 data: qualifying (bright green), underserved (salmon), and unserved (mustard) based on BEAD definitions



Similarly, there are a concerns associated with crowd-sourced speed tests:

- A subscriber may test poorly because he has chosen to purchase an inexpensive broadband plan.

- The subscriber may have done a poor job in configuring his home network. This is particularly common with Wi-Fi.

- A Wi-Fi network may be experiencing radio frequency interference from users outside of the home .

- The user may be at the limit of coverage of his or her Wi-Fi network.

- A mesh Wi-Fi network without a hard wired backhaul may have its nodes too far apart, limiting the speed of the mesh network at the extremities.

- The user may be running a speed test while others in the household are consuming bandwidth. The speed test, therefore, does not accurately reflect the performance of the fixed connection.

- The user may be using a device with outdated Wi-Fi technology, thus limiting performance.

- The consumer may be limited by the performance his switch or network interface cards (NIC). Examples include a computer with a 100 Mbps NIC accessing a Gigabit connection or a computer with a 1000 Mbps NIC accessing a 10 Gbps connection, or any Ethernet connection running through a switch that does not support the bandwidth of the ISP.

- Finally, with any survey the sample size and the response rate both matter. Without careful controls some segments are likely to be overrepresented while others are underrepresented. State surveys often rely upon motivated county and city officials to encourage participation.

Additionally, it is helpful to understand the role of mobile broadband and satellite in remote areas:

- In some cases a home has no wired broadband connection (either because it is not available or because it is too expensive or because traditional mobile providers offer a “fixed” service that is better – in the eyes of the consumer – than the alternatives).

- A fixed LTE solution is often a box with an LTE transceiver, Ethernet ports, and Wi-Fi. It plugs into the wall. It looks and feels a lot like a wired modem.

- In other cases the subscriber might purchase a stand-alone hotspot (typically a modem than *can* be plugged into the wall for power, but can alternatively operate on batteries). The consumer is likely to pay for the service on a per Gigabyte basis. Such a device provides connectivity via Wi-Fi or Ethernet and moves with the subscriber. If used for bandwidth-intensive purposes it is likely to be slow and expensive. Its most important attribute is its portability.

- An extremely casual internet user might choose to connect his laptop via his mobile phone “hotspot” feature. Such a solution is likely to be slow but might be adequate for some

users, especially those on vacation where a "fixed" connection is not readily available.

- In some cases low income consumers have used cell phone data connections for remote learning, usually with very poor results.

- Mobile broadband offerings often – but not always – lag wired solutions in performance. An increasing number of mobile providers are constructing pricing that mimics that of traditional fixed access (a flat monthly fee for a service at a specific location).

- LTE solutions offered by mobile operators are distinct from line-of-sight fixed wireless access solutions. The latter require professionally installed externally-mounted antennas. FWA technologies include radios that operate in a variety of bands, including UNII, CBRS, and millimeter wave. Lower frequency bands are often used to provide coverage in remote areas. The performance of the network is heavily dependent upon its design assumptions. Millimeter wave can be used to provide high bandwidth connectivity over short distances, especially in cities with modest rainfall.

- In remote areas with few wired infrastructure options some households choose satellite. Geosynchronous satellite systems have historically provided connectivity with usable download speeds but with usage caps, high latency, and high cost. Low earth orbit satellites solve the latency issue and remain an appealing – if somewhat expensive – alternative for those in remote areas with limited fixed options.

The discussion of mobile broadband is important because it sits in a gray area between fixed and mobile. Without understanding the range of possible use cases one could easily misinterpret some crowd-sourced results.

The methodologies described in this whitepaper mitigate many of the concerns associated with crowd sourced data by identifying blocks as "qualifying", "underserved", or "unserved" based on the *fastest* test within a block. If a particular test understates performance then it is likely that another nearby test will more accurately reflect the network performance. The faster test will then be used to characterize the block.

The average test score (mean or median) in a crowd-sourced testing environment will tend to understate the ISP's performance for the many reasons discussed.

Those hosting crowd-sourced tests or those consuming crowd-sourced data should seek to identify and manage factors that could skew the results.

The reader should note that interpreting crowd sourced data is an important task that is separable from the complex task of collecting it.

Most state broadband offices are moving quickly to prepare for the opportunities associated with BEAD, CPF, and other initiatives. This whitepaper mentions only those efforts that are visible to the public.

In some cases broadband offices have purchased commercial speed test data or have access to exceptionally high quality reporting from ISPs that will lead to exceptional decision-making framework using approaches not considered in this whitepaper.

Finally, the approaches described in this whitepaper with state-collected crowd sourced data can also be applied to commercial speed-test data.

Resources

Valuable resources include:

White papers:
https://broadbandtoolkit.com/pages/whitepapers

Product Documentation:
https://broadbandtoolkit.com/products/infrastructure-essentials-bead-toolkit

Need help understanding the concepts and /or the available tools and data sets? If so, send us an email or give us a call (415-346-5393). We'll be happy to step through the available resources and – if desired – demonstrate various tools via a Zoom / conference call.

Disclaimer. This whitepaper reflects one possible view of the subject. Readers are encouraged to carefully read all original data sources, to run the numbers themselves, to discuss these concepts, methodologies, and interpretations with their colleagues and with other subject matter experts, and to consult competent legal counsel for any issues involving an interpretation of the law.

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