Infrastructure Essentials Toolkit

Broadband Grant Opportunity Analysis

Introduction / User's Guide

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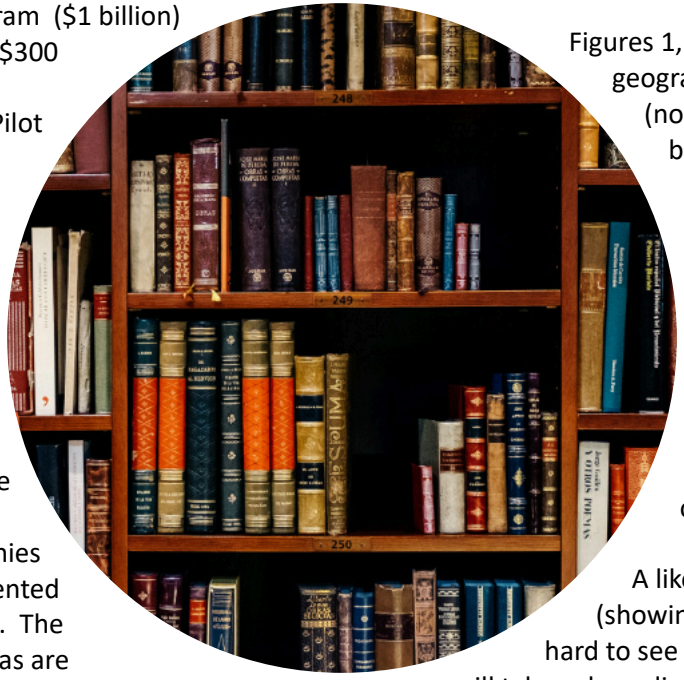
Introduction

On December 27th, 2020 the *Consolidated Appropriations Act, 2021* was signed into law. It provided $900 billion in stimulus relief and $1.4 trillion in omnibus spending, for a total of $2.3 trillion.

In particular, it provided a series of NTIA grants that include:

- Tribal Broadband Connectivity Program ($1 billion)
- Broadband Infrastructure Program ($300 million)
- Connecting Minority Communities Pilot Program ($285 million)



These grant programs are expected to release funds quickly, which means that prospective recipients must be prepared to act quickly. The first two program have released NOFOs, with application deadlines of 8/17/2021 and 9/1/2021 respectively.

The Infrastructure Essentials Toolkit is a suite of analytical tools designed to help an organization quickly identify which geographies are likely to qualify for an infrastructure-oriented grant under either of the first two programs. The toolkit answers the questions of "Which areas are eligible?" and "Which areas are potentially profitable?" by enabling the reader to quickly estimate densities and homes passed.

It also visualizes a large collection of measured data, made available by the NTIA and by other organizations. The data is important in enabling a grant applicant to argue that an area shown as "served" by FCC Form 477 data is, in fact, not served and deserves grant funding.

This Toolkit is designed to enable grant applicants to move quickly through the decision-making process.

Nation at a Glance

Figures 1, 2, 3, and 4 give a quick view of the geography of the United States that is uncovered (no fixed broadband), covered at sub-broadband speeds, and covered at broadband speeds, at least according to the FCC's for 477 data (more on that to come). Figure 4 shows the result of the most impactful federal subsidy programs: RDOF, CAF II, and the USDA initiatives (most importantly ReConnect). The FCC defines broadband as a minimum of 25 Mbps down, 3 Mbps Up, and a maximum of 100 mseconds round-trip latency 95% of the time.

A likely response to the national coverage map (showing over 11 million blocks at once) it is that is hard to see what is happening. In the next section we will take a deep dive into some local geography. That exploration will highlight the many tools and data sets in the Toolkit and demonstrate how insights emerge when examining small regions with detailed local data.

Figure 1: Uncovered (Mustard) and Sub-Broadband (Salmon, less than 25-3) Census Blocks in the United States

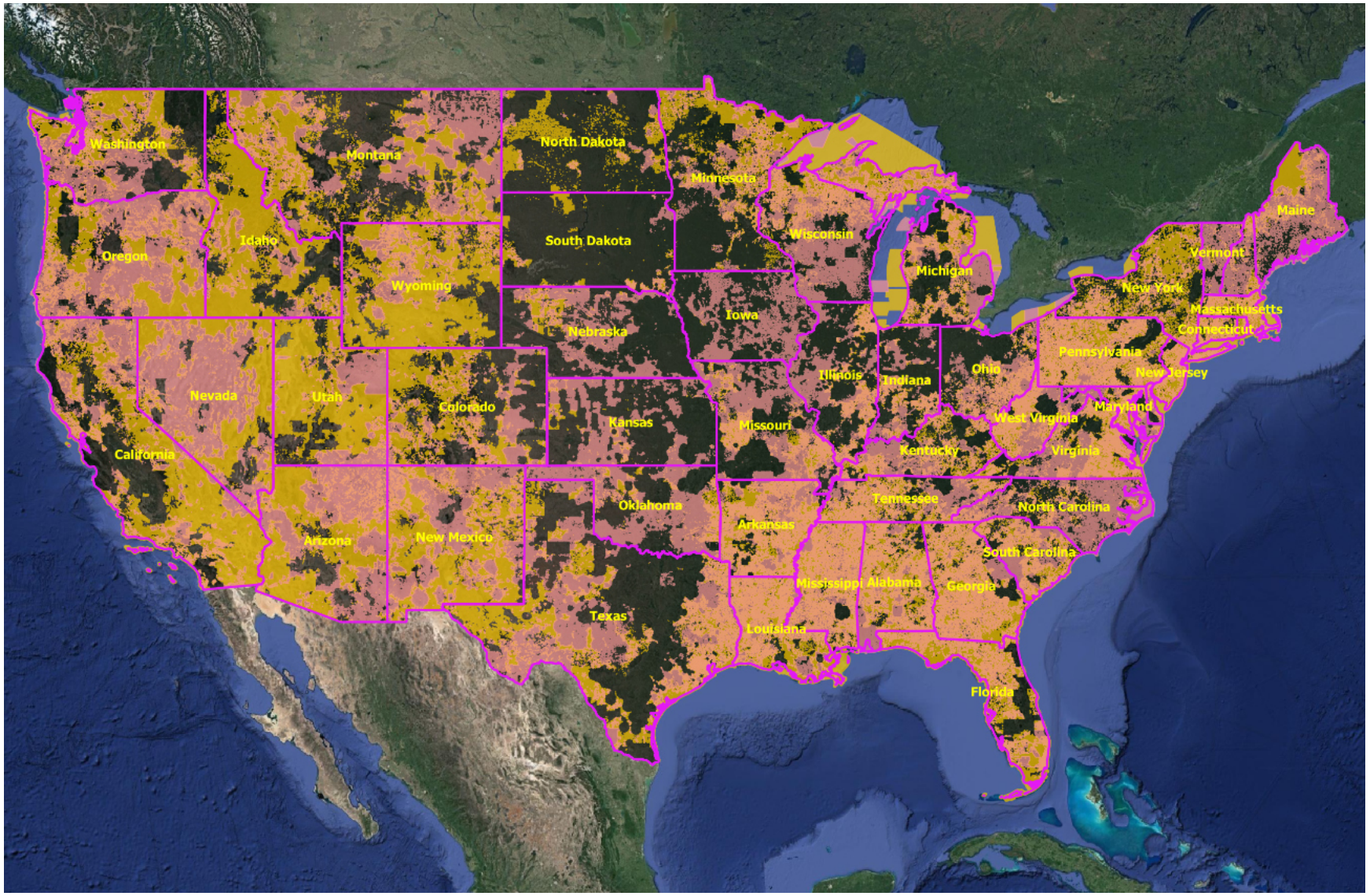


Figure 2: Broadband (25-3, Low Latency) Census Blocks, based on FCC Form 477

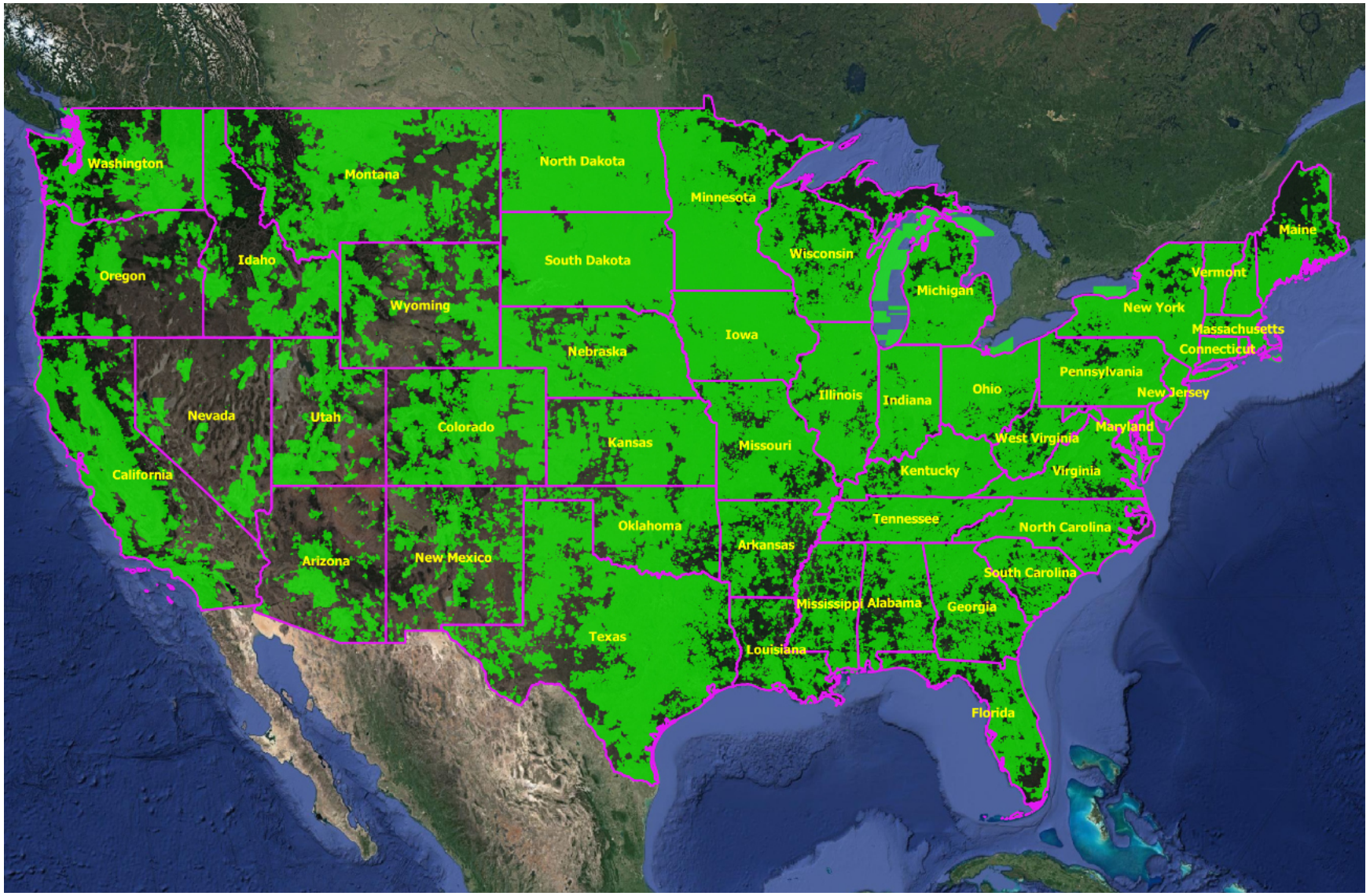


Figure 3: Uncovered (Mustard), Sub-Broadband (Salmon), and Broadband (Bright Green) Census Blocks

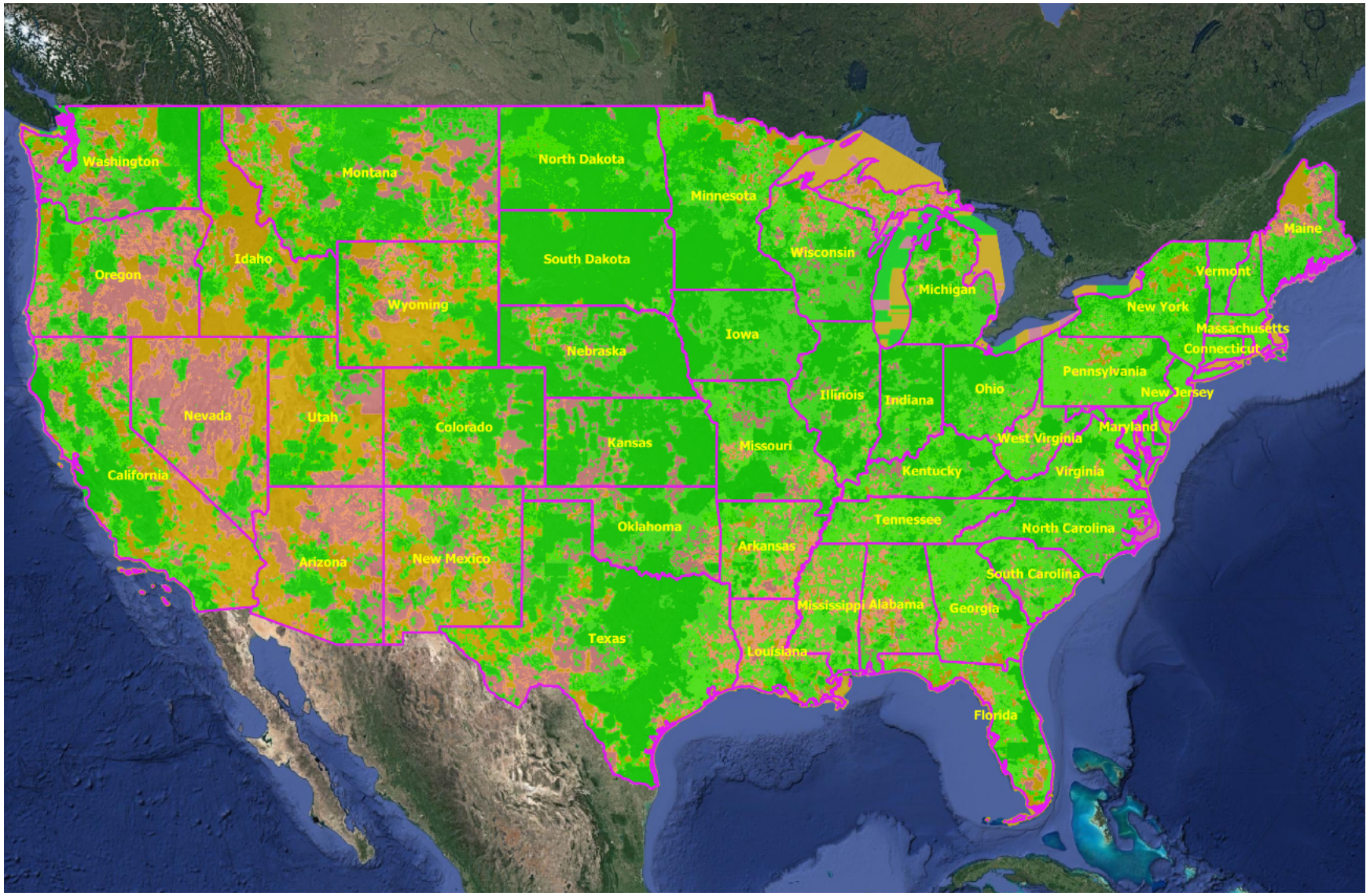
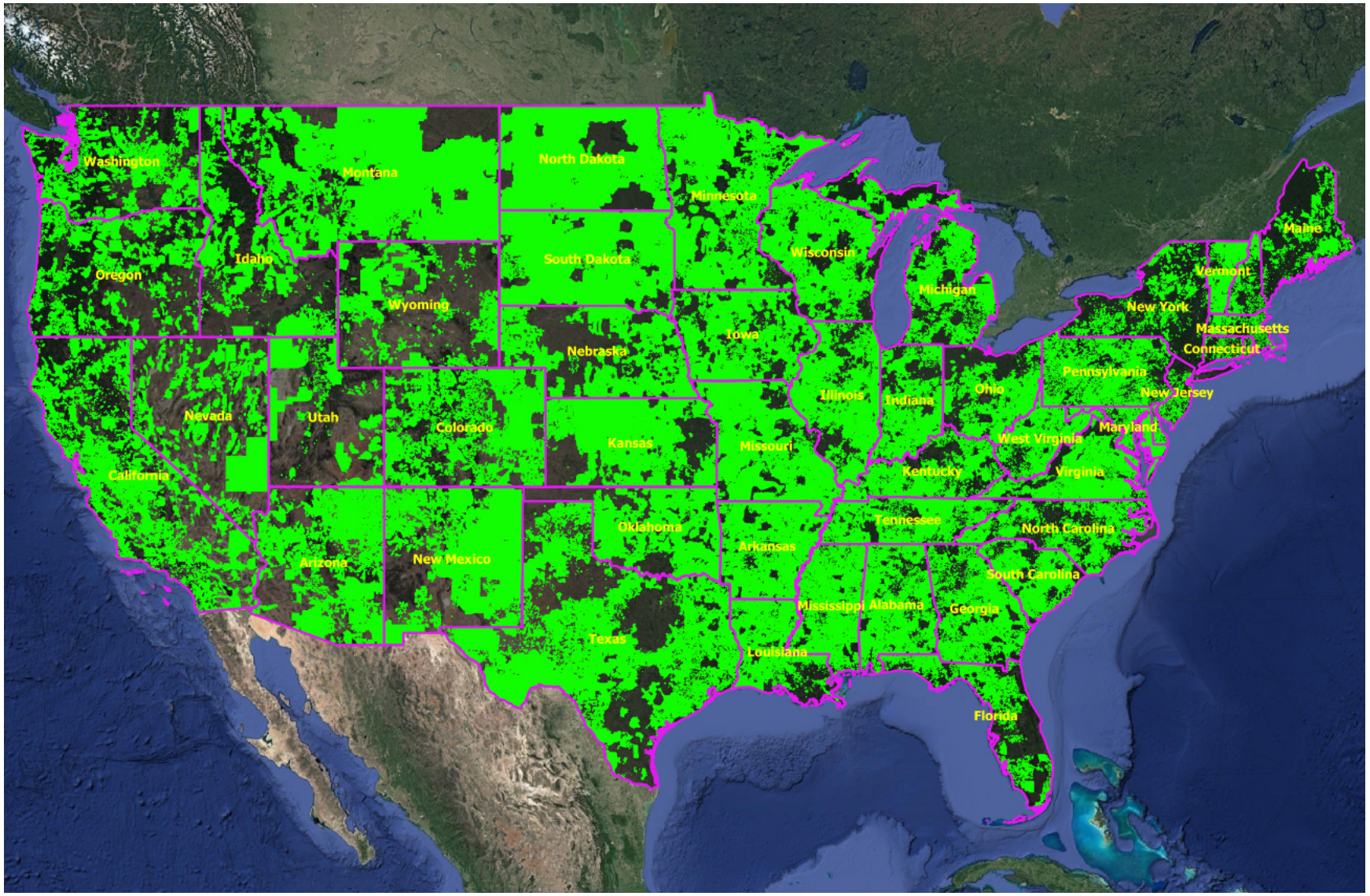


Figure 4: Incremental Broadband Coverage as a Result of CAF II, RDOF, and USDA Programs



Discovering Uncovered Geography

Many prospective grant applicants are eager to identify geographic areas that are eligible to receive grant funds and have enough size and density to serve cost-effectively.

Figures 5, 6, 7, 8, 9, and 10 illustrate that process.

- Figure 5 shows the state of Kansas using form 477 data. Every census block is characterized as uncovered, sub-broadband, or broadband.

- Figure 6 shows the same uncovered and sub-broadband data alongside measured coverage data. Tracts with a median speed of 25-3 or greater are colored green. We discover that a large portion of the geography previously characterized as having broadband service does not. Figure six has a rectangle enclosing the area surrounding Topeka, KS. We will look at that area in the next figure.

- Figure 7 is a close-up of Topeka, KS. The image shows the number of housing units by block group for Topeka and the surrounding area. This in important information because a prospective applicant needs to identify an area that lacks qualifying broadband and is not the recipient of duplicative funds (e.g. RDOF, CAF II, or USDA), but is also reasonably economic to cover. The bottom of the image shows a bright green polygon which, in this case, indicates the presence of disqualifying federal funds (but only in that small area).

- Figure 8 is identical to Figure 7 except that it shows measured data rates per tract instead of housing units per block group.

- Figure 9 displays the most detailed level of demographic data. It shows the number of housing units per block. The image is covered with tiny integers representing individual census blocks. We have inserted red and orange circles around what appear to be clusters of population in eligible geographies.

- Figure 10 is a close-up view of the orange circle. As we zoom in additional block labels may appear that were previously suppressed by QGIS as a result of a congestion of labels. One can see that the one area contains over 300 homes passed.

Figures 11, 12 and 13 show unrelated metrics:

- Figure 11 shows median household income per block group. Economic metrics are helpful in demonstrating need.

- Figure 12 shows the percentage of households receiving SNAP (a.k.a. food stamp) benefits. A SNAP recipient qualifies for a monthly subsidy under the Emergency Broadband Benefit Program (EBBP) and, when its funds run out, an ongoing subsidy under the Lifeline program.

- Figure 13 shows the lowest priced broadband subscription by Zip Code. It is helpful in that it highlights the relationship between availability and competition and affordability.

- Figure 14 shows the juxtaposition of several different data sets in an urban area. The image shows housing units per block in yellow and housing units per block group in white. The block group is enclosed in a magenta boundary. Every block with one or more group homes (college dormitories, nursing homes, prisons - basically any facility with people who are not living in households) has a large yellow dot.

Figure 5: Kansas, Uncovered (Mustard), Sub-Broadband (Salmon), and Broadband (Green), based on FCC Form 477

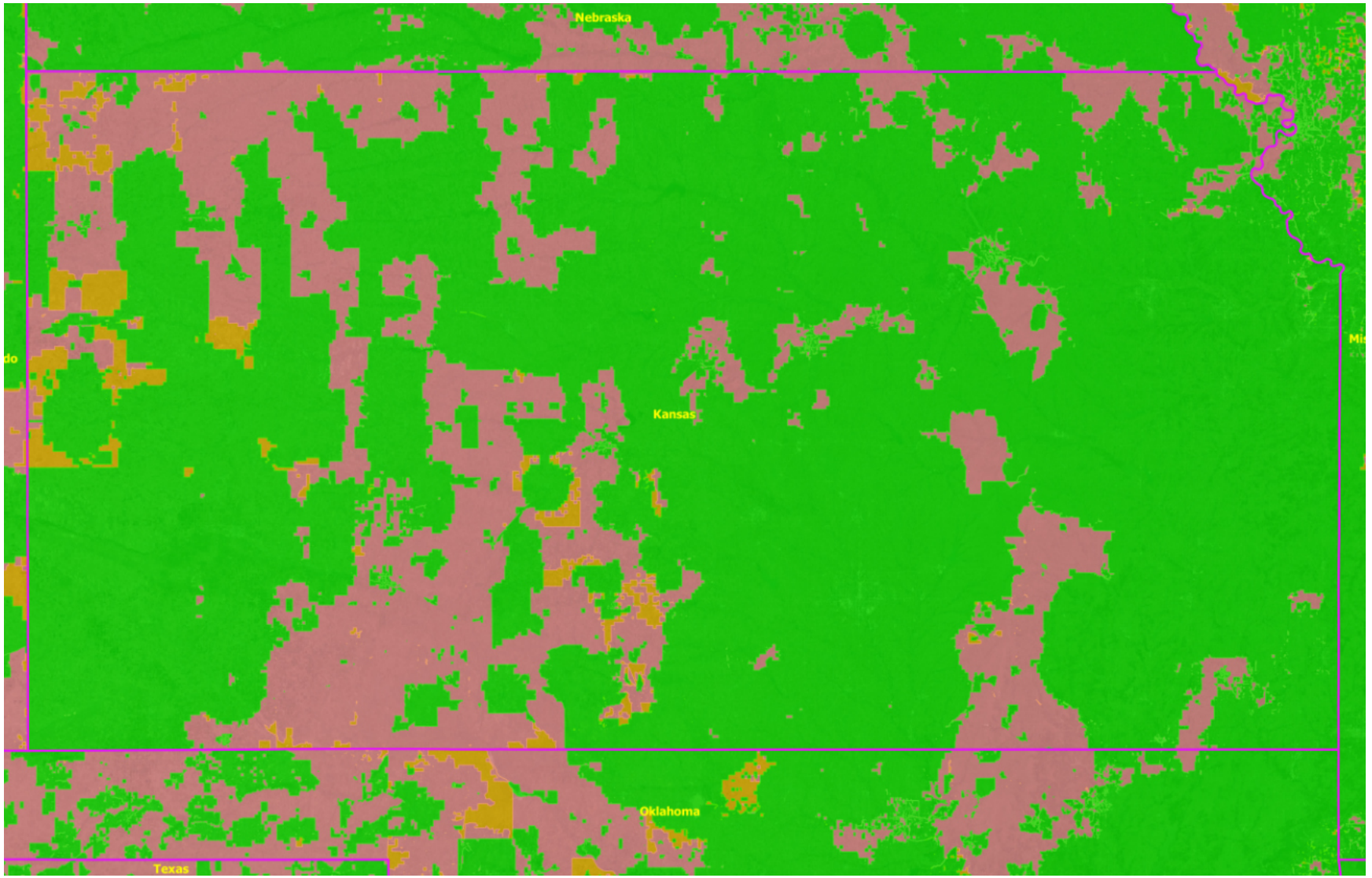


Figure 6: Kansas, Uncovered (Mustard), Sub-Broadband (Salmon), both based on Form 477, and Ookla Measured Speeds (Green if >= 25-3)

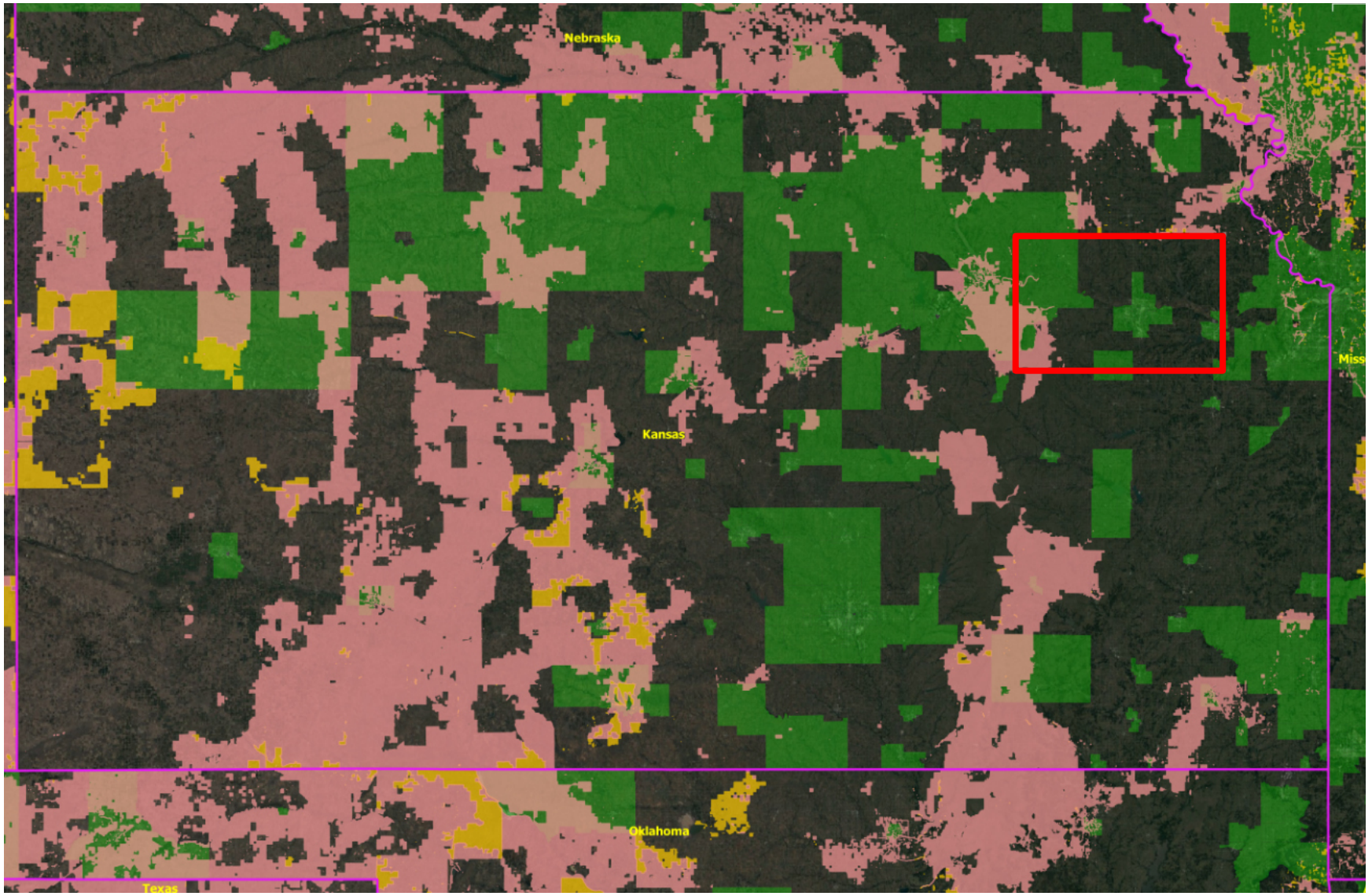


Figure 7: Housing Units by Block Group and Ookla Measured Speeds (Green is >= 25-3) by Tract

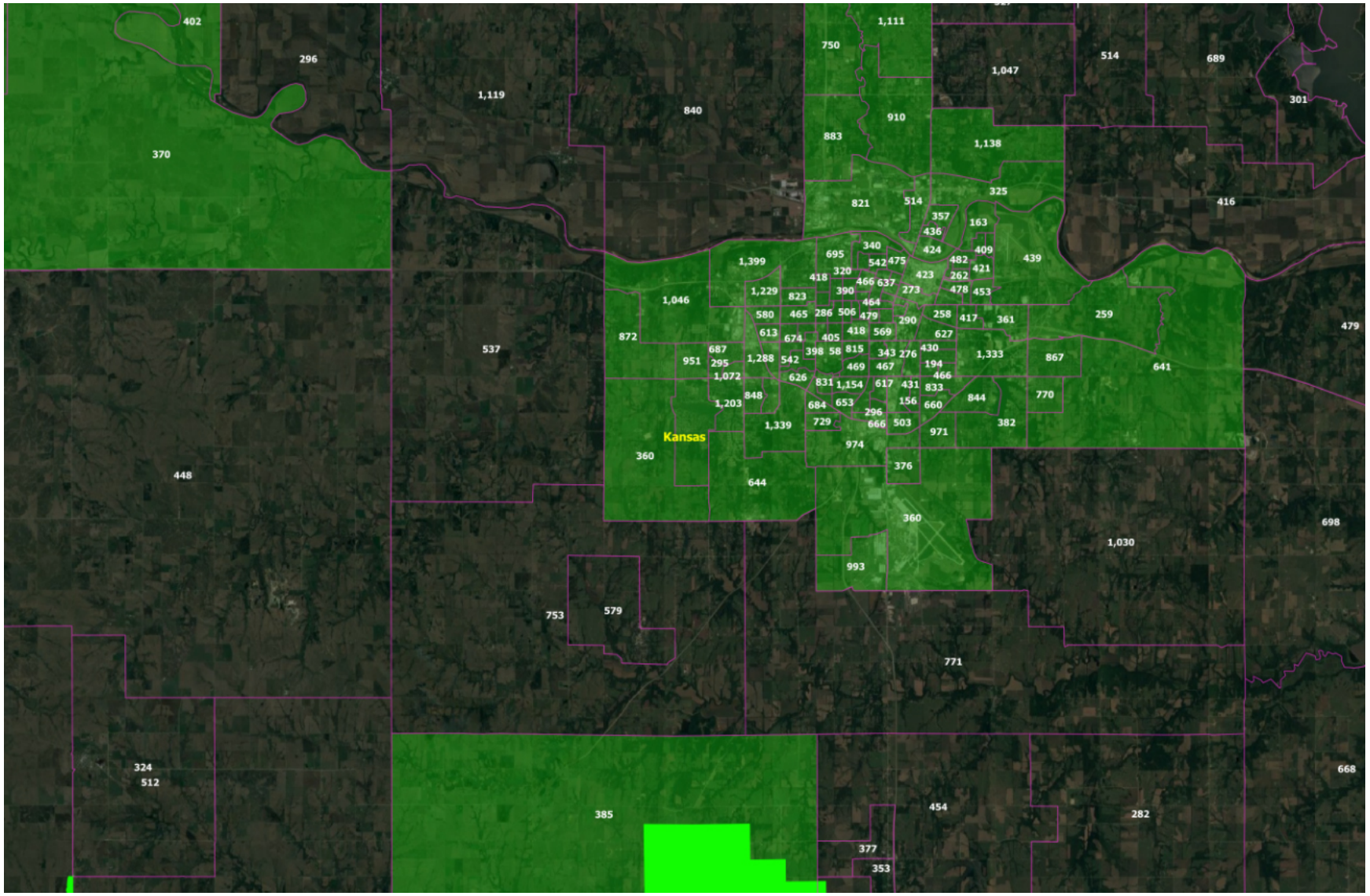


Figure 8: Median Speeds (Down-Up, Ookla) by Census Tract

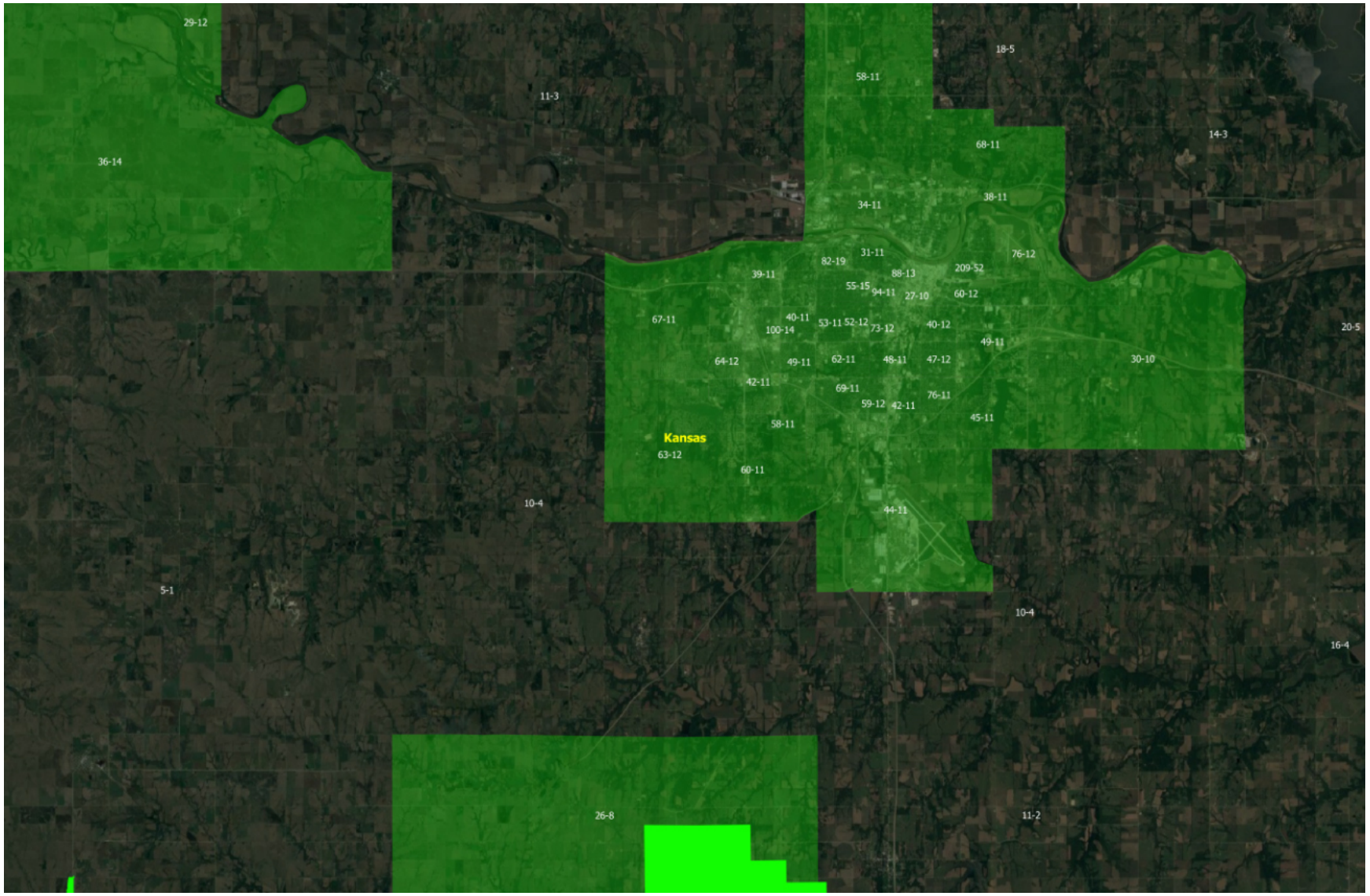


Figure 9: Identifying Attractive Clusters Using 2020 Block-Level Housing Unit Data

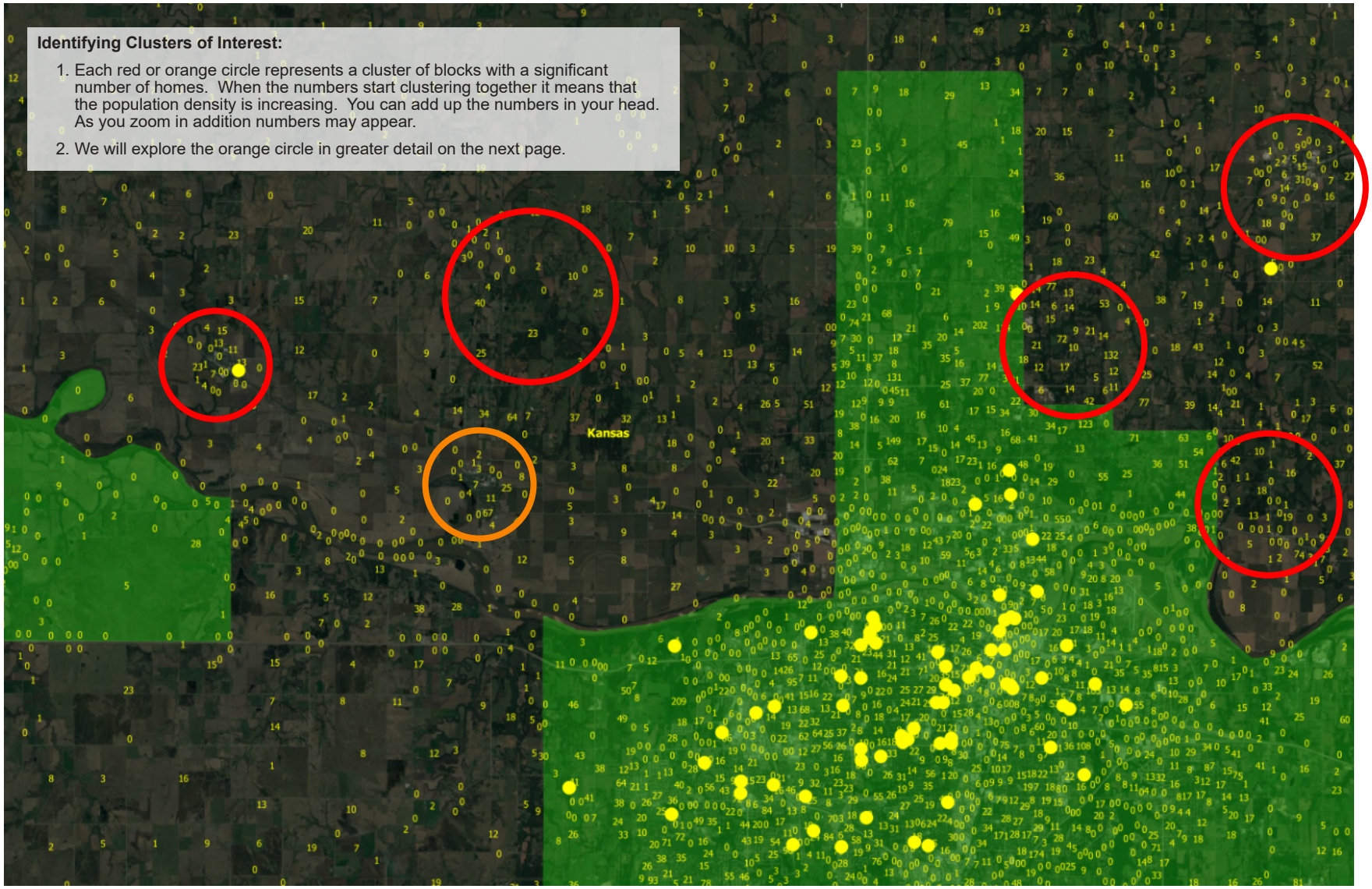


Figure 10: A Single Community, over 300 Homes Passed

Such venues often represent an opportunity to provide a larger broadband pipe.

Measuring Performance

There are a number of factors that greatly influence performance and contribute to the significant differences in reported speeds. These include:

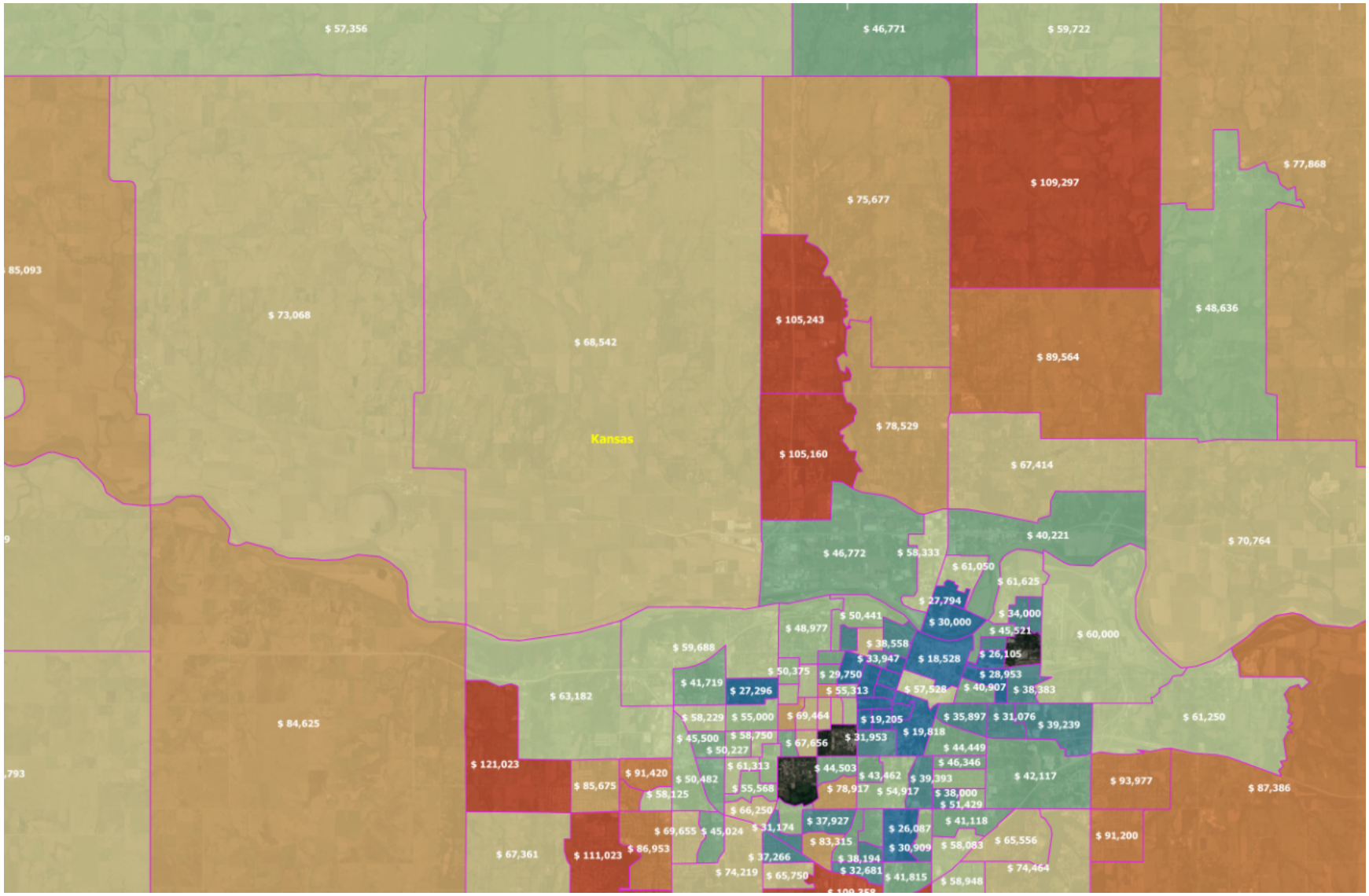
- *Advertised vs. Measured*. When an ISP reports its performance to the FCC on Form 477 it is asked to describe the "maximum advertised speed". This number of often greater than the average (mean or median) speed delivered. In some cases an ISP may advertise a speed that it can only deliver to some subscribers. In addition, most ISPs offer a range of plans and many subscribers do not purchase the most expensive plan. Thus, there is a difference (often a large difference), between the maximum advertised speed and the speed delivered to the average subscriber.

- *A Partially Covered Census Block*. When an ISP reports its performance to the FCC on Form 477 it identifies each census block it serves in whole or in part. If it has a single subscriber then that census block is categorized as served. The resulting coverage map – in the eyes of most consumers – overstates coverage. In an effort to address this discrepancy the Broadband Infrastructure Program and the Tribal Broadband Connectivity Program allow grant funds to be used to serve the unserved households within a partially served block.

- *Mean vs. Median*. The "average" speed can be measured many different ways. In most networks performance statistics are skewed to the right. In other words there are likely to be a few subscribers with very high speeds and a large number of subscribers with very modest speeds. The median speed (the number above which half of the data points fall and below which half of the data points fall) is generally consider a more meaningful metric, just as median household income is a better measure of spending power than mean income. We find with performance data some sets of measurements that report mean speeds and others that report median speeds. Means speeds in most cases will be significantly higher than median speeds. Both measurements may be technically correct but the resulting numbers are different. Additionally, one could consider time-of-day differences or use a cumulative distribution function. A service level agreement that promises to deliver a certain speed 99.9% of the time is far more stringent than a promise to deliver the same speed "on average".

- *Geographic Area*. The size of the geographic area considered greatly influences the numerical result and how meaningful it might be. In a large geographic area (especially one that includes both urban or dense suburban geography and rural geography) the urbanized portion is likely to be better served than the rural portion. A single performance number is likely to overstate rural quality of service. Also, since household densities are higher in urban areas the distribution of measurements is likely to disproportionately reflect urban households. The solution is to characterize network performance in as small a geographic area as possible. Blocks are better than block groups which are better than tracts which are better than counties.

Figure 11: Median Household Income by Block Group



- *Modem Speed vs. Wi-Fi Speed*. If one measures performance at the modem the result is likely to be more favorably than the same measurement on a device connected via Wi-Fi. Wi-Fi networks, while convenient, are notoriously unreliable. Like any radio access technology they are subject to signal strength degradation (due to obstructions, distance, and reflective fading) and to interference (especially in an urban environment). Equally importantly many consumers don't know how to set up a Wi-Fi network or how to optimize it for performance or how to measure performance. Many view Wi-Fi in binary terms, like electrical power that is either "on" or "off" (a black out). Wi-Fi networks are, of course, much more nuanced and can be a major factor limiting one's broadband experience. If a consumer has a poor experience because of a poorly configured Wi-Fi network it is unfair to blame the ISP.

- *Intentionality*. When someone runs a speed test it is likely that they believe they should have reasonable connectivity. In contrast, when machine-to-machine downloads are measured passively the consumer may be unaware that communication is taking place. A laptop user, for instance, might close his laptop and plug it in to charge in a room that has poor Wi-Fi coverage. A measurement of passive download speeds (e.g. operating system updates) may not represent the speeds the user experiences when deliberately connecting to the network.

- *Pricing of Service*. Most consumers do not purchase the most expensive broadband plan available. Consequently, a measurement of consumer speed is not necessarily an indicator of the capabilities of the associated outside plant.

FCC vs. Industry Data

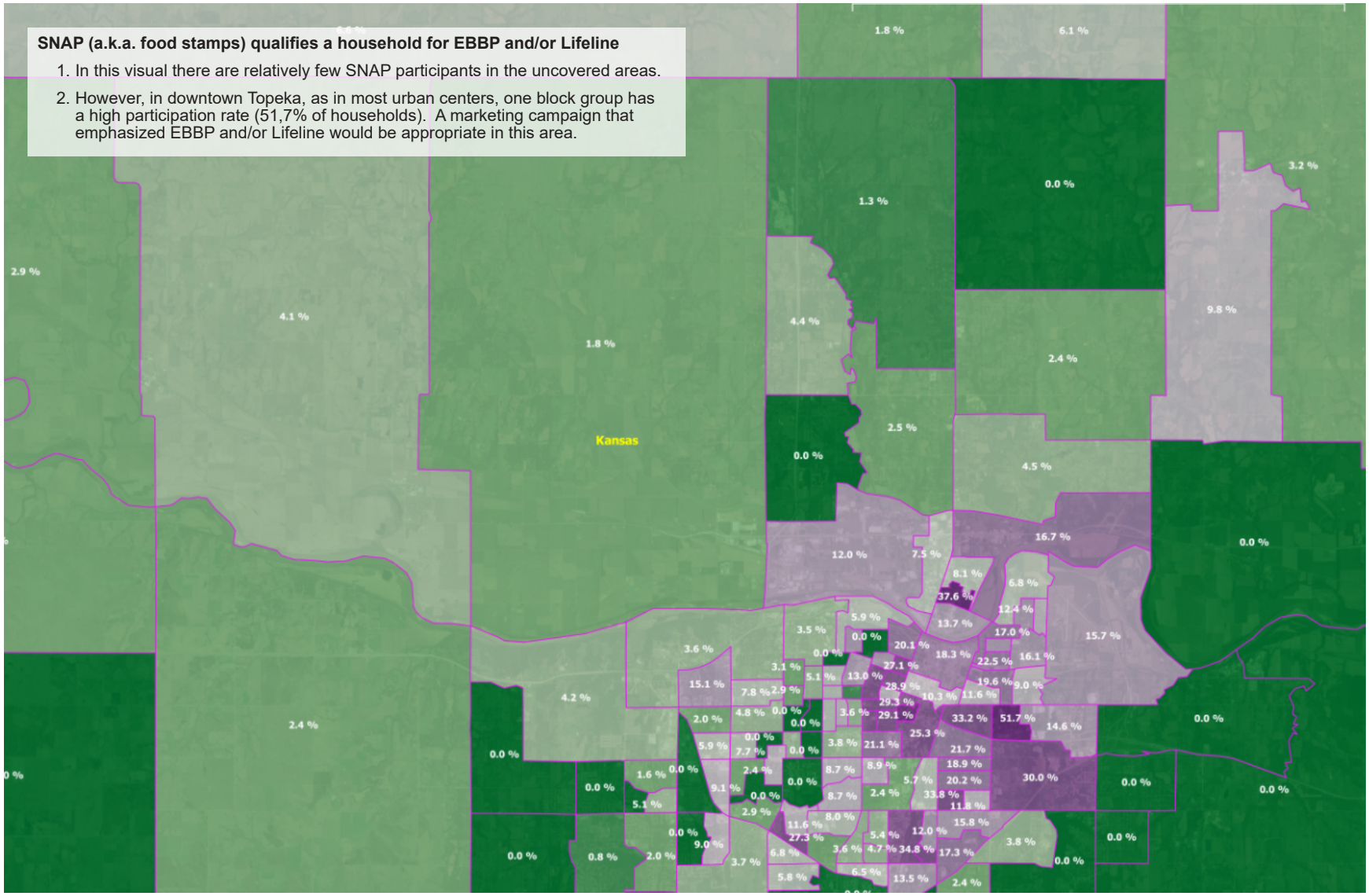
With the above caveats, here are the included data sets:

- FCC Form 477. The FCC requires ISPs to report service availability twice a year on Form 477. Despite its many limitations this data serves as a starting point to understand broadband availability by geography. The Toolkit includes three important layers (June 2020 networks, excluding satellite. The raw data was released by the FCC on March 28th, 2021). Calculated layers include:
  - Qualifying Broadband (census blocks with a minimum of 25 Mbps down and 3 Mbps up)
  - Non-Qualifying Service (less than the specified 25-3)
  - No Coverage (e.g. no ISPs serving the block)

- Federal Commitments. The federal government (the FCC, the USDA, and others) as well as state governments have subsidized the deployment of broadband infrastructure. The Toolkit includes data from the three most impactful federal programs. The NTIA grant programs general preclude infrastructure grants in these areas to avoid duplication. Various exceptions exist, including instances in which the funding commitment will not result in a network that meets the current definition of broadband. The Toolkit includes the following calculated results:

  - RDOF. A map layer shows all RDOF awards that fit the "low latency" category. The minimum award for RDOF is 25 Mbps / 3 Mbps.
  - CAF II. A map layer shows all CAF II awards that meet or exceed 25 Mbps / 3 Mbps and are "low latency".
  - USDA. A map layer showing all of the USDA

Figure 12: Food Stamp Participate Rate (% of Households) by Block Group



commitments, most notably ReConnect, with both grant and loan programs.

- Measured Data. The NTIA, as part of their National Broadband Mapping Program, collected measured data from multiple commercial and non-profit entities and made that data available to the public. The contributors included Ookla, M-Lab, and Microsoft. Links to each of the source data sets, including additional descriptive information and, in some cases, public use licenses, are included in the "Web Site Links" folder of the Toolkit. The data is provided in multiple resolutions and with a wide variety of metrics. The Toolkit visualizes the most important metrics. Here is a quick summary of each data set:

    - *Ookla*. Ookla, the owner of speedtest.net, reports gathering 37 billion speed tests worldwide. The data they provided to the NTIA was collected between January 1st and June 30th of 2020. It is aggregated by census tract and by county. It reports median download and upload speeds.

    - *M-Lab*. M-Lab is "a consortium of research, industry and public-interest partners dedicated to: Providing an open, verifiable measurement platform for global network performance. " M-Lab similarly reports median download and upload speeds. The data they provided to the NTIA was similarly collected between January 1st and June 30th of 2020. The results are aggregated on a county basis.

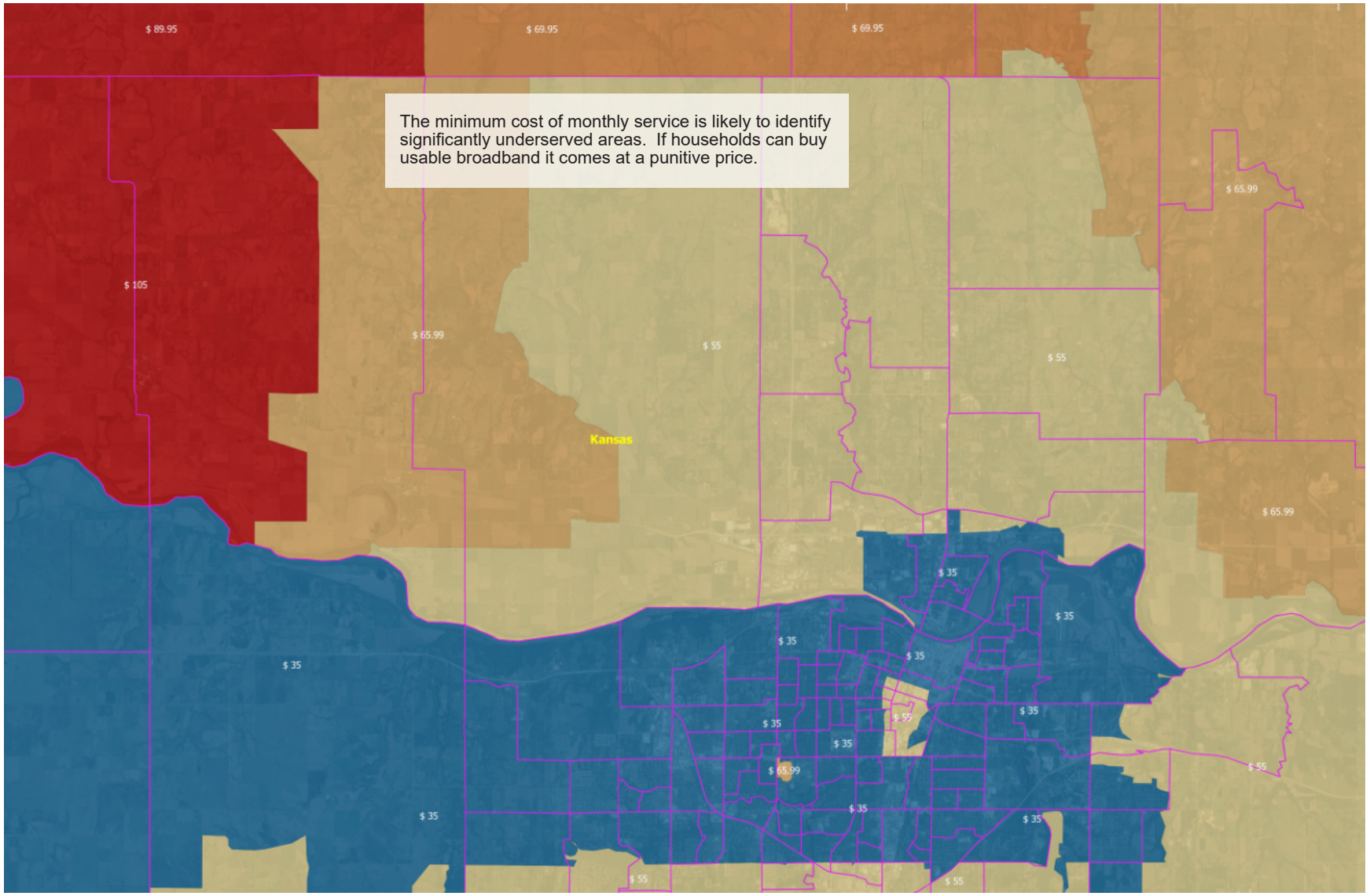
    - *Microsoft*. Microsoft reports the performance associated with passive machine-to machine downloads (operating system and other updates). The sample size is spectacular. The results (characterizing the percentage of downloads fulfilled over a 25 Mbps / 3 Mbps or better connection) are more pessimistic than others, possibly because of the passive nature of the communication and the possibility that many devices may be in poor Wi-Fi coverage. The results are aggregated on a county basis.

    - BroadbandNow (also BroadbandNow Research) collects a range of metrics on a Zip Code basis. They were not included in the NTIA collection but represent another credible source of measured data. In terms of resolution a Zip Code is better than a county but not as good as a tract. The Toolkit shows BroadbandNow download speeds and the "The Lowest Regular Monthly Priced Terrestrial (Wired + Fixed Wireless) Residential Standalone-Internet Broadband (25 Mbps Download / 3 Mbps Upload) Plan available." Areas with poor internet connectivity often have high prices, as shown by this metric.

In the current set of grant programs the NTIA strongly encourages applicants to present their own data. This could be data they collect themselves or data acquired in collaboration with an existing entity. It is important to note that the quality and resolution of data provided to the NTIA does not begin to reflect the capabilities of the associated organizations.

Test data is important for any applicant who may wish to make the case than an area, while theoretically covered based on Form 477 submissions, is, in fact, not covered to the 25-3 standard, and

Figure 13: Minimum Monthly Cost of Broadband by Zip Code (BroadbandNow)



therefore deserves grant funding.

Layers of Visualization

- Inputs required to identify eligible geographies (tract and block group):
    - Household size
    - Median household income
    - Poverty threshold as a function of household size

- Key demographic inputs (block group):
    - Population density
    - Household density
    - Housing unit (physical structures, whether currently occupied or not) density

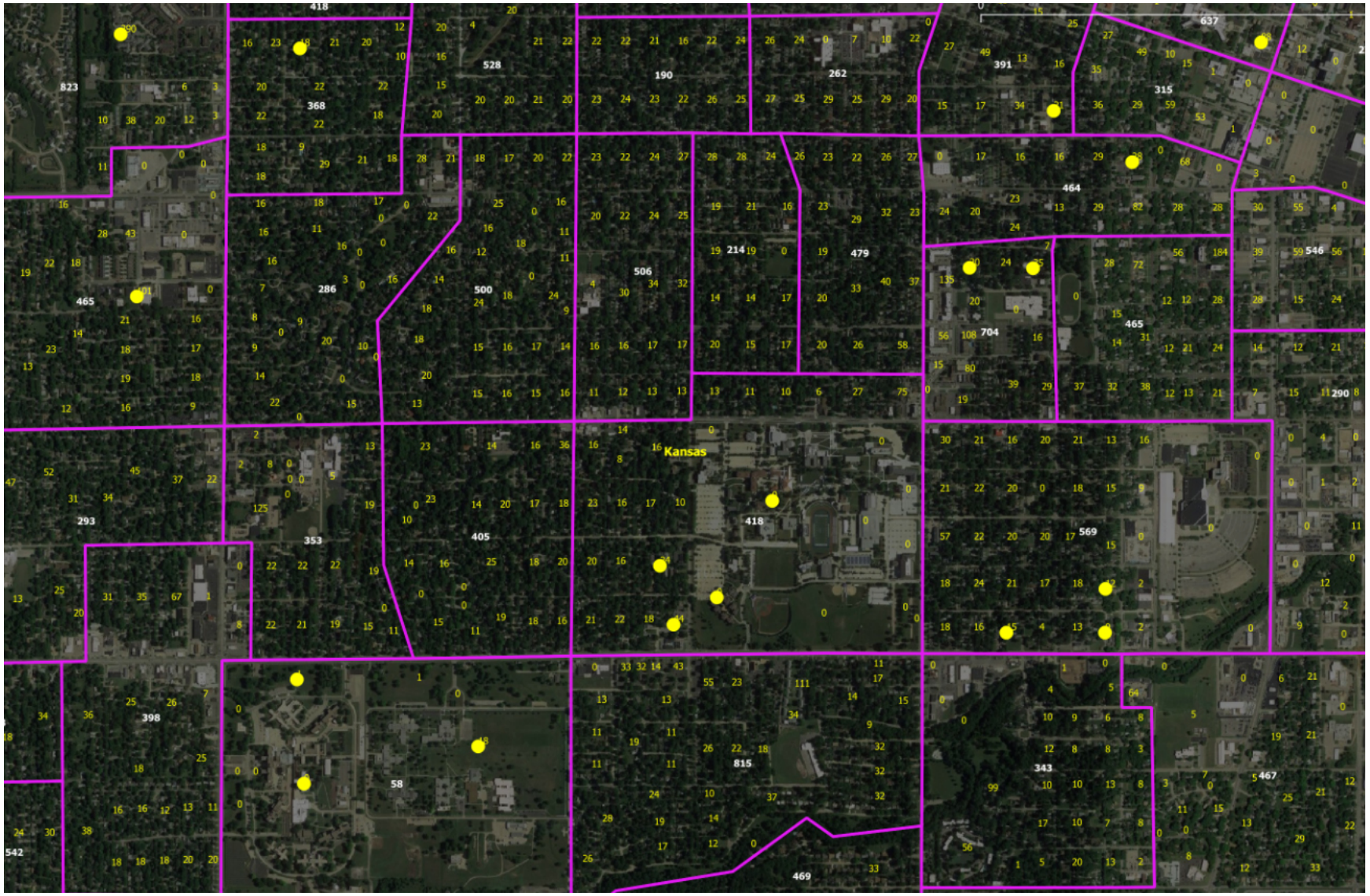
- Key income inputs (block group):
    - Income per capita
    - Mean income per household
    - Median income per household
    - Average household size
    - Estimated poverty line
    - SNAP (a.k.a. food stamps) household participation rate

- Important contextual data:
    - A wide variety of streamable background maps (physical geography, roads, etc.) from leading map content providers, as well as solid backgrounds (for readability).
    - Geographic boundaries (block groups, tracts, zip code tabulation area, counties, states, and congressional districts) alone, or with associated numerical codes and/or names.
    - FCC license areas (BEAs, BTAs, CMAs, EAGs, MEAs, MTAs, PEAs, REAs, RPCs), relevant to those who may be providing wireless solutions.
    - Roads (primary and/or secondary, with or without labels).
    - Elevation data. The user may, optionally, view the underlying terrain in a color-coded format that reflects land elevation, hills, and valleys. Imposing natural boundaries often dictate services areas. The data is both visual and numerical.

- The data sets take several forms that can be used in any combination:
    - Visual data in a geographical information system tool (where layers can be enabled or disabled).
    - Color-coded layer information (enabling rapid assessment of large geographic areas)
    - Numerical text layers (enabling the user to see exact numbers)
    - Selectable data (enabling the user to select a geographic area and extract that specific data from a large database).
    - Excel spreadsheet data (enabling the user to view and manipulate all of the data that ships with the tool).

Many of these included resources are described in greater detail in the coming pages.

Figure 14: Urban View. Housing Units by Block Group (White) and by Block (Yellow) and Group Homes by Block (Large Yellow Dot)



Demographic Data Sets

It is important to understand the significance of the various demographic data sets:

- *Housing Units* reflect the number of physical structures (single family homes, apartments, condominiums, mobile homes, etc.) in which a household could reside. The occupancy rate is the ratio of (rented HUs + owner-occupied HUs) / total HUs.

  In a city with 100% occupancy housing units could – conceptually – equal households, although such a situation rarely, if ever, exists.

- *Households* are the number of groups of people (family and non-family) that live together. A household would generally have a single fixed internet connection to the home. We know the number of households and the population associated with the households for each census block.

- *Group Quarters* are larger groups who do not live in households. Group quarters include university dormitories, nursing homes, and prisons, as examples. The population in group quarters is distinct from the population living in households.

- *Population*. This is the total number of people living in an area, regardless of their housing situation. This total population includes those living in households (the vast majority, whether in family or non-family households) plus those living in group quarters.

Income-Related Data

The Toolkit provides a number of layers of data describing income and income-related programs:

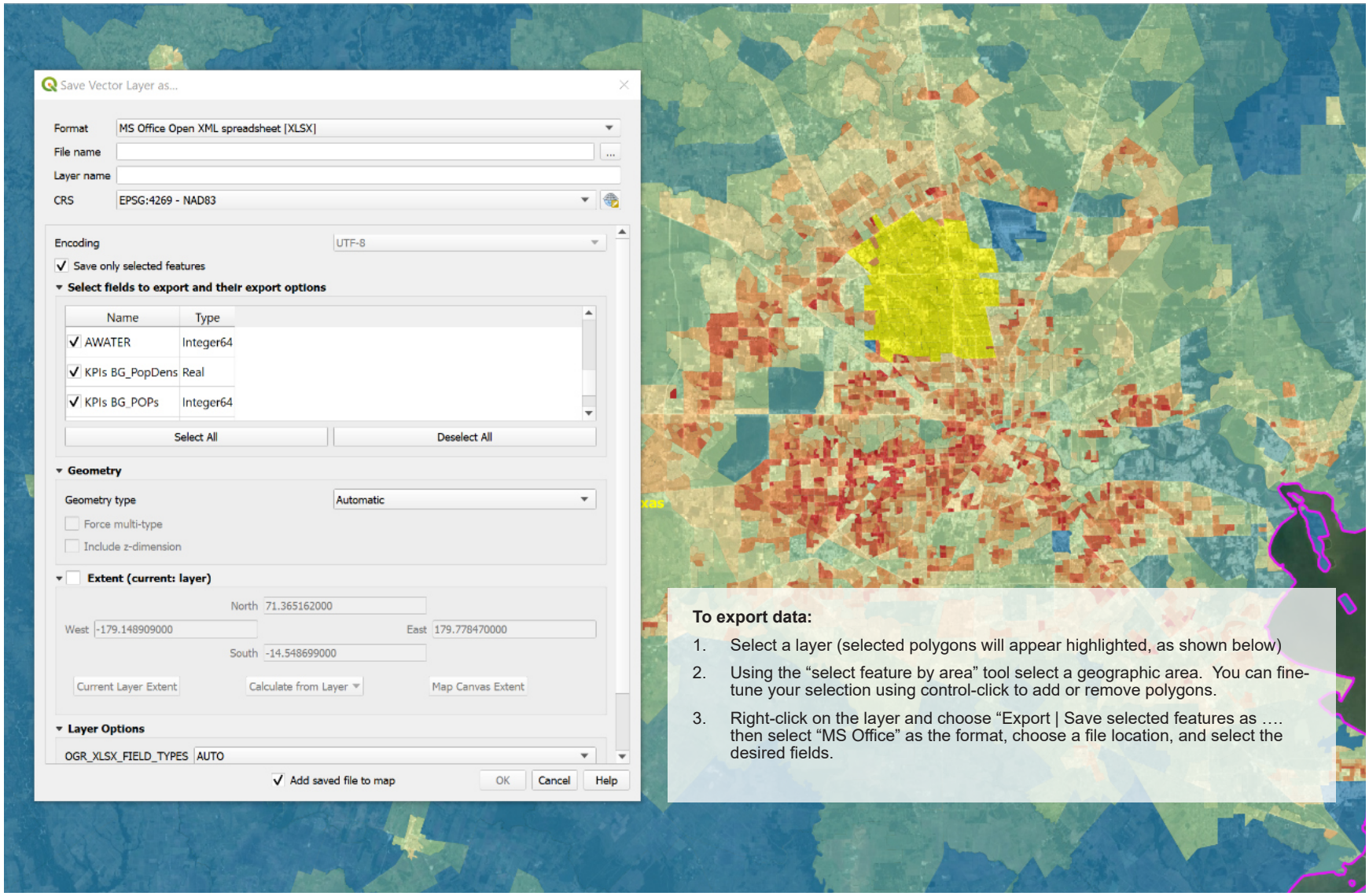
- *Annual Income per Capita*. This is annual aggregate income divided by total population.

- *Mean Annual Household Income*. This is annual aggregate household income divided by total households. The portion of the population that lives in group quarters (college dormitories, nursing homes, and prisons, as examples) is excluded.

- *Median Annual Household Income*. The median annual household income is a number above which half the households earn more and below which half the households earn less. In most geographic areas median income is lower than mean income because a few larger earners pull the mean upward. Median income is considered the best indicator of household buying power for non-luxury goods.

- *Poverty Line*. The Act refers to the "poverty line". Both the US Census Bureau and the US Department of Health and Human Services (HHS) provide poverty metrics. The Census Bureau uses "Poverty Thresholds" for statistical purposes. It is a 48-cell matrix that includes family size, number of children, 1 and 2 person units, and whether or not an individual is elderly. There is no geographic dimension. In contrast, the Department of Health and Human Services uses a relatively simple "Poverty Guidelines". The latter can be calculated based on family size and geography (Alaska vs. Hawaii vs. the Contiguous 48 States). The NTIA decided to

Figure 15: How to Select and Export Data



use a national average of the Census Bureau "Poverty Threshold", a calculation, the way the NTIA uses it, that is dependent only upon household size. The reader rounds the average household size in a geographic area up to the next integer value then performs a lookup.

- *Household Size*. The household size is calculated for each block group using the total number of households and the total population in households (excluding the population in group quarters).

- *SNAP Participation Rate*. The Supplemental Nutrition Assistance Program (SNAP), a.k.a. food stamps, participate rate is shown as a percentage of households within each block group. A household receiving SNAP benefits is eligible for Lifeline subsidies and, presumably, for benefits under the $3.2 billion *Emergency Broadband Benefit Program (EBBP)*, which is also part of the *Consolidated Appropriations Act, 2021*. The EBBP is administered by the FCC and USAC.

Opportunity Zones

Opportunity Zones were created by the 2017 Tax Cuts and Jobs Act to spur economic development and job creation in distressed communities. Opportunity zones have been designated in all 50 states and in every inhabited US territory (American Samoa, Guam, Northern Mariana Island, Puerto Rico, and the US Virgin Islands). Investors benefit from deferral or exclusion of capital gains. The community benefits from financial investment. They are designed to encourage investment in areas with high socioeconomic needs. The statute excludes specific luxury investments (e.g. golf courses) and specific "sin industries", but is otherwise applicable to any business.

The Toolkit visualizes Opportunity Zones either as bright green polygons (if one wishes to find them on a map) or as clear tiles in an ocean of whited out space. Understanding the location of Opportunity Zones relative to other measurable metrics – particularly indications of need – is extremely powerful. It enables a business to deploy capital in locations that are likely to have a favorable social impact while offering investors unique tax incentives. Local governments (urban and rural) may wish to encourage outside investment based on the juxtaposition of Opportunity Zones with important needs identified by other layers of data.

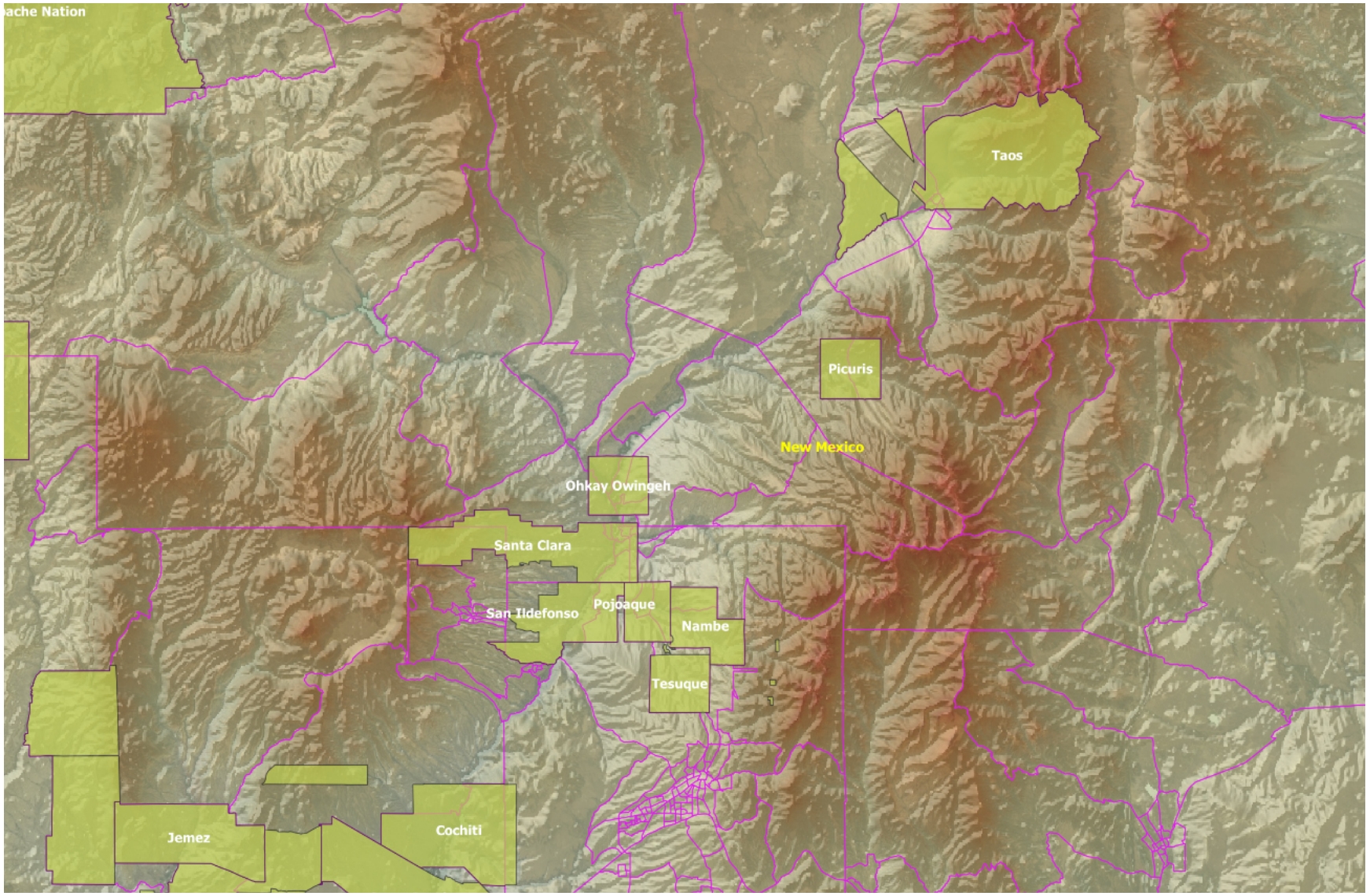
Geocoded Data

The visual portion of the Toolkit includes a number of important features:

- *Scrollable / pannable user interface*. A user can easily zoom in for a closer view or zoom out for a more distant view using the mouse's wheel. Similarly, a user can grab the image and drag it in any direction. One can start in Florida, zoom out then fly to Hawaii or Alaska (with the national tool) then zoom in again for a detailed view. As the user manipulates the screen all of the underlying data scrolls and pans accordingly.

- *Many layers*. The Toolkit includes many layers of data that can be individually toggled on or off. The Toolkit is designed to show one graphical layer at a time. Each layer is translucent, so that the underlying map is visible.

Figure 16: Elevation Data



- *Meaningful colors*. Numerical data is displayed using a range of colors. In most cases the scale runs from blue (low values) to red (high values). The color scheme provides a hint as to the type of data. In each case there are ten color thresholds that represent quantiles (an equal number of data points). There is no absolute meaning to "red" or "blue" across data elements, since the color scheme changes with each data element to reflect the underlying range of the data. The colors are designed to provide a visual cue to help the user see patterns and identify outlying values within any particular data set. Each data set has a legend that the user can see by clicking the "expand" triangular icon next to the "Visual" label for the data set. The legend displays the exact range of values associated with each color.

- *Numerical overlays*. Most of the data sets (all of demographic and economic data) display not only colors, but also numbers. With demographic and economic data it is desirable to turn on the numerical overlay to see the exact value of each underlying region, especially when zoomed in to a small geographic area. If the user zooms out it is generally desirable to turn off the numerical display and enjoy a rich mosaic of color. If numerical text continues to be displayed when zoomed out the text associated with adjacent regions starts to overlap and quickly becomes unreadable.

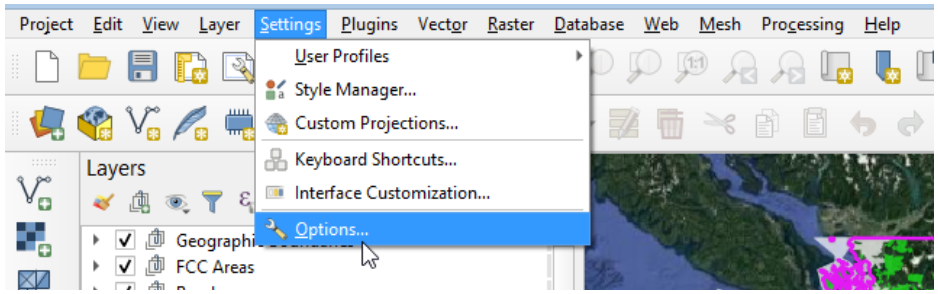
- *Geographic Boundaries*. The Toolkit includes a long list of boundaries that can be turned on or off. These include state lines, county lines, congressional districts, zip code (ZCTA) boundaries, census tracts, census block groups, and census blocks.

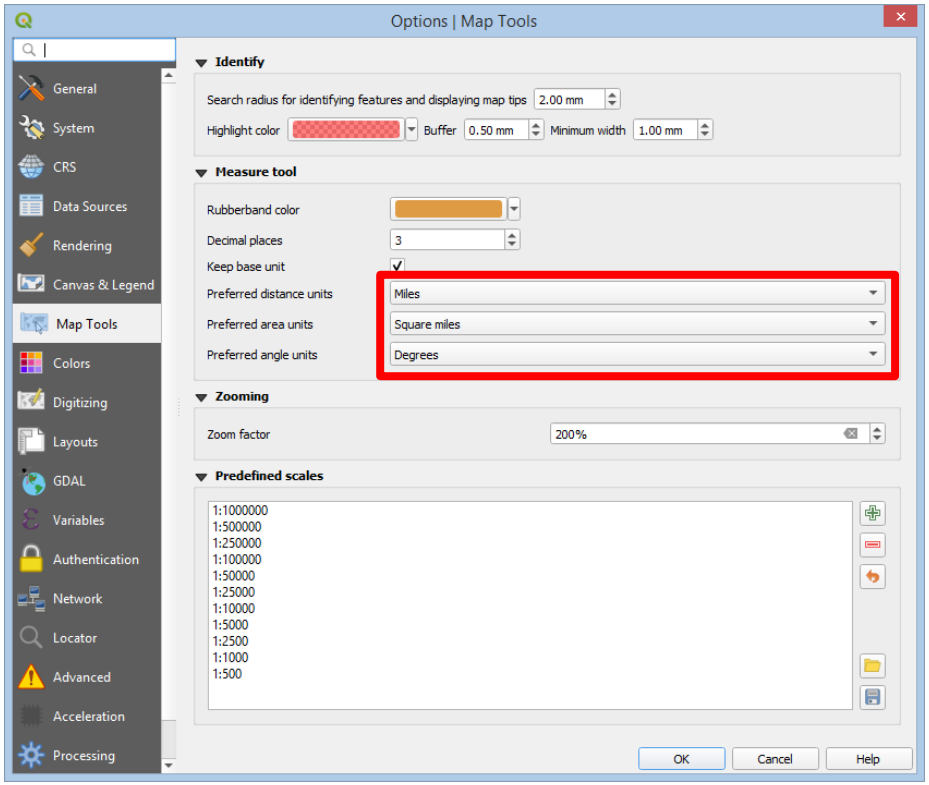
- *License Areas*. The FCC has licensed spectrum over the years using different geographic boundaries. Some users of the Toolkit may own spectrum. The toolkit therefore includes boundaries for the most widely used license areas. These include: Cellular Market Areas (CMAs), Basic Trading Areas (BTAs), Major Trading Areas (MTAs), Regional PCS Areas (RPCs), Economic Areas (EAs or BEAs), Major Economic Areas (MEAs), Regional Economic Areas (REAs), Economic Areas Groupings (EAGs), and Partial Economic Areas (PEAs).

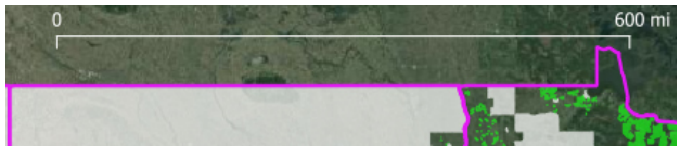
- *Boundary names and other data*. In most cases the name of the boundary (e.g. the state or county) can be displayed. Alternatively a code may be displayed. The Census Bureau has a hierarchical numbering scheme called FIPS that begins at the state level (2 digits) then goes to the county level (2+3 = 5 digits) then to the tract level (2 + 3 + 6 = 11 digits) then to the block group level (2 + 3 + 6 + 1 = 12 digits) then to the block level (2+ 3+ 6 +1 +3 = 15 digits). If a user wishes to pull up spreadsheet data that corresponds to a visualize image it is helpful to turn on the numerical display for FIPS, take a screen shot, then look for the corresponding data set of spreadsheet data. Since everything is hierarchical one can select a county (the first 5 digits of the FIPS) by selecting all the block group data with the desired county code in the first 5 digits, as an example.

- *Roads*. The Toolkit includes primary and secondary roads, with or without name labels. Road layers may be turned on or off. Alternatively, one might choose an underlying map that includes road and place labels. Google, Bing, and OpenStreets, in the Maps folder, each include this option.

Figure 17: Setting the Legend to Miles







Choice of Units for Distance and Area Measurements. In the United States people discuss distances in miles and areas in square miles or perhaps acres. The scientific community tends to use kilometers and square kilometers. The FCC and the Census Bureau have increasingly adopted metric units in their publications.

1 km = 0.621371 statutory miles. Similarly 1 square kilometer = 0.386102 square miles. A square mile is equal to 640 acres or 258.999 hectors.

The Toolkit can display the map legend in either kilometers or miles. *Figure* 10 shows how to change from one set of units to another.

The internal databases of the Toolkit, including the spreadsheets, represent units in meters, square meters, kilometers, and square kilometers.

Graphical Versus Tabular

To build a business case one needs real data, not just a pretty picture. The Toolkit includes a comprehensive set of geocoded spreadsheet data that largely matches the demographic and economic data sets in the visual tool. Each data set includes:

- *Numerical Code*. A numerical identifier for the region (typically a FIPS code), either a block or block group or a fragment of a block.

- *Name of Region or Entity*. The name of the region (e.g. a state and county or tribal nation) or an entity (a college, university).

- *Calculated Metrics*. Examples include areas, percentages, prorated metrics, growth factors, median household income, etc.

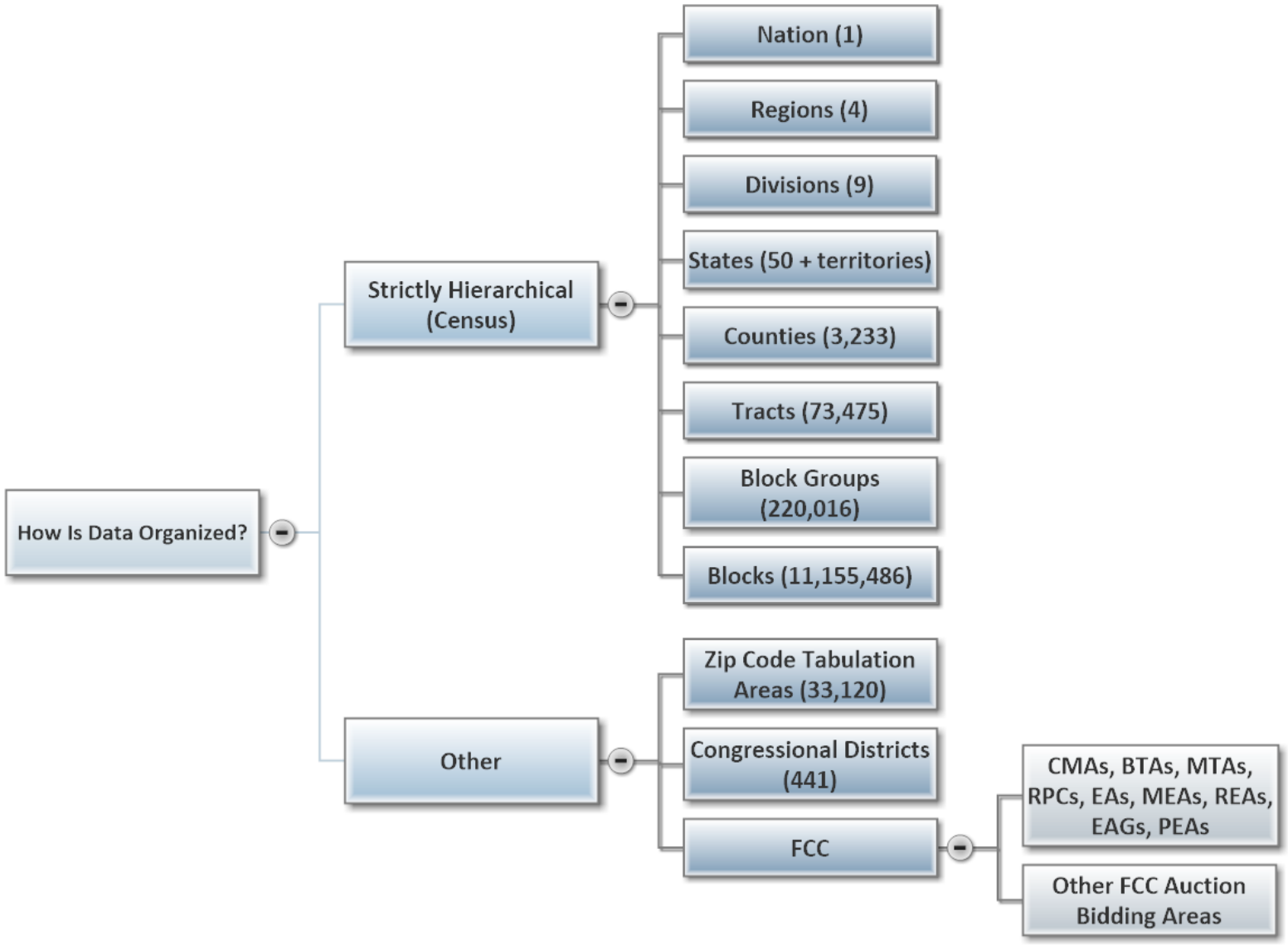
- *Raw "Counter" Data*. Raw data. The most important elements are housing units (structures), households (people), population (people), and the population included in households. Census polygons are hierarchical. Each block group, for instance, sums all of the blocks within it.

- *Population Estimates / Forecast.* In addition, the Toolkit includes separate population estimates / forecasts for every county in the 50 United States plus for the District of Columbia and Puerto Rico, based on the most recent yearly data from the Census Bureau. Recent county-level growth rates are used to produce near-term forecasts through the date of the auction (July 1, 2020).

Optimizing Performance

Geographical Information Systems, such as the QGIS browser, are data crunching machines and miraculous pieces of software in that they seek to visualize overwhelmingly large amount of data elegantly. The Visual Toolkit, as an application, has been highly optimized for performance, using as few computer resources as possible to achieve its objectives. Even so, it is helpful for every user to be aware of factors that impact performance:

Figure 18: Hierarchy of Geographic Boundaries



- *Computer Hardware*. Every GIS application demands significant hardware resources. Ideally, one would run the Toolkit on a computer with a 64-bit operating system, lots of RAM, reasonable processing power, and fast disk access (ideally SSD). The current version of QGIS and the current highly optimized version of the Toolkit will both run with modest resources.

- *Application Loading Time*. Expect any GIS application to take a few minutes to load. Think of it as an opportunity to get a fresh cup of coffee. During the load process it connects to all of the linked data sets and prepares to load the associated data on demand. It doesn't work like Microsoft Word, where one clicks on a document and, an instant later, the document appears. Once loaded, though, the application is designed to be responsive, with a few caveats.

- *First Time Loading a Layer*. The first time a user loads a visual layer after launching the application in QGIS the application may pause for a few seconds as it finds the desired data. Afterwards, one can select and deselect that data layer and expect the text and graphics to appear and disappear almost instantaneously, because it has been cached by the application. One can then sometimes zoom in and out and pan with minimal delay.

- *Streaming Maps*. In theory, streaming maps can cause the user interface to be slow because map data must be retrieved from a remote server. In practice, with the current version of QGIS and with a fast internet connection, the delay is negligible. Do be careful not to enable multiple maps at the same time. Doing so will multiply the volume of data that must be downloaded. Also, the user will see only one map at a time, so most of the effort will be wasted. If the user is in an airplane or has a slow internet connection or no connection at all then the user should disable the map by unchecking the map layer. If one is unsure about the impact of the map it is easy to disable it and to enable, instead, a solid color background (gray, black, white) to see if the application becomes visibly more responsive. Dark solid backgrounds, while not as pretty as a map, are wonderful for reading detailed overlaid data.

- *Text Overlays*. A text overlay can sometime slow the display. This is generally the case when text is enabled with a high resolution data set and the user is zoomed out. Imagine, for instance, looking at the continental United States, viewing data at the block group level, with text enabled. QGIS would attempt to write 200,000 numerical values on the screen, one number for each polygon visualized. The user interface would be slow and the resulting image would be a mess. It is best to turn off text overlays before you zoom out then decide what text is appropriate at the new zoom level. Up close, one might be interested in block group FIPS codes, but zoomed out one might be interested in state boundaries and state names, as an example. High resolution boundaries (e.g. block group boundaries) when zoomed out can also slow the user interface and flood the resulting image with a single color of ink (reflecting the color of the boundaries). The implications of most of these decisions will become obvious the first time one uses the application.

Curated Sources

The carefully curated data in the Toolkit comes primarily from a small number of exceptionally high quality government sources:

- US Census Bureau
- Federal Communications Commission (FCC)
- National Telecommunications Information Administration (NTIA)
- U.S. Geological Survey (USGS)
- U.S. Congress (legislative text)

The more significant sources include:

- US Census Bureau, American Community Survey. The ACS surveys 3.5 million households + 185,000 persons in group quarters per year on subjects ranging from household income to demographics to physical space and amenities to devices and connectivity to monthly household expenditures. These are converted into single-year and 5-year estimates and other data products. The Toolkit uses the 2019 5-year estimates, which were published on December 10th, 2020.

- US Census Bureau, Population and Housing Estimates (PEP), The International Data Base, County Business Patterns, and a wide rage of geographic boundary products and definitions. Extremely important are well-documented processes, which give the numerical data important context and meaning.

- The Federal Communications Commission. The FCC collects fixed and mobile coverage by technology by operator, as well as other service metrics and publishes detailed auction results. The CBRS Toolkit (available separately, in state and national versions) includes visualized fixed and mobile competitive deployment data (Form 477). This tool, the Tribal and Minority Community Toolkit, includes FCC reverse auction (CAF II and RODF) funding commitments for geographies that meet or exceed the FCC's definition of broadband, as well as USDA (e.g. ReConnect) funding commitments. Visibility into funding commitments is important for infrastructure-oriented grants to prevent a duplication of funding.

Video Tutorials

Video tutorials exist to help new users get started, understand the sophisticated functionality, enable and disable options, and effectively use the various Toolkit products. Be sure to visit *https://www.youtube.com/channel/UCDgYo4d8RJfVfE294CbsbHQ*.

Next Steps

The New Initiatives page includes a complete set of information on the Tribal and Minority Community Toolkit. It includes the latest manuals and links to tutorial videos:

http://cbrstoolkit.com/pages/initiatives

The Toolkit team will be happy to answer your questions / discuss your needs by phone or video conference.

You can reach us at **support@cbrstoolkit.com**.