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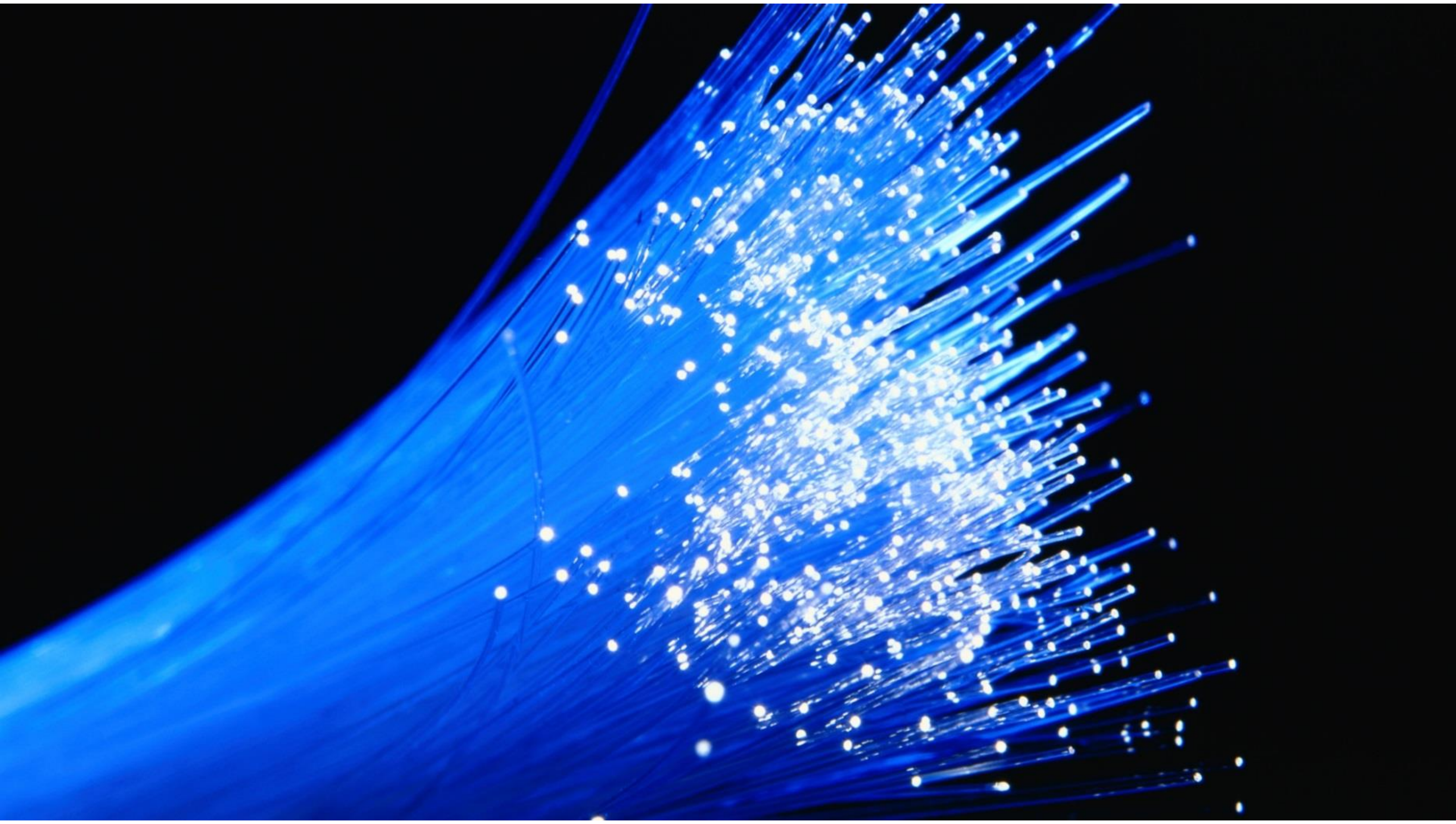

Broadband and Digital Equity Strategic Plan

Prepared for the City of Dallas and
Dallas Independent School District
August 2021

Columbia Telecommunications Corporation

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1 Executive summary

The City of Dallas (City) and Dallas Independent School District (DISD) commissioned this plan in late 2020 as the Covid-19 pandemic highlighted and exacerbated students' and residents' need for broadband access. Both DISD and the City have taken significant steps to address broadband-related gaps in the City and DISD district, but barriers to equitable internet access and use remain in Dallas, just as they do across the country.

This project aimed to identify the magnitude of digital equity challenges and broadband gaps, and to develop actionable strategies that could be undertaken by the City and the DISD to help Dallas residents, including student households, to access affordable, high-speed home broadband service—and possess the devices and skills necessary to make fullest use of broadband. This Plan represents a vision for achieving digital equity and strategic alignment among community partners. It contains four broad based recommendations with initiatives associated with each of the recommendations. Each has its own track and timeline for completion. This document also provides guidance on a range of federal programs and Economic Development Agency (EDA) grant opportunities.

At the outset, we highlight four primary recommendations:

1. **Proceed with the City's plan to construct 100 miles of City fiber and add additional fiber to create a 180-mile network**

We recommend the City proceed with its existing plan to build 100 miles of fiber and expand it with additional fiber to support digital divide initiatives and connect City facilities. The 100 miles of fiber would cost about $13.5 million to build and $1 million to operate each year and could pay for itself (by enabling the City to avoid the costs of leased circuits of fiber at that scale) in about six years. The backbone could provide backhaul for a range of City applications; spare strands of City fiber could then assist digital equity efforts by, among other things, providing options for connectivity in areas of the City where fiber deployments by private providers has lagged. The connectivity solution could include wider fixed wireless deployments as summarized in the next recommendation.

Adding fiber for a total of 180 miles of fiber would cost approximately $25 million instead of $13.5 million. This design incorporates the full 100-mile build, plus additional fiber to further expand the potential of the network to facilitate City applications and reach priority areas for possible broadband solutions. This would make a meaningful impact toward the goal of getting fiber close to every resident and business within the City. Compared to acquiring the same fiber through leased services, this project could provide significant long-term operational savings. We summarize our recommendation and financial analysis of this option in Section 2.1 and provide the full financial analysis and underlying assumptions in Section 6.

2. **Consider expanding targeted fixed wireless infrastructure using school rooftops to supplement existing broadband offerings to serve both DISD families and other residents**

Though broadband is widely available in Dallas, broadband-level speeds are not available to all residents—and affordability is an issue for many families. We recommend the City and DISD expand their initial successful fixed-wireless pilot projects to explore additional targeted fixed-wireless broadband buildouts. Using DISD's fixed-wireless pilot project at Lincoln High School as a template, we created models for expanding such service using equipment mounted on DISD building rooftops. We provide a summary of the capital and operating costs of this approach at a variety of scales and models in Section 2.2, and full technical descriptions and other relevant information in Section 5. However, before making a decision about a wireless buildout, we recommend that the City and DISD evaluate the pilot projects.

3. **Increase staffing for digital equity programs, such as by establishing a call center to help qualified low-income residents enroll in subsidy programs**

Dallas is already served with near ubiquity by Charter and AT&T and some other providers. Though speeds lag in some areas, the core issue for many residents is one of affordability. We recommend the City increase staffing for digital equity programs to assist residents in enrolling in existing subsidy and low-cost programs including Spectrum Internet Assist, Access from AT&T, and the Federal Communications Commission's (FCC) Lifeline and Emergency Broadband Benefit programs. The mail survey conducted for this study documented significant gaps between the number of families who are potentially eligible for these programs and the number actually using them—a problem local stakeholders also reported in our meetings. We recommend the City and DISD set up a call center and technical support to assist residents in enrolling in these programs at significant scale. We summarize the potential costs of such an effort in Section 2.3 and provide a fuller discussion in Section 7.

4. **Expand programmatic efforts aimed at helping residents access computers and develop digital skills**

The broadband gaps and challenges faced by Dallas residents are not limited to service access or affordability. Many residents lack the resources to purchase and maintain up-to-date computers and the skills necessary to make the most effective use of broadband and computers. We recommend increasing the scale of the device and skills efforts already in place in Dallas. We estimate that a one-time device purchase program to provide a device to the roughly 65,000 households that lack a computer would cost $13 million. We estimate that a program to provide skills training to an initial 5,000 residents would cost $1 million and could be scaled further to meet the need. Community-based groups and nonprofits could play a key role in implementing these efforts. We summarize these recommendations in Section 2.4 and provide more detail on all programmatic recommendations in Section 7.

1.1 Project overview

This project began with efforts to gather data on the Dallas broadband market, identify gaps in access, evaluate current programmatic solutions, and develop potential pilot solutions for serving unconnected students. In late 2020 and early 2021, CTC conducted research to identify, quantify, and understand the nature of the digital divide affecting DISD families and Dallas residents more broadly, including through a mail survey that provided insights into the interplay of challenges related to broadband access, affordability, device access, and digital literacy.

Among other tasks, CTC:

- Identified gaps in infrastructure and affordability in determining areas for investment and targeted initiatives
- Provided engineering assistance in partner selection and implementation of DISD and City pilot networks to provide broadband to Dallas residents
- Developed a design and cost estimate for a fixed wireless service
- Analyzed the potential for a City-owned fiber ring to connect City facilities and estimated costs to expand fiber to Dallas neighborhoods, with a focus on areas least served by broadband
- Developed strategies to use emerging federal broadband subsidy programs to expand broadband access through existing providers
- Made recommendations for how the data developed could inform expansion of the digital equity initiatives underway in Dallas

This effort was focused on determining gaps for purposes of addressing equity goals. CTC's engineers estimated that a ubiquitous fiber-to-the-premises (FTTP) network for Dallas would exceed $1.5 billion in capital costs and would, as a result of putting extensive resources into neighborhoods that are already served with broadband, not address equity issues most efficiently. A citywide FTTP approach would divert capital funds to that are more affluent and create long-term costs that could better be directed toward targeted equity efforts.

This work was commissioned by the City of Dallas and the DISD. Although strategic planning for Dallas County was outside the scope of this plan, the County has been a strong partner to the City and the DISD through collaborative efforts and work on the Internet for All Coalition. As such, there is considerable potential for the County to serve as a strong partner in all of the initiatives recommended here, given the goals and interests it shares with the City and the DISD.

1.2 Network investment has not occurred consistently across all Dallas neighborhoods

Our analysis of the Dallas broadband market found that several providers—chiefly Charter and AT&T, augmented by fixed wireless service—provide service to the great majority of the City. But a review of service availability and some speed test results suggest that there persist gaps in the provision of broadband speeds (defined as at least 25 Mbps download, 3 Mbps upload—a standard set by the FCC in 2015).

At the outset, it is important to note that even speeds of 25/3 are not necessarily sufficient to meet the needs of students and other residents. Those minimum speeds might be workable if internet usage were mainly in the form of internet browsing, email, and even streaming movies (i.e., primarily downloads). But videoconferencing and other common applications demand high bandwidth in the upload direction as well. For example, at the home of a family of four, if two children are attending classes using Zoom and two adults are using their broadband connections to attend occasional meetings, send e-mail, and do research, their combined required bandwidth could easily exceed this FCC-minimum level of broadband service.[1] Bandwidth needs are constantly increasing, too, so even sufficient speeds today may be inadequate tomorrow.

Our analysis found that investment in networks—specifically, fiber deployment or the upgrade of DSL networks to reach higher speeds—has not occurred consistently throughout the City and DISD market area. Online speed testing conducted for this study detected sub-broadband speeds at households using both Charter and AT&T at various locations around the City.[2]

The parts of Dallas that have seen the least investment fall into two categories and are illustrated in Figure 1 (below):

1. Areas in which the maximum reported DSL download speed is 30 Mbps or lower, **and** where fiber service is not available. The only option for a wired internet service in these areas would be cable, or DSL operating at download speeds of 30 Mbps or less.

2. Areas in which fixed wireless is the only fixed service reported to be available (i.e., areas in which there is no option for a wired service).

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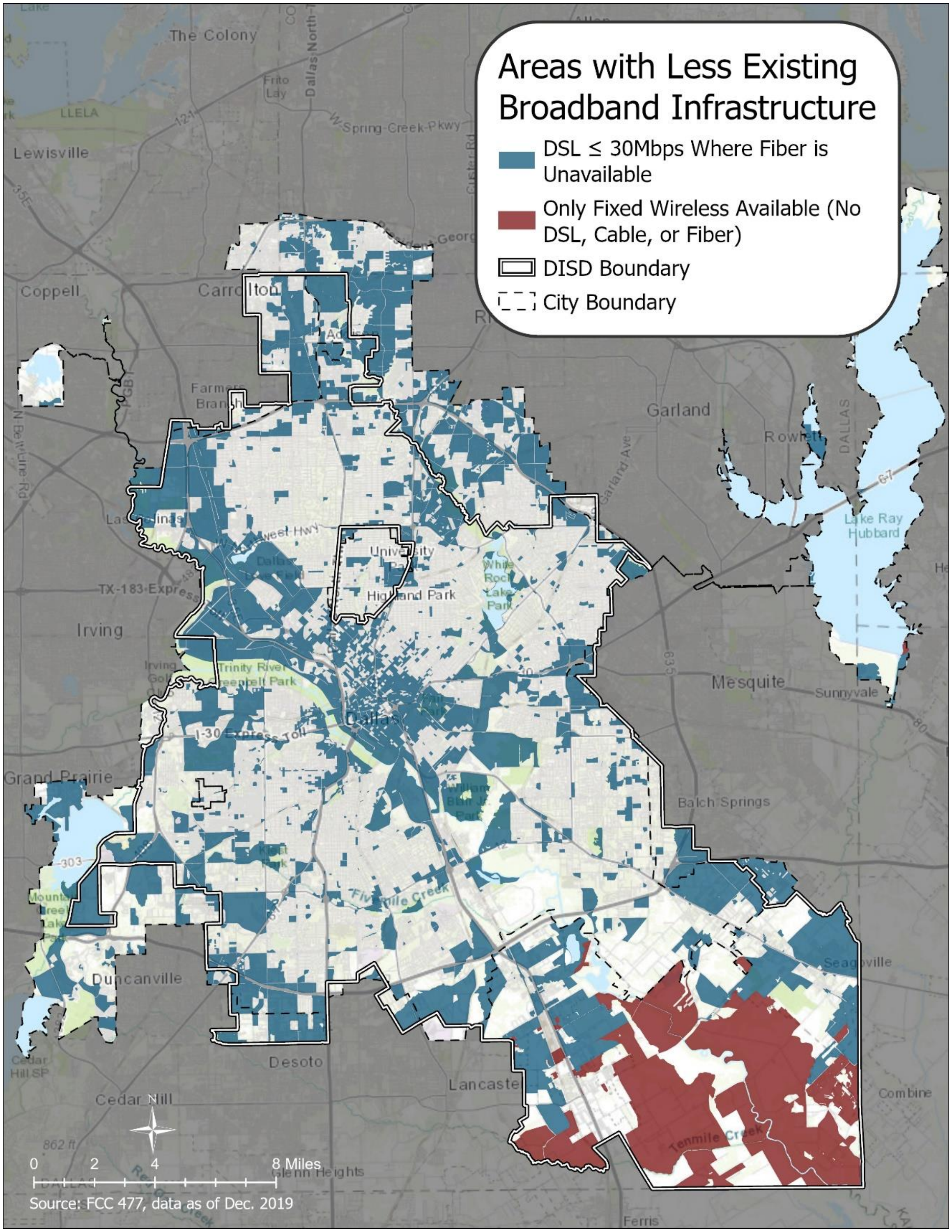
[1] "Broadband Speed Guide," Federal Communications Commission, https://www.fcc.gov/consumers/guides/broadband-speed-guide?contrast=.

[2] See Section 1.3 for more details. Identifying potential factors in the home that could contribute to a reduction in speeds was beyond the scope of this effort.

This figure is based on structures in these zones (not population) but we estimate that more than 210,000 people live in the DSL-only areas (teal) and that about 5,000 people live in the areas served only by fixed wireless service (red).

Figure 1: Low-Investment Areas Within the City and DISD Boundaries



In addition, we analyzed the low-investment areas' overlap with other factors throughout the City and DISD service area, including the City of Dallas Office of Equity and Inclusion's Covid-19 risk score data. The City developed the risk scores with consideration of the following questions:

- "Do Black, Hispanic and Native American populations together make up more than 70% of the community?
- Does the area have 15% or more of its families at or below 100% of the federal poverty level?
- Do less than 50% of the area's households own the home they live in?
- Is the area rated "High" on the CDC's Social Vulnerability Index, Socioeconomic Level?
- Are more than 12% of the area's residents 65 or older?"[3]

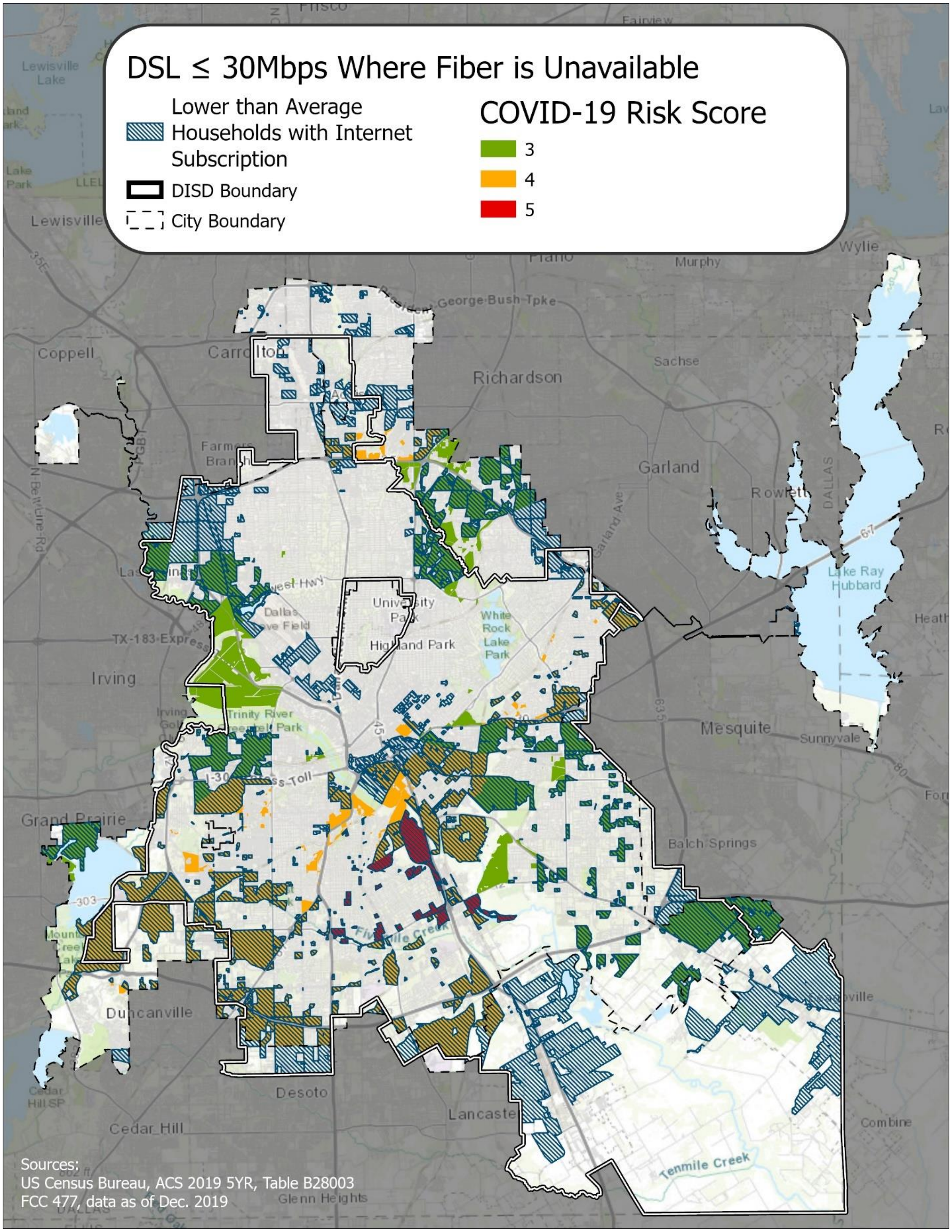
The City's Covid-19 risk scores were used in this context not to evaluate the pandemic's relationship to broadband needs (though it certainly has accentuated those needs) but rather as a local data proxy for a range of social and economic challenges facing segments of the Dallas community.

We found that several areas of the City that have been assigned Covid-19 risk scores of three, four, or five (i.e., the three highest scores, indicating the most risk) overlap with areas that do not have access to fiber—suggesting that some areas with high social and economic challenges are further challenged by lower levels of broadband investment and availability of high-speed services.

Further, we identified areas with high Covid risk that also, according to the Census Bureau's American Community Survey data, have lower-than-average rates of residential internet subscription. Figure 2 shows the overlap of the high-risk areas with areas lacking fiber investment and areas having lower-than-average residential internet subscriptions.

[3] Covid-19 risk score description and methodology, City of Dallas, https://dallasgis.maps.arcgis.com/home/item.html?id=186b98f0fab940118dbd9a4422db7eaa&view=table&sortOrder=desc&sortField=defaultFSOrder#overview (accessed April 29, 2021).

Figure 2: Areas Without Fiber, Lower-Than-Average Internet Subscriptions, and High Covid-19 Risk



1.3 Speed-test survey results identified lack of uniform broadband speeds

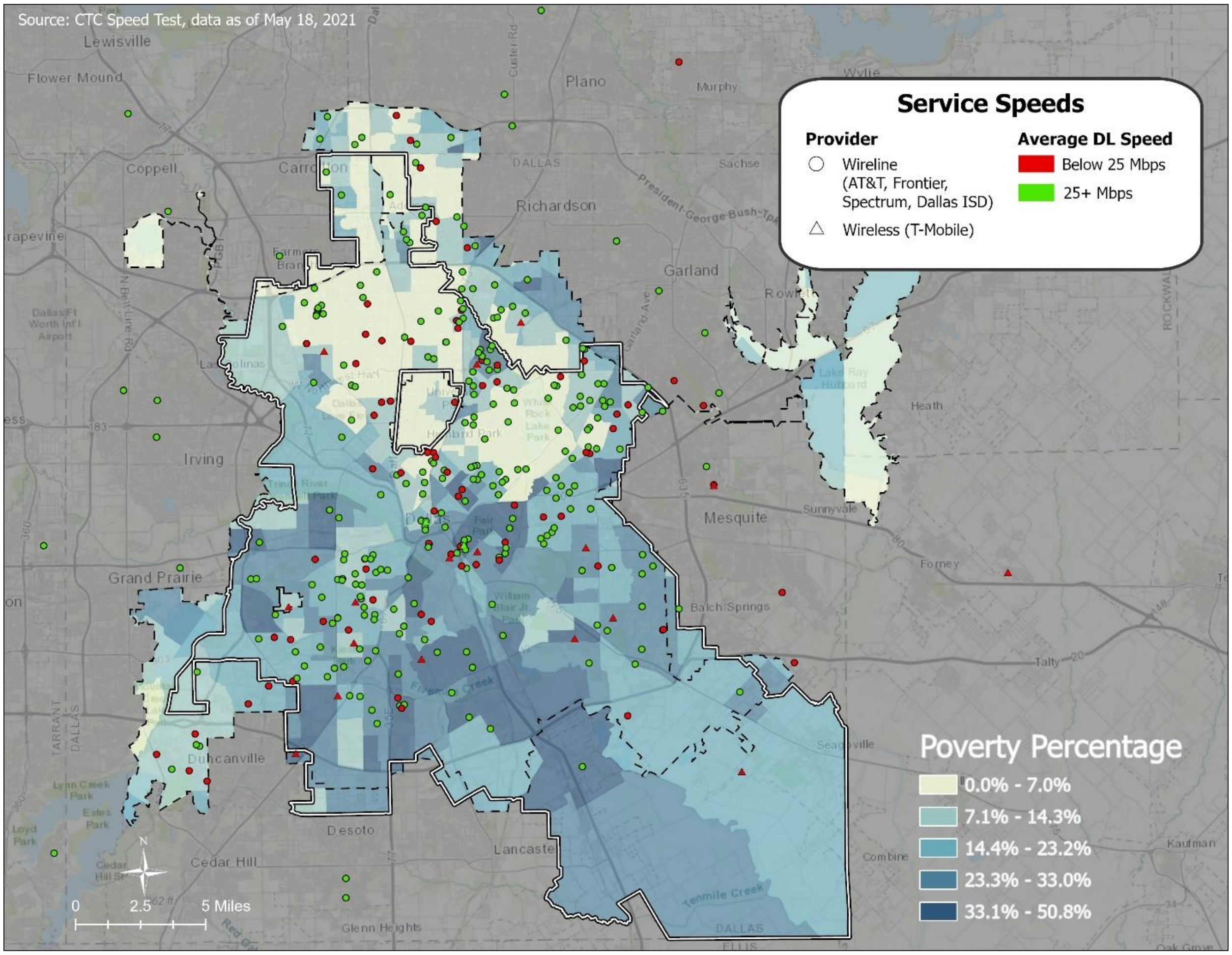
CTC developed, launched, and hosted a custom online speed test website (SpeedSurvey, https://dallas.speedsurvey.org/) to gather additional data on broadband in Dallas. The website included a means to conduct an internet speed test, a brief survey about levels of satisfaction with service, and an option to enter an address where no service was available. DISD, the City, and the Internet for All coalition promoted the SpeedSurvey link and encouraging participation by DISD households and other Dallas-area residents.

The overall goal was to develop the most granular data possible about broadband speeds available to households in the area. Between October 19, 2020, and May 18, 2021, 444 individuals filled out the SpeedSurvey survey or conducted speed tests. Tests were conducted mainly by Spectrum, AT&T, and DISD fixed wireless pilot project users.

Although the tests could not determine the cause of slower speeds in any given household—meaning, whether it is caused by slow service to the premises or factors in the home—the data suggest that Dallas-area residents may not be uniformly obtaining the minimal broadband speeds needed to meet the demands of remote learning and telework.

Figure 3 (below) shows the locations of tests and whether they met the 25 Mbps threshold. We mapped the speed test results on a base map of poverty levels but did not have enough datapoints to show any relationship between the two.

Figure 3: Distribution of SpeedSurvey Tests Above or Below Broadband Speeds



1.4 Survey results indicate gaps in broadband access, affordability, device ownership, and digital skills among DISD families and Dallas residents

The City and DISD commissioned a mail survey of households to gather data about the types of services to which residents subscribe (including subsidized programs such as AT&T Access and Spectrum Internet Assist) and a wide range of other topics including residents' ability to afford services, their ownership and ability to maintain computers, their skills in using broadband and computers, and their concerns about online harms. The survey was printed in both English and Spanish (of 790 responses, 23 replied in Spanish) and documented significant increased reliance on broadband during the Covid-19 pandemic. The full survey report is provided in Section 4.

The following is a sample of report highlights:

- **Some low-income households lack access.** Overall, 96 percent reported having internet service (either home or mobile/cellular connection). However, 18 percent of low-income households earning under $25,000 per year have no internet service. Eleven percent of the lower-income segment with children (<$50,000, children in home) do not have internet.

- **Most households with children have internet access, but it may be insufficient for some families.** About 16 percent of respondents agreed or strongly agreed that their children cannot complete their homework because they do not have internet access. One-third of households earning under $50,000 per year (with children) agreed or strongly agreed.
- **Residents may be significantly underutilizing existing broadband subsidy programs.** Just 4 percent of AT&T customers are enrolled in the ISP's Access program for low-income households, and 3 percent of Spectrum customers are enrolled in its Internet Assist program. Just 1 percent of low-income subscribers receive the FCC Lifeline program's $9.25 monthly subsidy, and 7 percent are unsure whether they receive the subsidy.
- **Residents want affordable broadband internet service.** Most respondents strongly agreed the City or DISD should ensure all students (81 percent) and residents (65 percent) have access to affordable broadband service. Three-fourths of respondents strongly agreed the City or DISD should provide free access at home to internet-based educational resources for students from low-income families. Households with children were even more likely to support these efforts to reduce broadband access gaps.
- **Lower-income residents have fewer computing resources than higher-income residents.** Nine in 10 respondents indicated they have a computer in the home (desktop, laptop, tablet) with internet access. But only two-thirds of low-income households (earning less than $25,000 per year) have both internet access and a computer.
- **Many households experienced frequent issues with their computing devices breaking down.** Six in 10 respondents with internet access have experienced trouble with their computer not working properly; 15 percent experience problems at least weekly.
- **More than one-fourth of internet subscribers would not be able to quickly replace non-working computers.** Eight percent of respondents said they could not replace their computer in the foreseeable future if it became unusable, and 19 percent said it would take one to six months to replace it. Adding these two datapoints, 27 percent of households with home internet service are at risk of not being able to use broadband for long periods because of computer problems.
- **Low-income households are at greater risk of computer issues**. One-fourth of internet subscribers earning less than $25,000 experience issues at least weekly with their primary computer becoming inaccessible or unusable. Furthermore, six in 10 low-income

subscribers would not be able to replace their computer (30 percent) or would take one to six months to replace it (30 percent) should their computer become unusable.

- **Many respondents are interested in becoming more confident in using computers, smartphones, and the internet.** Specifically, 43 percent of respondents agreed or strongly agreed that they would like to become more confident in using computers and related technology, and 29 percent agreed or strongly agreed they would like to attend training.

- **Online harms are of significant concern in Dallas.** Many respondents disagreed or strongly disagreed that their children have the skills to detect and avoid false or misleading information (56 percent), avoid online bullying (43 percent), detect and avoid financial scams and predators (51 percent), and avoid exposure to graphic violence or pornography online (41 percent). Six in 10 respondents agreed or strongly agreed that they have the time and skills to protect their children from online risks.

1.5 The City and DISD's infrastructural and programmatic efforts to ameliorate digital inequities provide a strong foundation for expansion

The City, DISD, and other nonprofits and stakeholders are actively engaged in addressing digital equity issues related to:

- **Access**: that broadband infrastructure exists, and reliable high-speed broadband plans are available for purchase
- **Affordability:** that broadband service is not only available but can be obtained at reasonable prices by all
- **Devices:** that residents own or have access to well-functioning, up-to-date computers—and have the capacity to maintain and replace these devices if needed.
- **Skills:** that residents have the ability to make full use the often-complex functions and computers and online resources—and thus are able to use these tools to communicate, work, learn, attend medical appointments, and so on—and avoid online harms.

A wide range of entities provide support services in Dallas, including device rentals and digital skills training. In Section 7 we summarize the existing range of programs in the Dallas area that offer reduced-cost broadband service and access to devices and training, highlight data from our research that may prove useful to guide program development, discuss examples of programs in other cities, and make recommendations about potential ways to build on efforts already underway in Dallas.

DISD and the City have also launched wireless pilots to explore solutions to their broadband gaps. The pilots are in place as of the writing of this report. We recommend the City and DISD continue to rigorously evaluate the outcomes of the pilots in light of their goals.

1.5.1 DISD operates an educational wireless network pilot at Lincoln High School

In late 2020 and early 2021 DISD began to pilot an educational network to provide broadband service to DISD families located near Lincoln High School. (More details are in Section 5.2.) This effort to explore options for meeting students' broadband needs used low-cost, open-access wireless spectrum, as well as radios located at DISD buildings (to avoid facility lease fees), and fiber connectivity to DISD's network.

BearCom, in partnership with Motorola, installed an antenna and related radio equipment on the rooftop of the school and, in the first months, about 50 participating families living in close proximity to the school were provided indoor Wi-Fi routers (also called customer premises equipment, or CPE) to deliver service within their homes. The first phase included indoor CPE equipment with Wi-Fi and USB interfaces, capable of connecting to DISD-provided Chromebooks and other Wi-Fi-based devices.

As of the writing of this report, DISD is planning to expand the pilot to more families and schools and test different CPE equipment to expand the range of the network and improve performance to homes with more challenging lines of sight. One option is a window-mounted CPE radio that can be installed by the DISD family at a location with the best connection to the network, which then acts as a Wi-Fi hotspot connecting to student devices.

1.5.2 The City of Dallas launched two Wi-Fi pilots in priority zones

At approximately the same time as the DISD pilot, the City of Dallas also began two pilots using Wi-Fi technology. The City selected Neo Networks for the first pilot. Locations were selected in 10 priority zones consistent with proximity to City facilities, DISD and City collaborative projects, and areas with limited household connectivity.

This pilot provides a Wi-Fi wireless mesh network with five to 10 outdoor access points in each of the areas. Wi-Fi access points were installed for this purpose. Devices on the poles are solar powered, with battery backup. In this proof-of-concept phase, residents in the area would connect using their own Wi-Fi-enabled devices.

The second pilot was completed by city contractors. Locations were selected in 10 priority zones consistent with the findings of the Mayor's Task Force on Safe Communities, as well as in strategic lighting zones which take into account factors such as the Market Value Analysis, and areas of racial and ethnically concentrated poverty. This pilot included the installation of streetlights and fiber optic network connections from adjacent City facilities to wireless access points (WAP) on the streetlights installed on the selected blocks.

2 Summary of recommendations

We recommend the City and DISD consider the following next steps related to fiber and wireless infrastructure; digital equity programs; and federal funding and subsidy opportunities.

2.1 Proceed with building a fiber backbone and add additional fiber to create a 180-mile network to support growing City needs and digital equity efforts

Proposed City-owned fiber would greatly benefit City operations and provide the ancillary benefit of supporting digital equity efforts. We recommend the City continue the analysis already underway, taking into account the availability of funds and the nature and geographic distribution of its current and future networking needs.

We further recommend the City develop and refine a "hybrid" approach, with City-driven dark fiber likely a key element of the core and connectivity to many City sites and neighborhoods. In this approach, we envision a mixture of City-built fiber and managed fiber network services at the edge (accompanied by City and other wireless technologies). Approaches such as fiber lease could also be used where high capacity is needed and where it can be cost-effectively provided (but where the flexibility and capability of City-driven fiber is not as necessary).

The current City plan is to build a fiber backbone between hub points that include key public safety and library locations, with the first stage likely comprising approximately 100 miles. This would bring fiber to many City buildings, support public safety applications, and, with strategic routing, provide a strong foundation for future digital equity efforts (by bringing fiber into areas that have seen lower levels of fiber investment by private providers).

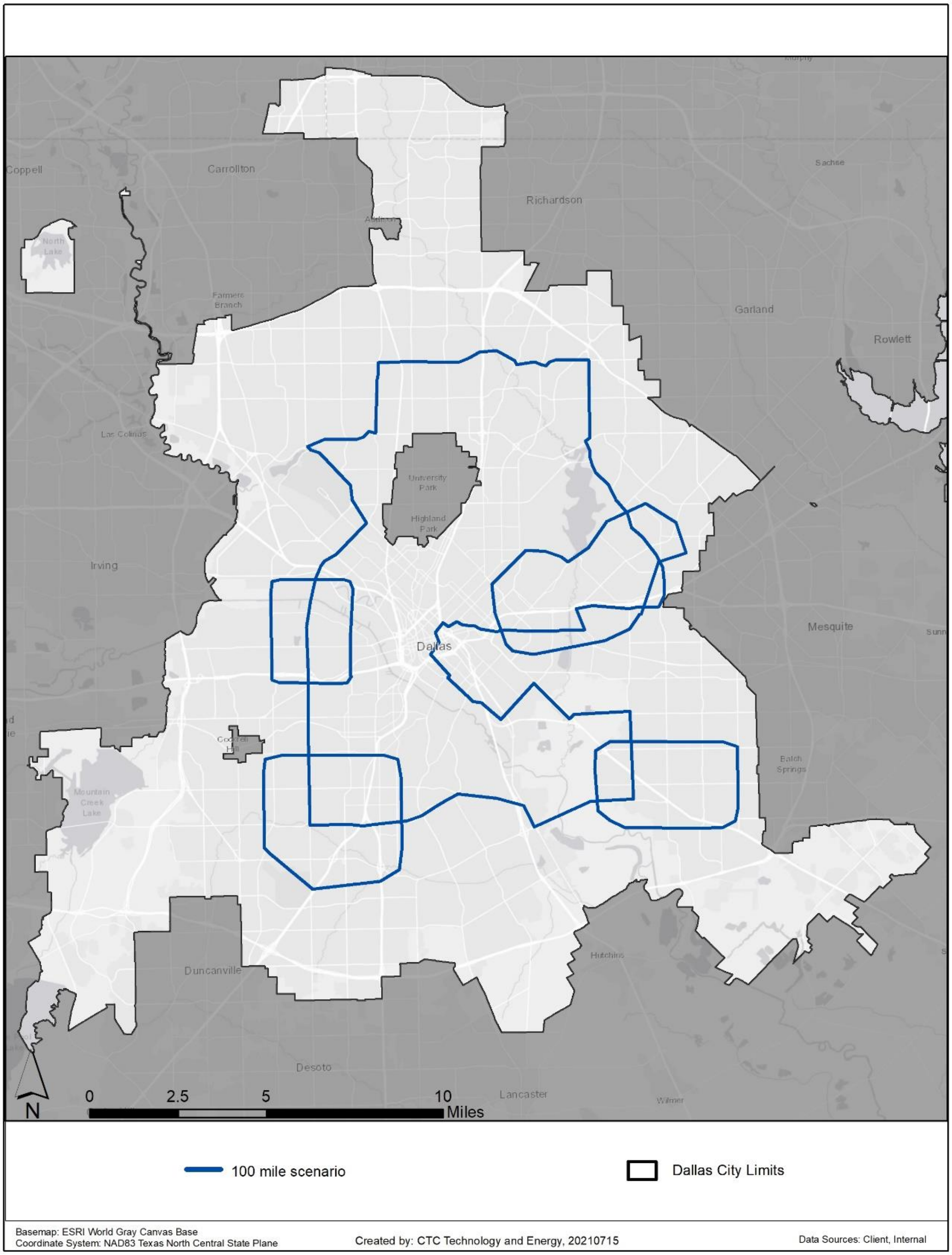
Constructing a 100-mile fiber backbone would cost approximately $13.5 million (Table 1).

Table 1: Estimated 100-Mile Fiber Backbone Costs

Item	Cost
Fiber Optic Outside Plant (OSP) Construction	$12,500,000
Network Hardware	$800,000
Network Integration and Testing	$200,000
Total Capital Costs	**$13,500,000**
Annual Operating Costs	**$1,000,000**

Figure 4 illustrates a conceptual design of a 100-mile fiber backbone. This design consists of one primary loop totaling 58 miles and four loops to extend further from the city center.

Figure 4: City of Dallas Fiber Backbone and Rings: One Concept for a 100-Mile Design



The 100-mile fiber backbone could be a first step toward expansion of City fiber into Dallas neighborhoods. We recommend an architecture that adds additional fiber in rings that connect to the initial backbone, starting with neighborhoods that are the least served by broadband and those with the greatest need for connecting City infrastructure, such as buildings and devices including police and traffic cameras, traffic signal controllers, as well as City efforts to address the digital divide.

Recently, the City has expanded this concept to a 180-mile network that provides a backbone and links approximately 100 City facilities, as well as approximately 100 locations that address the digital divide and provide Internet of Things connectivity along the route. Compared to acquiring the same fiber through leased services, this project could provide significant long-term operational savings. It would bring fiber to many City buildings, support public safety applications, and, with strategic routing, provide a strong foundation for future digital equity efforts (by bringing fiber into areas that have seen lower levels of fiber investment by private providers). More detailed discussion of these applications is provided in Section 6.

It is important to note that making a detailed determination of the “right” amount of City fiber, choosing among hundreds of potential sites to be connected, and assessing the appropriate construction timeline will require a more intensive City planning process, and is beyond the scope of this analysis.

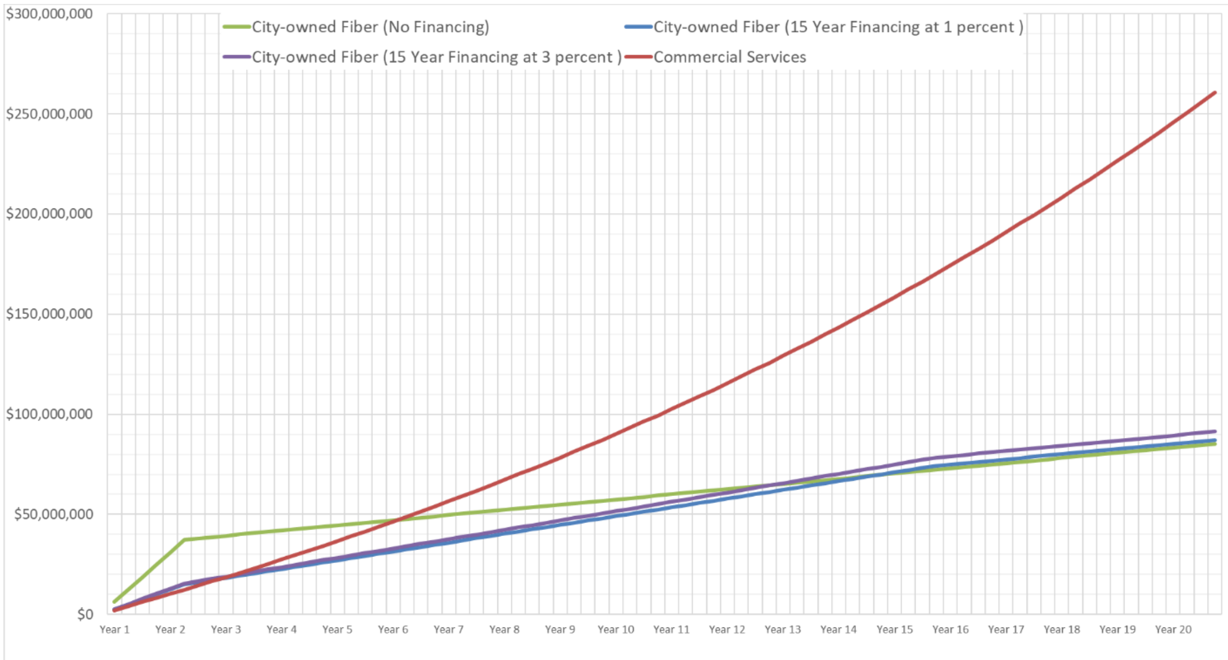
At the City’s request CTC conducted a financial analysis of what 180 miles of fiber to meet the objectives described above would cost to build and operate. Constructing and connecting 180 miles of fiber would cost approximately $25 million (Table 2) and then entail ongoing operating costs of about $2 million per year.

Table 2: Estimated Costs of 180 Miles of Fiber

Item	Cost
Fiber Optic Outside Plant (OSP) Construction	$22,500,000
Network Hardware	$2,000,000
Network Integration and Testing	$500,000
Total Capital Costs	**$25,000,000**
Annual Operating Costs	**$2,000,000**

Figure 5 (below) illustrates models of the cumulative cost of City-owned fiber operated by the City, as described above, under three separate models of City funding (no financing, 15-year financing at 1 percent, and 15-year financing at 3 percent) and compares them on a year-by-year basis to the expected cost of the leased backbone services. In short, we estimate that the 10-year costs of building and owning 180 miles of City fiber would be less than the seven-year cost of leased backbone networking services under current lease pricing, and that the savings would grow significantly over time. The assumptions we used in producing this financial analysis are detailed in Section 6.2.

Figure 5: Cost Scenarios for 180 Miles of City Fiber



2.2 Consider building wireless infrastructure as a partial solution to filling broadband gaps for DISD families and other residents

Using the specifications of the DISD pilot at Lincoln High School, we developed five models to estimate the effectiveness and costs of expanding the pilot concept to other parts of the City by adding antennas to the rooftops of additional DISD buildings. In our modeling we considered the rooftops of all 282 DISD schools as potential radio locations and determined the maximum number of potential subscribers that could be served under different parameters. (The addition of other publicly owned rooftops and other infrastructure, including that of the city of Dallas and the county, would further extend the potential of the network and improve coverage.)

The first two models are for DISD families only. The third, fourth, and fifth models are for all City residents. In all models we use DISD rooftops as antenna sites, both because the model is proven in the DISD pilot and because DISD buildings have fiber connections that would be necessary to connect the antennas to the internet.

Model 1 aims to serve all DISD families (and could also, as noted below, serve about 2,600 households living in DHA housing). For Model 2, we used the DISD Community Resource Index (CRI) as one tool to help establish prioritization; CRI was designed by the Child Poverty Action Lab to inform investment decisions and resource allocations because it measures various characteristics of Dallas neighborhoods, such as education, economics, and health.[4] For Model 3, we considered areas where broadband-level speeds are not available everywhere and that have seen less investment in fiber by the incumbent providers. In Model 4 we also considered the City of Dallas Office of Equity and Inclusion's Covid-19 risk score data.[5] And in Model 5 we considered expanding the wireless capacity to serve all residents reachable from DISD rooftops in areas with a Community Resource Index (CRI) score under 40.

The five wireless infrastructure models we developed are:

- Model 1: All DISD families are potential subscribers
- Model 2: Only DISD families who can be connected from schools with a Community Resource Index (CRI) score under 40 are potential subscribers
- Model 3: All City residents (DISD families and others) in areas with less existing broadband infrastructure (as shown above in Figure 1) are potential subscribers
- Model 4: All City residents (DISD families and others) in City-designated Covid Risk 5 areas are potential subscribers
- Model 5: All residents (DISD families and others) in Dallas who can be served using DISD rooftops in areas with a Community Resource Index (CRI) score under 40

These models were used to estimate the greatest number of DISD families and other City residents who could be reached using different target areas and selection parameters. The table below illustrates the models' estimated capital and operating costs, as well as key parameters for each.

We note that the wireless models' operating costs are not insignificant, and that those annual costs are one of the challenges of wireless networking. That said, the models illustrate that as the wireless networks reach more families, the comparison with a bulk-buy subsidy option (discussed in Section 2.6) grows more favorable. For example, we note Model 2 has an estimated capital cost of $21 million and an estimated annual operating cost of about $2.5 million (Table

[4] A CRI score of less than 40 (i.e., schools with "a relative lack of resources") was chosen as the criterion for our analysis. "DISD Community Resource Index," Child Poverty Action Lab, https://childpovertyactionlab.org/disd-cri (accessed May 2021).

[5] Within that framework, the highest risk is denoted as a Risk 5 area, followed by Risk 4 and so on. Covid-19 risk score description and methodology, City of Dallas Office of Equity and Inclusion, https://dallasgis.maps.arcgis.com/home/item.html?id=186b98f0fab940118dbd9a4422db7eaa&view=table&sortOrder=desc&sortField=defaultFSOrder#overview (accessed April 29, 2021).

3). By comparison, a subsidy for the same number of student households would cost about $10.8 million annually. The infrastructure program would be more cost-effective by year three.

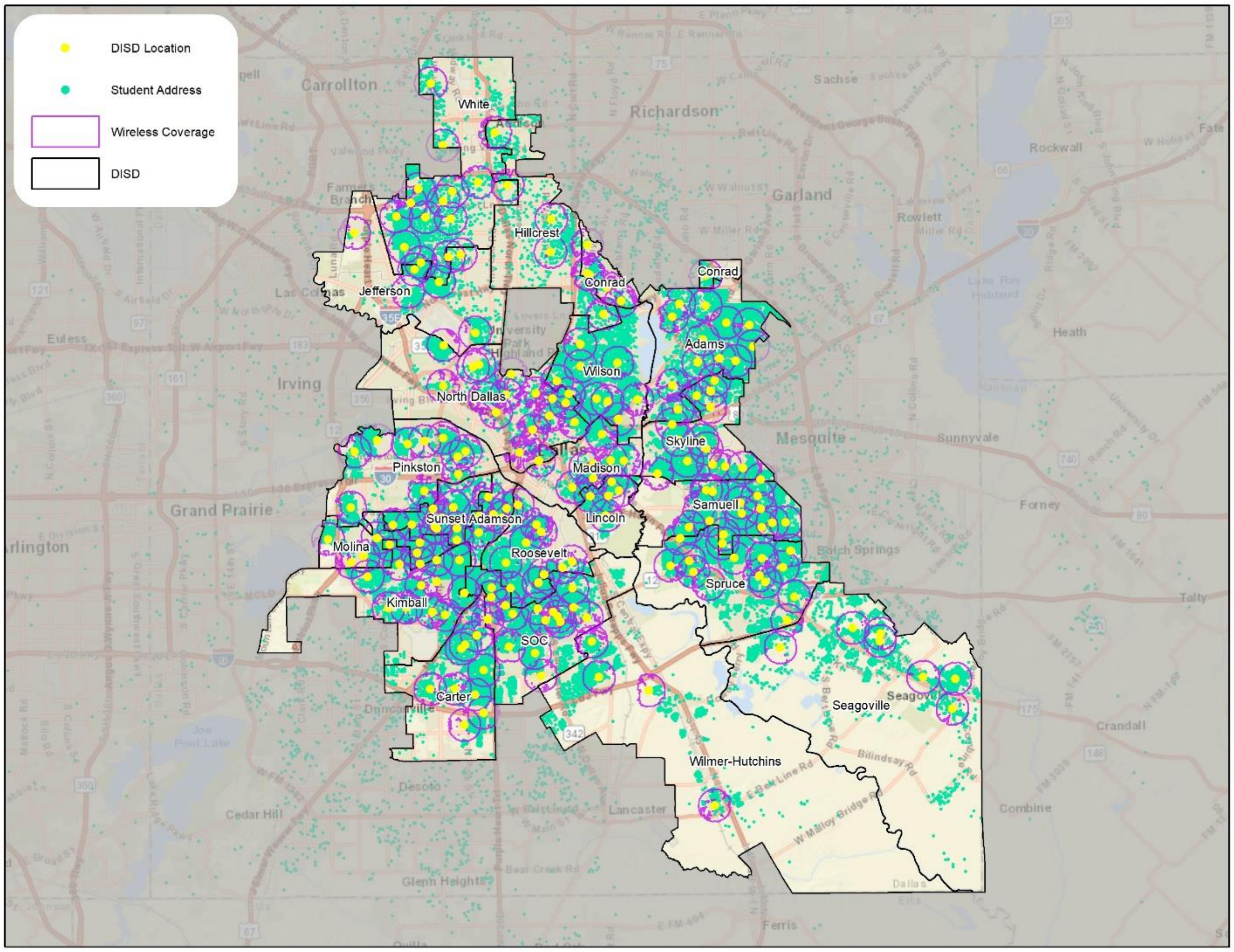
Table 3: Estimated Fixed Wireless Costs

Model	Households Served	One-time Capital Cost	One-time Capital Cost per Household[6]	Annual Operating Cost	Annual Operating Cost per Household[7]
1: DISD families at all schools	74,500	$38,173,800	$854	$4,334,500	$97
2: DISD families at schools with CRI of less than 40	44,800	$20,993,280	$781	$2,548,250	$95
3: All City residents in areas with less existing broadband infrastructure (see Figure 1)	28,235	$21,870,831	$1,291	$2,265,725	$134
4: All City residents in Covid Risk 5 areas	774	$893,664	$1,926	$453,040	$976
5: All City residents who can be served from DISD rooftops – CRI<40	106,721	$56,156,064	$877	$8,424,700	$132

The map in Figure 6 below illustrates Model 1 coverage and locations. Further details on all five models are provided in Section 5.5.

[6] Assumes 60 percent penetration. Includes $350 per household served for installation and customer premises equipment.
[7] Assumes 60 percent penetration.

Figure 6: Model 1 Coverage and DISD Locations



If the City decides to deploy a wireless service to partially fill its broadband gaps, we recommend a free, rather than paid, service. First, offering free service entails less operating cost and complexity than a paid service with respect to sales, marketing, billing, collections, and other elements of paid broadband service. Second, given the significant cost barriers associated with low adoption of broadband, a free service has potentially far greater impact than a paid service.

We anticipate a free service would be provided on a "best effort" basis, without particular service level guarantees, but the program would still necessitate certain operations support to deliver a reliable service and ensure the overall technical success of the initiative.

2.3 Expand the Digital Navigators program to maximize participation in low-cost programs and federal subsidy programs

CTC recommends the City and its partners on the Internet for All Coalition expand the piloted Digital Navigators program to help expand enrollment in providers' low-cost programs (i.e., Charter's Spectrum Internet Assist program, AT&T's Access program) as well as the FCC's Lifeline and Emergency Broadband Benefit[8] programs. These programs offer opportunities for qualifying residents to receive low-cost or discounted broadband services,[9] but each program has its share of hurdles that make enrollment challenging—and participation rates (both locally and nationally) have historically been low.

The survey data show these programs are extremely underutilized in Dallas. A partnership between the Digital Navigators, DISD, and potentially Dallas County to undertake this effort could educate residents about eligibility and program benefits. Such a strategy would leverage existing efforts to maximize the impact of existing, long-standing programs that are available to a large number of residents.

The Digital Navigators program may want to consider providing call center support to help residents understand and navigate these programs; the call center could also help small ISPs get qualified by the FCC to participate in Lifeline and the Emergency Broadband Benefit program, and then to determine that families are eligible.[10] (Well-trained call center staff could also potentially assist residents in obtaining other resources, such as rental assistance or food assistance.)

In our experience, a relatively modest call center staffed by three people could have a potentially large impact—assisting approximately 8,000 families per year. (The number aided by three staff members could be higher or lower based on demand for the service and the ease or difficulty in connecting families with the relevant programs.)

The table below estimates the costs of staffing, marketing, and operations for a call center and related communications efforts to increase community awareness of these opportunities. The first section provides year-one costs; the second section provides annual costs for the initiative in subsequent years. The numbers are based on CTC's experience with similar initiatives.

[8] See Section 2.7 for more details.

[9] Further information about these programs and the difficulty in enrolling in them is provided in Section 7.

[10] This approach would take some of the burden off smaller ISPs. For big ISPs, this is a relatively easy chore; they have access to the federal Lifeline verifier, as well as their own low-income programs.

Table 4: Estimated Initiative Budget – Providing Resources to Help Residents Enroll in Low-Cost and Subsidy Programs[11]

Year One	**Budget**
Creation and distribution of informational materials such as web pages, fliers, inserts, and mailers	$20,000
Call center technology and software licenses	$20,000
Three full-time call center staff ($40 hourly rate)	$249,600
Total	**$289,600**
Estimated cost per household if 8,000 households are assisted	*$36*
Subsequent Years	**Budget**
Creation and distribution of fliers, inserts, and mailers	$5,000
Maintenance of call center and equipment	$10,000
Three full-time call center staff, based on an hourly rate of $40	$249,600
Annual Costs for Year Two Onward	**$264,600**
Estimated cost per household if 8,000 households are assisted	*$33*

2.4 Purchase devices and fund the expansion of digital skills training and device recycling—building on the Digital Navigators program

In addition to access to robust and affordable broadband, residents require digital skills and devices in order to fully take advantage of the opportunities that come with a broadband connection. The survey identified both significant gaps in skills and broad interest in programs that would help close those gaps—with interest stronger among older residents.

Given the availability of funding in the current moment, Dallas could make a one-time purchase of new devices for households that lack computers and build on its Digital Navigators program to continue to support community organizations with the capacity needed to enable digital skills training initiatives. (The short, one-month duration of the program has been identified as a challenge.) Additional funding for the Digital Navigators program would allow service providers to expand their digital skills training initiatives and would allow the City to support additional organizations in providing such training, especially organizations that serve senior residents.

In concert with the digital skills training efforts, the City or DISD, and potentially the County, could forge partnerships with, or replicate programs offered by, organizations around the nation such as Comp-U-Dopt, PCs for People, Tech Soup, and Tech Goes Home. These organizations have a variety of successful and scalable models for reselling, refurbishing, or offering new laptops and

[11] Numbers are estimates derived from CTC's experience designing and operating call centers to support broadband subsidy programs on behalf of state government entities.

other devices and training to partner organizations. Table 5 describes the estimated budget for training 5,000 residents.

Table 5: Estimated Budget for Digital Navigators Training Program

Category	Budget
Training cost per student	$200
Estimated cost if 5,000 residents are assisted	*$1,000,000*

In addition, given the availability of funds for efforts such as this, we also recommend the City purchase new devices at a far larger scale to address Dallas residents' immediate challenges. A one-time purchase of new computers for the roughly 65,000 households that lack a computer[12] would cost approximately $13 million (Table 6).

Table 6: Estimated Budget for One-Time Device Purchase Program

Category	Budget
Obtain 65,000 devices (based on 2019 American Community Survey data that 12.8% of Dallas households lacked a computer)	$13,000,000
Total	**$13,000,000**
Estimated cost per household	*$200*

Community-based groups in Dallas are well-positioned to offer direct support services to residents. Supporting these established organizations would be an effective and efficient way for the City to enable digital skills training programs and device distribution efforts that meet residents' needs. Potential grantees include community centers, senior-serving organizations, health care centers, neighborhood organizations, faith-based organizations, immigrant support organizations, and organizations that provide support to those experiencing homelessness.

2.5 A municipal fiber-to-the-premises deployment would be unlikely to succeed without large and ongoing subsidies

While the City and DISD did not request an estimate for building a citywide fiber-to-the premises network, the topic arose during several of our meetings and reflected the City and DISD's desire to ensure all residents have access to state-of-the-art broadband service. Based on our decades of experience in other jurisdictions—and considering the presence of two incumbent providers with large service footprints—we can assert with a reasonable degree of confidence that building fiber-to-the-premises in Dallas would entail substantial capital expenditures—likely more than

[12] "Quick Facts: Dallas city, Texas," U.S. Census Bureau, https://www.census.gov/quickfacts/fact/table/dallascitytexas/PST045219 (accessed June 2021).

$1.5 billion—and would likely require ongoing operating subsidies from the City, DISD, or another entity. While such a network would provide state-of-the-art service, this approach would not constitute a digital equity solution. To support capital and operating expenses, the monthly costs to consumers would not necessarily be more affordable than existing options, and in fact could be more expensive, even with subsidies.

2.6 DISD should prepare for procurement of home-based services under the Emergency Connectivity Fund—potentially with bulk purchase from Charter or AT&T

The FCC's Emergency Connectivity Fund represents a significant opportunity for DISD to apply for federal funding to offset the costs of its efforts to ensure all unserved DISD families have broadband access for the coming school year. Importantly, federal reimbursement from the ECF could dovetail with a bulk-purchase of services from Charter or AT&T for unserved DISD families.[13]

As an estimate of the number of DISD households lacking broadband, we consider wireless infrastructure Model 2 (see Section 2.2), which aims to serve the 45,000 student households at schools with low CRI scores. If we estimate that a bulk purchase price might be around $20 per household per month, DISD could potentially facilitate the provision of broadband to those families for about $10.8 million per year—reimbursed by the Emergency Connectivity Fund in the first year to the extent a student is not currently connected. (While there has been some discussion in Washington of continued subsidy, we would not assume that ECF will continue to pay in future years.)

By way of background, the FCC's E-rate program has previously subsidized broadband service to schools and libraries. As we describe in Section 8.2.3, the American Rescue Plan Act included a $7.2 billion appropriation to create the Emergency Connectivity Fund, which extends E-rate support to reimburse schools and libraries for providing equipment and connectivity services to K-12 students *at their homes and other locations*. All schools and libraries that are eligible for E-rate are also eligible for the Emergency Connectivity Fund.

The FCC issued rules for the Emergency Connectivity Fund in May 2021. Priority is given to students and library users who will be unserved by broadband in this school year. The first application window has passed, but a second ECF application window will be open on Sept 28,

[13] Charter offers bulk-purchase option for entities such as cities or school districts to purchase internet services for residents. In February, Charter responded to a Region 10 ESC request for proposals (RFP) with an offer to provide 50 Mbps service for $29.99 monthly per household, which would be reduced to $24.99 if 3,000 or more subscribers were added.

2021 to October 13, 2021 for the current school year (specifically for July 1, 2021 to June 30, 2022). ECF will allow for reimbursement retroactively for qualified expenses within this period.

This program will pay 100 percent of a school or library's "reasonable" costs for mobile hotspots (up to $250 each), connected devices (up to $400 per device), and services; it will not cover the cost of infrastructure construction. Wi-Fi hotspots for school buses are allowed—and present an option for delivering service beyond individual homes.

In terms of services purchased with Emergency Connectivity Fund money, the FCC does not specify a minimum definition of broadband (such as the 25 Mbps download and 3 Mbps upload requirement for some other programs); rather, it requires the connection be sufficient to enable remote learning, which includes videoconferencing. As mentioned above, if DISD were to negotiate a bulk purchase of Charter or AT&T services to connect unserved DISD families, that contract could be eligible for reimbursement.

Unlike the standard, rigorous E-rate procurement process, the Emergency Connectivity Fund will require participating school districts and libraries to verify and self-certify that beneficiaries are not also receiving benefits under other federal programs such as the FCC's Emergency Broadband Benefit Program subsidy. If DISD or the Dallas Public Library tap into this funding source, they should develop a rigorous process and document every step, so as to be prepared for a potential future audit of their participation.

2.7 Evaluate bulk purchase of service for unserved residents

If the City were to consider a bulk-purchase of services for unserved residents, the annual costs could be considerably higher than a bulk-purchase program only for DISD families—depending on the scope of the subsidy effort (Table 7).

According to the Census, as of the American Community Survey for 2019, only 76.6 percent of Dallas' 513,000 households had a broadband internet subscription. We thus estimate 23.4 percent of households, or 120,000, lack a broadband subscription. Assuming a bulk purchase price of $20 per month, subsidizing service to those households would cost $28.8 million annually.

Alternatively, if the City were to bulk-purchase service for the estimated 56,000 households in poverty, its annual cost would be an estimated $13.4 million.

Table 7: Estimated Alternative Annual Budget for Ongoing Broadband Connectivity Subsidy Program

Alternative Proposed Criteria for Eligibility	Estimated Number of Eligible Households	Total Annual Budget
Households without a broadband internet subscription as of 2019 (American Community Survey)	120,000	$28.8 million
Households in poverty as of 2019 (American Community Survey)	56,000	$13.4 million
Estimated annual cost per household	*$240*	

2.8 Pursue relevant recent federal funding opportunities

Recent federal actions have led to an unprecedented magnitude of available broadband funding. Both the Consolidated Appropriations Act and the American Rescue Plan Act (ARPA) created new broadband funding opportunities, and the latter included a sizeable appropriation for the Department of Commerce's Economic Development Administration (EDA) Public Works and Economic Adjustment Assistance Program—which continues to be one of the most promising sources of funding for broadband projects in urban communities such as Dallas.

Based on our analysis of legislative language and guidance available as of the end of August 2021, we believe certain programs represent strong options for the City and DISD, while others are not realistic targets of opportunity. That said, it is important to understand the funding landscape is shifting in real time—and the agencies writing rules to distribute funds are in some cases adding requirements that were not part of the statutory language that created some of the programs.

We note that the current version of the infrastructure bill includes $65 billion toward broadband infrastructure and funds for subsidizing broadband service. We can assess the potential for the bill to assist the City and DISD when it becomes law. In terms of other near-term opportunities, we also note that EDA (Economic Development Administration) grants have a rolling application process and that the National Telecommunications and Information Administration (NTIA) Historically Black Colleges and Universities (HBCU) Grant is due December 1. Section 8 provides more detailed discussion of grant and funding opportunities.

2.8.1 Coronavirus State and Local Fiscal Recovery Funds Program

The Local Fiscal Recovery Funds program may be Dallas' most viable source of broadband funding because the City will control the funds. Established in ARPA, this program will distribute $350 billion in emergency funding to eligible state, local, territorial, and Tribal governments. Treasury has allocated about $350 million to Dallas.[14]

When Treasury announced its interim final rules, those guidelines included new restrictions that were not part of the authorizing legislation. The interim rules said the Local Fiscal Recovery Funds should not be targeted for areas where there is "reliable" 25/3 Mbps broadband service. Treasury has since clarified that these funds can be used in areas that already have 25/3 if the funds are primarily targeted for areas where 25/3 is not available.

2.8.2 Connecting Minority Communities Pilot Program

The Connecting Minority Communities Pilot Program[15] will provide $285 million in grant funding to eligible recipients to purchase broadband or eligible equipment, or to hire and train IT personnel. The program will be administered by NTIA.

This nascent program represents an opportunity for several institutions in Dallas to pursue funding to support instruction and remote learning capabilities, with priority placed on serving students who meet certain criteria to indicate need. Entities in Dallas that are eligible to apply for this program include the following:

- Dallas Nursing Institute (PBI)
- El Centro College (HSI)
- Mountain View College (HSI)
- Paul Quinn College (HBCU)
- Richland College (AANAPISI & HSI)
- University of North Texas at Dallas (HSI)

For higher education recipients, grants are intended to support instruction and learning, including remote learning.

2.8.3 Emergency Broadband Benefit Program

The Emergency Broadband Benefit Program, administered by the FCC, provides a monthly discount to eligible households for broadband service. This program (which we describe in Section 7.1.4,) pays a subsidy directly to eligible residents (in the form of a credit on their ISP's

[14] "Allocation for Metropolitan Cities," U.S. Department of the Treasury, page 24, https://home.treasury.gov/system/files/136/fiscalrecoveryfunds-metrocitiesfunding1-508A.pdf (accessed May 14, 2021).

[15] "Consolidated Appropriations Act, 2021," U.S. Congress, December 21, 2020, https://rules.house.gov/sites/democrats.rules.house.gov/files/BILLS-116HR133SA-RCP-116-68.pdf (accessed May 10, 2021).

bill), so the City and DISD's role would be limited to encouraging and enabling residents to enroll, and potentially assisting residents who have difficulty accessing these benefits.

2.8.4 Coronavirus Capital Projects Fund

The $10 billion Coronavirus Capital Projects Fund is not a competitive-application program; states will receive a fixed allocation from this fund. Treasury's current guidance note that states will be asked to submit proposals on how the Capital Projects Fund allocations should be used. Until we have more defined rules, Treasury's guidelines indicate that state governments will have wide discretion for determining how to identify worthy projects.

That means, for example, that the City could propose to inject all funding from the Capital Projects Fund into its current programs with alignment to overall program guidelines on timing and purpose of expenditure.

We note that overbuilding is not a program goal. It is not clear what the final Capital Projects Fund rules will be, but Treasury's statement emphasizes the need to demonstrate bringing critical connectivity to those who do not currently have it. The companion State and Local Fiscal Recovery Funds also disincentivize overbuilds.

In other words, the Capital Projects Fund does not seem—according to Treasury's brief guidance released to date—to be designed to create more affordable service options by increasing competition (such as by building new infrastructure in an area that already has high-speed wireline service).

Section 8 describes grant and funding opportunities in greater detail.

3 Dallas is served by ubiquitous cable and DSL, and some fixed wireless, but significant broadband investment gaps remain

An analysis of the Dallas broadband market finds the area has extensive infrastructure but that service gaps persist.

CTC's market assessment process involved data collection and analysis of where fiber, cable, DSL, and fixed wireless internet services exist, what service offerings and pricing are available to consumers, and how those relate to demographic patterns. CTC used the Federal Communications Commission's (FCC) Form 477 data to analyze such services in the City of Dallas and Dallas Independent School District (DISD) territory.

Form 477 data, reported by ISPs biannually, are known to overstate actual broadband availability. The data are presented at the census block level, and the FCC considers a census block served by broadband if even one of the premises in the block could be served. The data thus tend to overestimate service availability, particularly in less populated areas where one census block may cover many square miles. Despite these flaws, Form 477 represents the most comprehensive national dataset for broadband availability and tends to be more accurate in urban than rural areas.

In addition, CTC researched websites of broadband providers operating in the Dallas market area and engaged in online phone conversations with representatives of some internet service providers in order to collect market data on residential broadband pricing, availability, and level of competition in the area.

Leaving aside satellite and mobile providers—which do not provide consistent or adequate residential broadband speeds or service quality—four primary fixed broadband providers serve the Dallas and DISD district:

Charter, the dominant cable provider, serves most of the City and DISD territory.

Suddenlink also provides cable service in a smaller southeastern area, including in the portion of the DISD district that extends past the City's boundaries.

AT&T is the dominant DSL provider and delivers service within most of the City and DISD boundaries. In addition, AT&T is the primary fiber provider, and claims to serve large swaths of the area, especially toward the northeast and southwest.

Rise Broadband, the only fixed wireless provider operating in the Dallas market, reportedly served the western and southeastern parts of the City and DISD territory.

In addition, **DISD** itself delivers internet access on a pilot basis in parts of the City.

3.1 Analysis of fixed broadband service providers

We reviewed prices and service plans offered by Charter, Suddenlink, AT&T, and Rise Broadband. This research was conducted in the spring of 2021; prices and plans are subject to change. We randomly selected residential addresses in respective providers' service areas to determine available service and advertised pricing.

3.1.1 Fiber availability and pricing

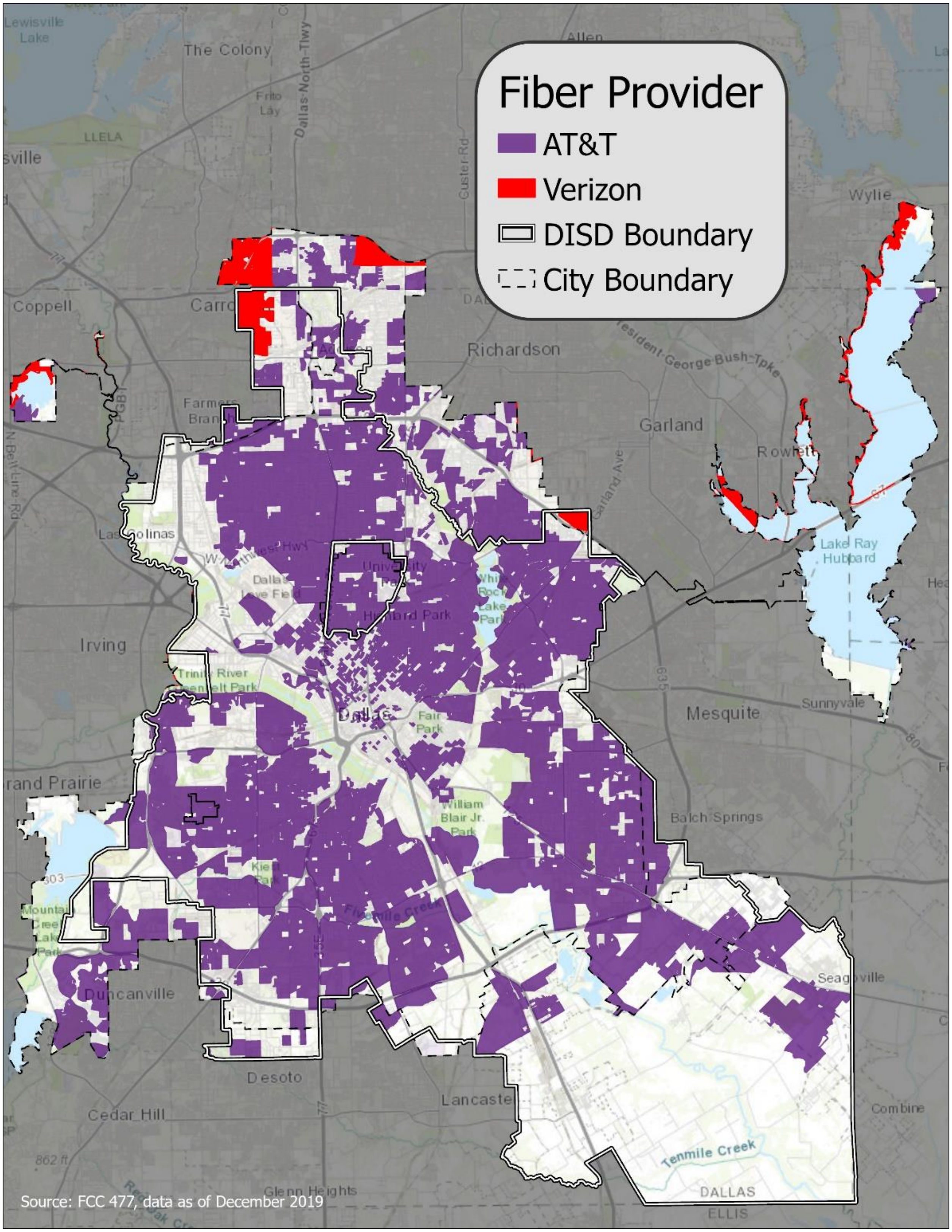
The data show that AT&T is the primary fiber provider operating in the market. AT&T reports to offer fiber service throughout much of the northeast and southwest regions. Additionally, the southeast pocket of the DISD territory that is beyond the City's boundaries is almost entirely unserved by AT&T fiber. Verizon reported that they offer fiber service in scattered pockets, mostly in the northern part of the City and DISD district. Figure 7 (below) illustrates where fiber providers report service.

AT&T was found to offer three fiber services. Each package included a promotional price that increased by $20 after a 12-month period. Table 8 summarizes the services offered.

Table 8: Fiber Services Offered by AT&T in the Dallas Market

Service	Advertised Download/Upload Speeds	Monthly Price (non-promotional)	Notes
Internet 100	100/100 Mbps	$35 for first 12 months, then $55	Equipment is additional $10/month
Internet 300	300/300 Mbps	$45 for first 12 months, then $65	Equipment is additional $10/month
Internet 1000	1/1 Gbps	$60 for first 12 months, then $80	Equipment is additional $10/month

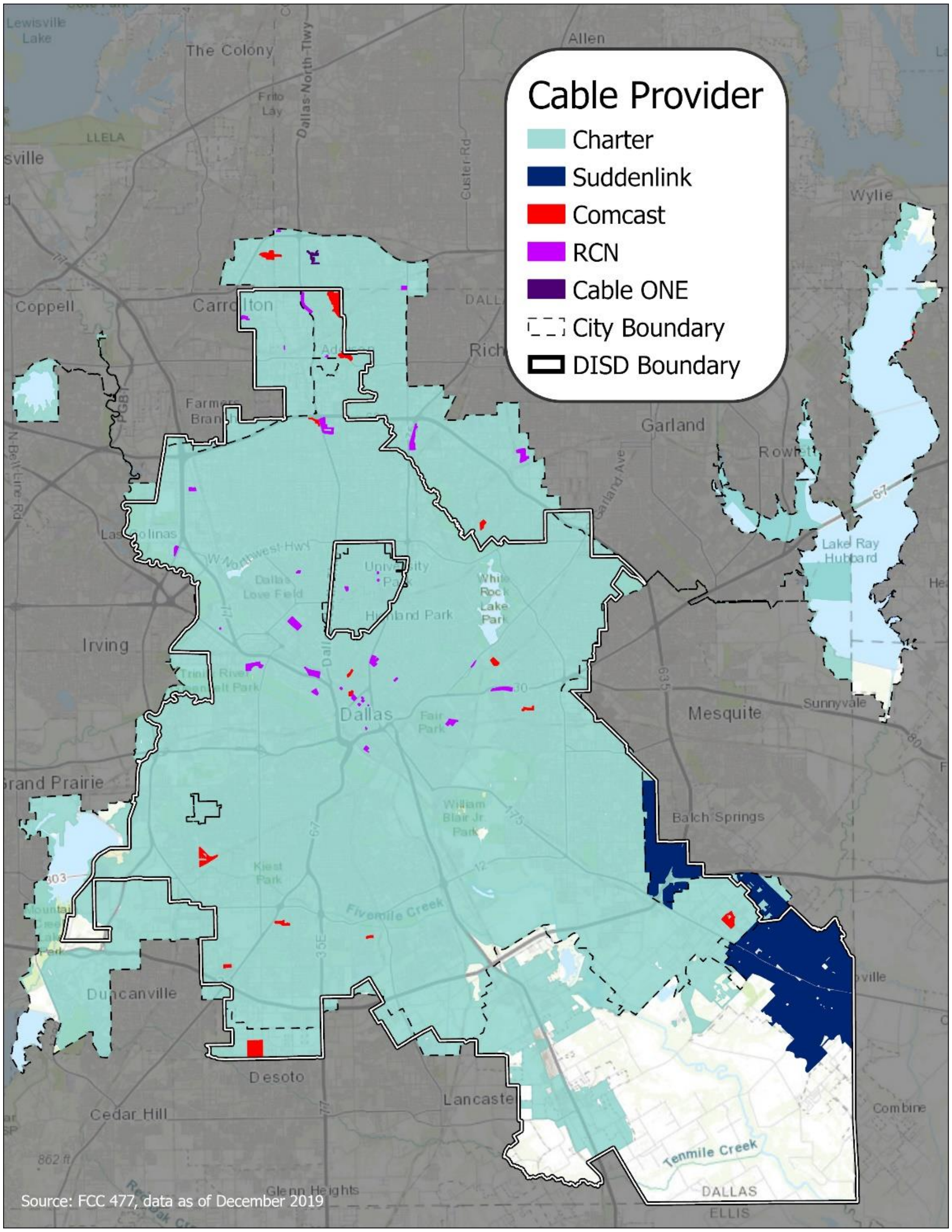
Figure 7: Fiber Providers Within the City and DISD Boundaries



3.1.2 Cable availability and pricing

Charter, the dominant cable provider in the Dallas area, reported covering nearly the entire City and much of DISD's boundaries. Suddenlink reported service in southeast regions of the City and DISD's boundaries. Comcast, RCN, and Cable ONE claimed to offer service in scattered pockets, but at such insignificant scales that we did not include them in our analysis. Figure 8 depicts where each cable provider reports residential service within the City and DISD boundaries.

Figure 8: Cable Providers Within the City and DISD Boundaries



Charter offered four plans, including a low-cost plan, Spectrum Internet Assist, for eligible households. Table 9 summarizes the services offered. Spectrum Internet Assist is available to households in which a member is a recipient of the National School Lunch Program (NSLP), the Community Eligibility Provision of the NSLP, or Supplemental Security Income. Households currently subscribed to Charter service are not eligible to switch to the Internet Assist program.[16]

Table 9: Cable Services Offered by Charter in the Dallas Market

Service	Advertised Download/Upload Speeds	Monthly Price (non-promotional)	Notes
Spectrum Internet Assist	30/3 Mbps	$17.99	Does not include installation cost; additional $5/month for in-home Wi-Fi
Spectrum Internet 50	50/5 Mbps	$29.99 for first 24 months, then $69.99	Does not include installation cost; additional $5/month for in-home Wi-Fi
Spectrum Internet Ultra	400/20 Mbps	$49.99 for first 24 months, then $94.99	Does not include installation cost; additional $5/month for in-home Wi-Fi
Spectrum Internet Gig	940/35 Mbps	$109.99 for first 24 months, then $154.99	Does not include installation cost; in-home Wi-Fi included

Suddenlink offered three internet packages (Table 10).

Table 10: Cable Services Offered by Suddenlink in the Dallas Market

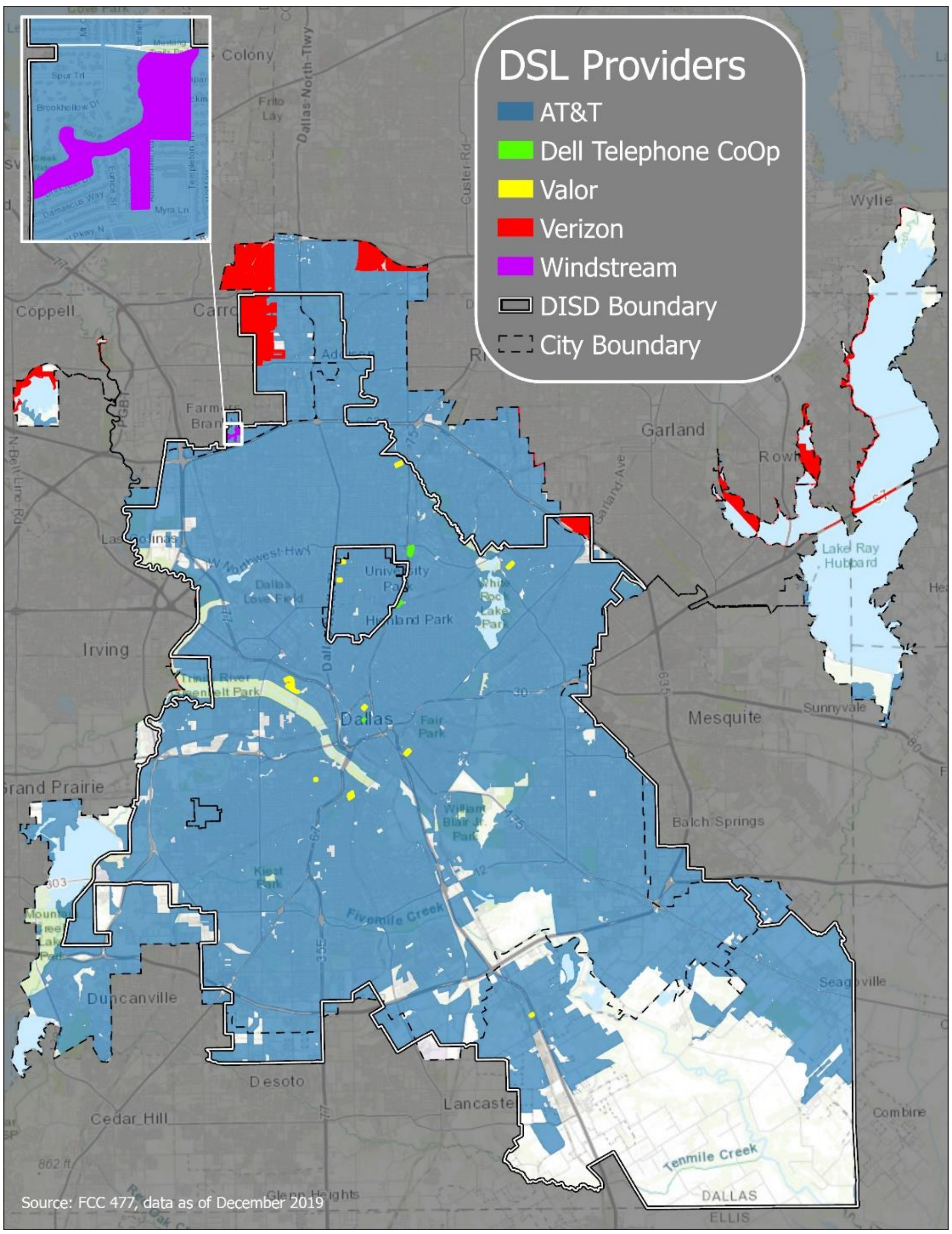
Service	Advertised Download/Upload Speeds	Monthly Price (non-promotional)	Notes
Internet 100	100/10 Mbps	$35	Equipment is additional $10/month
Internet 400	400/20 Mbps	$40	Equipment is additional $10/month
Internet 1 Gig	940/50 Mbps	$50	Equipment is additional $10/month

[16] Spectrum Internet Assist, Charter Communications, accessed April 23, 2021, https://www.spectrum.com/internet/spectrum-internet-assist

3.1.3 DSL availability and pricing

The data showed that AT&T is the primary DSL provider in the Dallas area, with service reported throughout much of the City and DISD territory. Verizon reported offering DSL service in regions in the northern part of the City and DISD territory, in largely the same areas it reported offering fiber service. In addition, Dell Telephone Co-Op, Valor, and Windstream each reported service in very limited pockets, but at such insignificant scales that we did not include these providers in our analysis. Figure 9 illustrates where DSL providers offer residential service in the Dallas territory.

Figure 9: DSL Providers Within the City and DISD Boundaries



In the Dallas area, AT&T is clearly the dominant DSL provider. But the speed offerings vary widely depending on the level of investment AT&T has made. From a business standpoint, AT&T (like other network operators) presumably invests in improving its DSL networks where it can make a business case to do so based on development density and the number of potential customers it can obtain or retain after increasing speeds. These business imperatives often mean that less-dense and lower-income areas are left with inferior speeds. As in other cities, AT&T has not uniformly upgraded its network in the Dallas area. As a consequence of this business practice, Dallas-area residents who use AT&T are not uniformly accessing the minimal broadband speeds needed to serve the demands of all schoolwork and remote work.

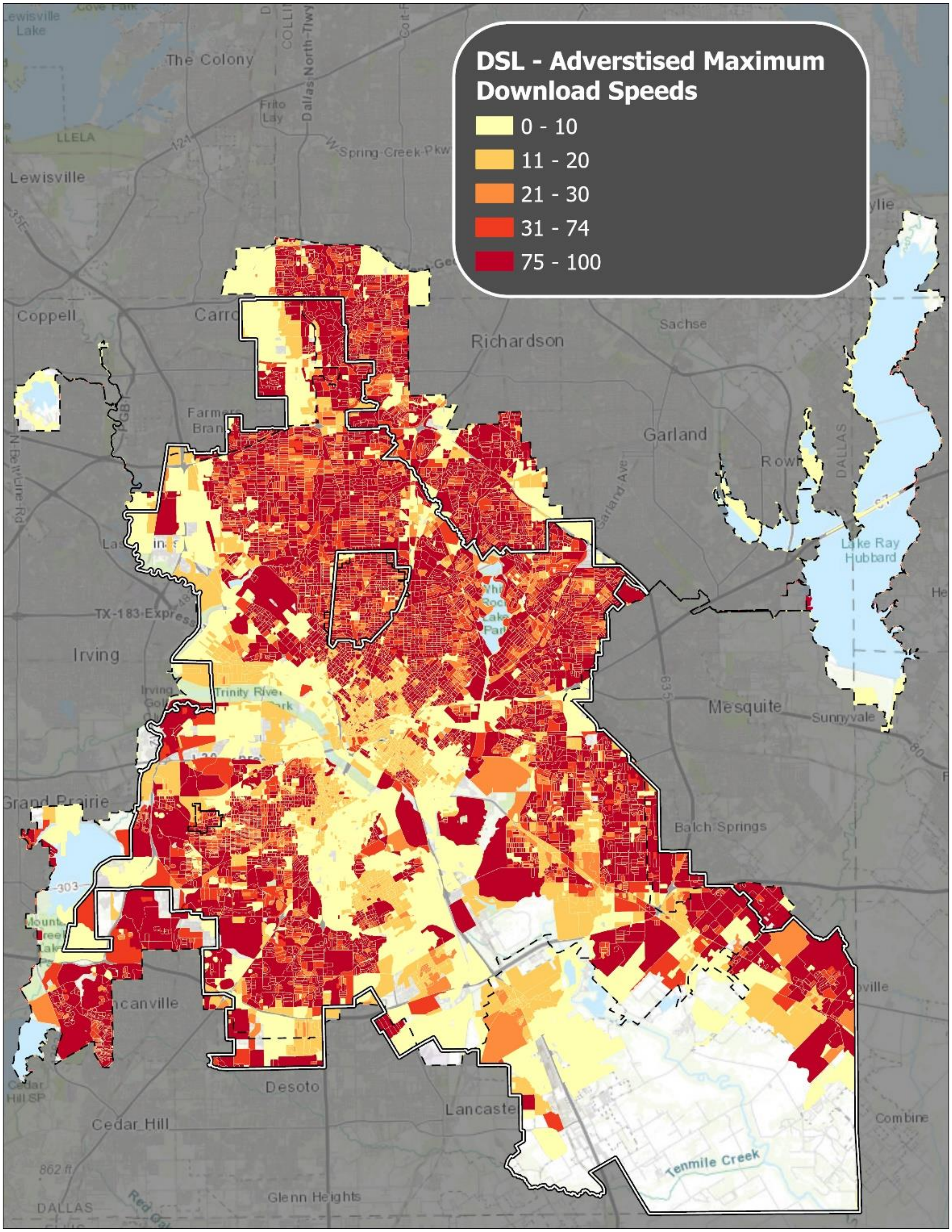
Only one option for AT&T Internet is available at each address, and that service represents the highest DSL speed that AT&T reports to offer at that location. The structure of this model means that those who live in areas of Dallas with slower reported DSL speeds would pay the same amount for the service as others receiving a higher speed elsewhere. Areas of the City with higher levels of poverty are also the areas where the DSL speeds are lower—but residents using this service still have to pay the same price. The packages represented in Table 11 are based on AT&T's information about AT&T Internet services available nationally. Through our research, we found the national prices to be consistent with what is offered in the Dallas market.

Table 11: DSL Services Offered by AT&T Nationally

Service	Advertised Download/Upload Speeds	Monthly Price (non-promotional)	Notes
Internet 10	10/1 Mbps	$45 for first 12 months, then $55	Equipment is additional $10/month
Internet 18	18/1 Mbps	$45 for first 12 months, then $55	Equipment is additional $10/month
Internet 25	25/2 Mbps	$45 for first 12 months, then $55	Equipment is additional $10/month
Internet 50	50/10 Mbps	$45 for first 12 months, then $55	Equipment is additional $10/month
Internet 100	100/20 Mbps	$45 for first 12 months, then $55	Equipment is additional $10/month

Figure 10 shows the maximum reported download speeds by DSL providers in the Dallas market area. As a practical matter, this map largely depicts AT&T DSL service, and shows that according to Form 477 data, broadband or better DSL service is very widely available in Dallas from AT&T.

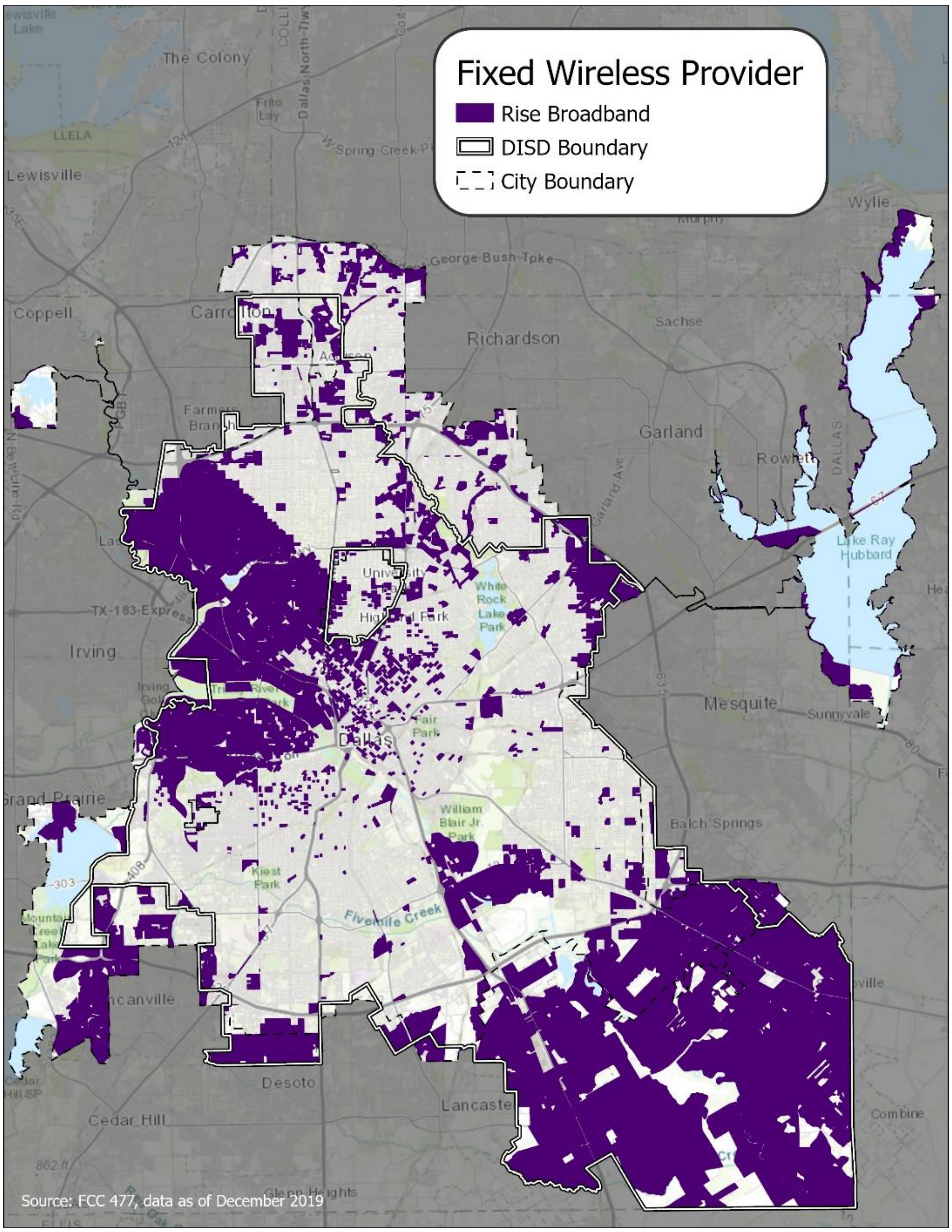
Figure 10: Maximum Reported DSL Download Speed (Mbps) Within the City and DISD Boundaries



3.1.4 Fixed wireless availability and pricing

Rise Broadband was found to be the only fixed wireless provider offering services in the Dallas market. Rise reports service in areas scattered throughout the market, with particular emphasis on the western and southeastern areas (Figure 11). Two other fixed wireless providers, Nextlink Residential and WiFires, reported on Form 477 that they offer service in some parts of Dallas, but telephone interviews with service representatives revealed that no such service was actually available.

Figure 11: Fixed Wireless Providers Within the City and DISD Boundaries



CTC found two plans that Rise Broadband offered. Each offered the same speeds, but one offered unlimited data while the other had a 250 GB monthly data cap. Table 12 summarizes the services offered.

Table 12: Fixed Wireless Services Offered by Rise Broadband in the Dallas Market

Service	Advertised Download/Upload Speeds	Monthly Price (non-promotional)	Notes
Internet	25/2.5 Mbps	$45.99	Includes required equipment cost; free installation; 250 GB data allowance per month.
Internet with Unlimited Data	25/2.5 Mbps	$70.94	Includes required equipment cost; free installation; unlimited data allowance.

3.2 Analysis of demographic patterns and network investment

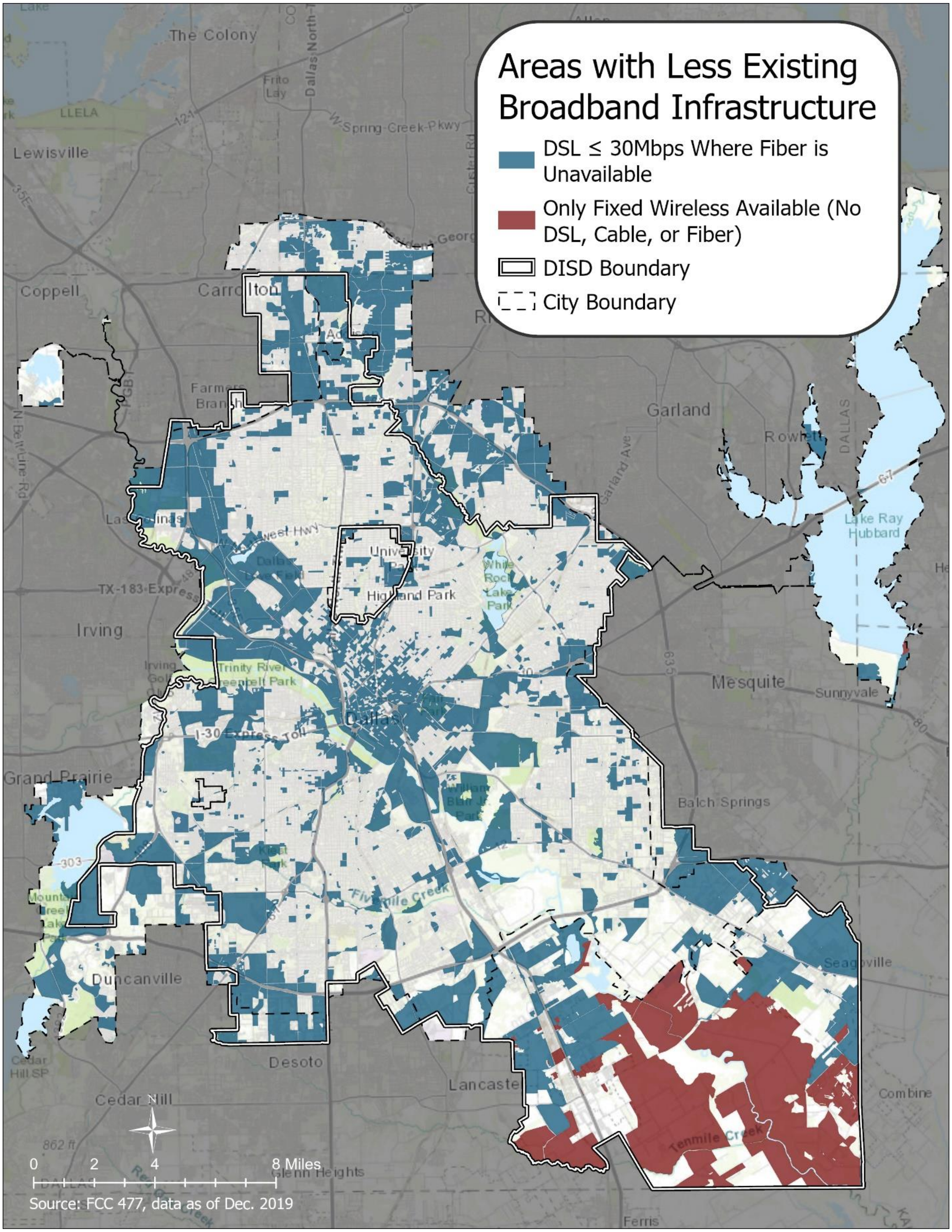
CTC's analysis found that investment in networks—specifically, fiber deployment or the upgrade of DSL networks to reach higher speeds—has not occurred consistently throughout the City and DISD market area. The areas that have seen less investment fall into two categories, which are illustrated in Figure 12 below:

1. Areas in which the maximum reported DSL download speed is 30 Mbps or lower, **and** where fiber service is not available. The only option for a wired internet service in these areas would be cable, or DSL operating at download speeds of 30 Mbps or less.

2. Areas in which fixed wireless is the only fixed service reported to be available. In other words, areas in which there is no option for a wired service.

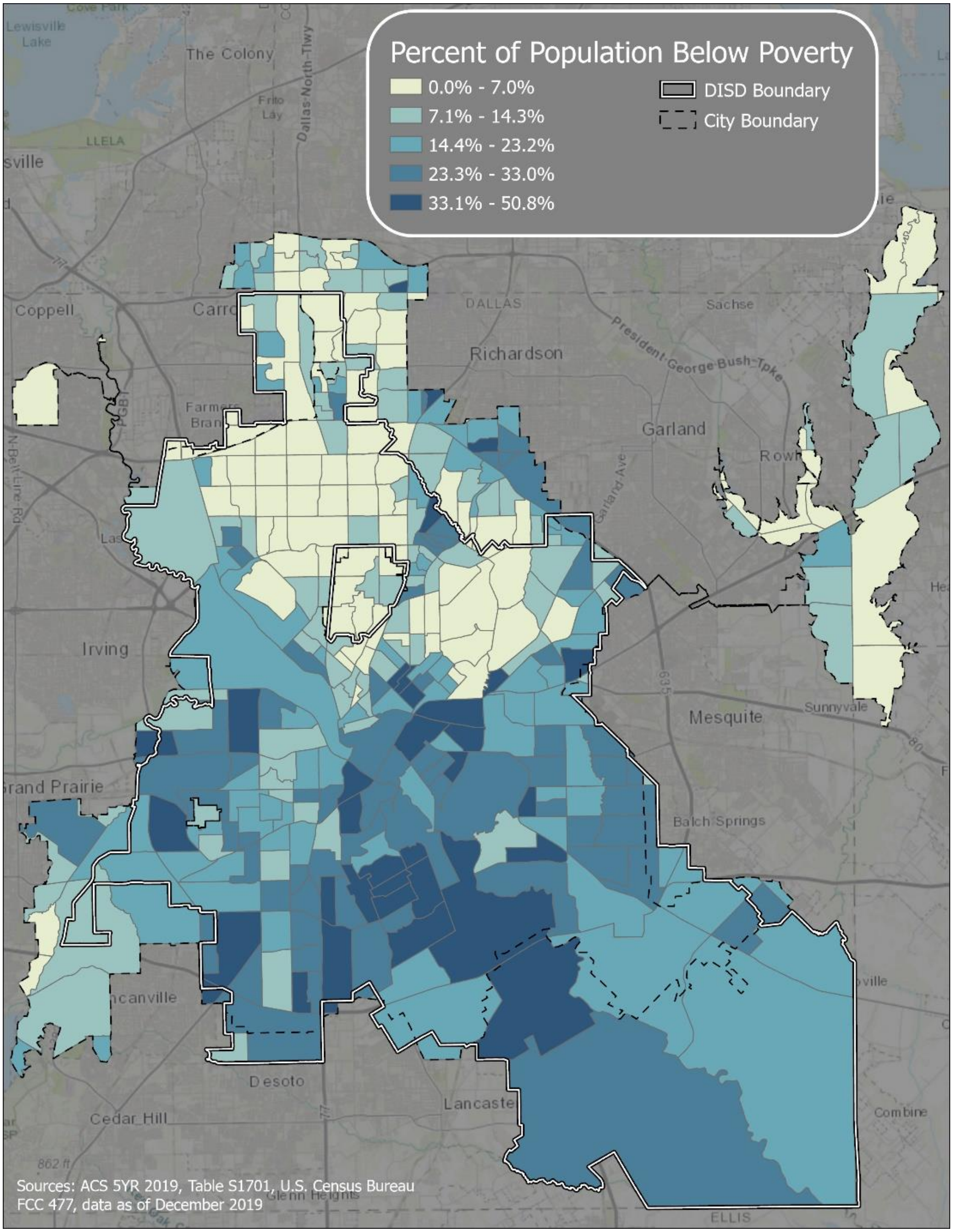
This figure is based on structures in these zones (not population) but we estimate that more than 210,000 people live in the DSL-only areas (teal) and that about 5,000 people live in the areas served only by fixed wireless service (red).

Figure 12: Low-Investment Areas Within the City and DISD Boundaries



These low-investment areas correlated in part with areas that experience higher rates of poverty, indicated in darker blues in Figure 13.

Figure 13: Poverty Rates Within the City and DISD Boundaries



In addition, CTC analyzed the low-investment areas' overlap with other factors throughout the City and DISD, including the City of Dallas Office of Equity and Inclusion's Covid-19 risk score data. The City developed the risk scores with consideration of the following questions:

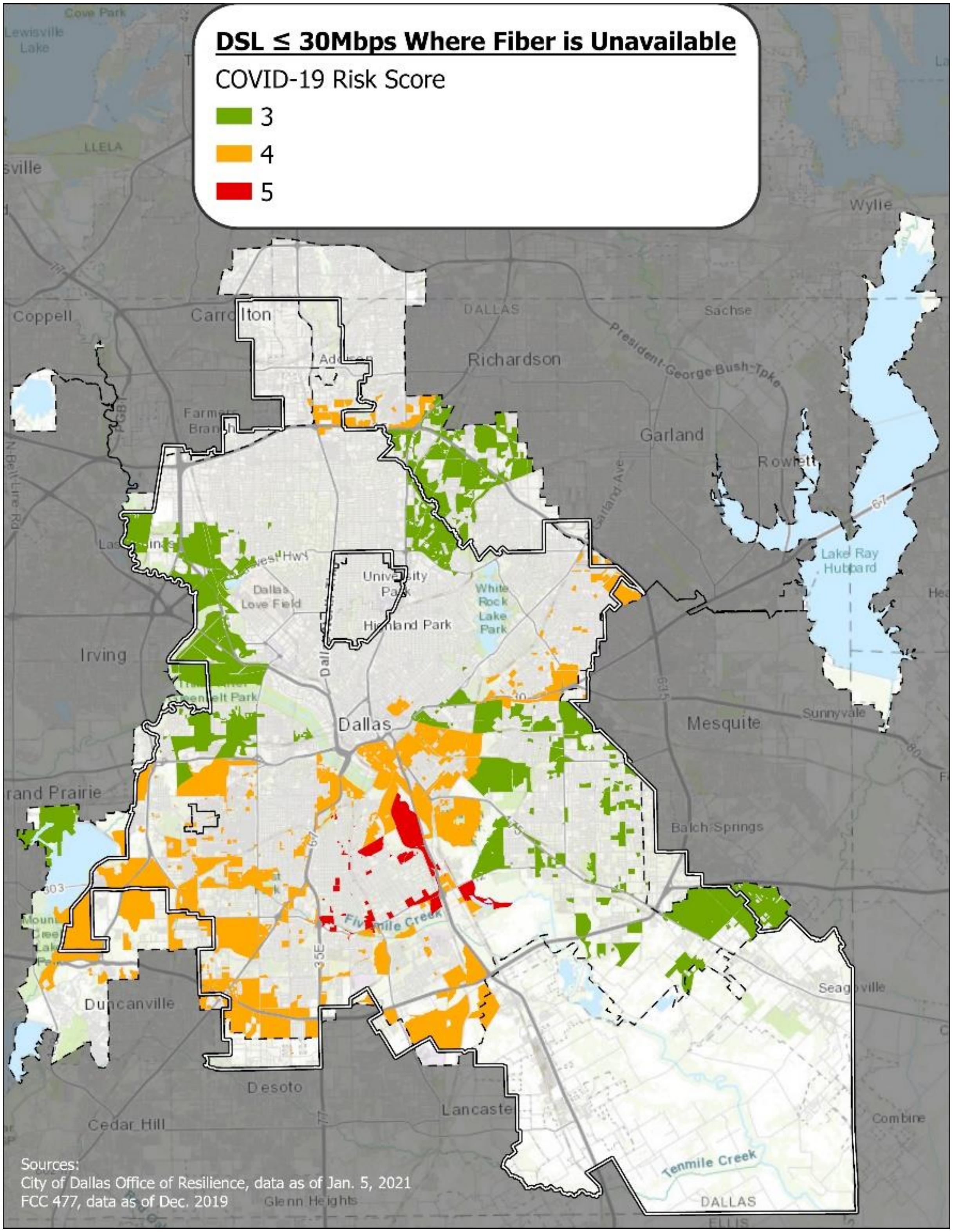
- "Do Black, Hispanic and Native American populations together make up more than 70% of the community?
- Does the area have 15% or more of its families at or below 100% of the federal poverty level?
- Do less than 50% of the area's households own the home they live in?
- Is the area rated "High" on the CDC's Social Vulnerability Index, Socioeconomic Level?
- Are more than 12% of the area's residents 65 or older?"[17]

Many of these questions are applicable in part to national patterns of broadband adoption. For example, Pew Charitable Trust data shows that those over 65 years are the age group least likely to have home broadband, and that income and education levels are correlated with home broadband use.[18] (The CDC's Social Vulnerability Index takes education level into account.[19])

The City's Covid-19 risk scores were used in this context not to evaluate the pandemic's relationship to broadband needs (though it certainly has accentuated those needs) but rather as a local data proxy for a range of social and economic challenges facing segments of the Dallas community. CTC found several areas of the City that have been assigned Covid-19 risk scores of three, four, or five (the three highest scores, indicating the most risk) that also overlapped with areas that do not have access to fiber, suggesting that some areas with high social and economic challenges are further challenged by lower levels of broadband investment and availability of high-speed services (Figure 14).

[17] Covid-19 risk score description and methodology, City of Dallas, https://dallasgis.maps.arcgis.com/home/item.html?id=186b98f0fab940118dbd9a4422db7eaa&view=table&sortOrder=desc&sortField=defaultFSOrder#overview (accessed April 29, 2021).
[18] "Internet/Broadband Fact Sheet," Pew Charitable Trusts, https://www.pewresearch.org/internet/fact-sheet/internet-broadband/?menuItem=2ab2b0be-6364-4d3a-8db7-ae134dbc05cd (accessed May 10, 2021).
[19] "CDC SVI 2018 Documentation," United States Centers for Disease Control and Prevention, https://www.atsdr.cdc.gov/placeandhealth/svi/documentation/pdf/SVI2018Documentation-H.pdf (accessed May 10, 2021).

Figure 14: Covid-19 Risk Levels Where Fiber Is Also Unavailable



In addition, the Census Bureau's American Community Survey collects data about the presence of a computer and an internet subscription in households. CTC identified the areas throughout the City and DISD where rates of households without a computer and those without an internet subscription were higher than the area's average (6.75 percent and 7.93 percent, respectively). When these areas were overlayed with the areas identified in Figure 12, there was a significant amount of overlap, as seen in Figure 15 and Figure 16.

Figure 15: Areas Without Fiber, Lower-Than-Average Computer Ownership, and High Covid-19 Risk

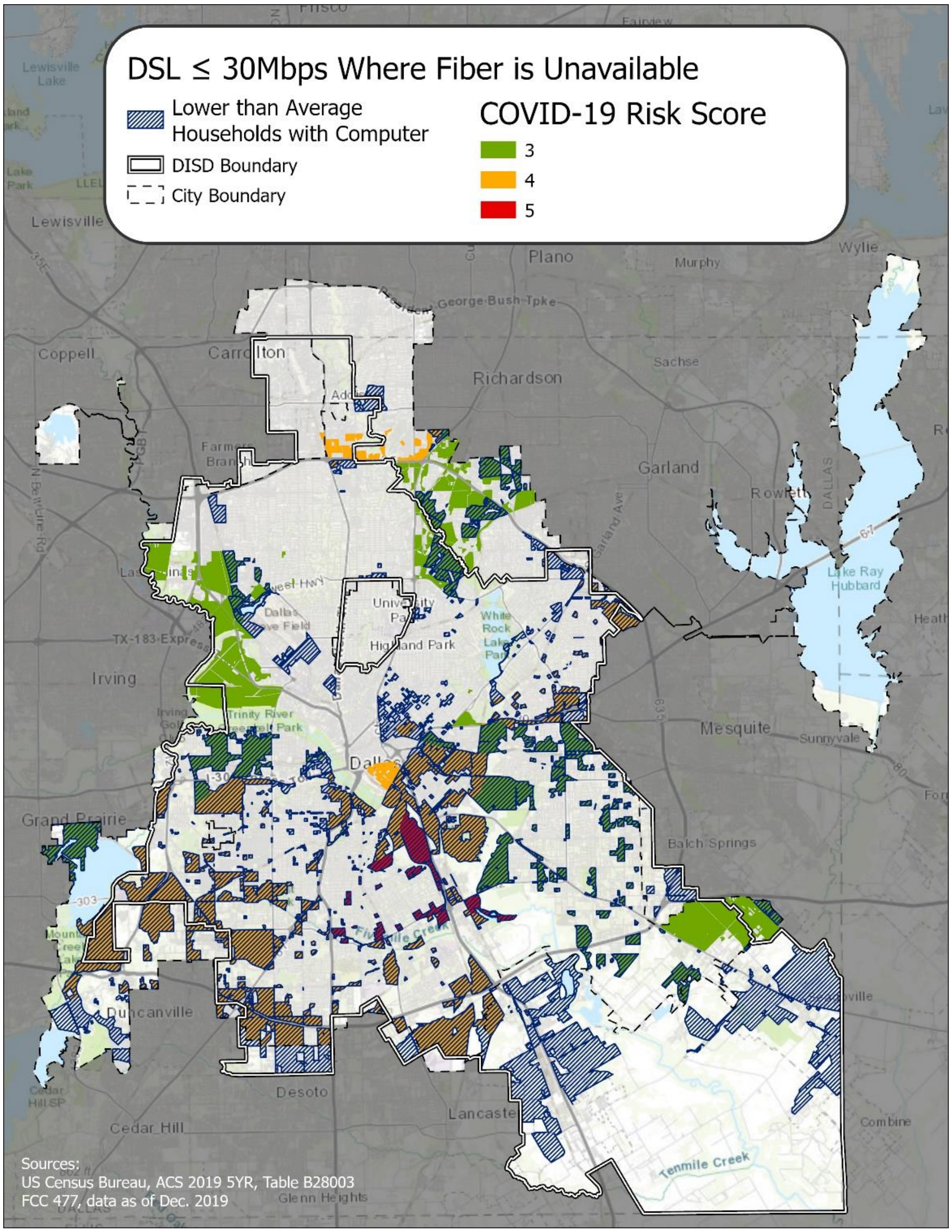
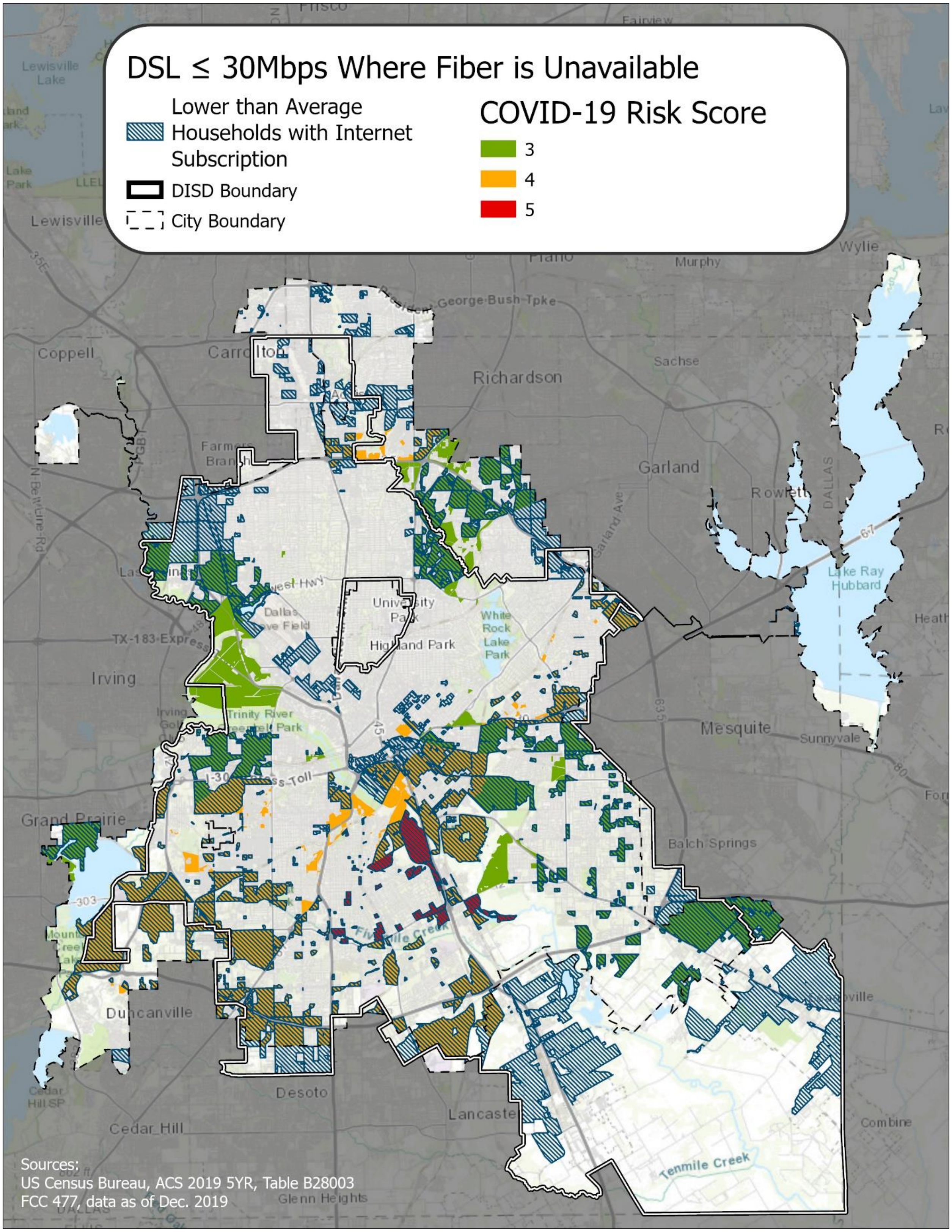


Figure 16: Areas Without Fiber, Lower-Than-Average Internet Subscription, and High Covid-19 Risk



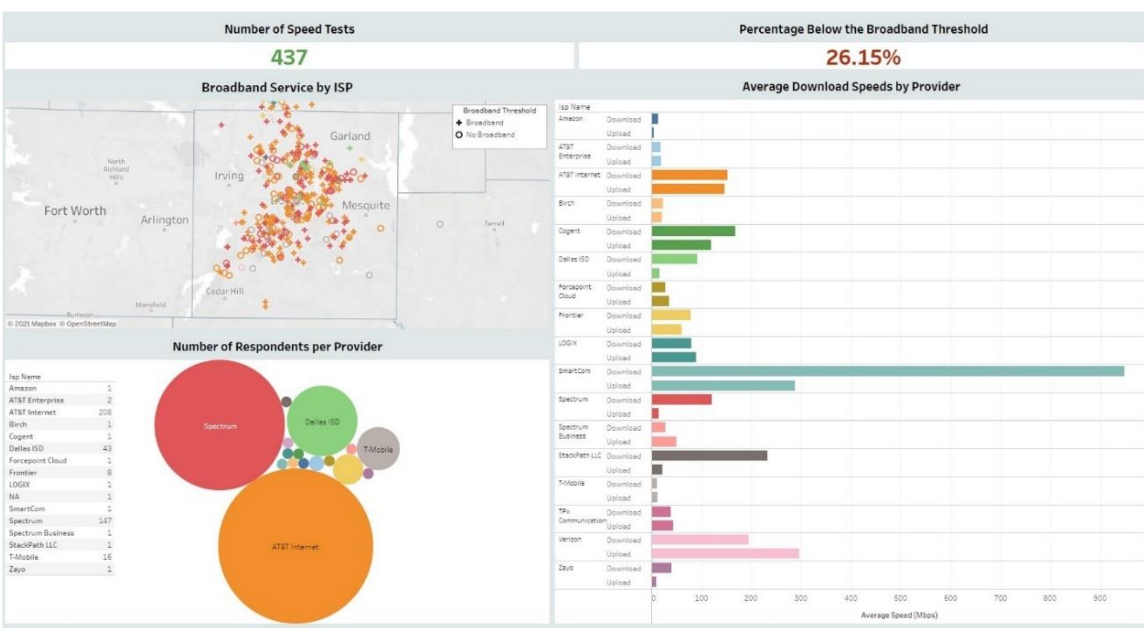
3.3 Online speed test results show sub-broadband speeds for many Spectrum and AT&T wired broadband customers

As part of this engagement, CTC developed, launched, and hosted a custom online speed test website called SpeedSurvey (https://dallas.speedsurvey.org/). The website included a means to conduct an internet speed test, a brief survey about levels of satisfaction with service, and an option to enter an address where no service was available. DISD, the City, and the Internet for All coalition promoted the SpeedSurvey link and encouraging participation by DISD families and other Dallas-area residents.

The overall goal was to develop the most granular data possible about broadband speeds available to households in the area. The value of the data rises along with the number of samples obtained. Between October 19, 2020, and May 18, 2021, 444 individuals filled out the SpeedSurvey survey or conducted speed tests. By this means, tests were conducted mainly by Spectrum, AT&T, and DISD users. The process also captured 19 tests from T-Mobile and two from Frontier, and numerous single datapoints from enterprise providers, which likely reflect tests conducted at workplaces.

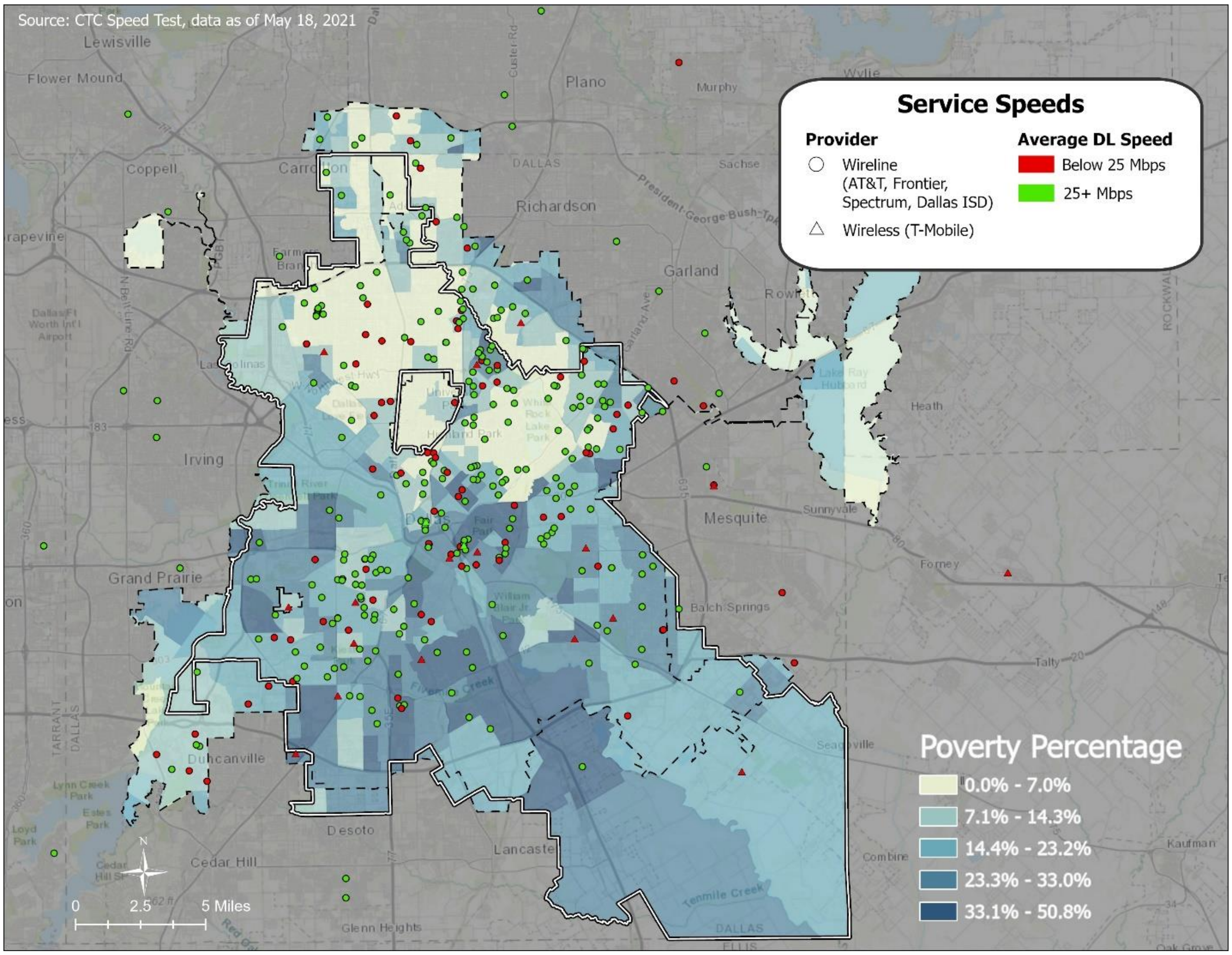
If a test was repeated at the same IP address, the results were averaged. (All data are reported as "average" regardless of whether the test was repeated.) Speed data can be affected by a number of factors, including distance of the test device from a Wi-Fi router and multiple devices using the network at the same time. With such caveats in mind, these test results can be considered a rough proxy for available broadband speeds. The raw data captured by SpeedSurvey is shown in Figure 17.

Figure 17: Raw SpeedSurvey Data



We removed the test results from individual enterprise providers and any tests taken farther than 15 miles from the outer boundaries of the DISD district. This left 400 tests: 370 conducted within the district and 30 taken within 15 miles of its outer boundaries. As noted above, all but a relative handful were from Spectrum, AT&T, and DISD. Among this group of 400, a total of 101 were below the broadband threshold of 25 Mbps download. Figure 18 shows the locations of tests and whether they met the 25 Mbps speed threshold for broadband.

Figure 18: Distribution of Tests Above or Below Broadband Speeds



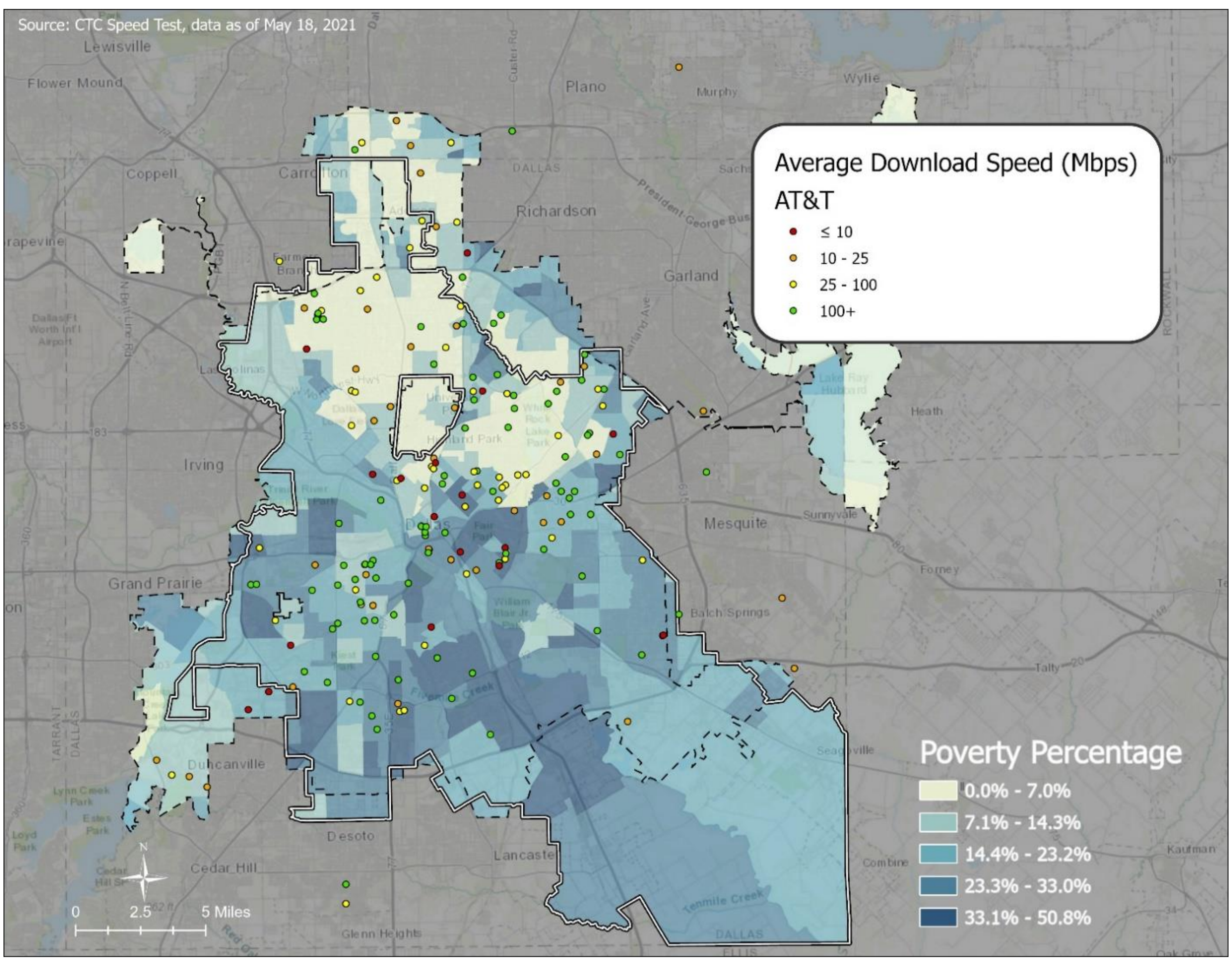
Relatively more people conducted tests in higher-income areas than lower-income areas. Table 13 shows the number of tests conducted in terms of neighborhood poverty rates.

Table 13: Where Tests Were Conducted Within Dallas and DISD, by Poverty Rate

Poverty %	All Providers	AT&T	Spectrum	DISD	Frontier	T-Mobile
0 – 7	76	49	26	0	1	0
7.1 – 14.3	83	42	32	3	0	6
14.4 – 23.2	93	50	33	5	1	4
23.3 – 33	64	29	23	7	0	5
33.1 – 50.8	54	20	17	13	0	4
TOTALS	**370**	**190**	**131**	**28**	**2**	**19**

We plotted the data individually for three providers: Spectrum, AT&T, and DISD. Given the low number of tests from Frontier and T-Mobile (and that T-Mobile is not a wireline provider) it would not be meaningful to map those data separately. The AT&T tests showed 139 at or above broadband speeds and 51 tests below broadband speeds. This reflects fiber or DSL service, not any AT&T wireless. Figure 19 shows these data, broken out in four speed categories, as indicated.

Figure 19: Speed Tests of AT&T Service Using Four Speed Categories



The tests taken by Spectrum customers showed 109 at or above broadband speeds and 22 below broadband speeds. Figure 20 shows these data using four speed categories.

Figure 20: Speed Tests of Spectrum Service Using Four Speed Categories

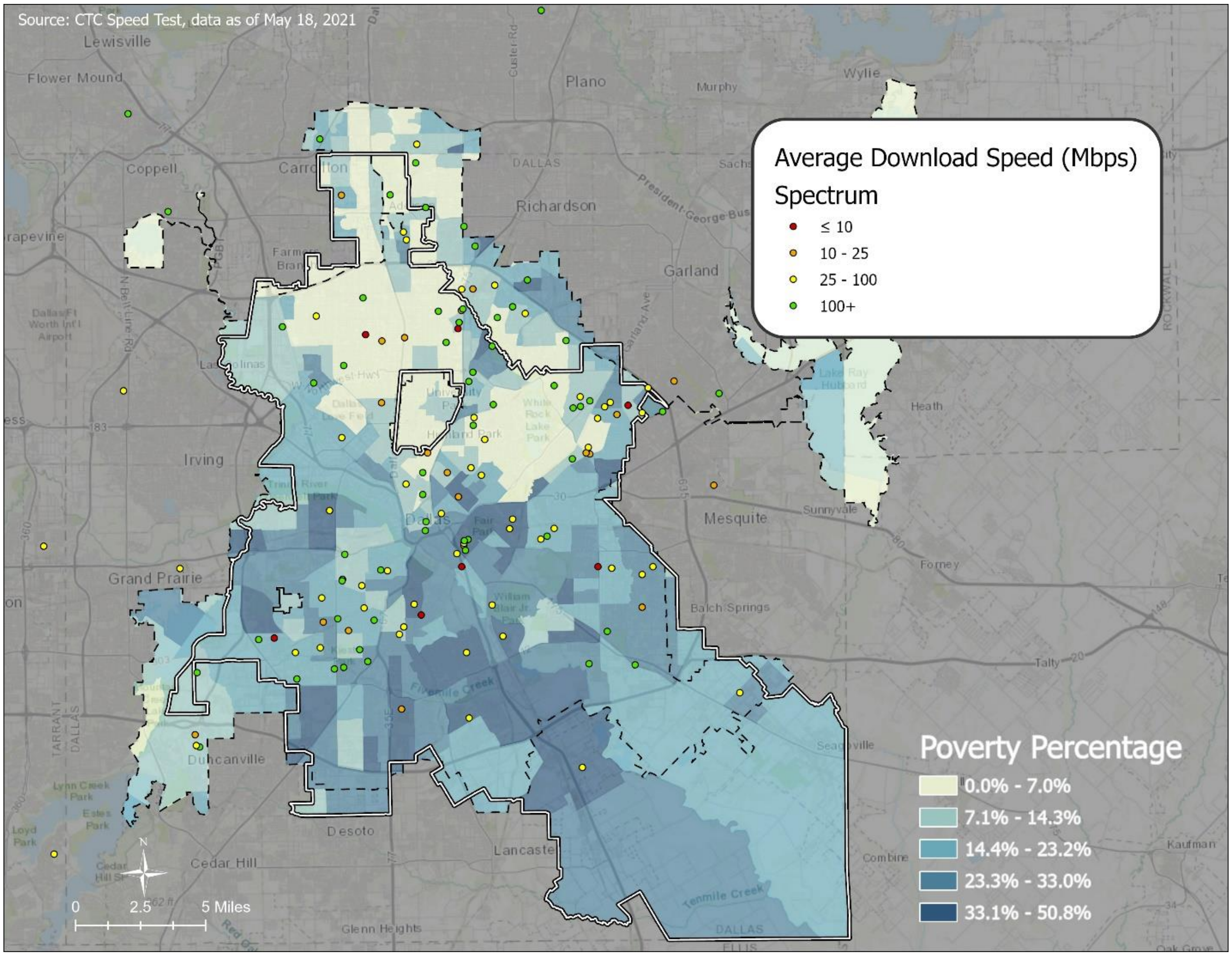
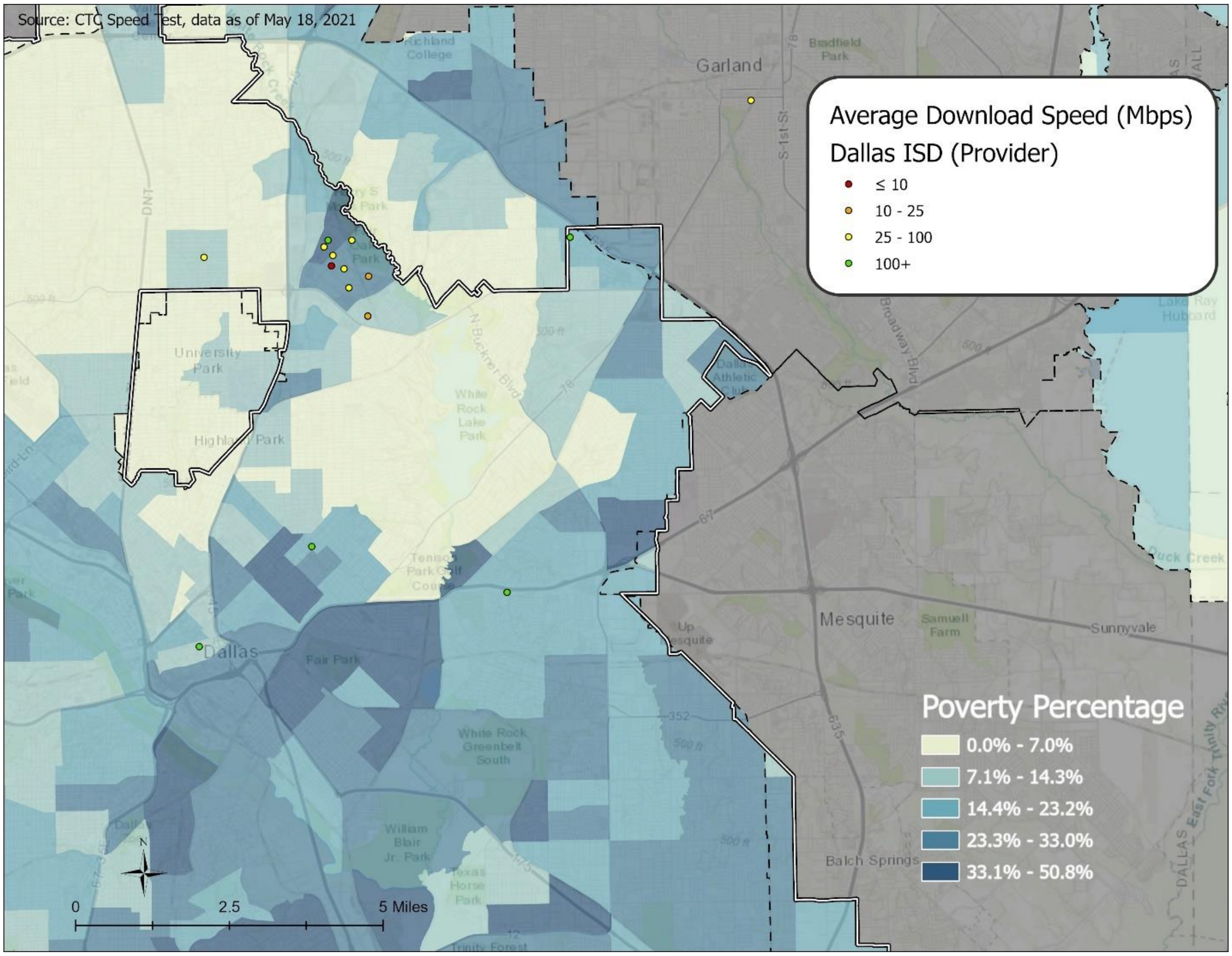


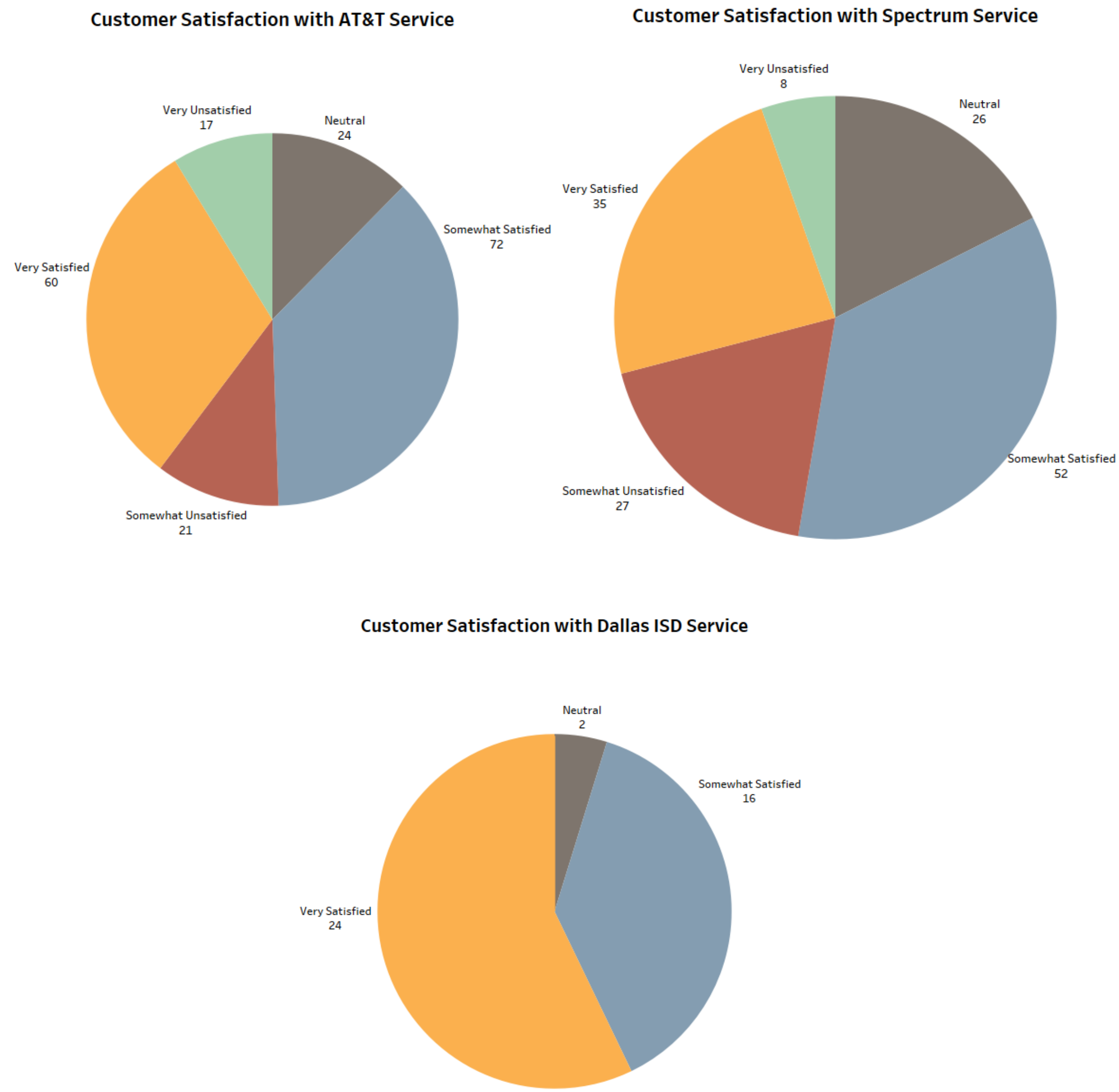
Figure 21 shows test results from households using the DISD service (i.e., the service provided within the schools, delivered over Unite Private Networks fiber) in some areas of the City. The tests showed 25 at or above broadband speeds and three below broadband speeds. In the figure, the number of icons is less than 28 because some icons represent more than one test taken in close proximity to one another.

Figure 21: Speed Tests of DISD Customers Using Four Speed Categories



The SpeedSurvey interface also asked users to rate their levels of satisfaction. Users reported high levels of satisfaction with the DISD service but had more mixed reviews of both AT&T and Spectrum service, with 38 percent either “unsatisfied” or “very unsatisfied” with AT&T service and 35 percent either “unsatisfied” or “very unsatisfied” with Spectrum service (Figure 22).

Figure 22: Speed Survey Results



In addition, the SpeedSurvey interface invited users to enter addresses where no service was available. Users reported 18 addresses where they asserted no service was available. Of these, six were within the City of Dallas or DISD territory. CTC queried Spectrum and AT&T's websites for these six addresses. Spectrum's website indicated it offered service at all six addresses and AT&T's website said it offered service at five. We discounted these as unreliable user reports.

4 Broadband use gaps exist among students and other residents in the Dallas area

As part of its efforts to perform a comprehensive evaluation of broadband gaps during the Covid-19 pandemic, the City of Dallas and DISD commissioned a mail survey of households. The survey, which was printed in English and Spanish, was intended to gather basic data about the types of services to which residents subscribe and their use of these services (including subsidized programs such as AT&T Access and Spectrum Internet Assist). Moreover, the survey was designed to provide insights about how the pandemic has impacted residents' use of the internet at various locations inside and outside the home and whether internet service is sufficient to meet residents' needs.

In brief summary, the survey found almost all respondents have access to the internet. However, for some respondents, that internet service was inadequate to meet their needs during the pandemic. Usage in the home for various activities increased significantly during the pandemic, but some lower-income households did not sufficient access to the internet and computers.

This sections below summarize the key findings, document the survey process, discuss methodologies, and present results intended to assist the City in developing strategies to close the identified gaps.

4.1 Key findings

Key findings are here presented thematically in four subsections: broadband access gaps, device utilization gaps, Covid-19 impacts on broadband use, and skills gaps in broadband and computer use. These and other findings are presented in greater detail in the body of the report.

4.1.1 Broadband access gaps

The survey found very few gaps in acquisition of residential internet services, but also that relatively few residents are taking advantage of available subsidized programs. The following are key findings:

- **Some low-income households lack access.** Overall, 96 percent reported having internet service (either home or mobile/cellular connection). However, 18 percent of low-income households earning under $25,000 per year have no internet service. Eleven percent of the lower-income segment with children (<$50,000, children in home) do not have internet.

- **AT&T and Spectrum are the leading internet service providers used.** One-half of respondents have either AT&T wired service (46 percent) or wireless service (3 percent) as their primary internet service, and 35 percent have Spectrum. Further detail on companies used by respondents is provided in the body of the report.

- **Most households with children have internet access, but it may not be sufficient for some families.** Although most respondents strongly disagreed that their children cannot complete their homework because they do not have internet access, 16 percent agreed or strongly agreed. One-third of households earning under $50,000 per year (with children) agreed or strongly agreed that the children in their care cannot complete their homework because they do not have access to the internet.

- **Some respondents are price sensitive.** Nineteen of 34 respondents without internet cited the high cost as the main reason for not purchasing home internet service. Also, willingness to purchase high-speed internet is very high for $10 per month (88 percent extremely willing) or $30 per (70 percent extremely willing), but this willingness drops sharply at higher price points.

- **Residents may be significantly underutilizing existing broadband subsidy programs.** Just 4 percent of all AT&T customers are enrolled in the ISP's Access program for low-income households, and 3 percent of Spectrum customers are enrolled in its Spectrum Internet Assist program. Just one percent of low-income subscribers receive the $9.25 subsidy under the FCC's Lifeline program, and 7 percent are unsure if they receive the subsidy.

- **Despite these various gaps, most respondents do use the internet.** Almost all (98 percent) respondents access the internet from any location, including a range of locations outside the home. However, use of the internet outside of the home has declined significantly during the Covid-19 pandemic.

- **Residents want affordable broadband internet service.** Most respondents strongly agreed the City or DISD should ensure all students (81 percent) and residents (65 percent) have access to affordable broadband service. Three-fourths of respondents strongly agreed that the City or DISD should provide free access at home to internet-based educational resources for economically disadvantaged students. Households with children were even more likely to support these efforts to reduce broadband access gaps.

4.1.2 Device utilization gaps

Most respondents have access to home internet service and computers, but a sizeable segment may face significant challenges in using, maintaining, and potentially repairing these devices. The following are key findings:

- **Most respondents have access to the internet and computers in the home.** Nine in 10 respondents indicated they have a computer in the home (desktop, laptop, tablet) with internet access. In comparison, two-thirds of low-income households (earning under $25,000 per year) have both internet access and a computer.

- **Many households have experienced frequent issues with their computing devices not working properly.** Six in 10 respondents with internet access have experienced trouble with their computer not working properly; 15 percent experience problems at least weekly.

- **More than one-fifth of respondents may have trouble maintaining their computers.** Twenty-two percent disagreed or strongly disagreed that they know how to troubleshoot issues with technology.

- **More than one-fourth of internet subscribers would not be able to quickly replace non-working computers.** Eight percent of respondents said they could not replace their computer in the foreseeable future if it became unusable, and another 19 percent said it would take one to six months to replace it. Adding these two datapoints, 27 percent of households with home internet service are at risk of not being able to use broadband for very long periods because of computer problems, rather than residential internet connectivity problems.

- **Low-income households are at greater risk of computer issues**. One-fourth of internet subscribers earning under $25,000 experience issues at least weekly with their primary computer becoming inaccessible or unusable. Furthermore, six in 10 low-income subscribers would not be able to replace their computer (30 percent) or would take one to six months to replace it (30 percent) should their computer become unusable.

4.1.3 Covid-19 impacts on broadband use

Respondents reported increased use of and demand for broadband services during the Covid-19 pandemic. They are utilizing the internet more at home and less often outside the home, as may be expected, and they are engaged in more online activities for work and education. The following are key findings:

- **Daily use of home internet service at various times has increased during the pandemic**. Prior to the Covid-19 pandemic, approximately one-half of respondents made daily use of the internet mid-morning or early afternoon, compared with approximately eight in 10 respondents during the pandemic. Four in 10 households have at least three members online during peak usage times during the Covid-19 pandemic.

- **Use of internet services outside of the home has declined significantly during the Covid-19 pandemic.** Use of the internet in key areas decreased significantly when comparing figures pre-Covid and during-Covid, including in work settings (79 percent vs. 58 percent), home of a friend or family member (64 percent vs. 50 percent), coffee shop or private businesses (58 percent vs. 30 percent), outdoor public spaces using free Wi-Fi (52 percent vs. 36 percent), schools or colleges (36 percent vs. 26 percent), libraries (32 percent vs. 13 percent), and other public buildings (26 percent vs. 13 percent).

- **Engagement in online activities has increased significantly during the Covid-19 pandemic.** Use of the internet for telework (58 percent vs. 73 percent), telemedicine or medical appointments (34 percent vs. 75 percent), homework (33 percent vs. 41 percent), attending online classes (28 percent vs. 49 percent), and attending homeschool (11 percent vs. 24 percent) increased substantially from pre-pandemic to during-pandemic. Additionally, 58 percent of respondents use the internet for teleworking on a *daily* basis, compared with 19 percent of respondents before the pandemic.

4.1.4 Skills gaps in using broadband and computers

Most respondents have adequate internet and computer skills. However, a small segment of respondents reported significant challenges with respect to their ability to perform basic functions online and avoid harms. Respondents also expressed interest in improving those skills. Key findings include:

- **Some respondents may be vulnerable to online harms and disinformation.** When asked if they knew how to recognize and avoid a phishing scam, 15 percent disagreed or strongly disagreed. Eleven percent disagreed or strongly disagreed that they knew how to recognize false information online and find credible sources of information.

- **Most respondents have the skills to perform basic tasks on the internet.** Overall, most internet subscribers strongly agreed that they know how to use the internet for various functions, including: accessing a bank account online (79 percent), bookmarking a website or adding to list of favorites (72 percent), purchasing groceries and food (70 percent), creating/managing a social media profile (68 percent), adjusting privacy settings (65 percent), and uploading content to a website (67 percent). Respondents were less likely to agree that they are skilled in creating their own personal website or in troubleshooting issues with technology.

- **Many caregivers report that children under their care have adequate broadband skills.** Among those with children, 50 percent agreed or strongly agreed they are sufficiently skilled in computer use to complete their homework on their own. One-fourth disagreed or strongly disagreed.

- **Most caregivers have adequate skills to help their children when needed.** Nearly one-half (46 percent) of respondents with children strongly agreed that their computer skills are good enough to help their children complete their homework, and 17 percent agreed.

However, 16 percent disagreed or strongly disagreed that they have sufficient computers skills.

- **Many respondents are interested in becoming more confident in using computers, smartphones, and the internet.** Specifically, 43 percent of respondents agreed or strongly agreed that they would like to become more confident in using computers and related technology, and 29 percent agreed or strongly agreed they would like to attend training.
- **Many respondents disagreed that their children are able to minimize or avoid specific online risks.** Many respondents disagreed or strongly disagreed that their children have the skills to detect and avoid false or misleading information (56 percent), avoid online bullying (43 percent), get help for online bullying (33 percent), detect and avoid financial scams and predators (51 percent), avoid exposure to graphic violence or pornography online (41 percent), and get help if exposed to graphic violence or pornography online (29 percent). However, six in 10 respondents agreed or strongly agreed that they have the time and skills to protect their children from online risks.

4.2 Survey process

In close coordination with the City of Dallas and DISD, CTC managed the survey project, including development of the questionnaire, sample selection, mailing and data entry coordination, survey data analysis, and reporting of results.

CTC developed the draft survey instrument based on the project objectives and provided it to City and school district staff for review and comment. The City and DISD provided revisions and approved the final questionnaire. (The survey instrument is included in Appendix A.)

A total of 10,000 survey packets were mailed first-class in December 2020 to a random selection of residential households located in the Dallas Independent School District. Recipients were provided with a postage-paid business reply mail envelope in which to return the completed questionnaire. A total of 790 useable surveys were received by the date of analysis, providing a gross response rate of 7.9 percent. The low response rate may be attributed to mailing during the holiday season.

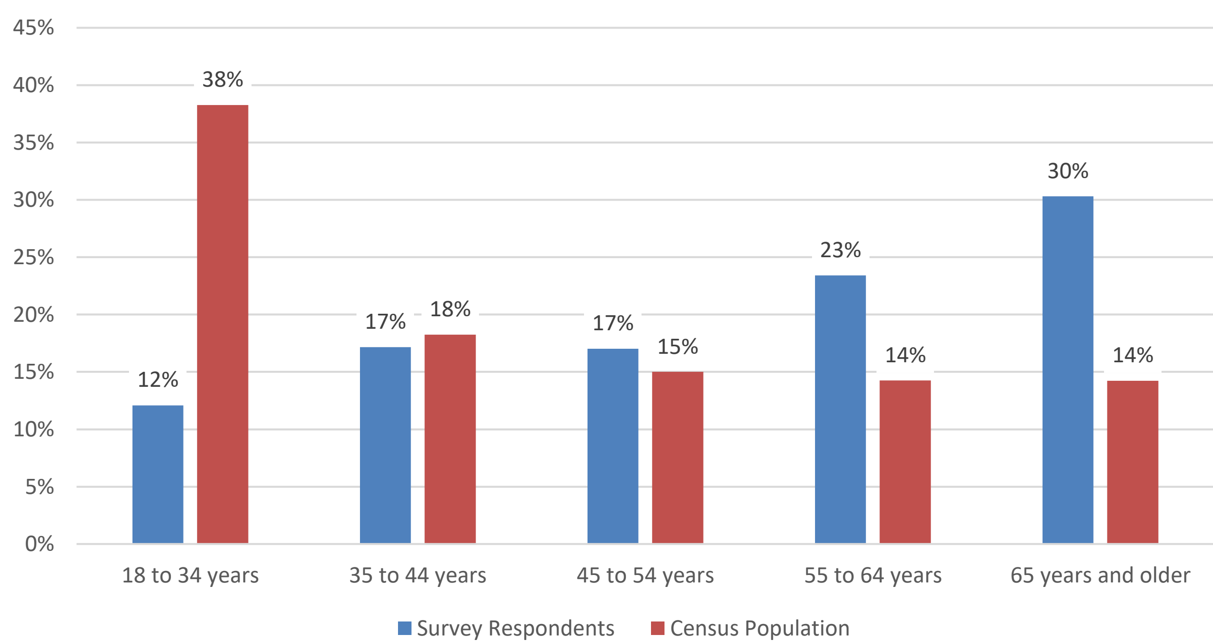
The margin of error for aggregate results at the 95 percent confidence level for 790 responses is ±3.5 percent. That is, for questions with valid responses from all survey respondents, one would be 95 percent confident (19 times in 20) that the survey responses lie within ±3.5 percent of the target population as a whole.

The survey responses were entered into SPSS[20] software and the entries were coded and labeled. SPSS databases were formatted, cleaned, and verified prior to the data analysis. The survey data was evaluated using techniques in SPSS including frequency tables, cross-tabulations, and means functions. Statistically significant differences between subgroups of response categories are highlighted and discussed where relevant.

The survey responses were weighted based on the age of the respondent, income, and presence of children in the household. The sample was stratified by income level and presence of children in the household to ensure a sufficient number of responses to analyze data among low-income households with children residing in them. Also, since older persons are more likely to respond to surveys than younger persons, the age-weighting corrects for the potential bias based on the age of the respondent. In this manner, the results more closely reflect the opinions of DISD's adult population.

Figure 23 summarizes the sample and population distributions by age.

Figure 23: Age of Respondents and Adult Population



[20] Statistical Package for the Social Sciences (http://www-01.ibm.com/software/analytics/spss/)

4.3 Survey results

The results presented in this report are based on analysis of information provided by 790 residents within the Dallas Independent School District. (Of that total, 23 respondents replied on the Spanish-language survey instrument.) Unless otherwise indicated, the percentages reported are based on the "valid" responses from those who provided a definite answer and do not reflect individuals who said "don't know" or otherwise did not supply an answer because the question did not apply to them. Key statistically significant results ($p \leq 0.05$) are noted where appropriate.

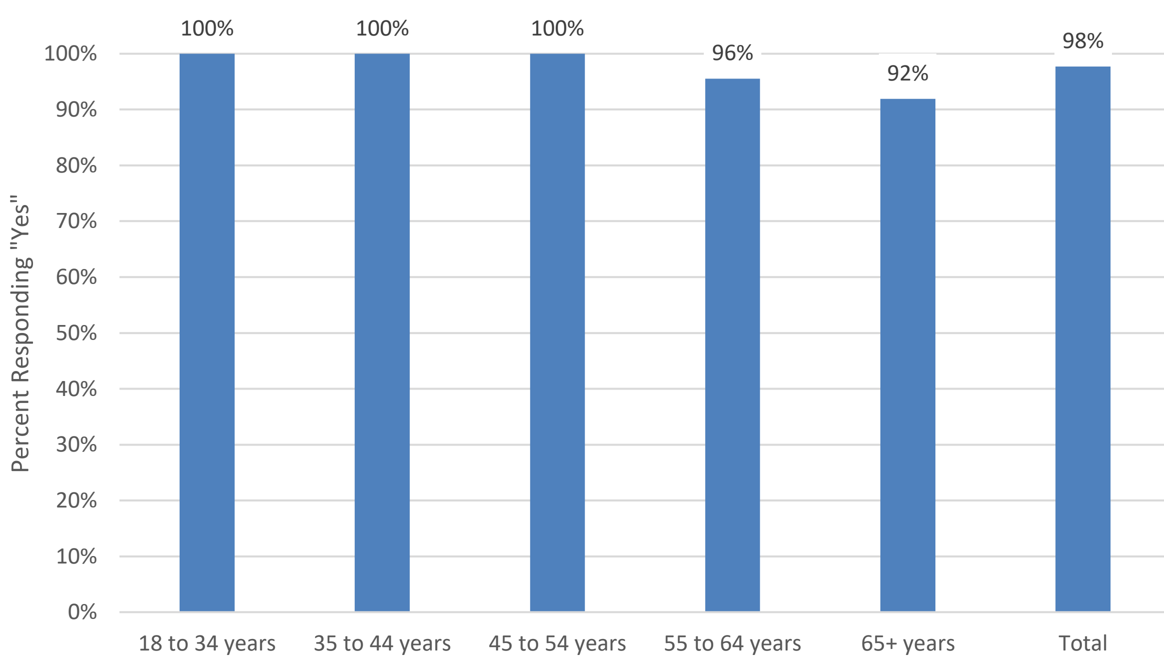
4.3.1 Internet connection and use

Respondents were asked about their use of the internet, including home internet connection providers, internet costs and enrollment in programs for low-income subscribers, and devices used. This information provides valuable insight into residents' need for various internet and related communications services.

4.3.1.1 Internet Usage

Almost all (98 percent) respondents make some use of the internet, on any device from any location, as shown in Figure 24. Usage is high across all demographic groups, ranging from 100 percent of respondents under age 55 to 92 percent of respondents ages 65 and older.

Figure 24: Internet Usage by Age of Respondent



Agreement with reasons for not accessing the internet are highlighted in Figure 25 and Figure 26. The leading barriers to internet access include concern with safety and privacy (15 out of 31 strongly agree) and cost of internet service (20 out of 36 strongly agree).

Figure 25: Reasons for Not Using the Internet (Mean Ratings)

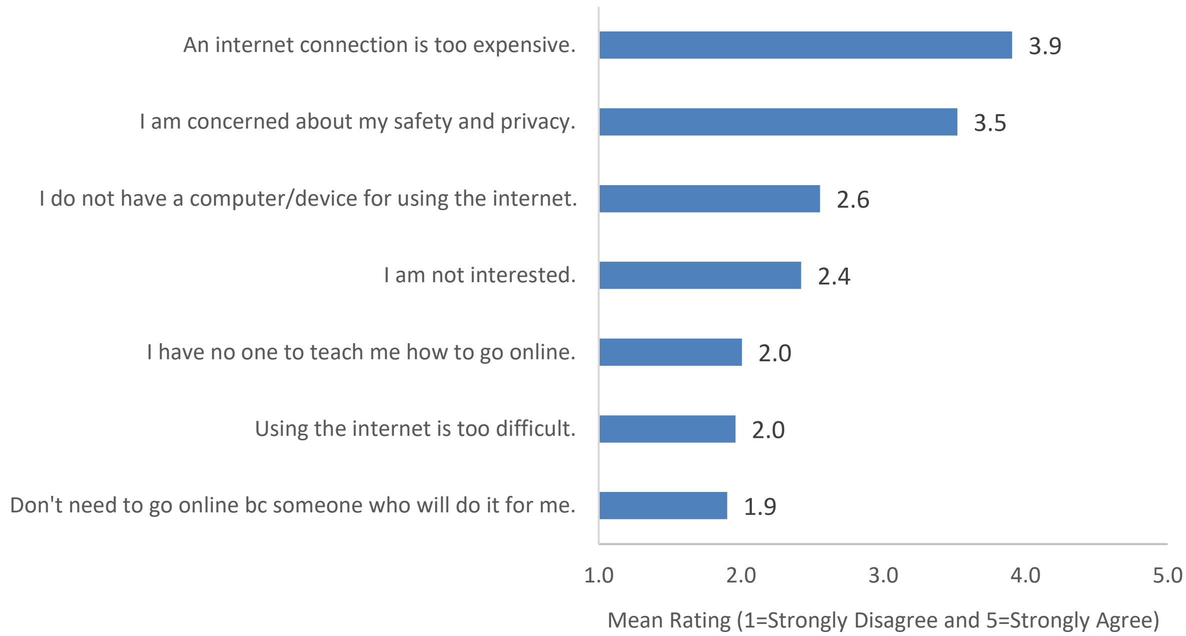
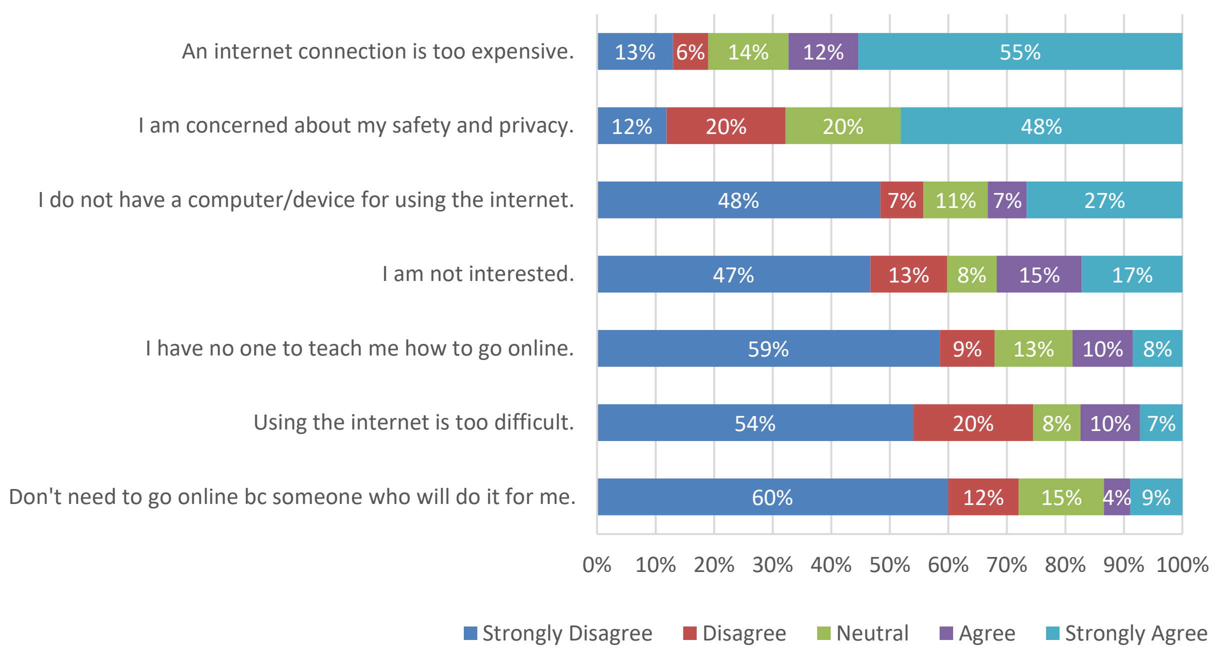


Figure 26: Reasons for Not Using the Internet



4.3.1.2 Importance of Communication Services

Respondents were asked to indicate the importance of various communication services to their household, using a scale where 1=Not at all important and 5=Extremely important. The mean importance of various service aspects is illustrated in Figure 27, while detailed responses are illustrated in Figure 28.

Figure 27: Importance of Communication Service Aspects (Mean Ratings)

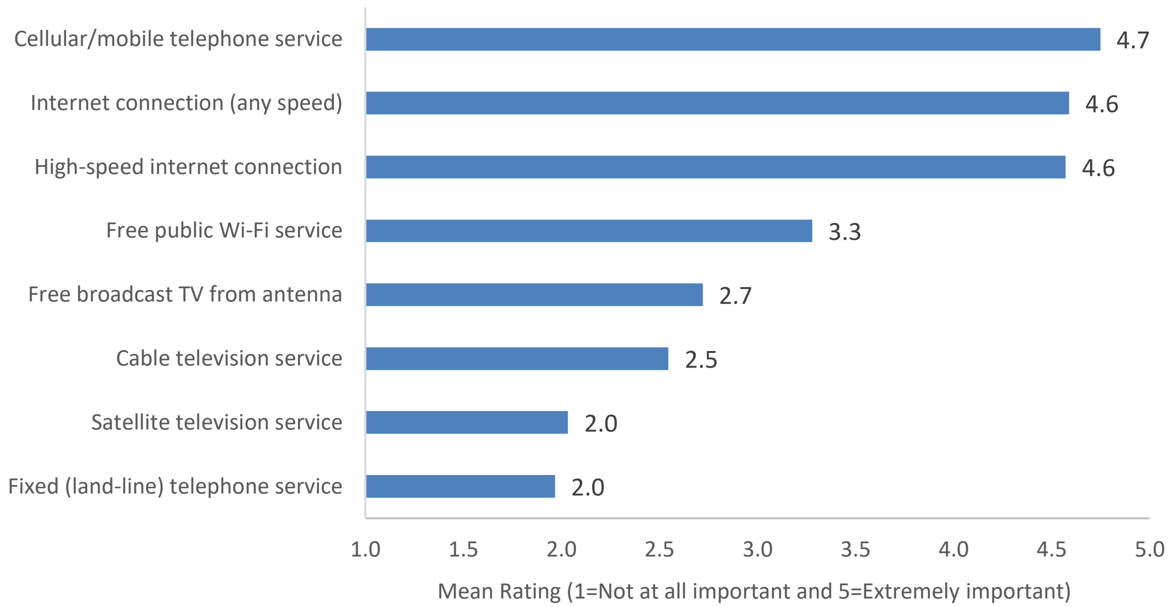
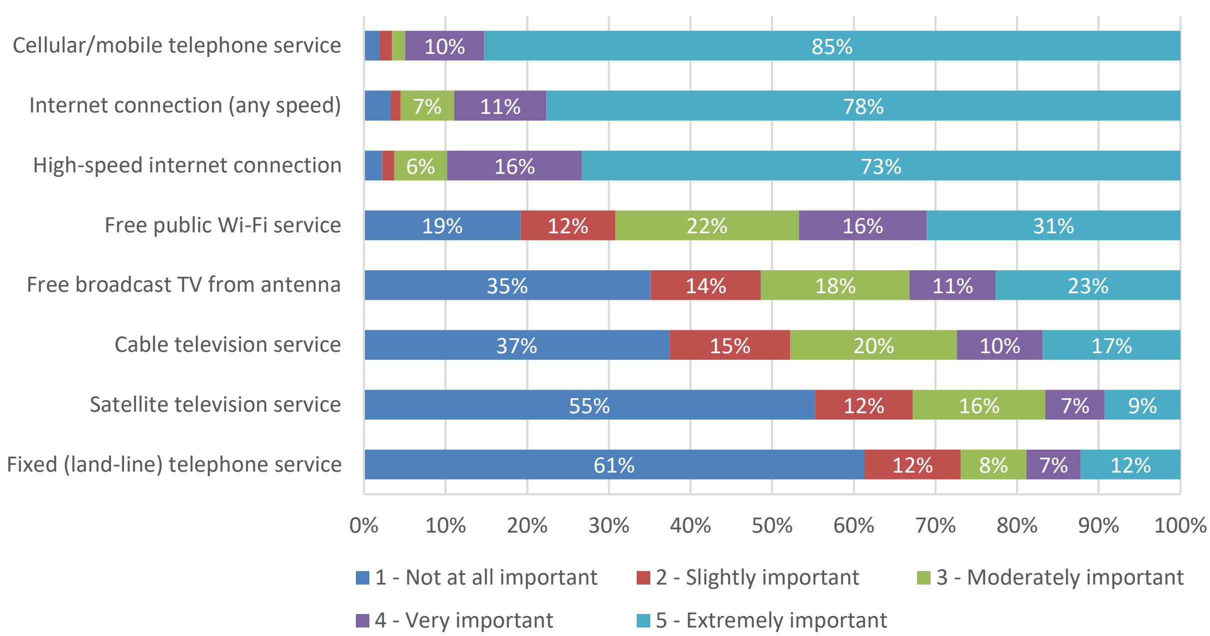


Figure 28: Importance of Communication Service Aspects



Cellular/mobile telephone and internet services are extremely important to respondents, while broadcast television service and satellite television service are significantly less important. Specifically, 85 percent said cellular/mobile phone service is extremely important, and 78 percent said an internet connection of any speed is extremely important. Another 73 percent of respondents said high-speed internet is extremely important.

Figure 29 and Figure 30 illustrate the importance of internet services and mobile telephone service by household income and presence of children in the household. Those in higher-income households and those with children at home placed more importance on these communication services compared with their counterparts.

Figure 29: Importance of Communication Services by Household Income

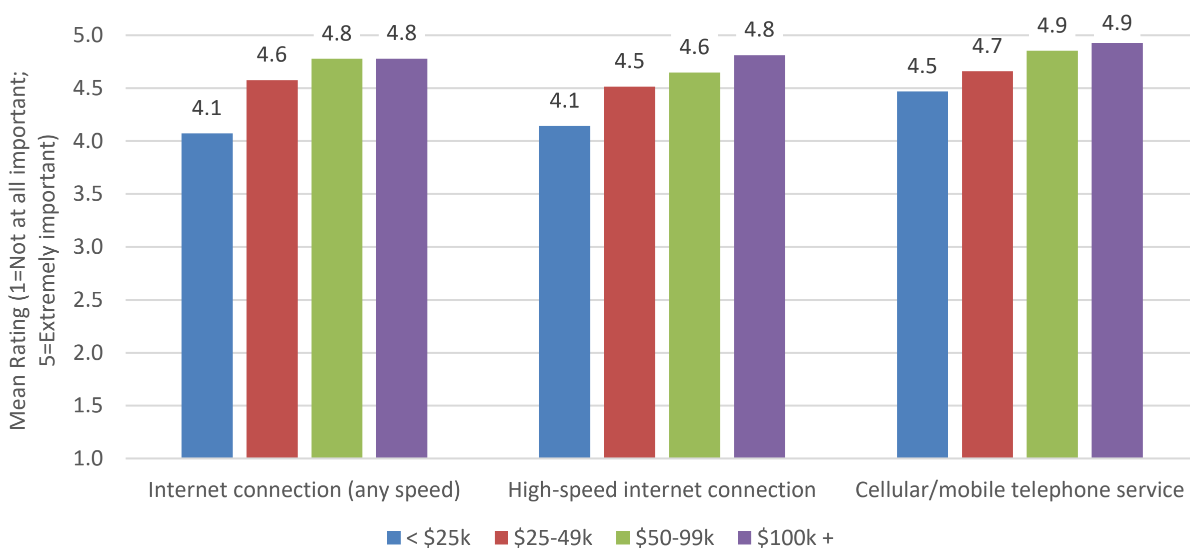
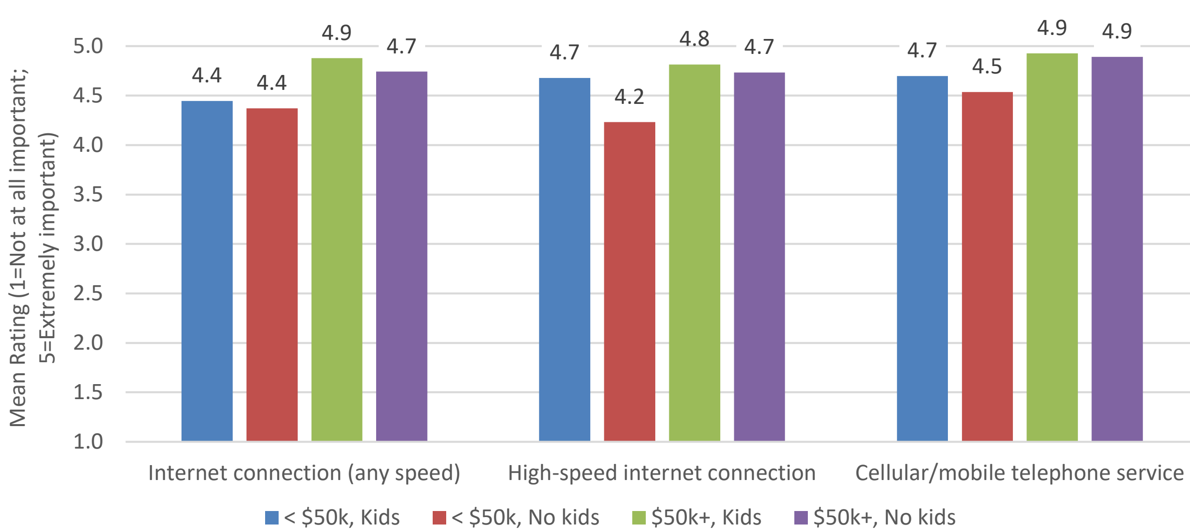


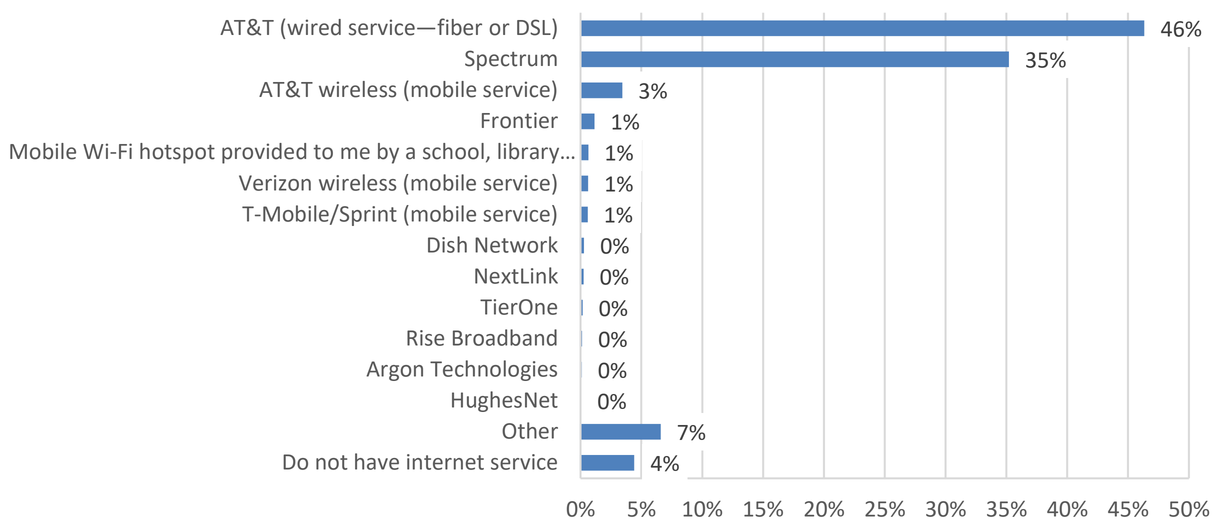
Figure 30: Importance of Communication Services by Segment



4.3.1.3 Internet Service Provider

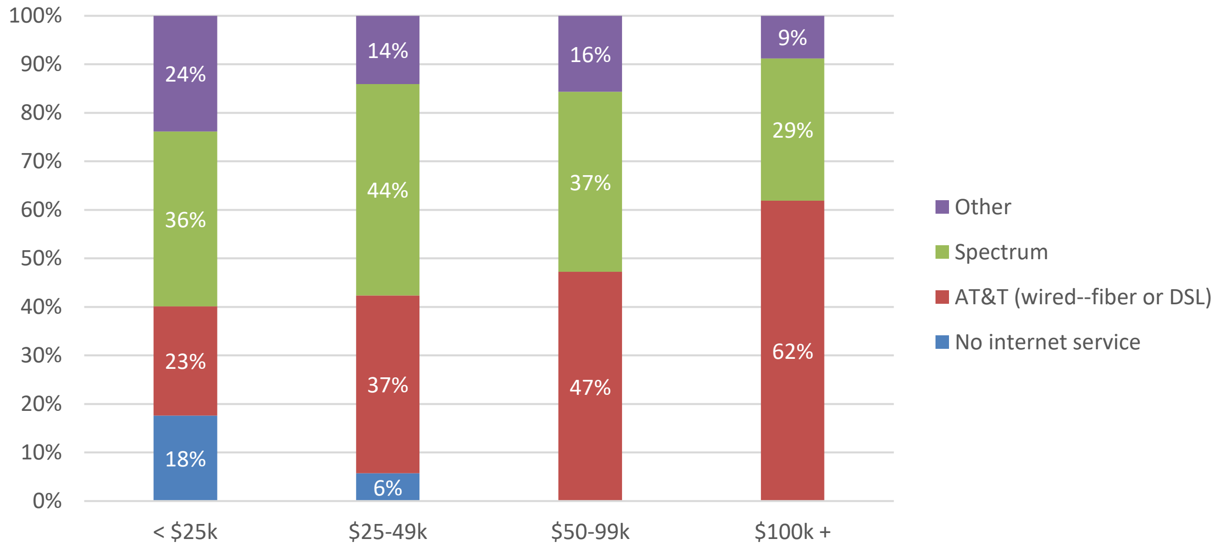
As illustrated in Figure 31, AT&T and Spectrum are the leading ISPs overall in the market area. Only 4 percent of respondents do not have internet service. More than one-half (57 percent) of AT&T (wired) subscribers have fiber, while 36 percent have a DSL connection, and 7 percent were unsure. Nineteen of 34 respondents without internet cited the high cost as the main reason for not purchasing home internet service.

Figure 31: Primary Internet Service Provider



Use of home or mobile internet service varies by household income. Eighteen percent of low-income households do not have any internet service, either a home internet connection or a mobile/cellular connection (see Figure 32).

Figure 32: Primary Internet Service by Household Income



As discussed previously, most respondents have some internet access. Total internet access is high across all demographic groups, as shown in Table 14. Respondents in lower income households are less likely to have internet service, as previously discussed, as are those with a high school education or less.

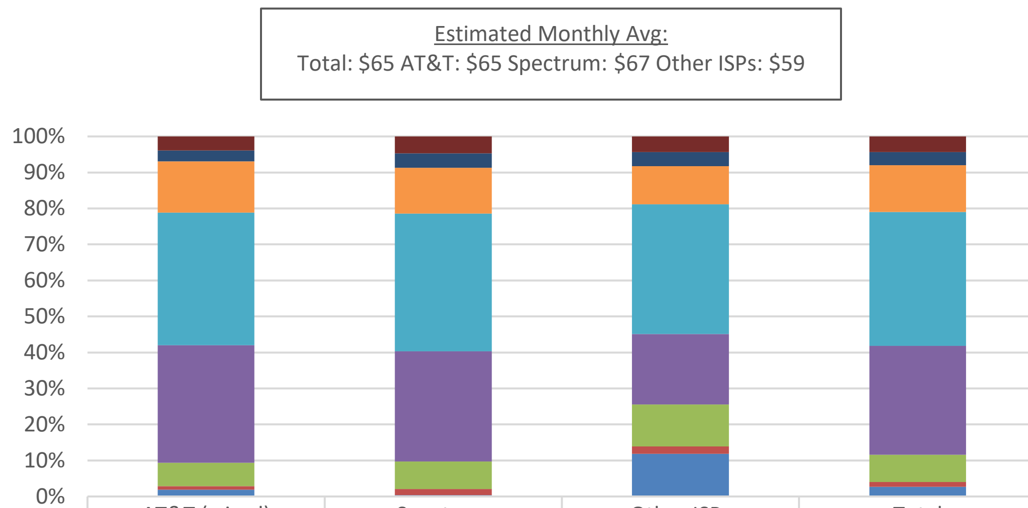
Table 14: Internet Access by Key Demographics

	No internet service	AT&T (wired)	Spectrum	Other ISP	Total Internet Access	*Weighted Count*
TOTAL	**4%**	**46%**	**35%**	**14%**	**96%**	***777***
Segment						
< $50,000, children	8%	26%	55%	11%	92%	*98*
< $50,000, no children	11%	34%	34%	21%	89%	*193*
$50,000+, children	0%	63%	29%	8%	100%	*96*
$50,000+, no children	0%	55%	33%	12%	100%	*262*
Respondent Age						
18 to 34 years	4%	42%	43%	10%	96%	*251*
35 to 44 years	1%	52%	36%	11%	99%	*130*
45 to 54 years	1%	51%	35%	12%	99%	*110*
55 to 64 years	7%	47%	31%	14%	93%	*126*
65 years and older	8%	44%	24%	24%	92%	*142*
Education						
HS education or less	14%	23%	43%	20%	86%	*159*
Two-year/technical degree	6%	47%	36%	11%	94%	*110*
Four-year college degree	1%	57%	33%	10%	99%	*237*
Grad, prof, doctorate	1%	51%	32%	16%	99%	*251*
Income						
Less than $25,000	18%	23%	36%	24%	82%	*106*
$25,000 to $49,999	6%	37%	44%	14%	94%	*185*
$50,000 to $99,999	0%	47%	37%	16%	100%	*121*
$100,000 or more	0%	62%	29%	9%	100%	*238*
Race/Ethnicity						
Black/African American, non-Hispanic	6%	46%	29%	19%	94%	*109*
Hispanic/Latino	10%	25%	50%	15%	90%	*179*
White/European-American, non-Hispanic	2%	59%	26%	13%	98%	*381*
Other/more than one	0%	35%	52%	13%	100%	*91*
Children in Household						
No children in HH	5%	47%	32%	16%	95%	*547*
Children in HH	4%	45%	43%	9%	96%	*221*

4.3.1.4 Internet Service Cost and Programs for Low-Income Subscribers

Respondents were asked to give the cost of their home internet service, as shown in Figure 33. The estimated monthly average cost for internet service is $65 overall, $65 for AT&T (wired) service and $67 for Spectrum. Two-thirds of respondents pay between $60 and $80 per month for their internet service. Another 8 percent pay more than $100 per month, and 12 percent pay less than $40 per month.

Figure 33: Monthly Price for Internet Service



	AT&T (wired)	Spectrum	Other ISPs	Total
More than $120	4%	5%	4%	4%
$101 to $120	3%	4%	4%	4%
$81 to $100	14%	13%	11%	13%
$61 to $80	37%	38%	36%	37%
$41 to $60	33%	31%	20%	30%
$21 to $40	7%	8%	12%	8%
$11 to $20	1%	2%	2%	1%
$0 to $10	2%	0%	12%	3%

As illustrated in Figure 34, just 4 percent of all AT&T customers are enrolled in the ISP's Access program for low-income households. Eleven percent of customers earning under $25,000 per year said they are enrolled in the program.

As illustrated in Figure 35, just 3 percent of all Spectrum customers and low-income customers are enrolled in the ISP's Internet Assist program for low-income households. Four in 10 customers earning under $25,000 said they had not heard of the program.

Figure 34: Enrolled in AT&T's Access Program

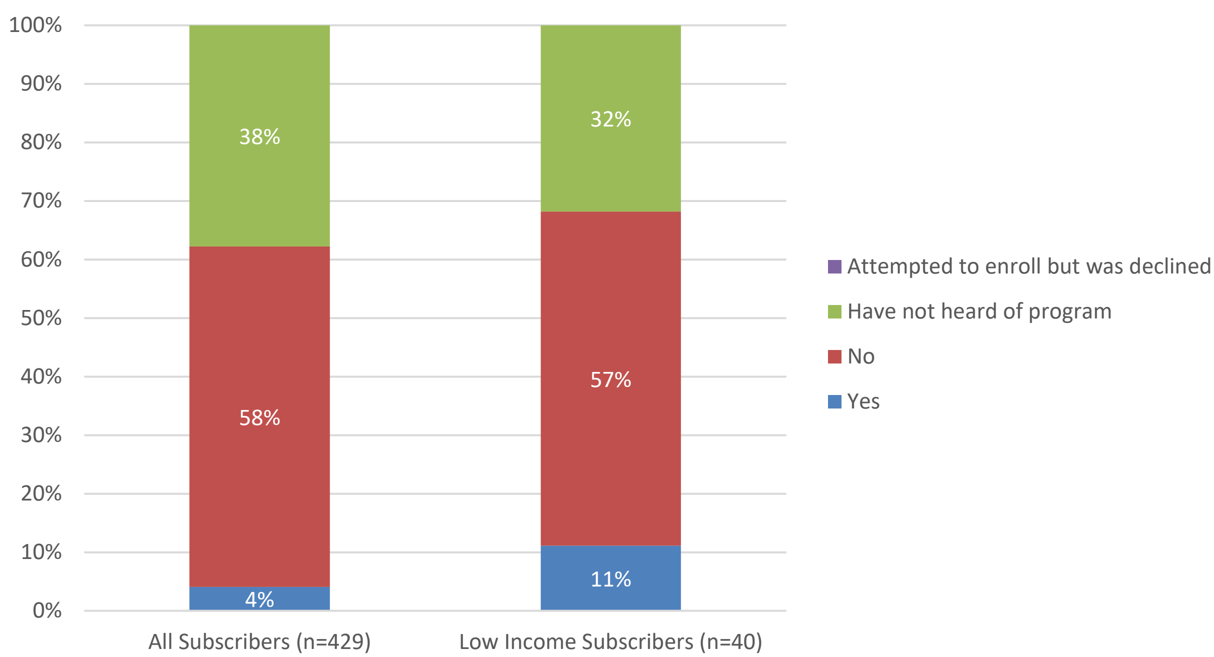
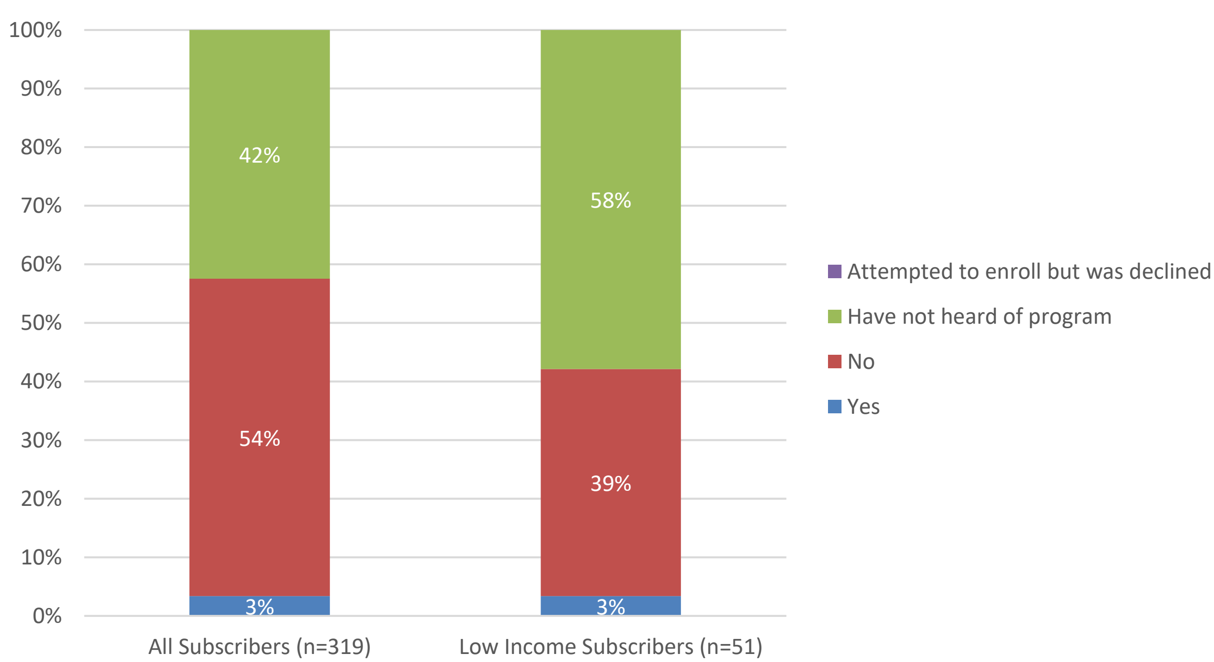
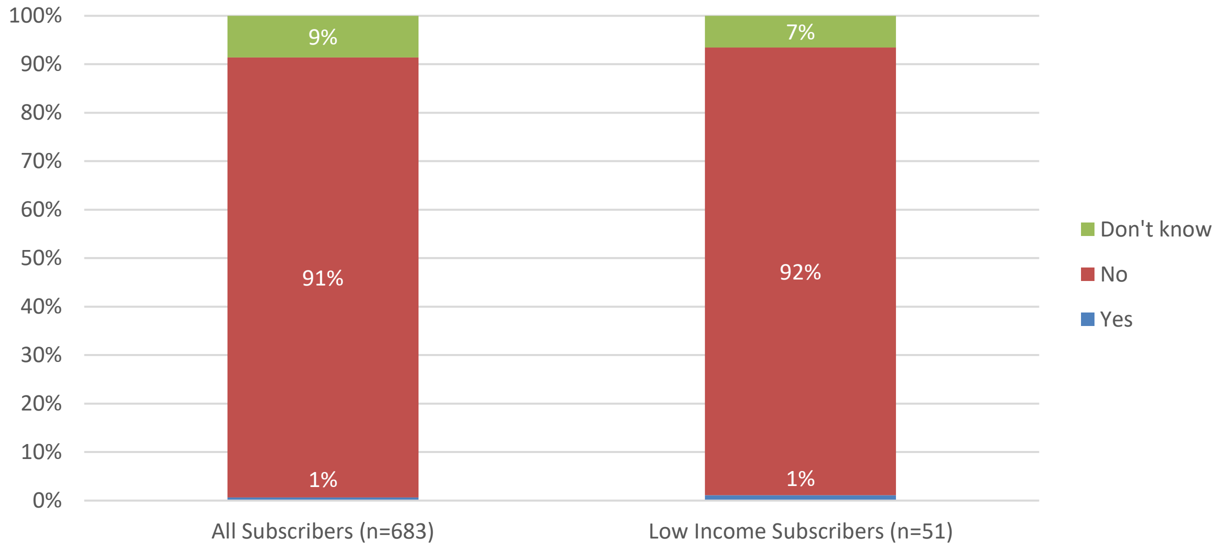


Figure 35: Enrolled in Spectrum's Internet Assist Program



Just 1 percent of low-income subscribers (earning under $25,000 per year) receive the $9.25 subsidy under the FCC's Lifeline program, and 7 percent are unsure if they receive the subsidy. Most households are not receiving the subsidy (see Figure 36).

Figure 36: Receive $9.25 Subsidy Under FCC's Lifeline Program



4.3.1.5 Personal Computing Devices

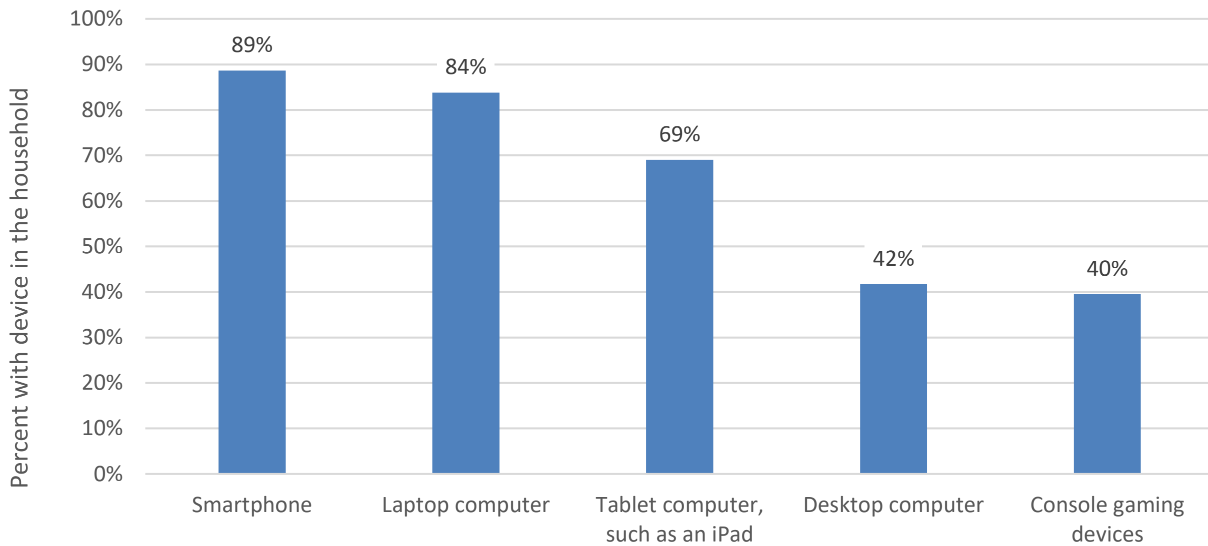
Respondents were asked to indicate the number of personal computing devices they have in the home. As shown in Figure 37, 56 percent of households with internet service have five or more devices. Most households with two or more members have at least five personal computing devices in the home, compared with 13 percent of those who live alone. Nearly one-half of those who live alone have three or four devices. Specifically, 85 percent of households with children and who earn $50,000 or more per year have five or more devices, compared with 62 percent of lower-income households with children.

Figure 37: Number of Personal Computing Devices in Home by Household Size

4.3.1.6 Devices in the Home

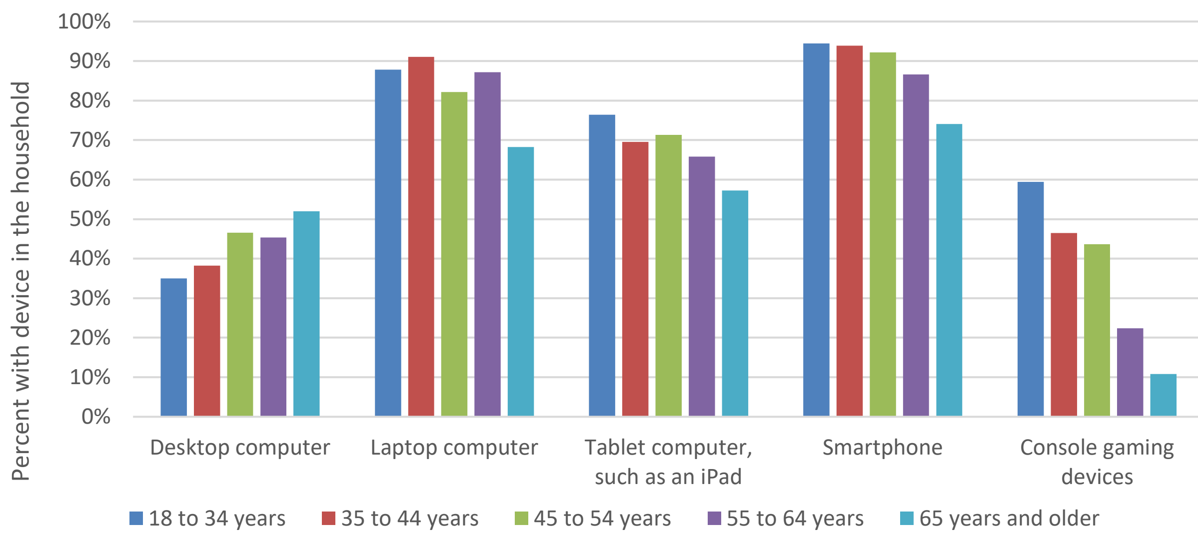
Availability of devices is relatively high in households with internet access, with respondents selecting an average of 3.3 types of devices in the home and only 4 percent not selecting any device.

Figure 38: Devices Available in the Home



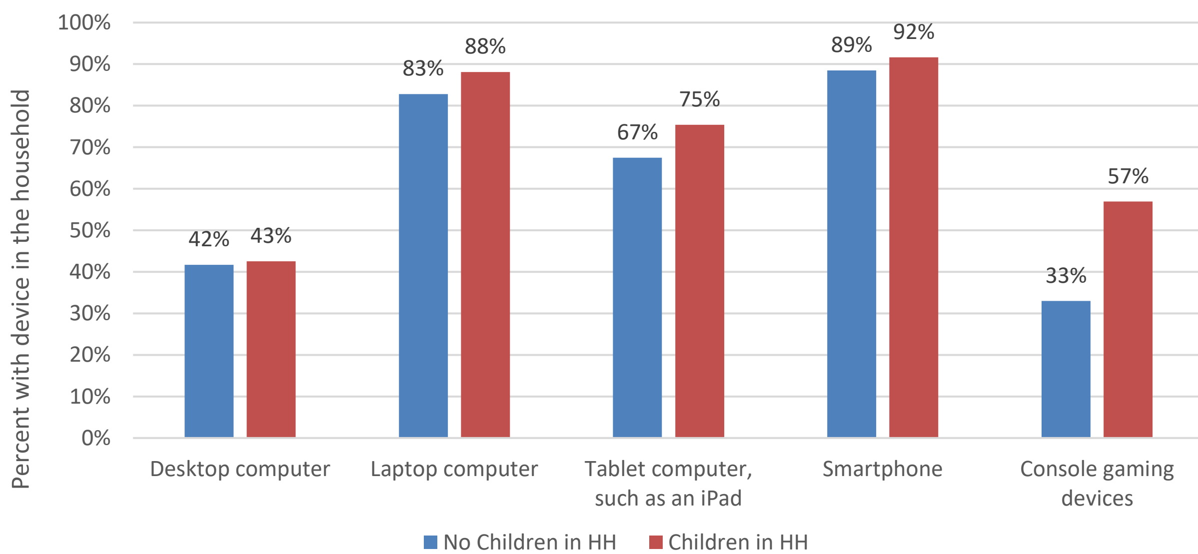
Use of smartphone is highest, with 89 percent of internet users having one, followed by laptops (84 percent) and tablets (69 percent). Forty-two percent of respondents with home internet have a desktop computer, and 40 percent have console gaming devices (see Figure 38). Respondents ages 65 and older are less likely than younger respondents to have various devices except desktop computers, as illustrated in Figure 39.

Figure 39: Devices Available in the Home by Respondent Age



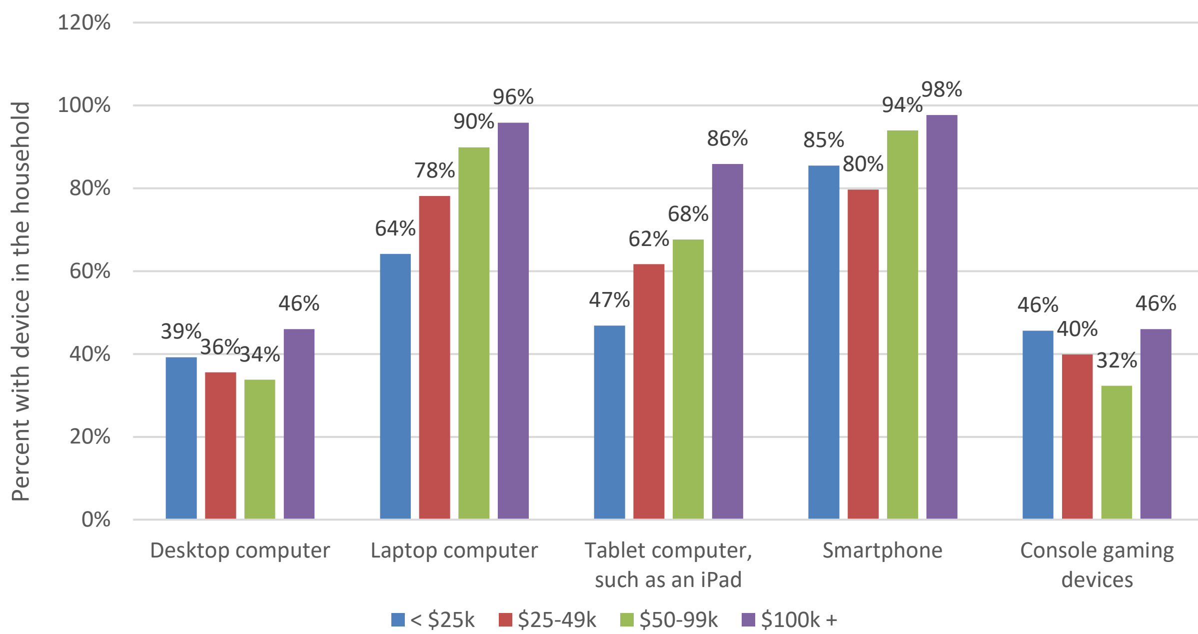
Households with children make strong use of key devices, as shown in Figure 40. Households with children are more likely than those without to children to have a tablet or a console gaming device.

Figure 40: Devices Available in the Home by Children in Household



Saturation of devices is correlated with household income. Almost all households earning $100,000 or more per year have a laptop computer or a smartphone, as depicted in Figure 41.

Figure 41: Devices Available in the Home by Household Income



Specifically, 81 percent of internet subscribers earning less than $25,000 per year have some sort of computer (desktop, laptop, or table), compared with 93 percent of those earning $25,000 but less than $50,000, 98 percent of those earning $50,000 but less than $100,000, and 99 percent of those earning $100,000 or more. (Two-thirds of low-income households have both internet service AND a computer, compared with nine in 10 of all households.)

Respondents with home internet service were asked how often their primary computer becomes inaccessible or unusable, and how long it would take to replace the computer if it became lost or damaged beyond repair. Six in 10 respondents have had some issues with their computer, including 15 percent who experience problems at least once per week (see Figure 42).

Eight percent of respondents said they could not replace their computer if it became unusable, and another 19 percent said it would take one to six months to replace it (see Figure 43). Six in 10 internet subscribers could replace their computer within one week if it were lost or damaged beyond repair.

Figure 42: Computer Becomes Unusable

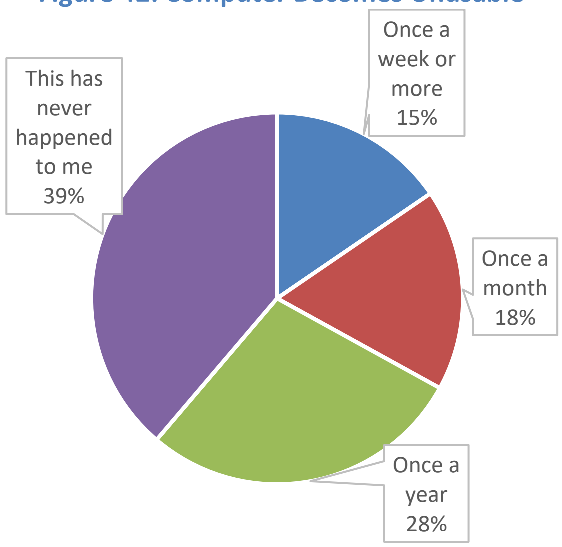
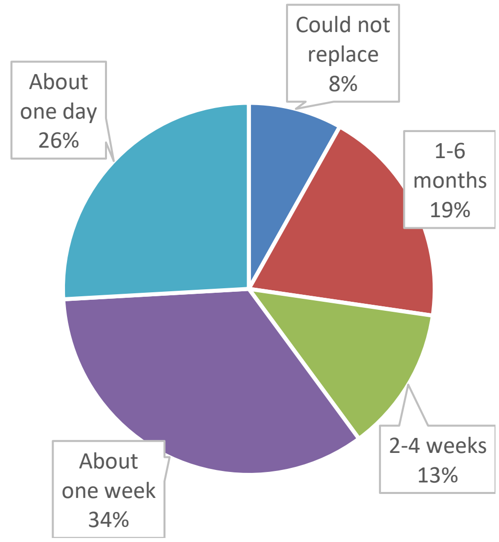


Figure 43: When Could Replace Computer



One-fourth of internet subscribers earning under $25,000 experience issues at least weekly with their primary computer becoming inaccessible or unusable (see Figure 44).

Three in 10 low-income respondents said it would take one to six months to replace a lost or damaged computer, and another 30 percent said they would not be able to replace it (see Figure 45).

Figure 44: How Often Computer Becomes Unusable by Household Income

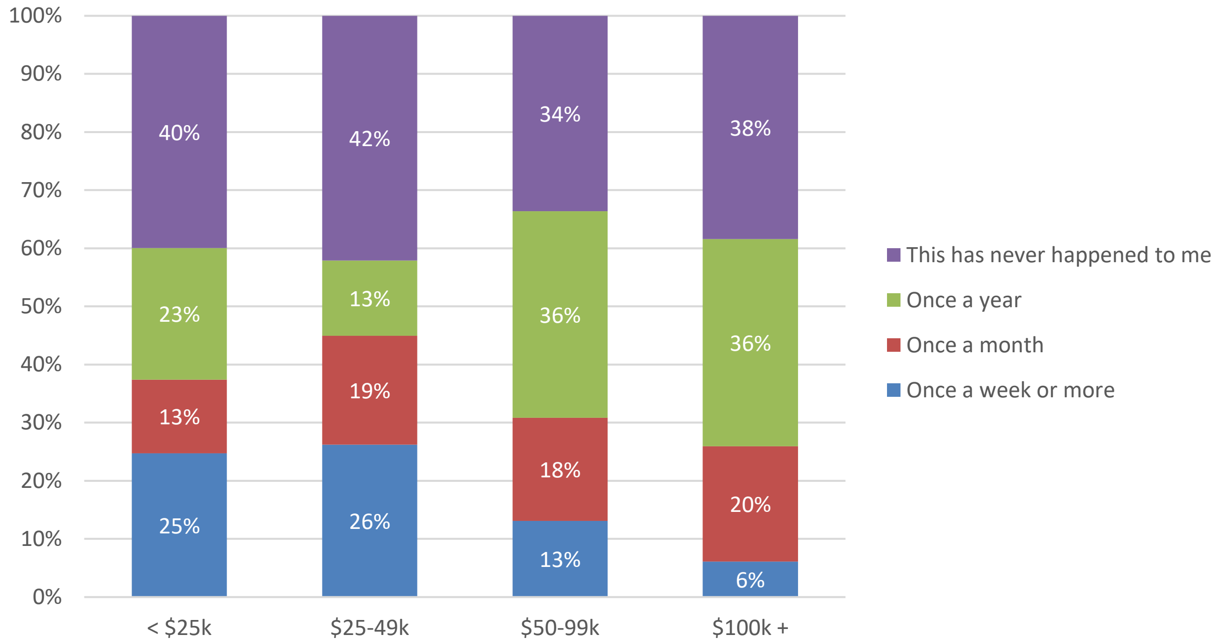
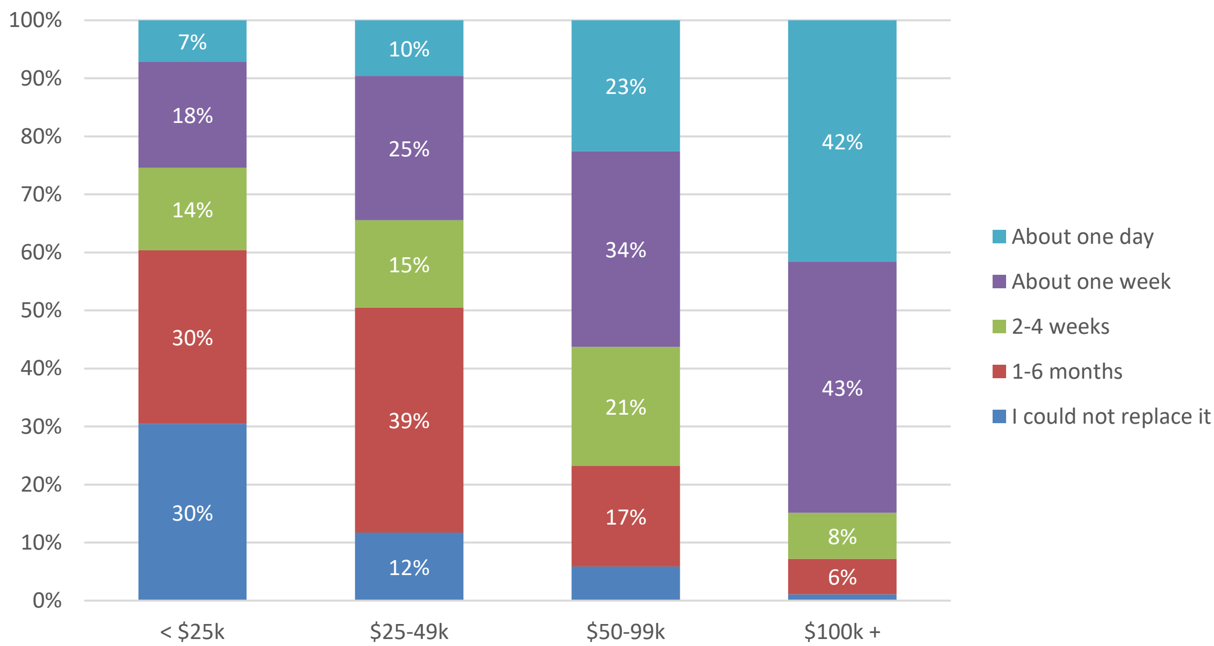


Figure 45: When Could Replace Computer by Household Income

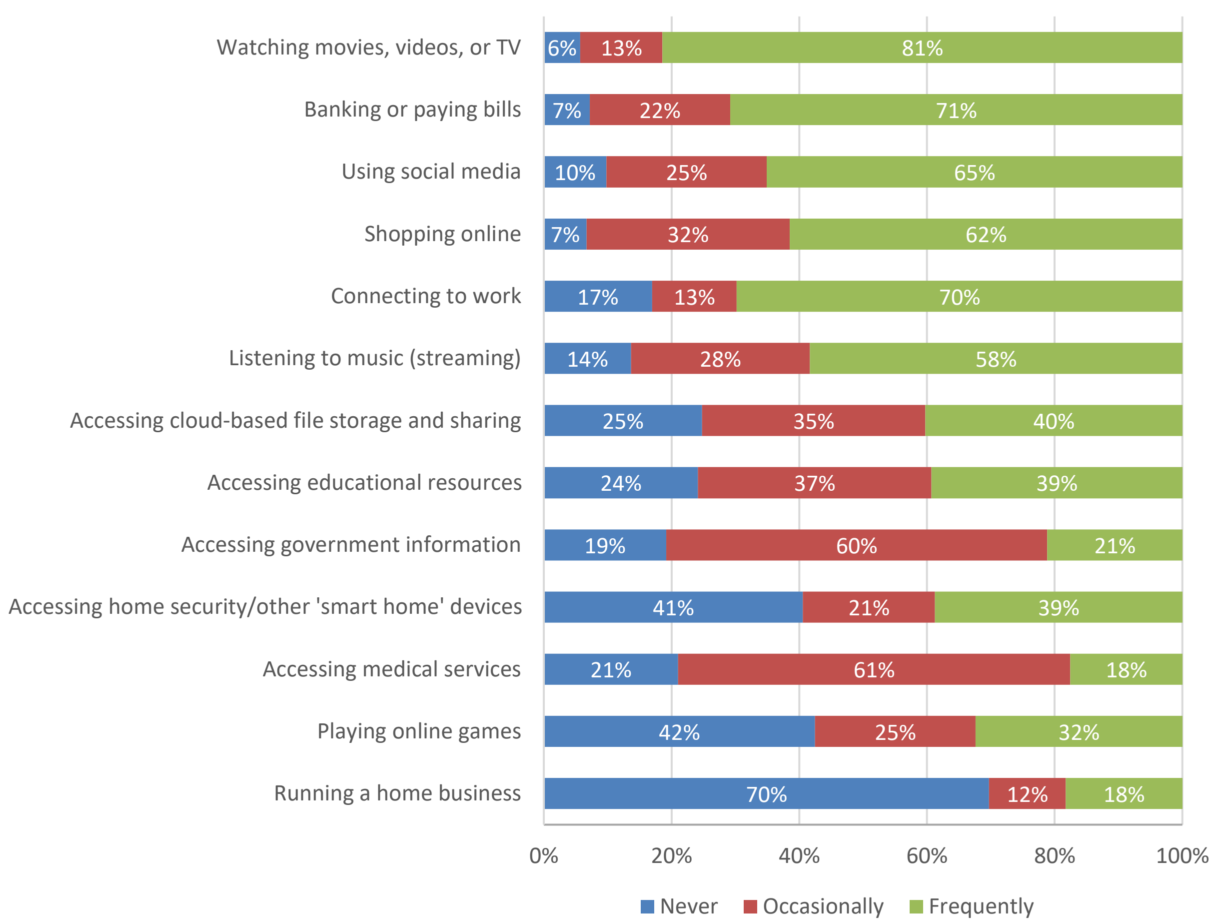


4.3.1.7 Internet Uses

Respondents were asked about their use of their home internet connection for various activities. Among those items listed, a home internet connection is most frequently used for watching videos, etc., banking or paying bills, using social media, shopping online, connecting to work, and streaming music, as shown in Figure 46. A majority of respondents engage in these activities frequently.

Some respondents use a home internet connection to access key information and services. Three-fourths of subscribers occasionally (37 percent) or frequently (39 percent) access educational resources. Approximately six in 10 subscribers occasionally use a home internet connection to access government information or to access medical services. Three in 10 respondents at least occasionally use a home internet connection for running a home-based business.

Figure 46: Home Internet Connection Use for Various Activities



4.3.1.7.1 Internet Uses by Respondent Age

Respondents under age 65 are more likely than older respondents to ever use their home internet connection for key activities, as illustrated in Table 15. Respondents under age 65 are more likely than older respondents to ever use their home internet connection for playing online games in particular. At the same time, most seniors use a home internet connection at least occasionally for various activities, and many seniors use it frequently for key activities like connecting to work, banking or paying bills, and watching movies, videos, or TV (see Table 16).

Table 15: Home Internet Connection Ever Used for Various Activities by Respondent Age

	< 45 years	45-54 years	55-64 years	65+ years
Listening to music (streaming)	94%	91%	95%	82%
Watching movies, videos, or TV	100%	98%	98%	89%
Playing online games	66%	66%	68%	41%
Connecting to work	94%	94%	84%	83%
Using social media	97%	93%	93%	87%
Shopping online	93%	94%	95%	94%
Running a home business	21%	33%	42%	37%
Accessing educational resources	81%	75%	80%	72%
Accessing government information	79%	85%	79%	81%
Accessing medical services	81%	74%	81%	75%
Banking or paying bills	98%	92%	97%	90%
Accessing home security/other 'smart home' devices	58%	73%	70%	59%
Accessing cloud-based file storage and sharing	84%	79%	78%	65%

Table 16: Home Internet Connection Frequently Used for Various Activities by Respondent Age

	< 45 years	45-54 years	55-64 years	65+ years
Listening to music (streaming)	75%	65%	66%	46%
Watching movies, videos, or TV	92%	91%	82%	69%
Playing online games	37%	35%	42%	21%
Connecting to work	82%	82%	72%	64%
Using social media	76%	66%	70%	57%
Shopping online	71%	64%	57%	52%
Running a home business	11%	22%	28%	22%
Accessing educational resources	47%	44%	55%	27%
Accessing government information	23%	22%	25%	19%
Accessing medical services	15%	16%	25%	17%
Banking or paying bills	75%	69%	81%	67%
Accessing home security/other 'smart home' devices	40%	46%	49%	31%
Accessing cloud-based file storage and sharing	47%	48%	44%	30%

4.3.1.7.2 Internet Uses by Children in Household

As shown in Table 17, most households with children ever use a home internet connection for key activities. Almost all (95 percent) households with children (and that have internet service) ever use a home internet connection to access educational resources, including 65 percent who access it frequently. Households with children are also more likely than households without children to frequently use a home internet connection for other activities like streaming music, playing online games, and accessing home security devices (see Table 18).

Table 17: Home Internet Connection Ever Used for Various Activities by Children in Household

	No Children in HH	Children in HH
Listening to music (streaming)	83%	95%
Watching movies, videos, or TV	93%	99%
Playing online games	51%	73%
Connecting to work	81%	89%
Using social media	88%	95%
Shopping online	93%	95%
Running a home business	29%	34%
Accessing educational resources	69%	95%
Accessing government information	81%	81%
Accessing medical services	79%	79%
Banking or paying bills	92%	95%
Accessing home security/other 'smart home' devices	54%	75%
Accessing cloud-based file storage and sharing	73%	81%

Table 18: Home Internet Connection Frequently Used for Various Activities by Children in Household

	No Children in HH	Children in HH
Listening to music (streaming)	54%	68%
Watching movies, videos, or TV	79%	88%
Playing online games	29%	41%
Connecting to work	67%	77%
Using social media	63%	70%
Shopping online	62%	61%
Running a home business	17%	22%
Accessing educational resources	30%	65%
Accessing government information	17%	32%
Accessing medical services	15%	26%
Banking or paying bills	69%	75%
Accessing home security/other 'smart home' devices	34%	52%
Accessing cloud-based file storage and sharing	37%	50%

4.3.2 Covid-19 impacts on home broadband

Respondents were asked a series of questions on how their broadband use has changed during the Covid-19 pandemic, including impacts on time and location of internet use, engagement in various internet activities, and usage during peak times. This information provides valuable insight into demand for broadband service during the pandemic.

4.3.2.1 Internet Use at Various Times

Respondents were asked to indicate how often they use the internet at various times before and during the Covid-19 pandemic. As shown in Figure 47, daily use of internet services at various times has increased during the pandemic. Most respondents are making use of the internet throughout the day, whereas prior to the pandemic usage was lower during daytime hours and peaked in the evening.

Figure 47: Daily Use of the Internet at Various Times Before and During Covid-19 Pandemic

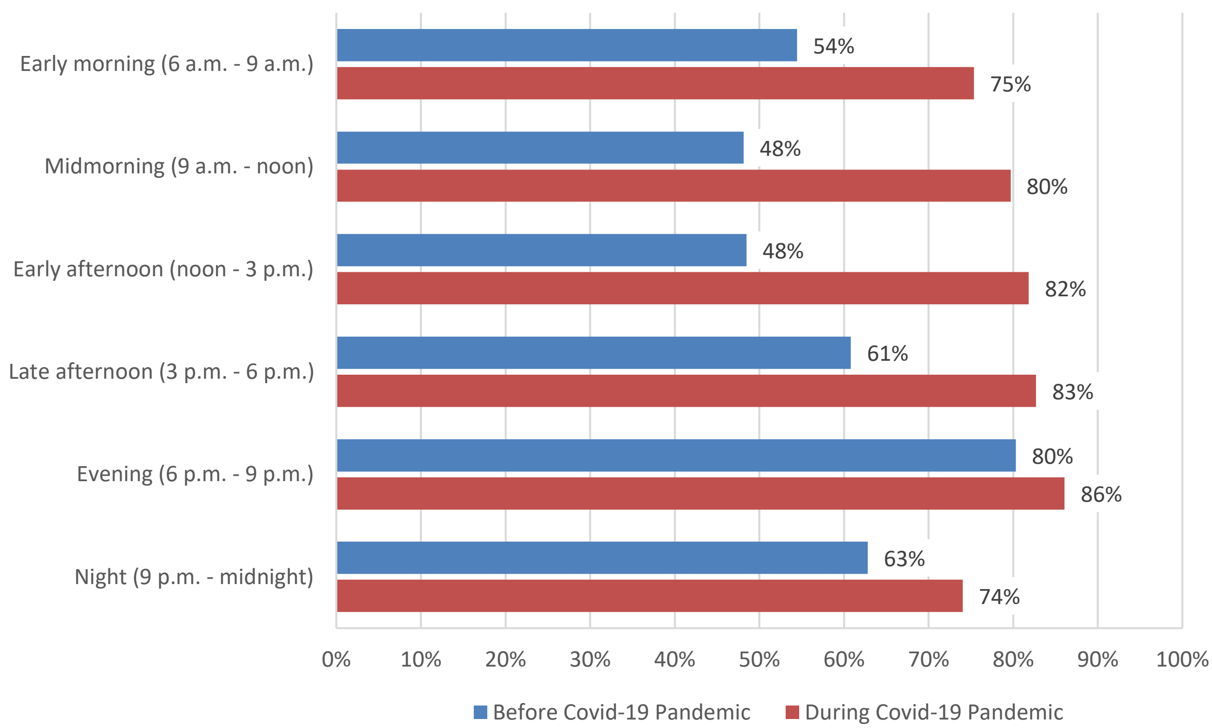


Figure 48 and Figure 49 show detailed usage of the internet at various times, before and during the pandemic. Most respondents made/make daily use of the internet in the evening, before and during the pandemic. Prior to the Covid-19 pandemic, approximately one-half of respondents made daily use of the internet in the morning or early afternoon, compared with approximately eight in 10 respondents during the pandemic.

Figure 48: How Often Use the Internet at Various Times Before Covid-19 Pandemic

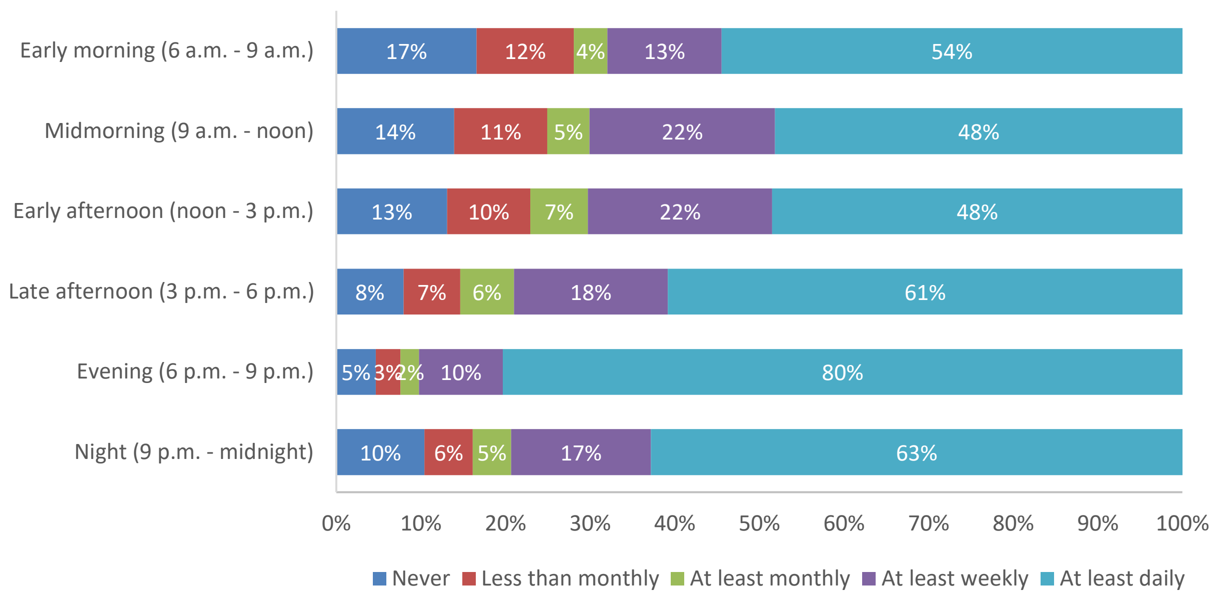
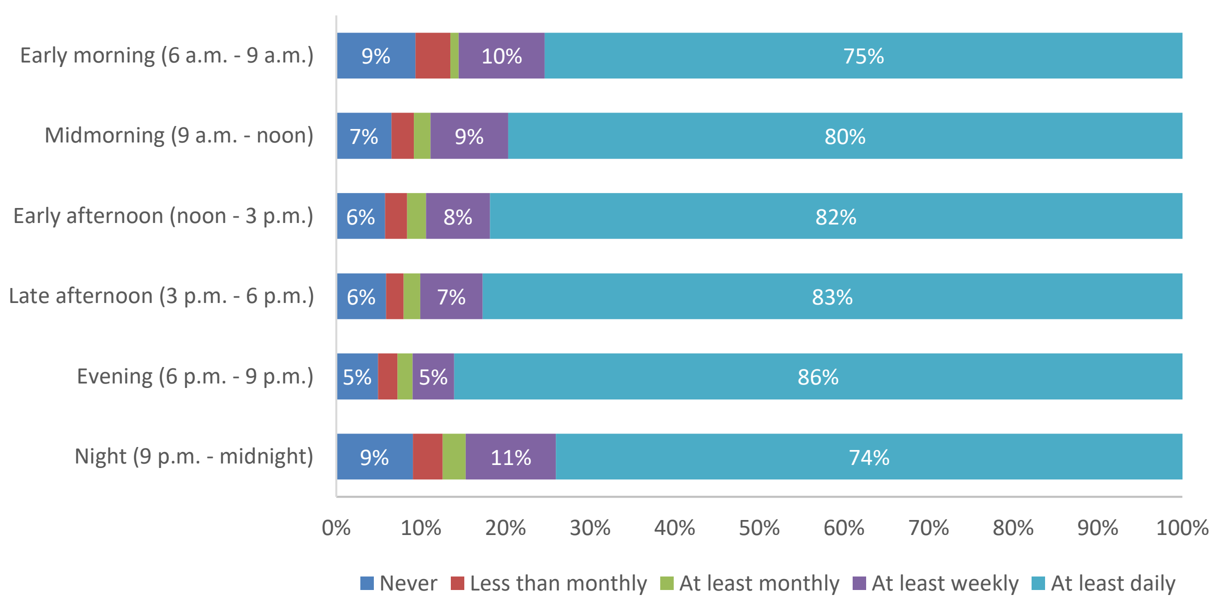
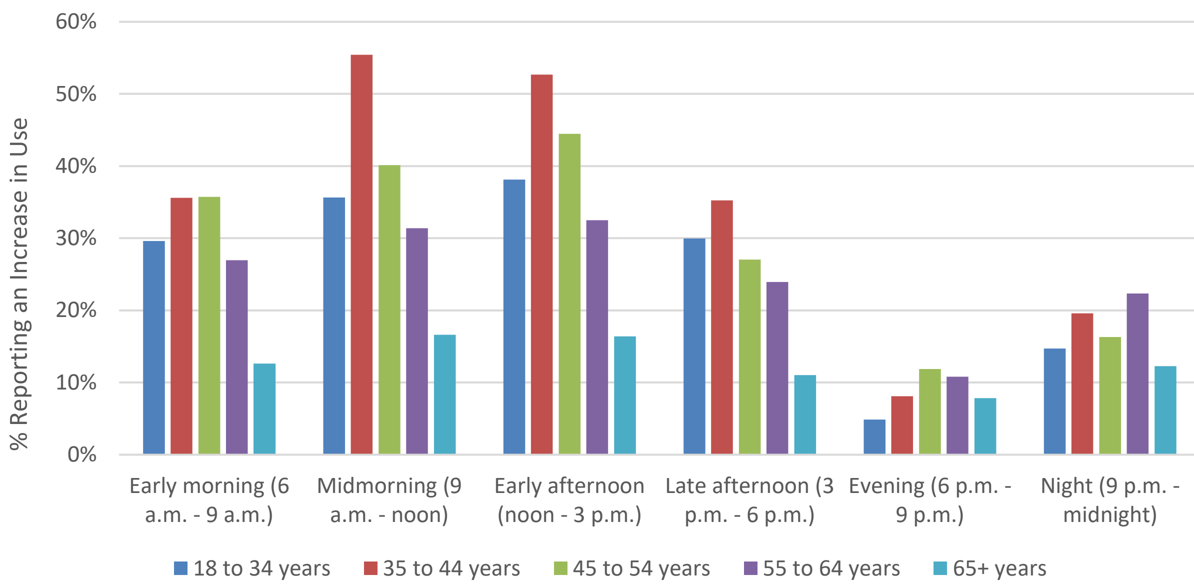


Figure 49: How Often Use the Internet at Various Times During Covid-19 Pandemic



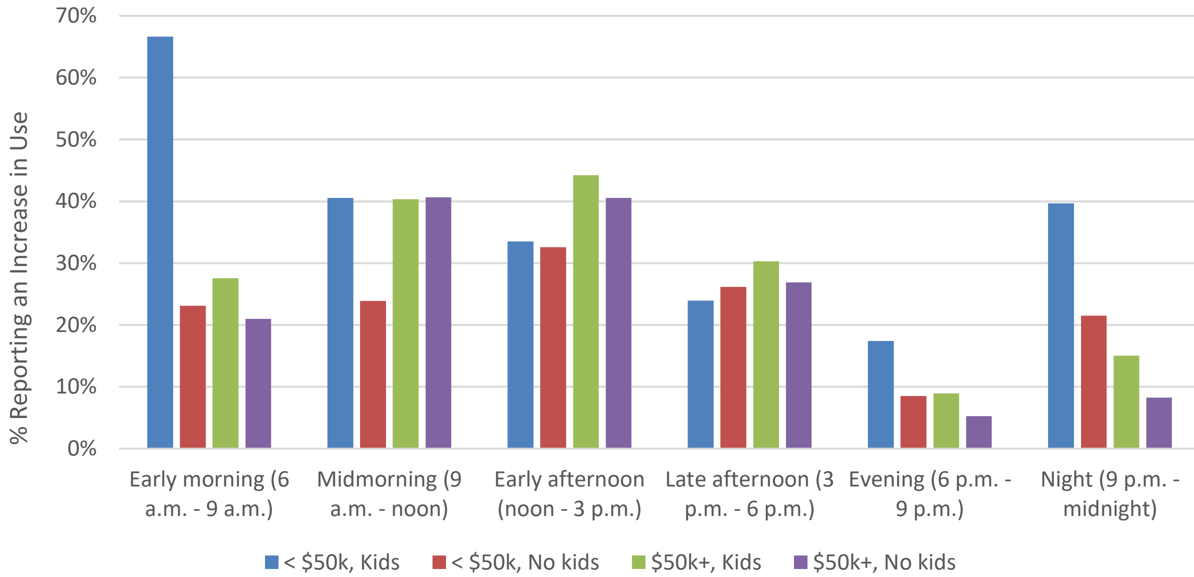
Overall, most respondents use remained the same (most of whom were already making daily use of the internet) across the time groups, but a sizeable share of respondents increased their frequency of use as discussed. This shift has occurred across most demographic groups, except those ages 65+ saw less of an increase in frequency of use at various times of the day. As illustrated in Figure 50, respondents ages 35-54 years saw the biggest increase in use in the mid-morning and early afternoon, with over one-half of respondents in this age cohort increasing their use of the internet at those times of day.

Figure 50: Increase in Internet Use at Various Times of Day by Respondent Age



In general, lower-income households and households with children saw the largest increase in frequency of internet use in the early morning hours, compared with higher income households and those without children (see Figure 51). Specifically, 67 percent of the "less than $50,000, children at home" cohort increased their internet use early mornings. A large proportion of the other segments were already making daily use of the internet in the early mornings.

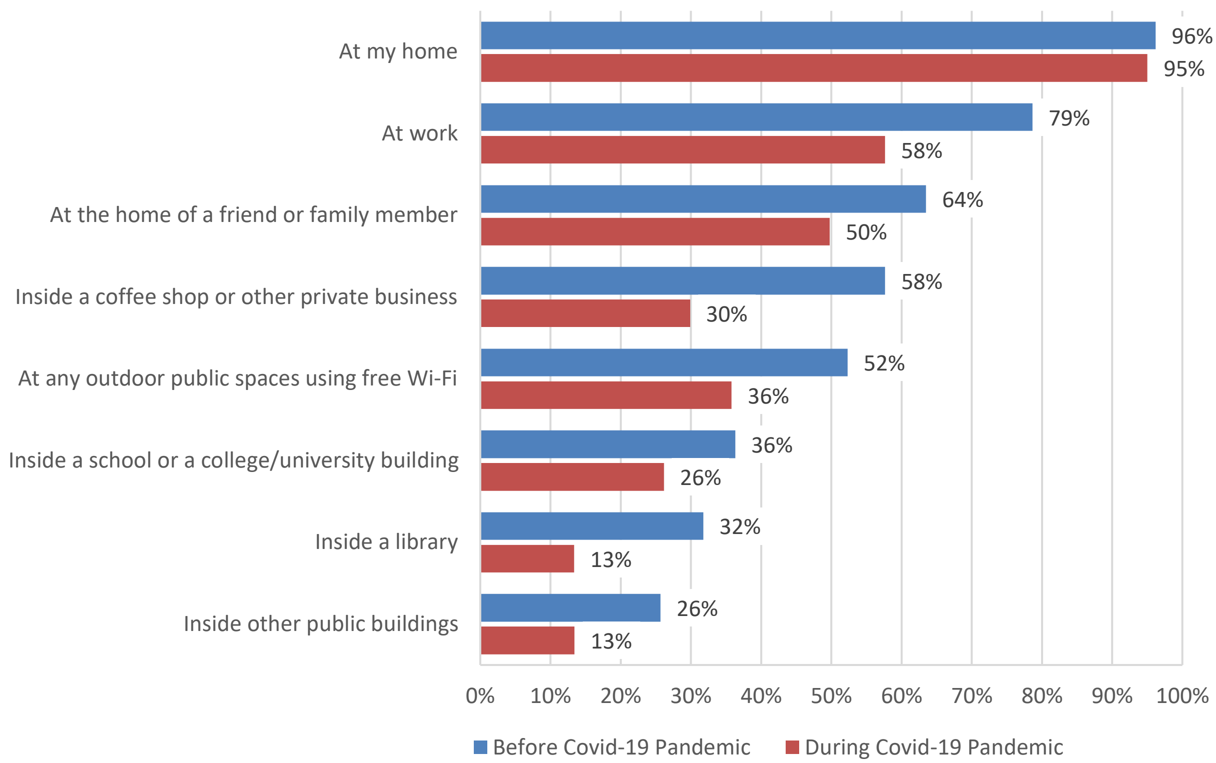
Figure 51: Increase in Internet Use at Various Times of Day by Segment



4.3.2.2 Internet Use by Location

Respondents were asked to indicate how often they use the internet in various locations before and during the Covid-19 pandemic. As shown in Figure 52, use of internet services outside of the home has declined significantly during the pandemic, which makes sense as many public areas and work settings have been less accessible.

Figure 52: Ever Use the Internet in Various Locations Before and During Covid-19 Pandemic



Significantly, use of the internet declined in work settings (79 percent vs. 58 percent) and private businesses (58 percent vs. 30 percent) when comparing pre-Covid and during-Covid figures. Use of the internet at schools or colleges declined from 36 percent of respondents pre-Covid to 26 percent currently. Use in libraries (32 percent vs. 13 percent), public buildings (26 percent vs. 13 percent), and outdoor public spaces (52 percent vs. 36 percent) also declined. Use of the internet at the home of a friend or family member declined from 64 percent of respondents pre-pandemic to 50 percent of respondents during the pandemic. Usage inside the home remained flat, with almost all respondents accessing the internet in the home pre-Covid (96 percent) and during-Covid (95 percent).

Figure 53 and Figure 54 show detailed usage of the internet at various locations, before and during the pandemic.

Figure 53: How Often Use the Internet in Various Locations Before Covid-19 Pandemic

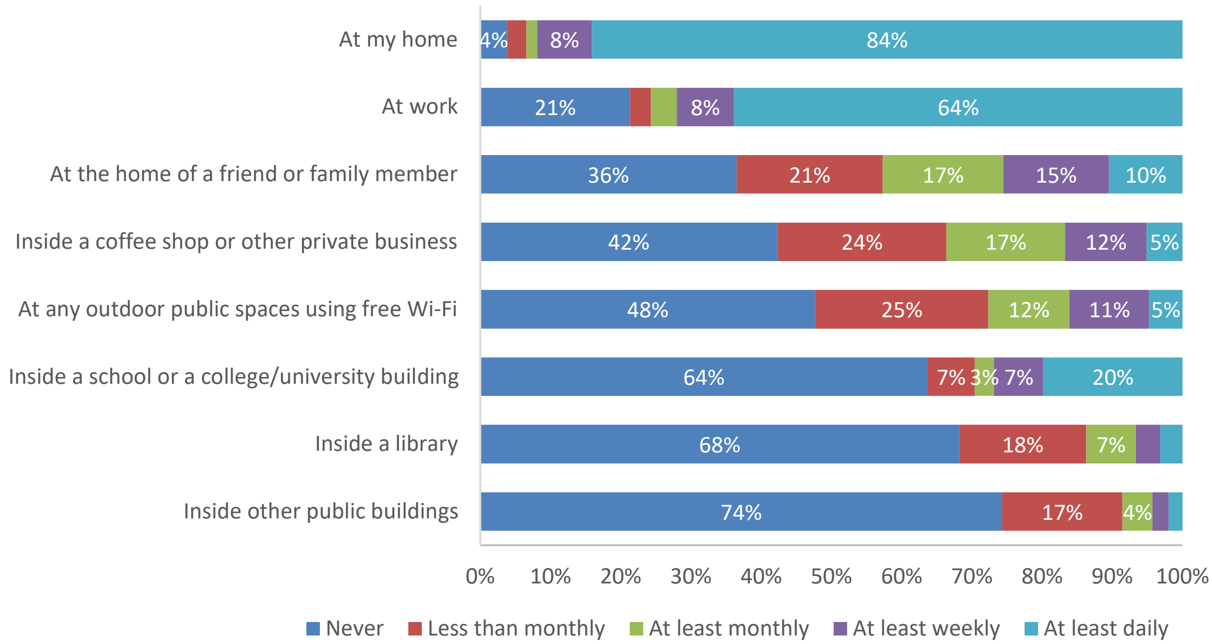
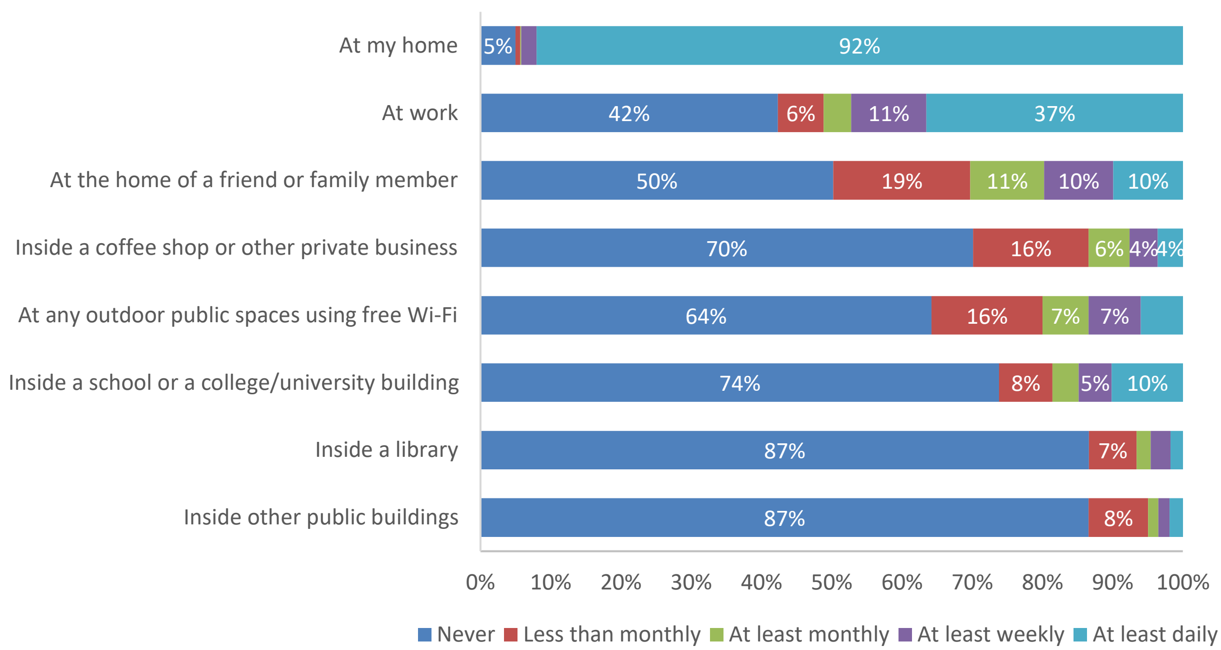
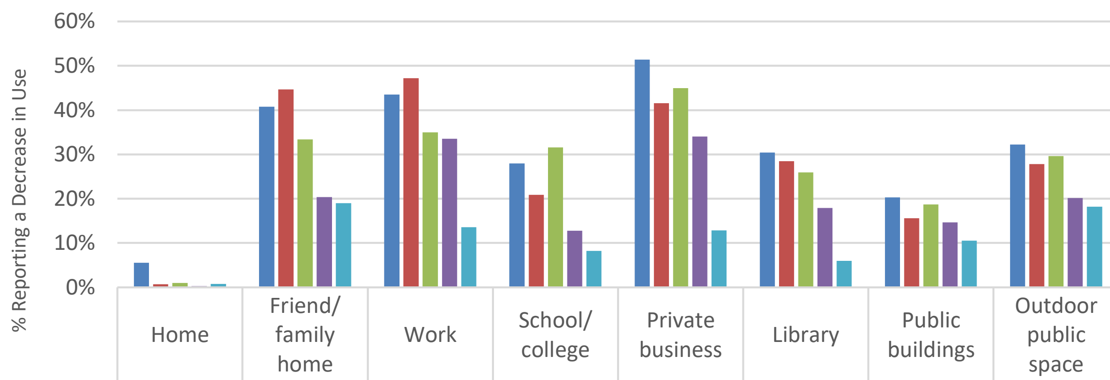


Figure 54: How Often Use the Internet in Various Locations During Covid-19 Pandemic



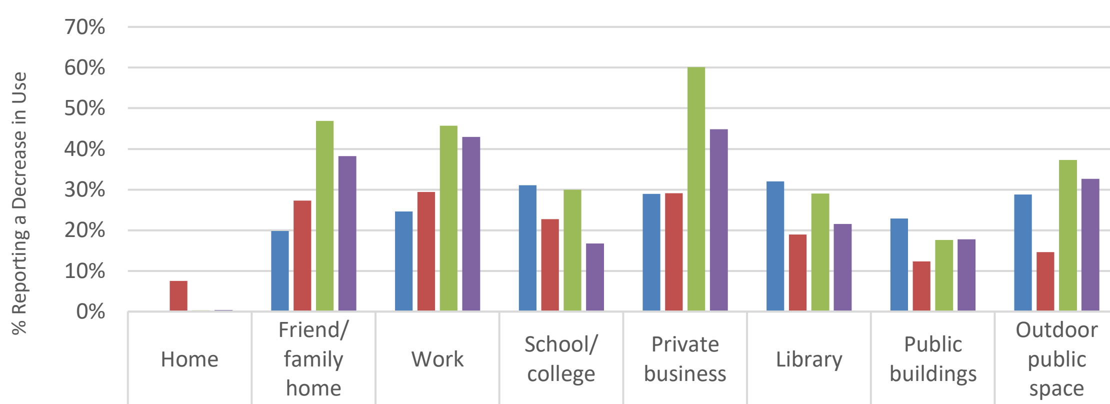
Prior to the pandemic, respondents ages 65 and older and those in lower incomes households were less likely than their counterparts to ever use the internet at various locations outside the home. They were also less likely to decrease their use during the pandemic at most locations, as illustrated in Figure 55 and Figure 56. However, three in 10 households with children, regardless of income level, reported a decrease in internet usage at schools or colleges. Prior to the pandemic, 54 percent of households with children used the internet within a school or college building (30 percent daily), compared with 36 percent during the pandemic (19 percent daily).

Figure 55: Decrease in Internet Use at Various Locations by Respondent Age



	Home	Friend/ family home	Work	School/ college	Private business	Library	Public buildings	Outdoor public space
18 to 34 years	6%	41%	44%	28%	51%	30%	20%	32%
35 to 44 years	1%	45%	47%	21%	42%	28%	16%	28%
45 to 54 years	1%	33%	35%	32%	45%	26%	19%	30%
55 to 64 years	0%	20%	34%	13%	34%	18%	15%	20%
65+ years	1%	19%	14%	8%	13%	6%	11%	18%

Figure 56: Decrease in Internet Use at Various Locations by Segment



	Home	Friend/ family home	Work	School/ college	Private business	Library	Public buildings	Outdoor public space
< $50k, Kids	0%	20%	25%	31%	29%	32%	23%	29%
< $50k, No kids	8%	27%	29%	23%	29%	19%	12%	15%
$50k+, Kids	0%	47%	46%	30%	60%	29%	18%	37%
$50k+, No kids	0%	38%	43%	17%	45%	22%	18%	33%

4.3.2.3 Engaged in Internet Activities

Respondents were asked about how they engaged in various internet activities before and during the Covid-19 pandemic. As shown in Figure 57 and Figure 58, engagement in online activities has increased significantly during the Covid-19 pandemic, with more respondents making daily use of the internet for key activities.

Nearly three-fourths (73 percent) of respondents have ever teleworked during the pandemic, compared with 58 percent before the pandemic. Teleworkers are making more regular use of working from home during the pandemic, with 58 percent of respondents engaging daily, compared with only 19 percent prior to the pandemic.

Seven in 10 respondents have used the internet for telemedicine or medical appointments during the Covid-19 pandemic (most on a monthly or less than monthly basis), compared with just 34 percent before the pandemic.

Use of the internet has also increased substantially for educational purposes. Use of the internet for online classes has increased from 28 percent of respondents pre-pandemic to 49 percent during the pandemic. Similarly, use of the internet for homeschooling increased from 11 percent before the pandemic to 24 percent during the pandemic. Use of the internet for homework increased slightly during the pandemic, from 33 percent to 41 percent of respondents. The percentage of respondents making daily use of the internet for homework increased from 14 percent pre-pandemic to 28 percent during the pandemic.

Figure 57: Ever Used the Internet for Various Activities Before and During Covid-19 Pandemic

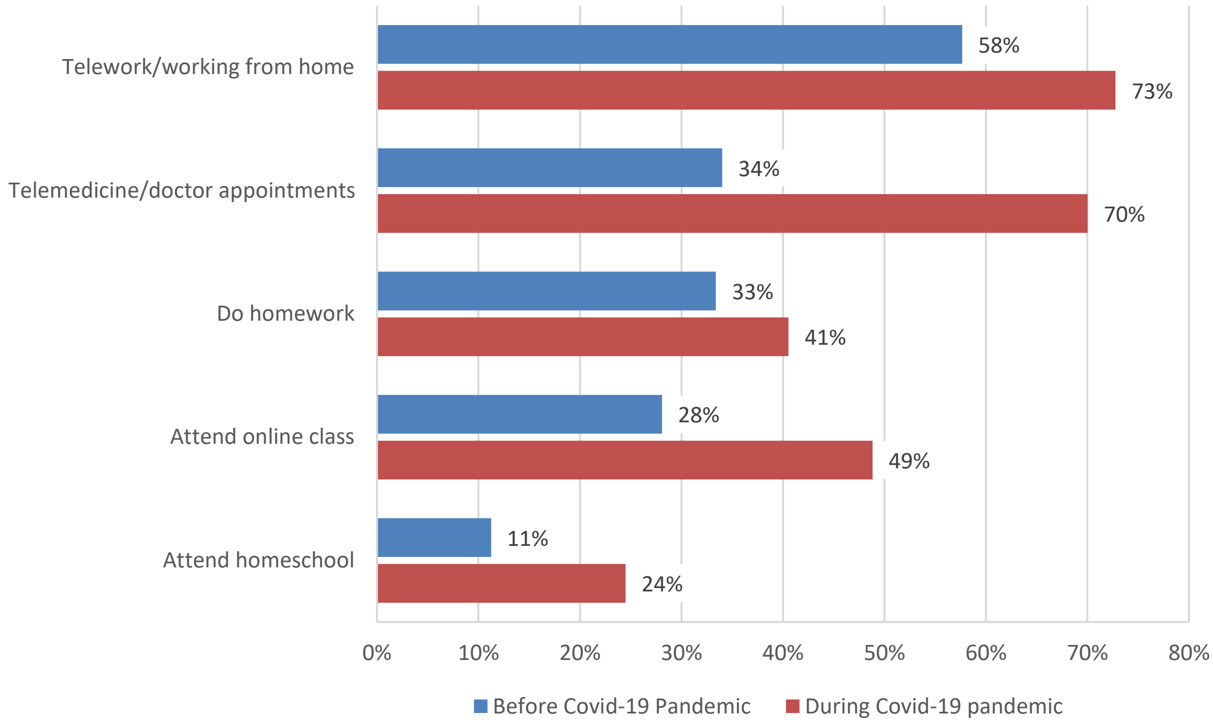


Figure 58 and Figure 59 show detailed usage of the internet for various activities, before and during the pandemic.

Figure 58: How Often Used the Internet for Various Activities Before Covid-19 Pandemic

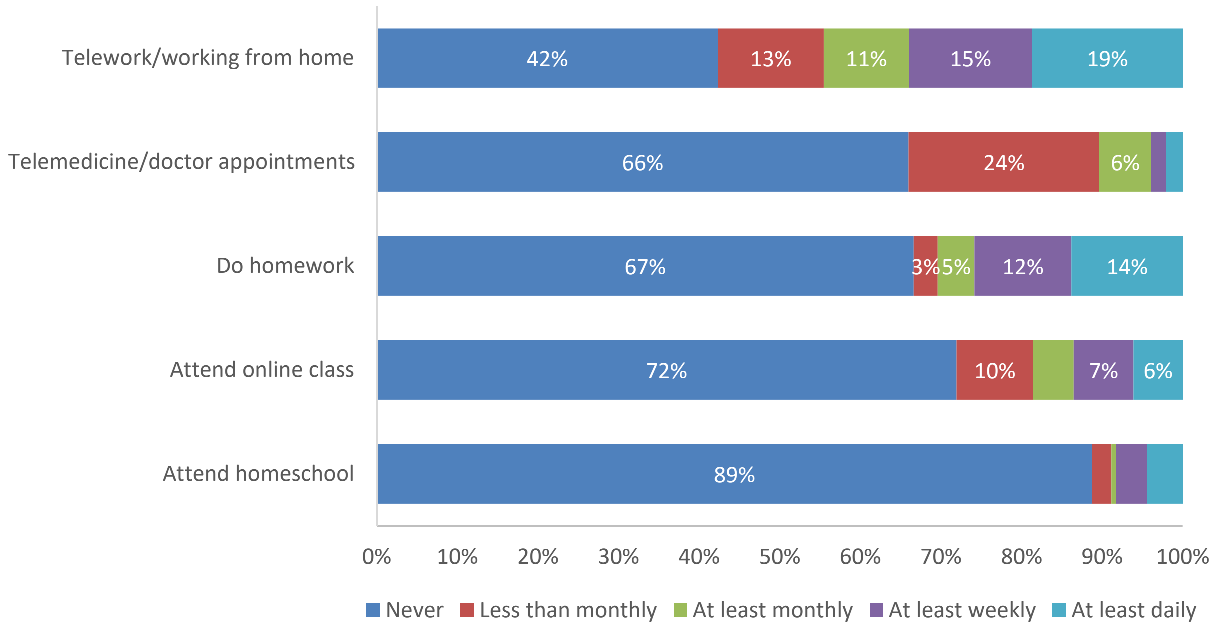
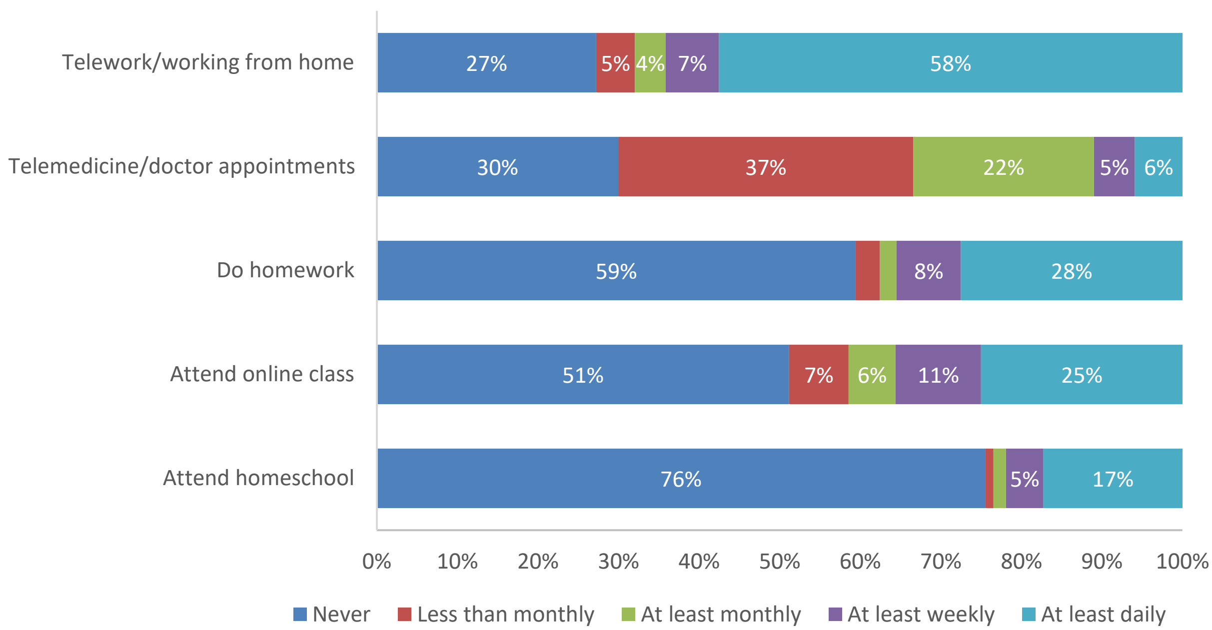
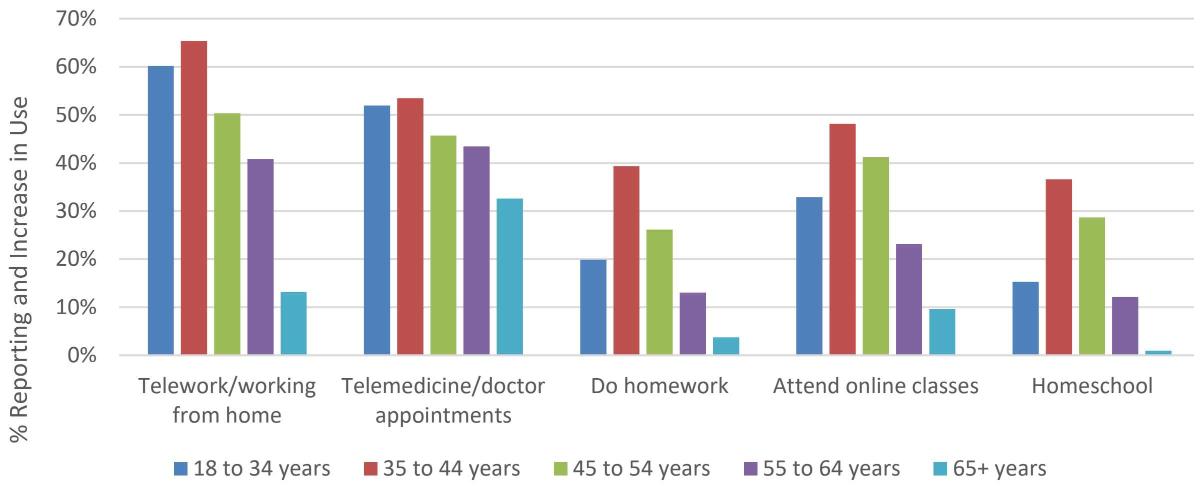


Figure 59: How Often Used the Internet for Various Activities During Covid-19 Pandemic



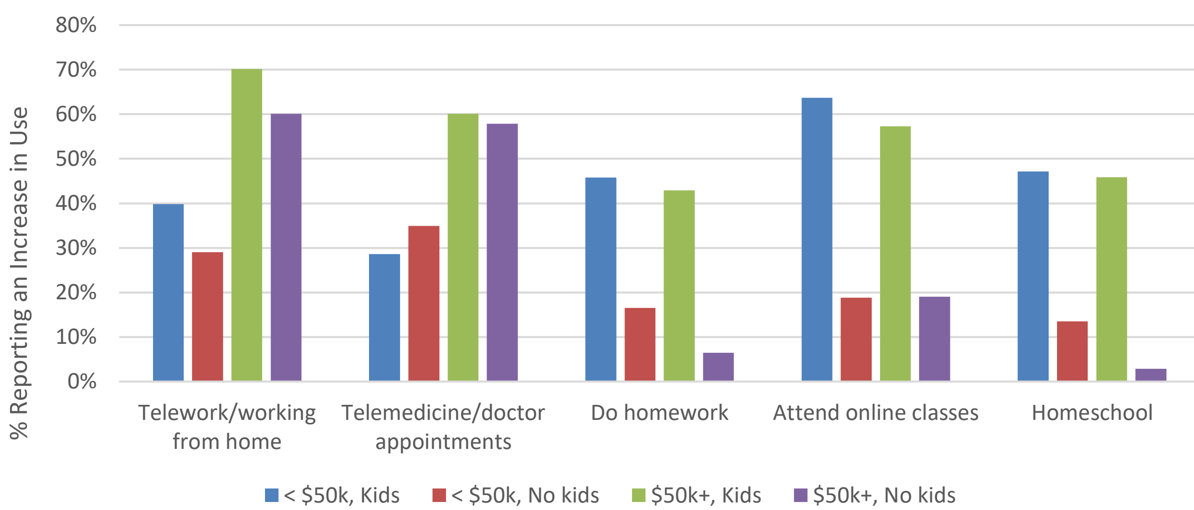
Respondents ages 65 and older were less likely than younger respondents to ever use the internet for work or education, both before and during the Covid-19 pandemic. More than six in 10 respondents under age 45 increased their frequency of use of the internet for teleworking during the pandemic (see Figure 60). Specifically, 18 percent of 18-34 year-olds and 18 percent of 35-44 year-olds used the internet daily for telework prior to the pandemic; during the pandemic, 66 percent of 18-34 year-olds and 75 percent of 35-44 year-olds used the internet daily.

Figure 60: Increase in Internet Use for Various Activities by Respondent Age



Additionally, those in higher-income households were more likely to increase their use of the internet for telework and telemedicine during the pandemic. Households with children were more likely than those without children to have increased their use of the internet for education (see Figure 61).

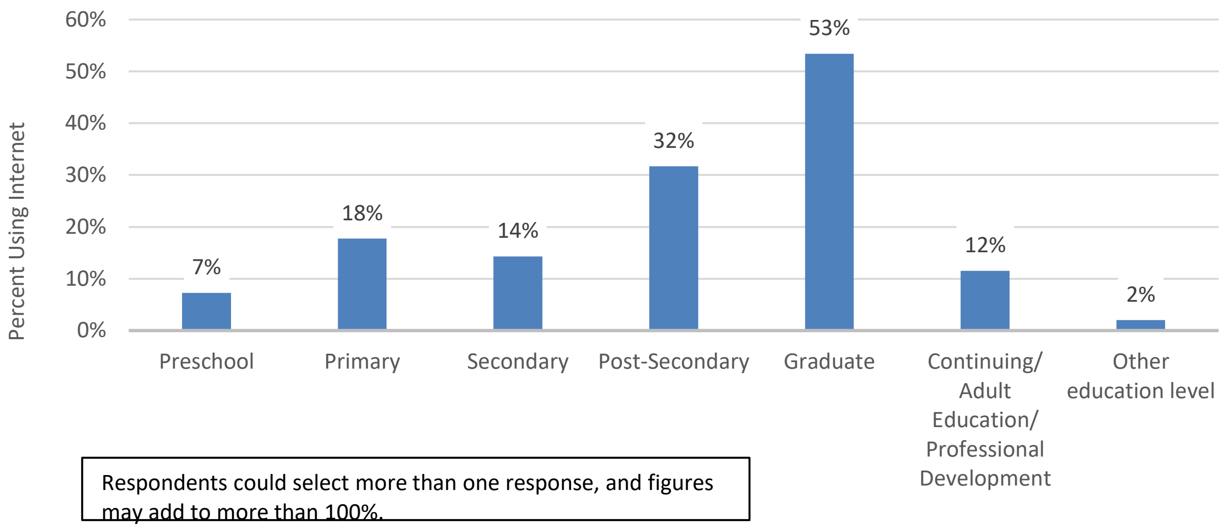
Figure 61: Increase in Internet Use for Various Activities by Segment



4.3.2.4 Education Level of Household Internet-Users

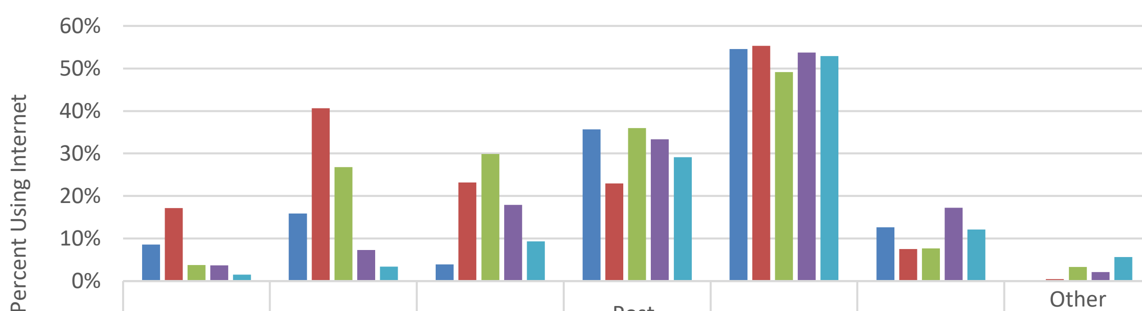
As shown in Figure 62, most household members who use the home internet connection have a post-secondary (32 percent) or graduate (53 percent) level of education. A smaller segment of users has a primary (18 percent) or secondary (14 percent) level of education; this may include both adult household members and children who live in the household.

Figure 62: Education Level of Household Internet Users



Respondents less than age 55 are more likely than older respondents to have a household member with a primary level of education who uses the internet. Respondents ages 35-54 are more likely than older and younger respondents to have a household internet user with a secondary level of education (see Figure 63).

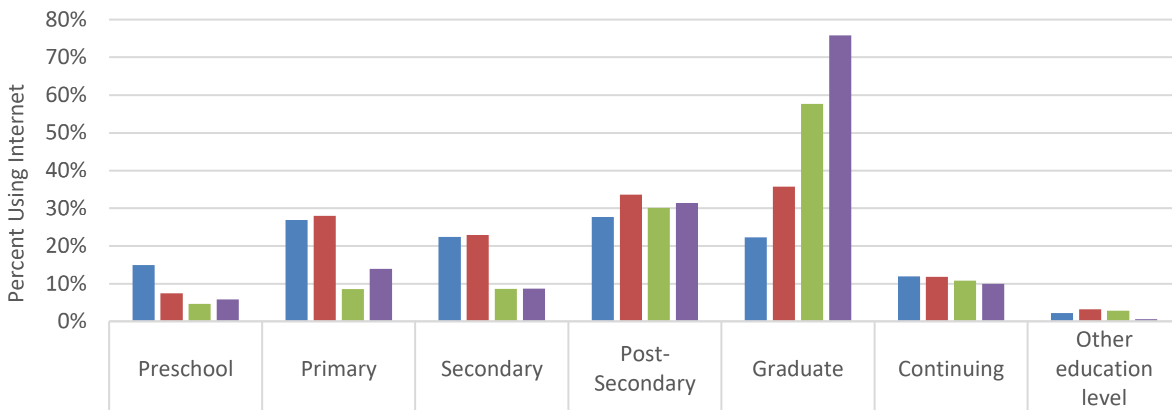
Figure 63: Education Level of Household Internet Users by Respondent Age



	Preschool	Primary	Secondary	Post-Secondary	Graduate	Continuing	Other education level
18 to 34 years	9%	16%	4%	36%	55%	13%	0%
35 to 44 years	17%	41%	23%	23%	55%	8%	0%
45 to 54 years	4%	27%	30%	36%	49%	8%	3%
55 to 64 years	4%	7%	18%	33%	54%	17%	2%
65+ years	2%	3%	9%	29%	53%	12%	6%

The education level of household members who use the internet is also correlated with household income and presence of children in the household, as shown in Figure 64 and Figure 65. Three-fourths of households earning $100,000 or more per year have a household internet-user with a graduate level of education.

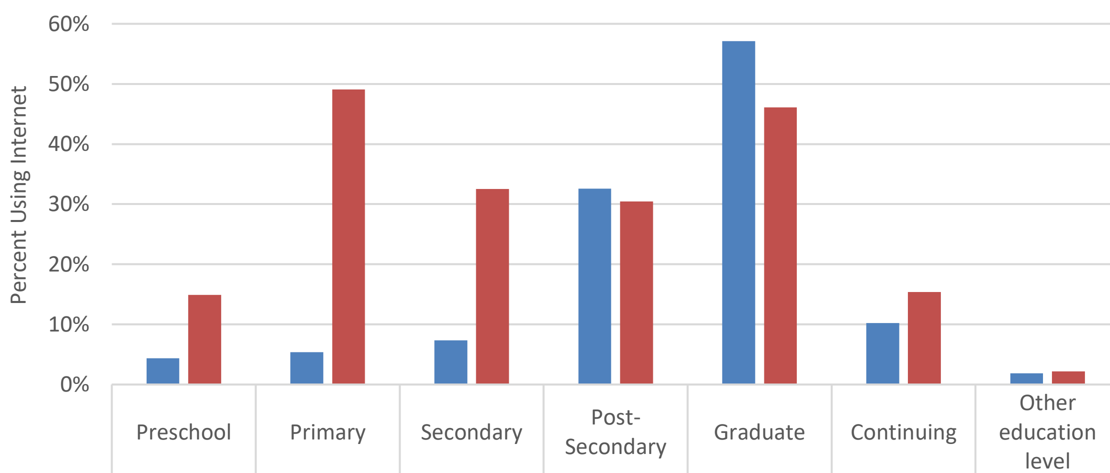
Figure 64: Education Level of Household Internet Users by Household Income



	Preschool	Primary	Secondary	Post-Secondary	Graduate	Continuing	Other education level
< $25k	15%	27%	22%	28%	22%	12%	2%
$25-49k	7%	28%	23%	34%	36%	12%	3%
$50-99k	5%	9%	9%	30%	58%	11%	3%
$100k +	6%	14%	9%	31%	76%	10%	1%

One-half of households with children have a household internet-user with a primary level of education, and 33 percent have a householder with a secondary level of education.

Figure 65: Education Level of Household Internet Users by Children in Household

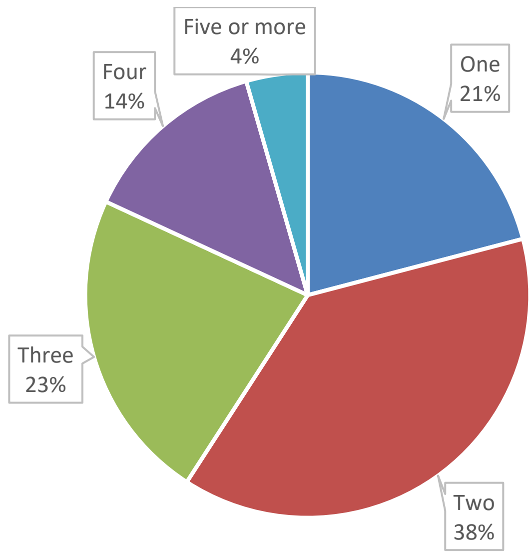


	Preschool	Primary	Secondary	Post-Secondary	Graduate	Continuing	Other education level
No Children in HH	4%	5%	7%	33%	57%	10%	2%
Children in HH	15%	49%	33%	30%	46%	15%	2%

4.3.2.5 Number of Household Members Online During Peak Usage Times

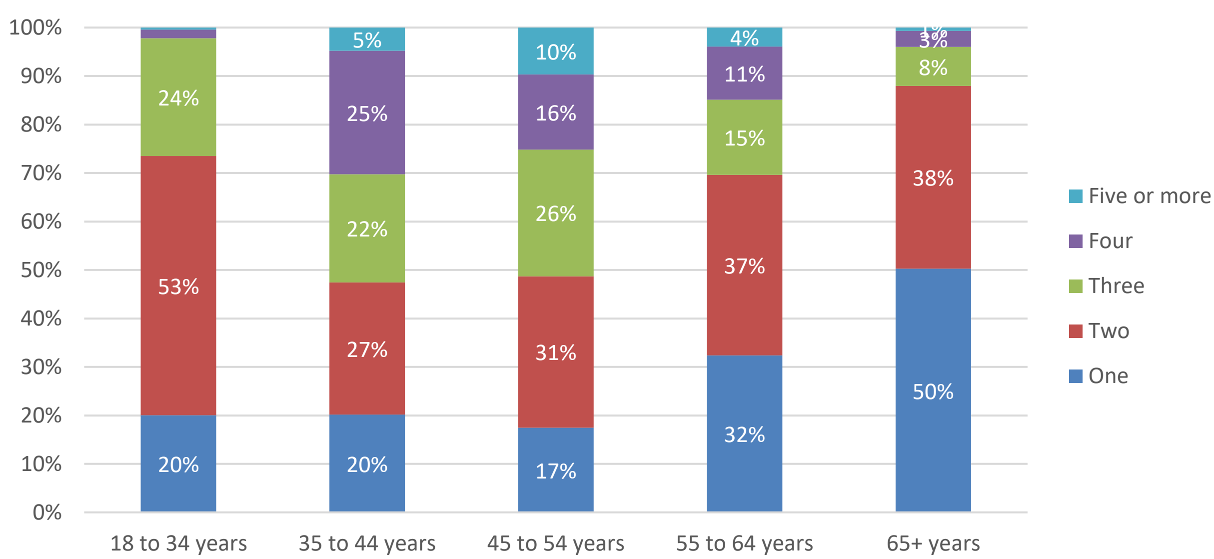
Eight in 10 households have multiple members online during peak usage times during the Covid-19 pandemic, including four in 10 households with at least three members online (see Figure 66).

Figure 66: Number of Households Members Online During Peak Usage Times



Respondents ages 35-54 years have the most members online during peak usage, with more than one-half reporting they have three or more members online at the same time. This age cohort is also more likely than older and younger respondents to have children in the household. Respondents ages 65 and older have fewer members online during peak usage; however, one-half have at least two members using the internet (see Figure 67).

Figure 67: Number of Households Members Online During Peak Usage Times by Age



4.3.3 Computer and internet skills

Respondents were asked a series of questions on how skilled they are using computers and the internet, as well as their interest in training to learn more about these topics. This information provides valuable insight into where there may be gaps in abilities and opportunities to educate residents.

4.3.3.1 Internet Skills

Respondents were asked to indicate their level of agreement with various statements about their computer and internet skills. Average rating scores are highlighted in Figure 68, while Figure 69 shows detailed responses.

Figure 68: Agreement with Statements About Internet Skills (Mean Ratings)

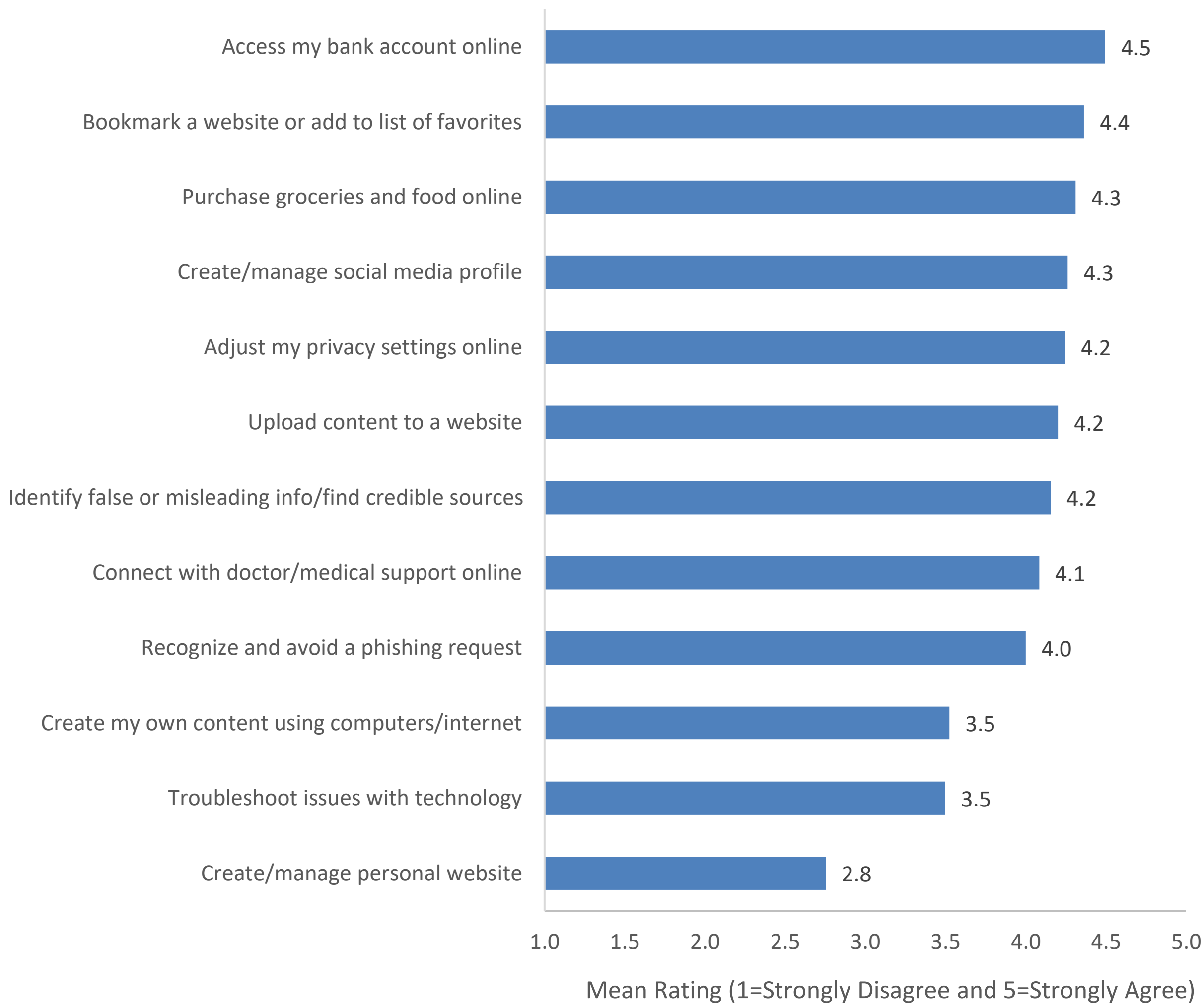
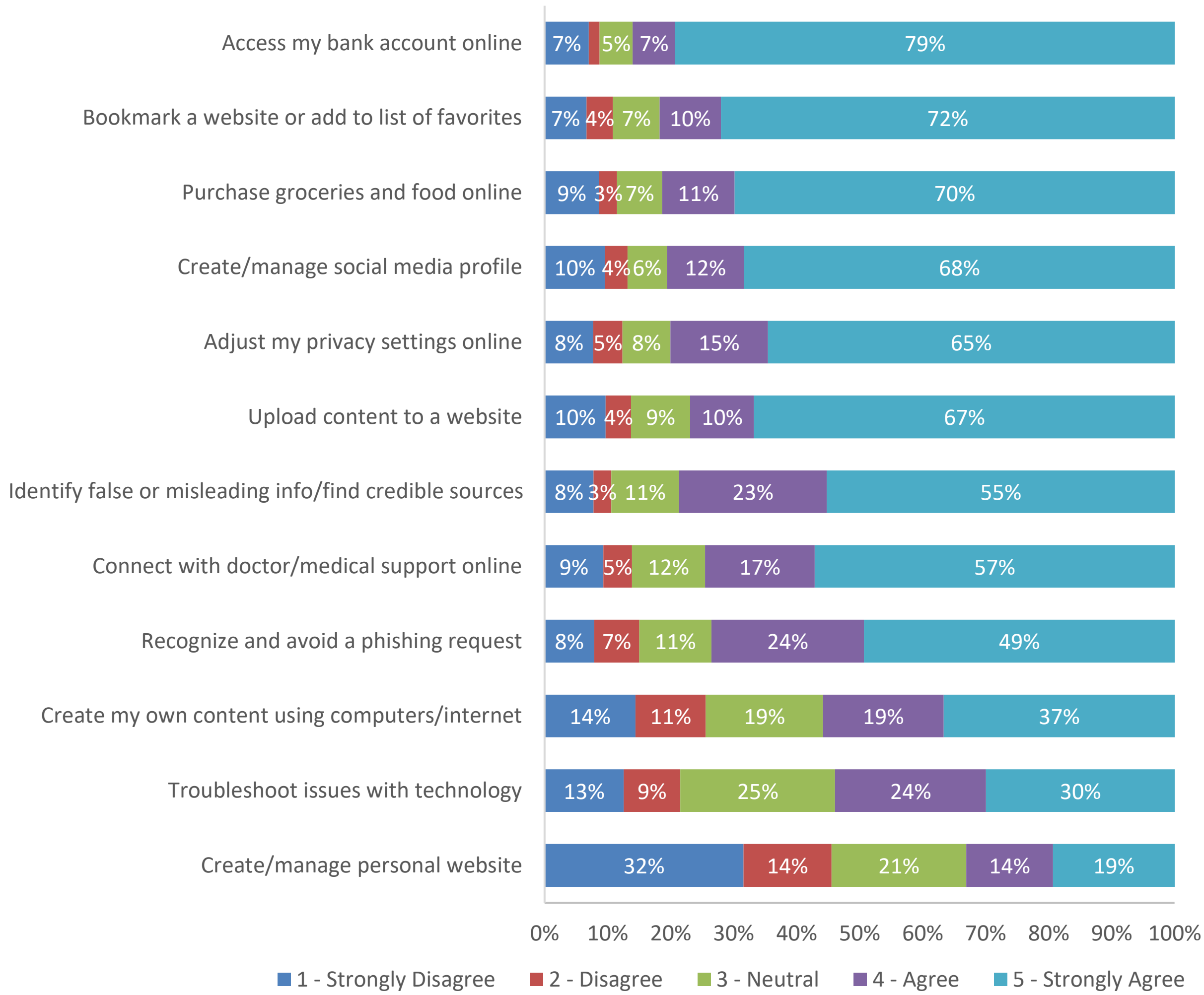


Figure 69: Agreement with Statements About Internet Skills



Overall, most internet subscribers agree that they know how to use the internet for various functions. Nearly eight in 10 respondents strongly agreed they can use the internet for accessing a bank account online. Seven in 10 strongly agreed they can use it for bookmarking a website or purchasing groceries and food online.

Approximately two-thirds of respondent strongly agreed they can use the internet for managing their own profile on social media, adjusting privacy settings online, and uploading content to a website. More than one-half of respondents strongly agreed they can use the internet to connect with doctors or other medical support online or to identify false or misleading information.

Respondents were less likely to agree that they are skilled in creating content or their own personal website or troubleshooting issues with technology.

Specifically, respondents ages 65 and older were less likely to agree that they are skilled in various uses of the internet (see Table 19 and Table 20). Respondents under age 35 are particularly skilled in internet uses compared with older respondents, especially for identifying false information, recognizing phishing scams, and creating content. Two-thirds of respondents under age 45 agreed or strongly agreed they are confident in their ability to troubleshoot issues with technology.

Table 19: Agreement with Statements About Internet Skills (Mean Ratings) by Age

	< 35 years	35-44 years	45-54 years	55-64 years	65 + years
I know how to upload content to a website	4.5	4.5	4.4	4.0	3.4
I know how to adjust my privacy settings online	4.7	4.5	4.4	3.9	3.3
I know how to bookmark a website or add to favorites	4.9	4.6	4.4	4.0	3.6
I know how to identify false or misleading information online and find credible sources of information	4.5	4.3	4.1	4.0	3.6
I know how to create and manage my own personal profile on Facebook or other social network site	4.8	4.4	4.4	3.9	3.2
I know how to create and manage my own personal website	3.1	3.0	3.1	2.5	1.9
I know how to recognize and avoid a phishing scam	4.4	4.0	3.9	3.9	3.4
I know how to create my own content using computers and the internet	4.1	3.7	3.6	3.2	2.5
I know how to access my bank account online to perform tasks such as paying bills or depositing checks with my phone	4.8	4.7	4.6	4.3	3.8
I feel confident in my ability to troubleshoot issues with technology when they arise	4.0	3.8	3.5	3.1	2.6
I know how to purchase groceries and food online	4.7	4.6	4.4	4.0	3.6
I know how connect with my doctor or other medical support online	4.3	4.2	4.1	3.9	3.9

Table 20: Agreement with Statements About Internet Skills (% Strongly Agree) by Age

	< 35 years	35-44 years	45-54 years	55-64 years	65 + years
I know how to upload content to a website	80%	79%	70%	58%	36%
I know how to adjust my privacy settings online	80%	76%	66%	51%	37%
I know how to bookmark a website or add to favorites	91%	80%	71%	56%	45%
I know how to identify false or misleading information online and find credible sources of information	66%	64%	51%	53%	32%
I know how to create and manage my own personal profile on Facebook or other social network site	90%	77%	70%	55%	31%
I know how to create and manage my own personal website	25%	26%	21%	15%	7%
I know how to recognize and avoid a phishing scam	66%	49%	45%	43%	28%
I know how to create my own content using computers and the internet	51%	41%	33%	27%	15%
I know how to access my bank account online to perform tasks such as paying bills or depositing checks with my phone	92%	88%	79%	68%	58%
I feel confident in my ability to troubleshoot issues with technology when they arise	37%	43%	30%	20%	10%
I know how to purchase groceries and food online	85%	82%	68%	59%	42%
I know how connect with my doctor or other medical support online	63%	60%	60%	54%	46%

Additionally, respondents in households earning under $25,000 were less likely to agree that they are skilled in various uses of the internet (see Table 21 and Table 22). Just 14 percent of respondents in low-income households strongly agreed they are confident in their ability to troubleshoot issues with technology.

Table 21: Agreement with Statements About Internet Skills (Mean Ratings) by Income

	< $25k	$25-$49k	$50-$99k	$100k +
I know how to upload content to a website	2.9	4.1	4.4	4.7
I know how to adjust my privacy settings online	3.5	4.1	4.4	4.6
I know how to bookmark a website or add to favorites	3.5	4.0	4.7	4.8
I know how to identify false or misleading information online and find credible sources of information	3.2	3.8	4.4	4.6
I know how to create and manage my own personal profile on Facebook or other social network site	3.6	4.1	4.4	4.7
I know how to create and manage my own personal website	2.2	2.4	2.9	3.3
I know how to recognize and avoid a phishing scam	3.2	3.7	4.2	4.4
I know how to create my own content using computers and the internet	2.7	3.4	3.6	4.0
I know how to access my bank account online to perform tasks such as paying bills or depositing checks with my phone	3.5	4.5	4.8	4.9
I feel confident in my ability to troubleshoot issues with technology when they arise	2.7	3.2	3.6	4.1
I know how to purchase groceries and food online	3.4	4.0	4.5	4.8
I know how connect with my doctor or other medical support online	2.8	3.9	4.2	4.6

Table 22: Agreement with Statements About Internet Skills (% Strongly Agree) by Income

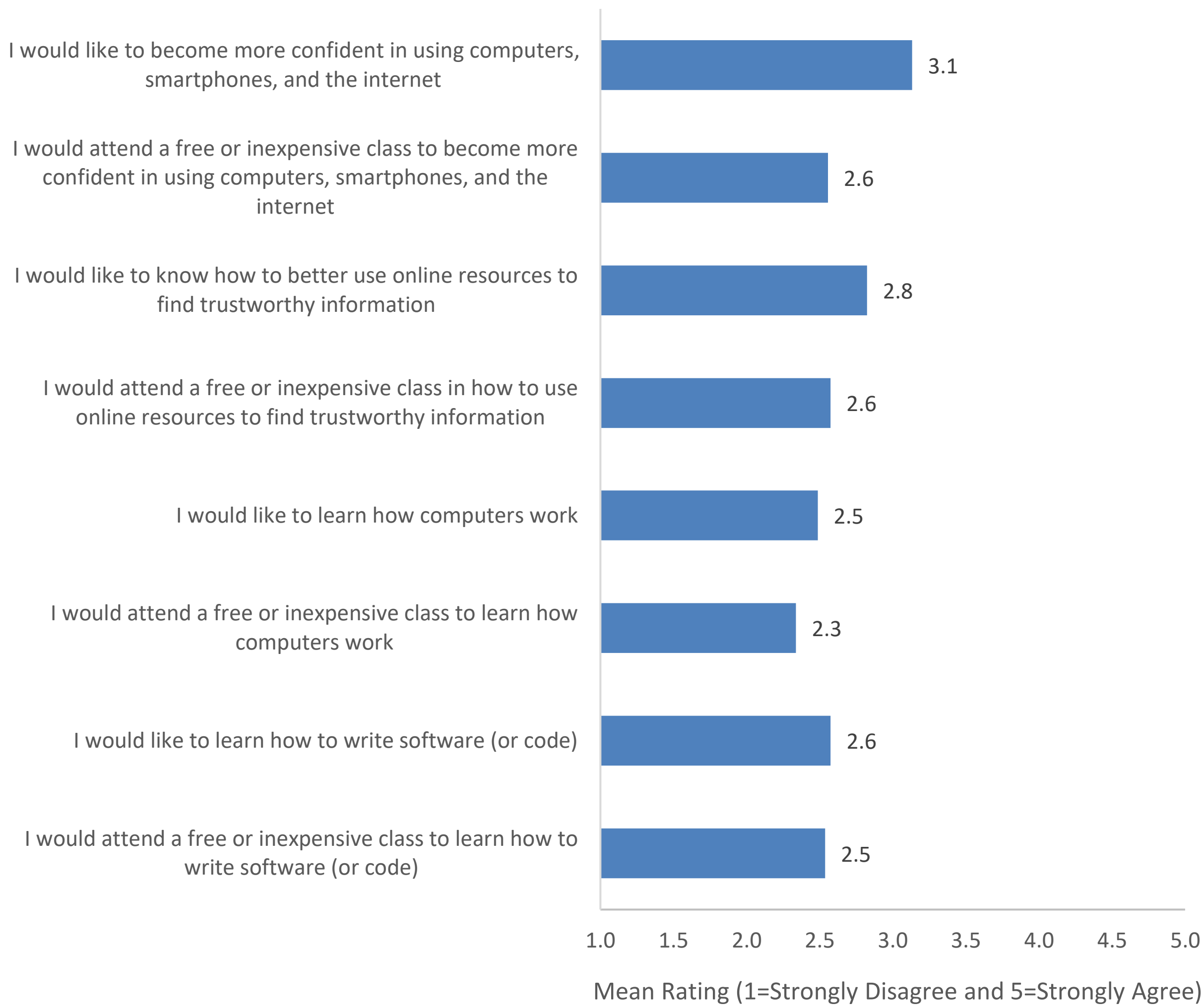
	< $25k	$25-$49k	$50-$99k	$100k +
I know how to upload content to a website	26%	63%	74%	85%
I know how to adjust my privacy settings online	39%	66%	64%	76%
I know how to bookmark a website or add to favorites	42%	62%	82%	91%
I know how to identify false or misleading information online and find credible sources of information	24%	47%	62%	73%
I know how to create and manage my own personal profile on Facebook or other social network site	42%	65%	73%	85%
I know how to create and manage my own personal website	5%	13%	17%	32%
I know how to recognize and avoid a phishing scam	24%	47%	47%	65%
I know how to create my own content using computers and the internet	16%	36%	36%	49%
I know how to access my bank account online to perform tasks such as paying bills or depositing checks with my phone	49%	76%	88%	95%
I feel confident in my ability to troubleshoot issues with technology when they arise	14%	26%	27%	44%
I know how to purchase groceries and food online	42%	63%	71%	89%
I know how connect with my doctor or other medical support online	22%	52%	57%	73%

4.3.3.2 Computer and Internet Training

Respondents were also asked their level of agreement with various statements about receiving training related to computers and the internet. Average rating scores are highlighted in Figure 70, while Figure 71 shows detailed responses.

Overall, there is only slight to moderate interest in learning about or in attending a class about writing software/code or in learning how computers work. On average, there is moderate interest in becoming more confident in using computers, smartphones, and the internet, or in using online resources to find trustworthy information. However, there is less interest in attending a free or inexpensive class about these topics.

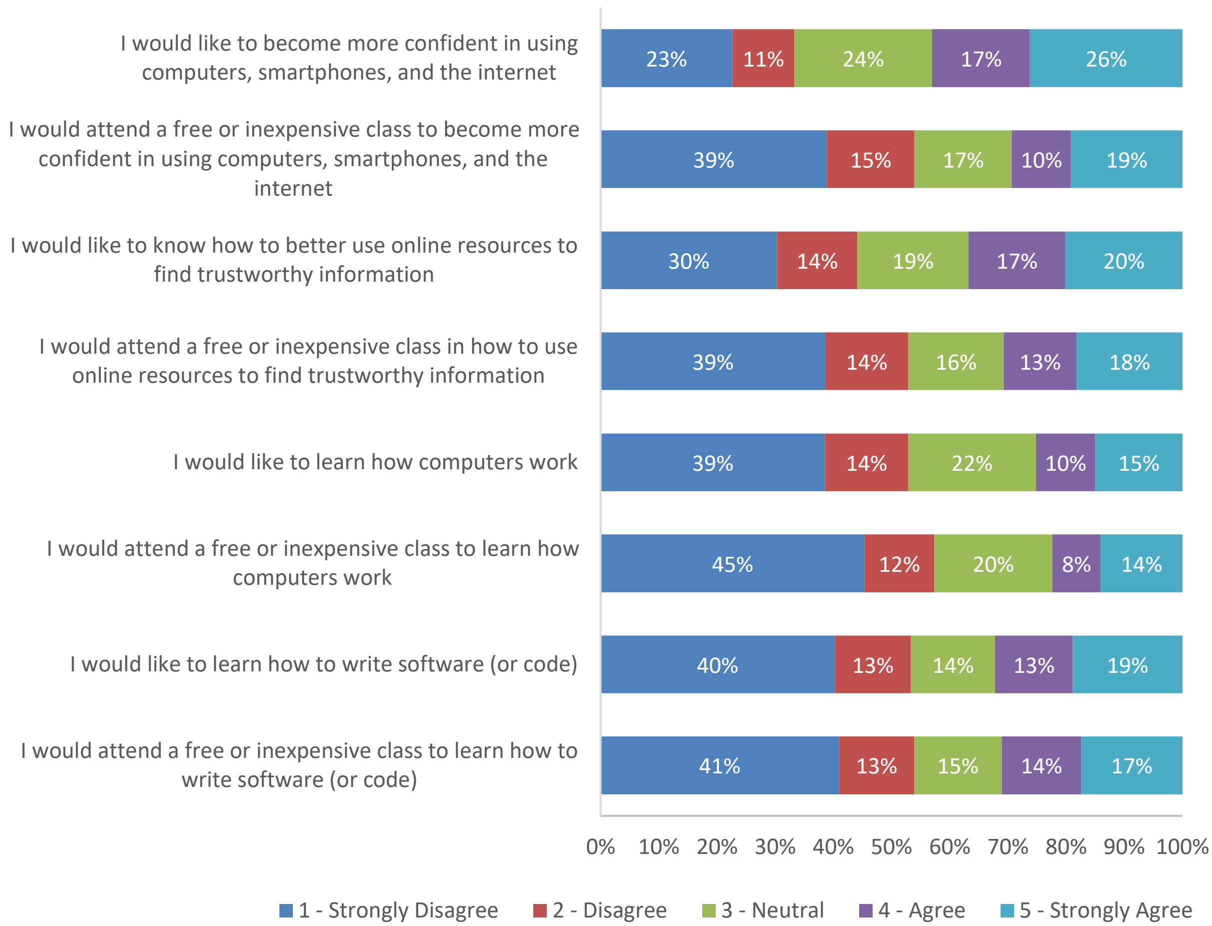
Figure 70: Agreement with Statements About Training Related to Computers and the Internet (Mean Ratings)



Specifically, more than four in 10 respondents agreed or strongly agreed that they would like to become more confident in using computers and related technology, but just 29 percent agreed or strongly agreed they would like to attend training.

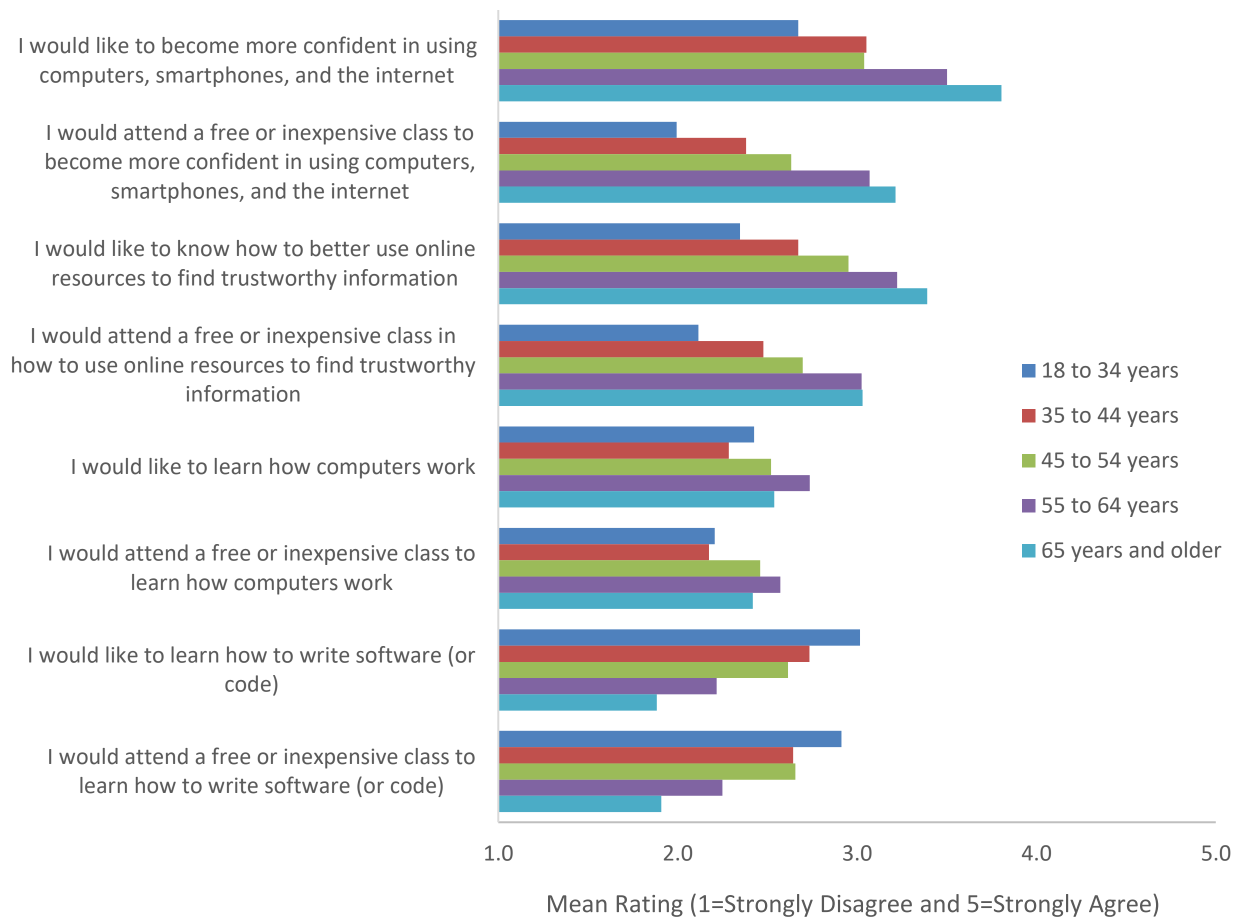
Similarly, 37 percent of respondents agreed or strongly agreed about wanting to know how to better use online resources to find trustworthy information, and 31 percent agreed or strongly agreed they are interested in training while 30 percent strongly disagreed.

Figure 71: Agreement with Statements About Training Related to Computers and the Internet



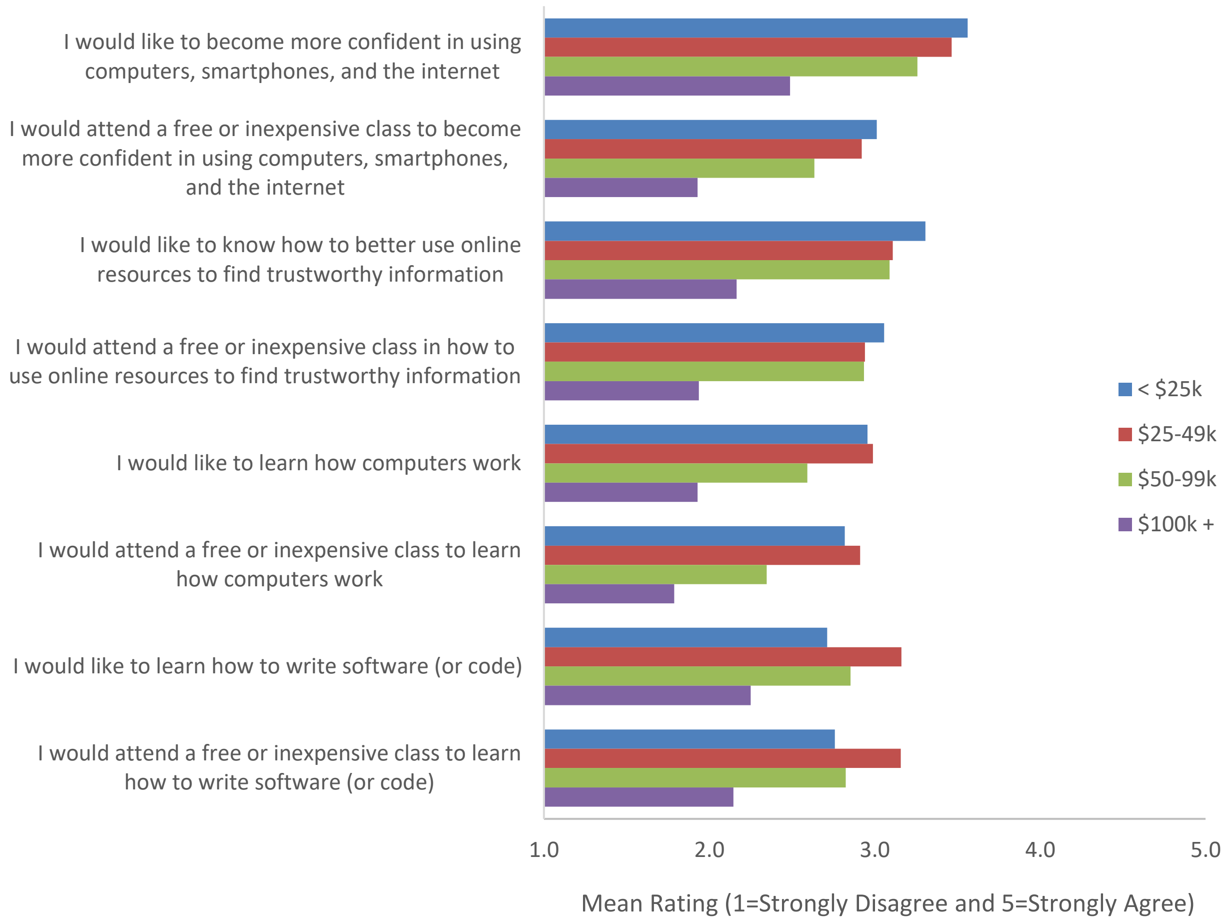
Interest in training varies significantly by age of respondent. As illustrated in Figure 72, those ages 55 and older expressed greater interest in becoming more confident in using computers and related technology and in learning how to better use online resources, as well as attending a class about these topics, compared with younger respondents. Those under age 35 are more likely than older respondents to agree they would like to learn how to write code or to take a class about this topic.

Figure 72: Agreement with Statements About Training by Respondent Age



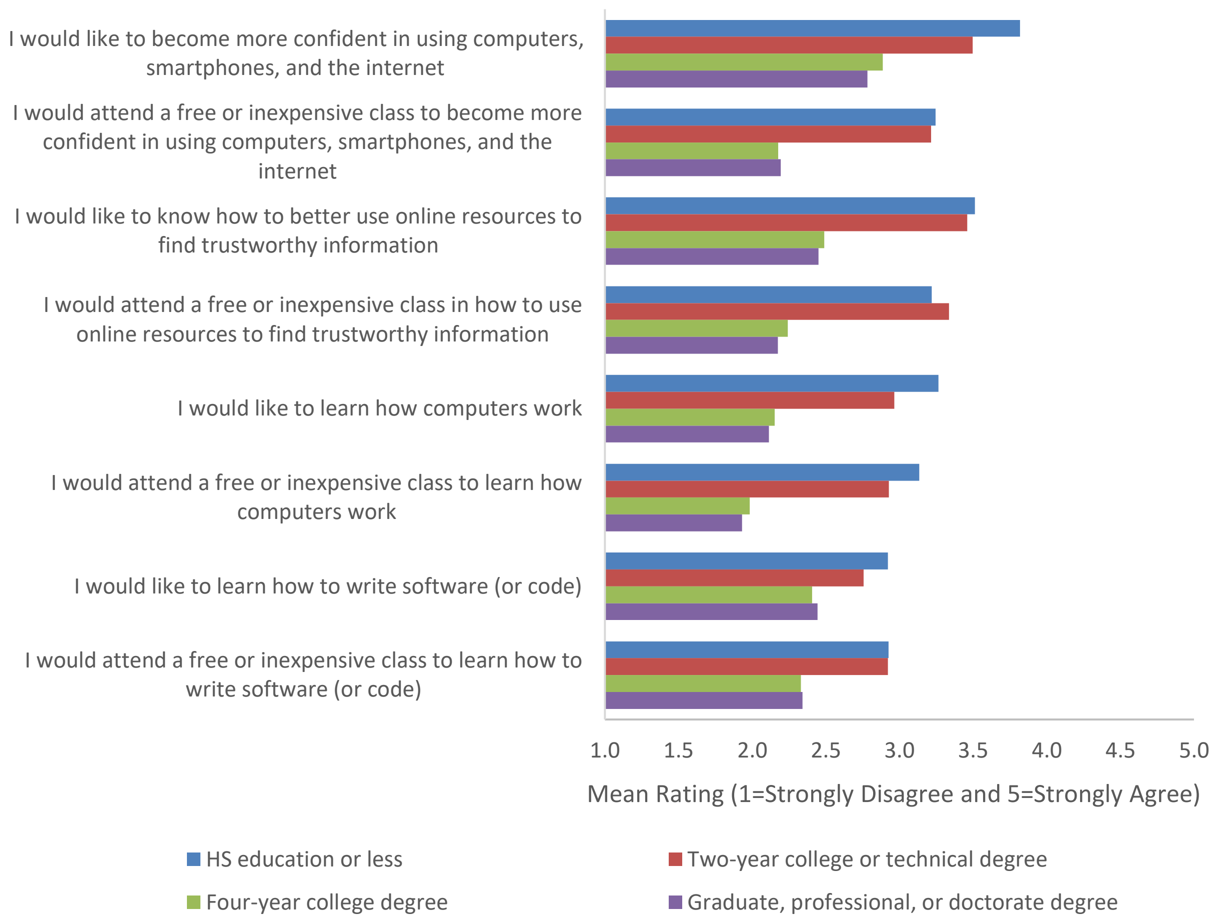
As illustrated in Figure 73, agreement with the various statements about computer and internet training are correlated with household income. Those earning less than $100,000 per year were more likely than those earning $100,000 or more per year to agree that they would like to learn more or would attend training.

Figure 73: Agreement with Statements About Training by Household Income



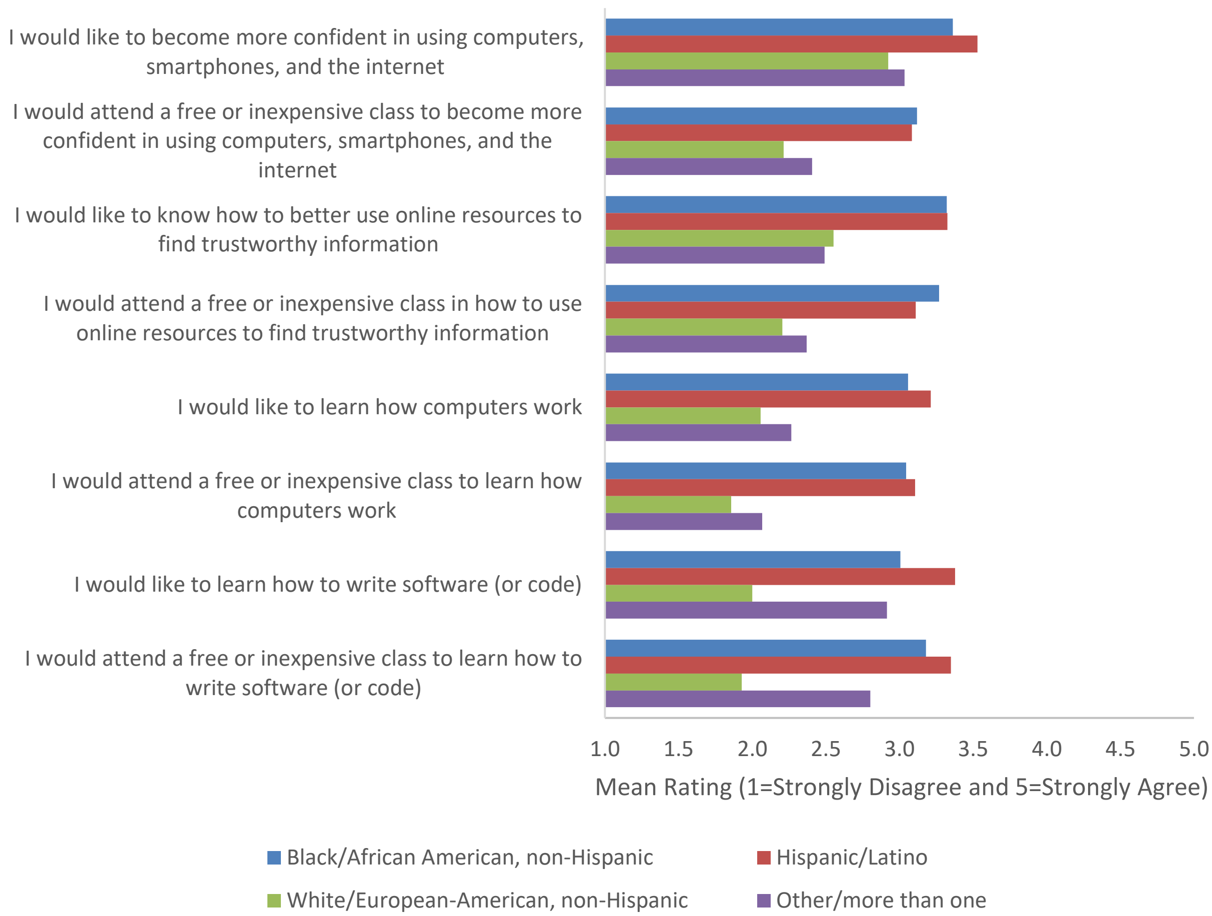
Respondents with a two-year college or technical degree, and those with a high school education or less, rated their level of agreement with various statements about computers and related technology higher than did more educated respondents (see Figure 74).

Figure 74: Agreement with Statements About Training by Household Income



Compared with White/European American (non-Hispanic) respondents, respondents who identify primarily as Black/African American (non-Hispanic) or Hispanic/Latino expressed greater interest in becoming more confident in using computers and related technology, learning how to better use online resources, learning how computers work, and learning how to write software (code), as well as attending a class about these topics (see Figure 75).

Figure 75: Agreement with Statements About Training by Household Income



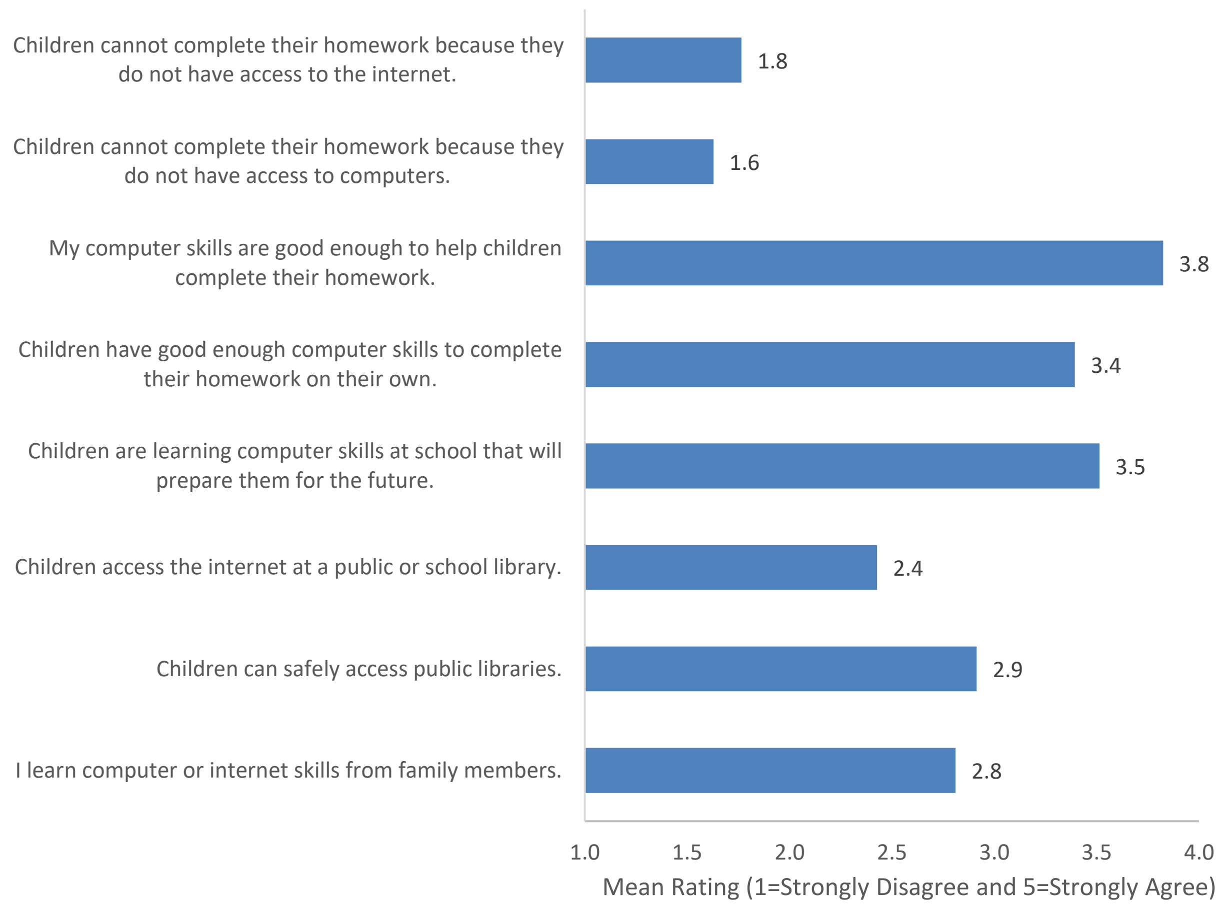
4.3.4 Technology for minor children

Just 26 percent of the weighted total of respondents said they are the parent, guardian, or primary caretaker of children or grandchildren under the age of 18. One-half of respondents ages 45-54 and 58 percent of respondents ages 35-44 are a parent, guardian, or caretaker.

4.3.4.1 Use of Technology

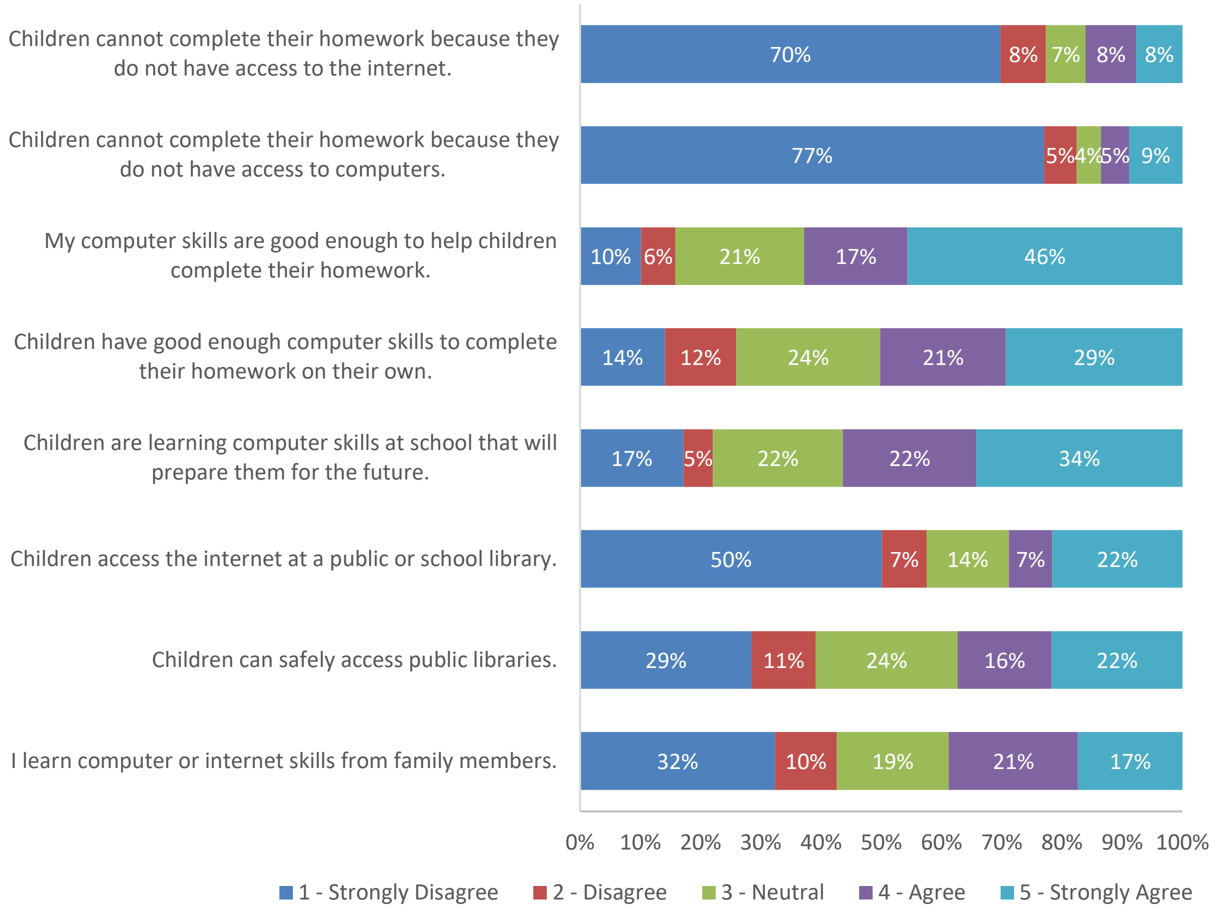
Respondents who are the parent, legal guardian, or primary caretaker for any child or grandchild under the age of 18 were asked their level of agreement with statements about how their minor child is able to make beneficial use of technology. Average rating scores are highlighted in Figure 76, while Figure 77 shows detailed responses.

Figure 76: Agreement with Statements About Children's Use of Technology (Mean Ratings)



A majority of respondents indicated that the children in their care have sufficient internet access. Most respondents strongly disagreed that the children in their care cannot complete their homework because they do not have access to the internet (70 percent) or computers (77 percent).

Figure 77: Agreement with Statements About Children's Use of Technology During the Covid-19 Pandemic



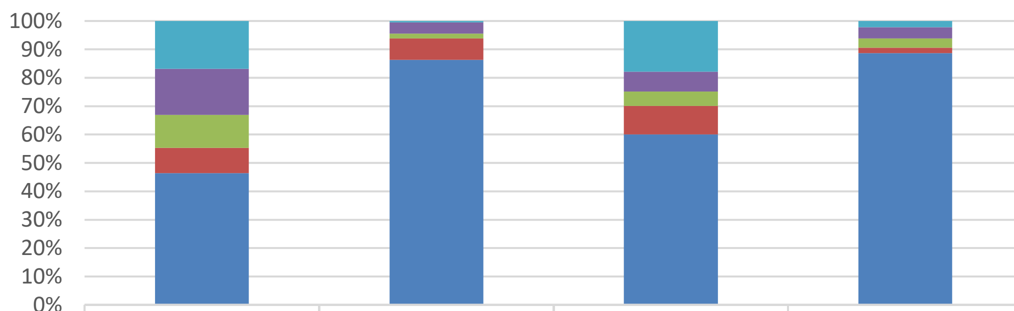
Still, accessibility may be an issue for a small segment of households without access to internet or computers. Sixteen percent of respondents agreed or strongly agreed that the children in their care cannot complete their homework because they do not have access to the internet. Also, just 29 percent of respondents agreed or strongly agreed that their children access the internet at a public or school library, while 50 percent strongly disagreed.

Most respondents agreed that they and their children have sufficient computer skills. Nearly one-half of respondents (46 percent) strongly agreed that their computer skills are good enough to help their children complete their homework, and 17 percent agreed. However, 16 percent of respondents disagreed or strongly disagreed that they have sufficient computers skills.

One-half of respondents agreed or strongly agreed that their children have good enough computer skills to complete their homework on their own, while 26 percent of respondents disagreed or strongly disagreed. More than one-half of respondents (56 percent) agreed or strongly agreed that their children are learning computer skills at school that will prepare them for the future, and 22 percent disagreed or strongly disagreed.

Internet accessibility is a greater issue for lower-income households earning under $50,000 per year, compared with households earning more. One-third of lower-income households agreed or strongly agreed that the children in their care cannot complete their homework because they do not have access to the internet. One-fourth of lower-income households agreed or strongly agreed that the children in their care cannot complete their homework because they do not have access to computers (see Figure 78).

Figure 78: Agreement with Reasons Children Cannot Compete Homework by Household Income



	Do not have access to the internet.		Do not have access to computers.	
	<$50k	$50k+	<$50k	$50k+
5 - Strongly Agree	17%	1%	18%	2%
4 - Agree	16%	4%	7%	4%
3 - Neutral	12%	2%	5%	3%
2 - Disagree	9%	8%	10%	2%
1 - Strongly Disagree	46%	86%	60%	89%

1 - Strongly Disagree 2 - Disagree 3 - Neutral 4 - Agree 5 - Strongly Agree

4.3.4.2 Minimize Online Risks

Respondents with minor children were also asked their level of agreement with statements about the skills they or their children possess to avoid or minimize online risks. Average rating scores are highlighted in Figure 79, while Figure 80 shows detailed responses.

Although most households with minor children do have access to the internet and computers, respondents agree that there are some risks associated with internet use. Overall, six in 10 respondents agreed or strongly agreed that they are aware of the extent their children are exposed to various risks or content, and 62 percent agreed or strongly agreed that they have the time and skills to protect their children or grandchildren from risks.

At the same time, a sizeable segment of respondents disagreed that their children are able to minimize or avoid specific online risks. Specifically, many respondents disagreed or strongly disagreed that their children can detect and avoid false or misleading information (56 percent), avoid online bullying (43 percent), get help for online bullying (33 percent), detect and avoid financial scams and predators (51 percent), avoid exposure to graphic violence or pornography online (41 percent), and get help if exposed to graphic violence or pornography online (29 percent).

Figure 79: Agreement with Statements About Minimizing Online Risks (Mean Ratings)

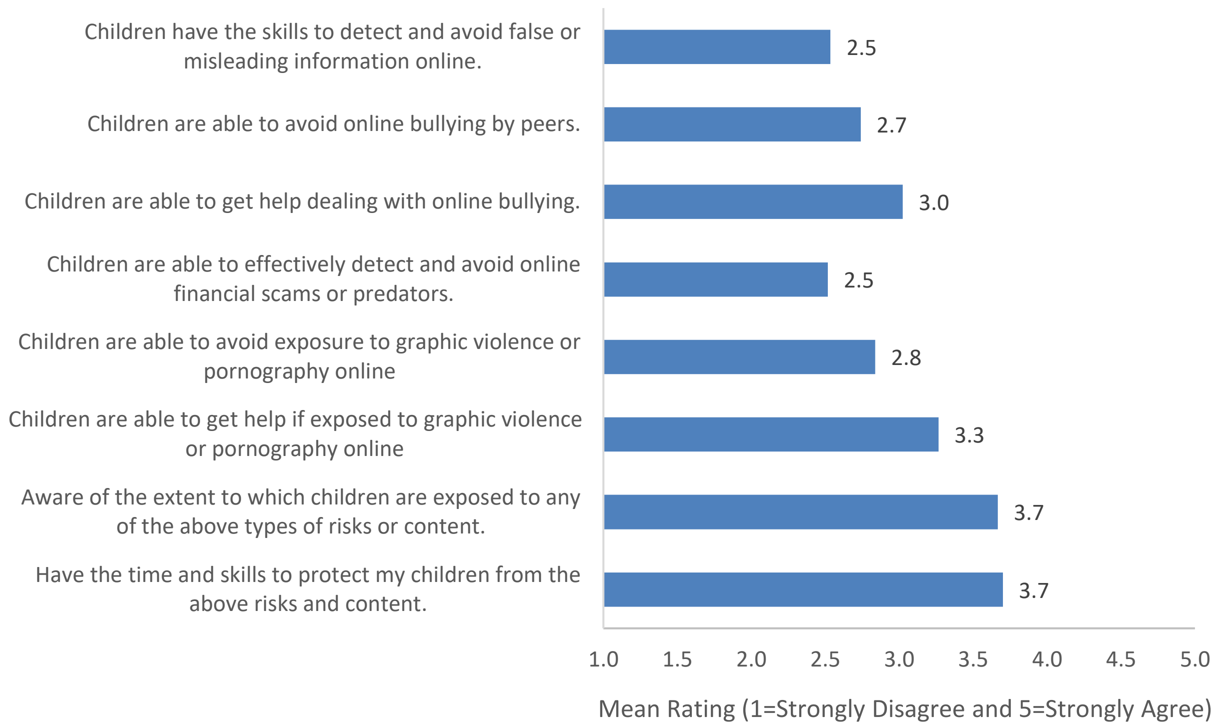
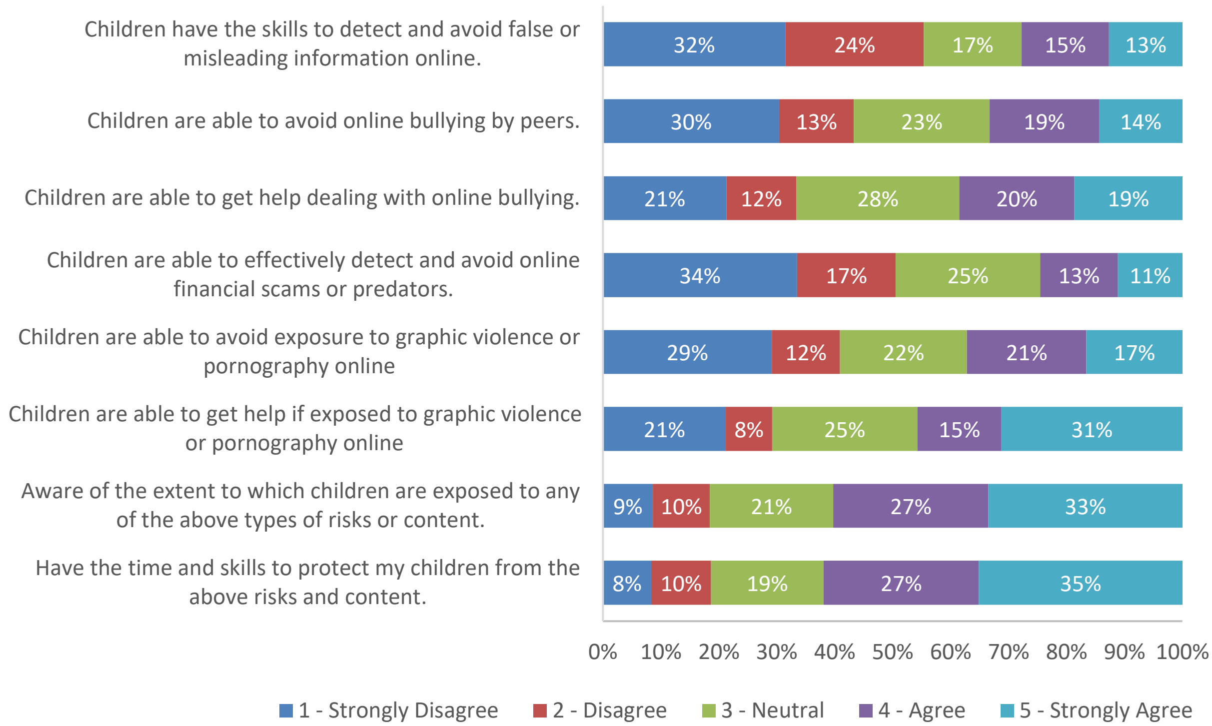


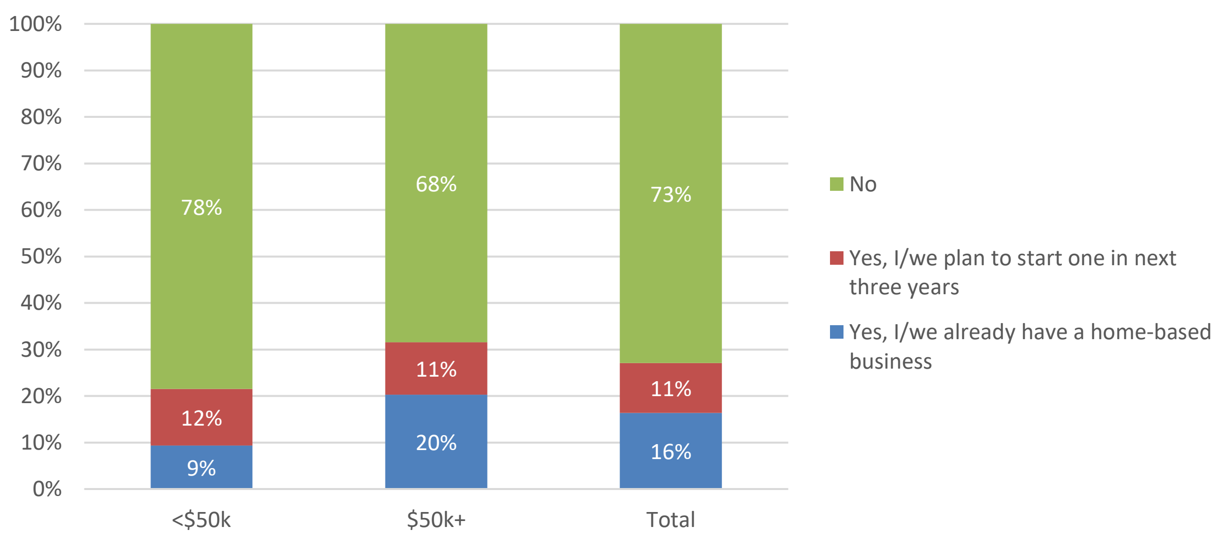
Figure 80: Agreement with Statements About Minimizing Online Risks



4.3.5 Internet use for jobs/careers

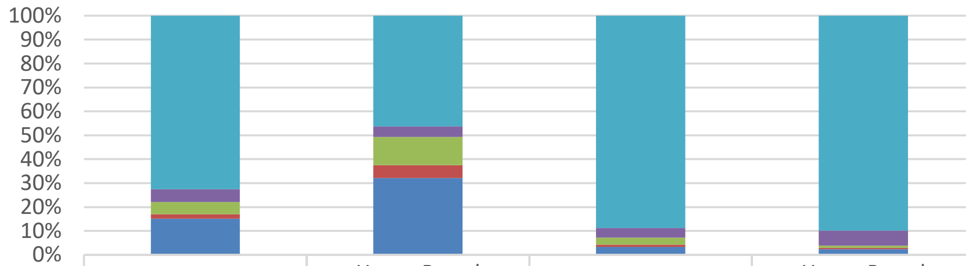
More than one-fourth of households either have a home-based business or are planning to start one within the next three years, as illustrated in Figure 81. One-fifth of households earning $50,000 or more per year have a home-based business.

Figure 81: Own or Plan to Start a Home-Based Business



Nearly three-fourths of respondents said a high-speed internet connection is extremely important for teleworking, and 46 percent said it is extremely important for running a home-based business (see Figure 82). Nine in 10 of those who have a planned/existing home-based business said high-speed internet access is extremely important.

Figure 82: Importance of High-Speed Internet



	Total		Those with home-based business	
	Teleworking	Home-Based Business	Teleworking	Home-Based Business
5 - Extremely important	72.5%	46.3%	88.7%	89.9%
4 - Very important	5.4%	4.4%	4.1%	6.3%
3 - Moderately important	5.2%	11.8%	2.9%	1.0%
2 - Slightly important	1.8%	5.4%	1.0%	.5%
1 - Not at all important	15.1%	32.1%	3.3%	2.3%

4.3.6 Respondent opinions

Respondents were asked their opinions about the role of the City or DISD in providing or promoting broadband communications services within the area. Figure 83 illustrates the mean ratings, while Figure 84 provides detailed responses to each portion of the question.

Figure 83: Opinions About the Role(s) for the City or DISD (Mean Ratings)

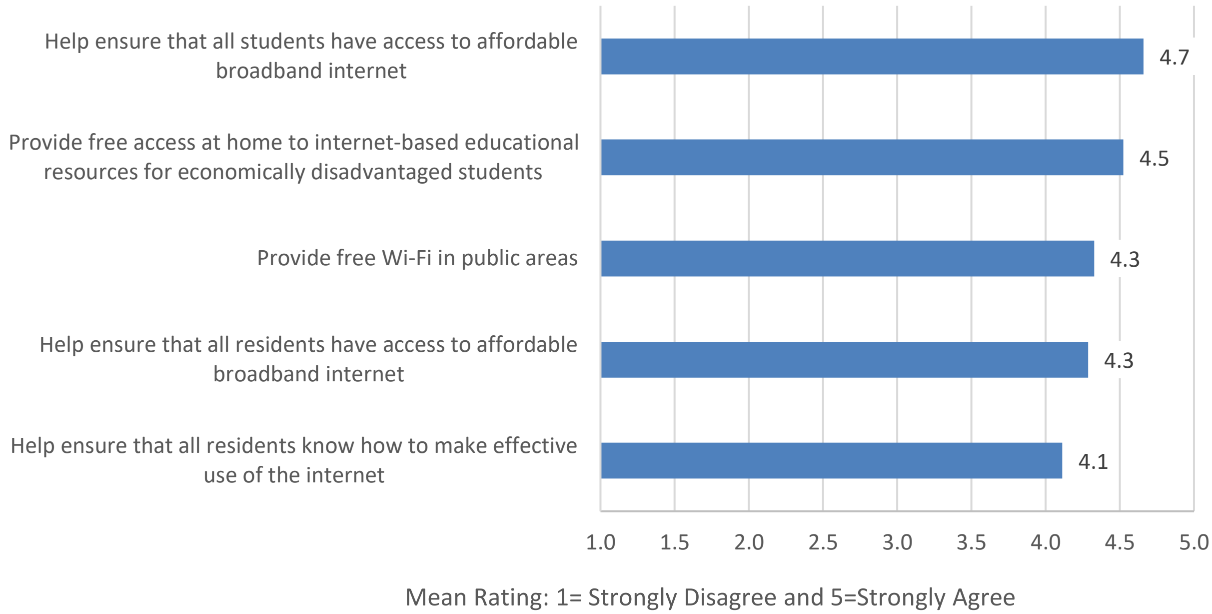
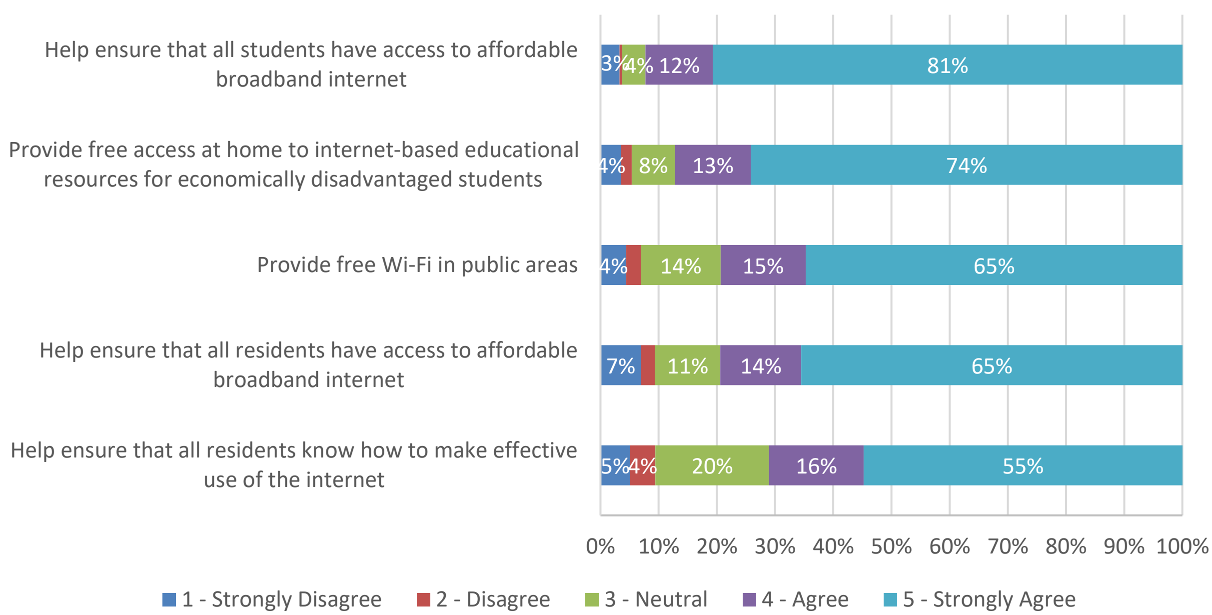


Figure 84: Opinions About the Role(s) for the City or DISD

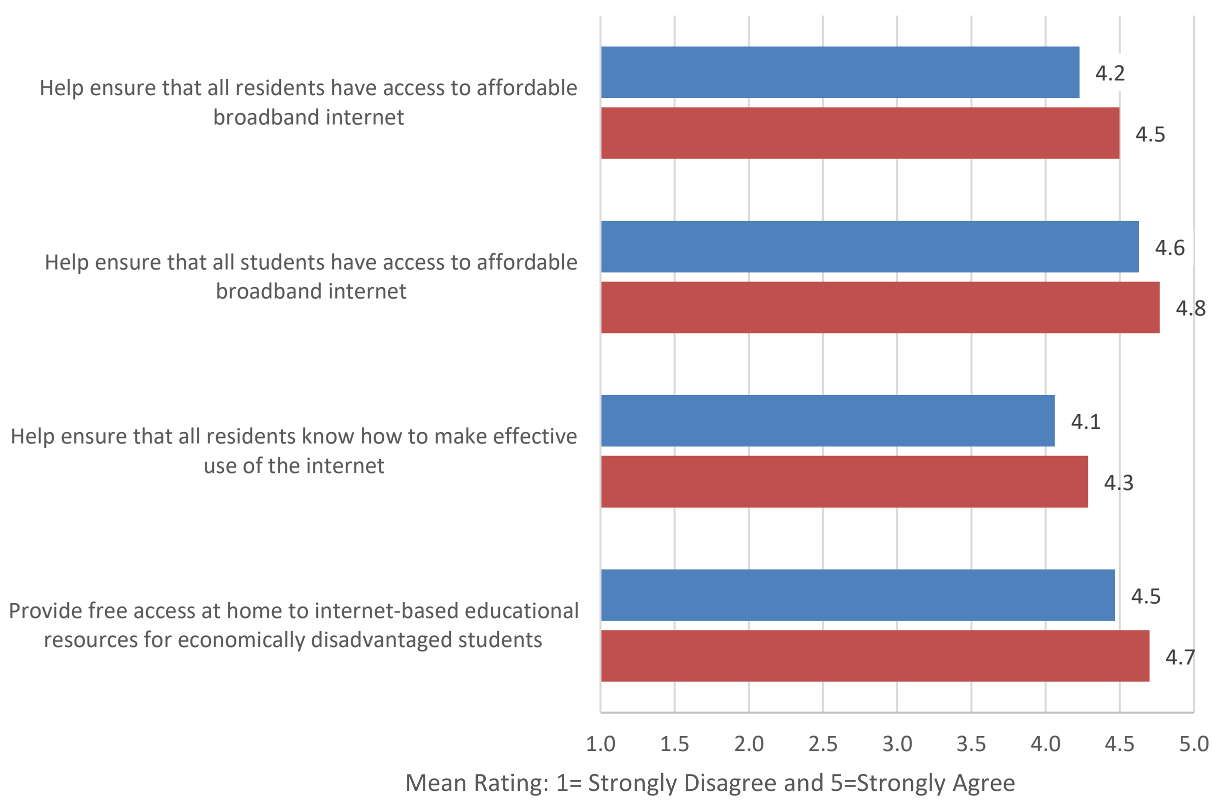


Overall, there is strong support for ensuring all students have access to affordable broadband services, with 81 percent strongly agreeing. Three-fourths of respondents strongly agreed that the City or DISD should provide free access at home to internet-based educational resources for economically disadvantaged students.

Additionally, there is relatively strong support for providing some form of internet access to residents. Sixty-five percent of respondents strongly agreed that the City or DISD should ensure all residents have access to affordable broadband service, and 65 percent strongly agreed that it should provide free Wi-Fi in public spaces. Additionally, 55 percent of respondents strongly agreed that the City or DISD should help ensure that all residents know how to make effective use of the internet.

Respondents with children in the household were somewhat more likely than those without children to agree with the various statements about the City's or DISD's role in offering broadband internet service or support, as illustrated in Figure 85. Specifically, 85 percent of respondents with children strongly agreed the City or DISD should help ensure all students have affordable broadband access, and 82 percent strongly agreed the City or DISD should provide free access at home to internet-based educational resources for economically disadvantaged students.

Figure 85: Opinions About the Role(s) for the City or DISD by Children in Household



4.3.6.1 Willingness to Purchase High-Speed Internet Service

Respondents were asked if they would be willing to purchase extremely fast internet service (defined as 1 Gbps) for various price levels. The mean willingness to purchase across this array of questions is illustrated in Figure 86, while detailed responses are illustrated in Figure 87.

Figure 86: Willingness to Purchase 1 Gbps Internet at Price Levels (Mean Ratings)

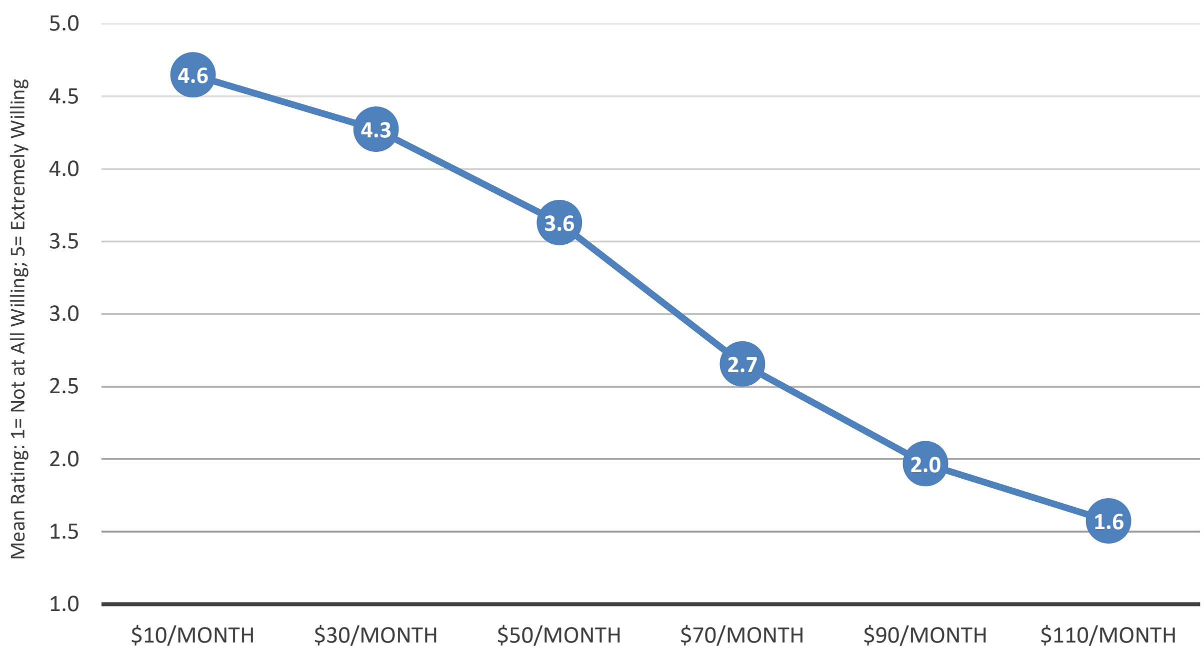
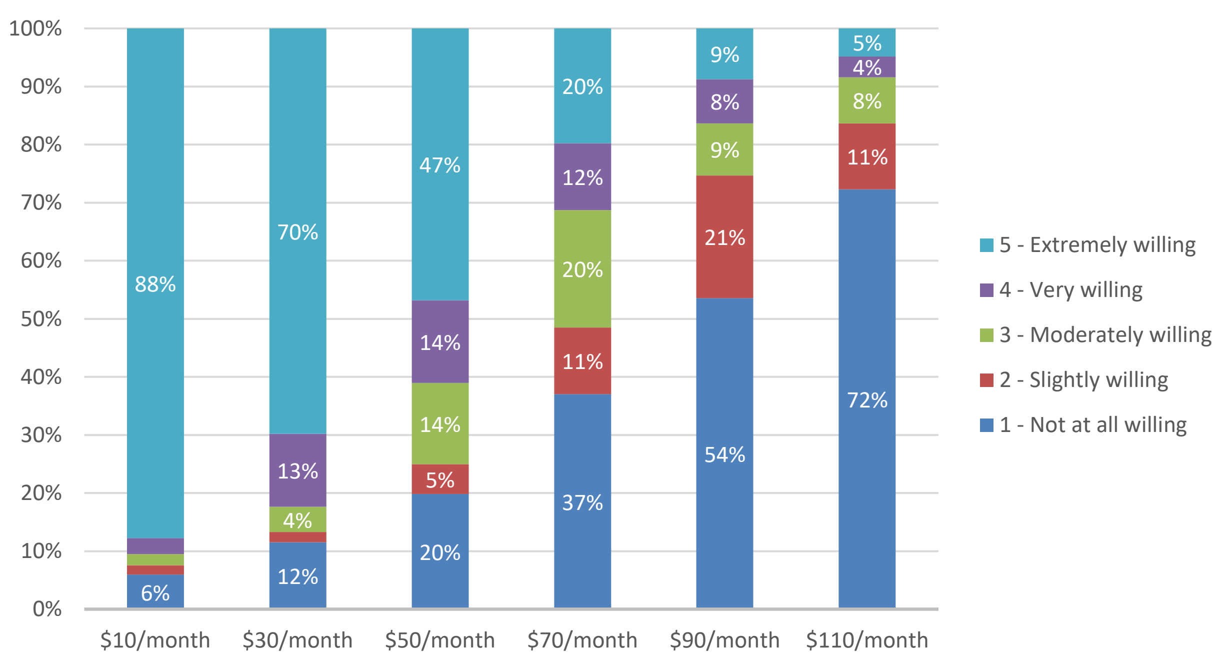


Figure 87: Willingness to Purchase 1 Gbps Internet at Various Price Levels

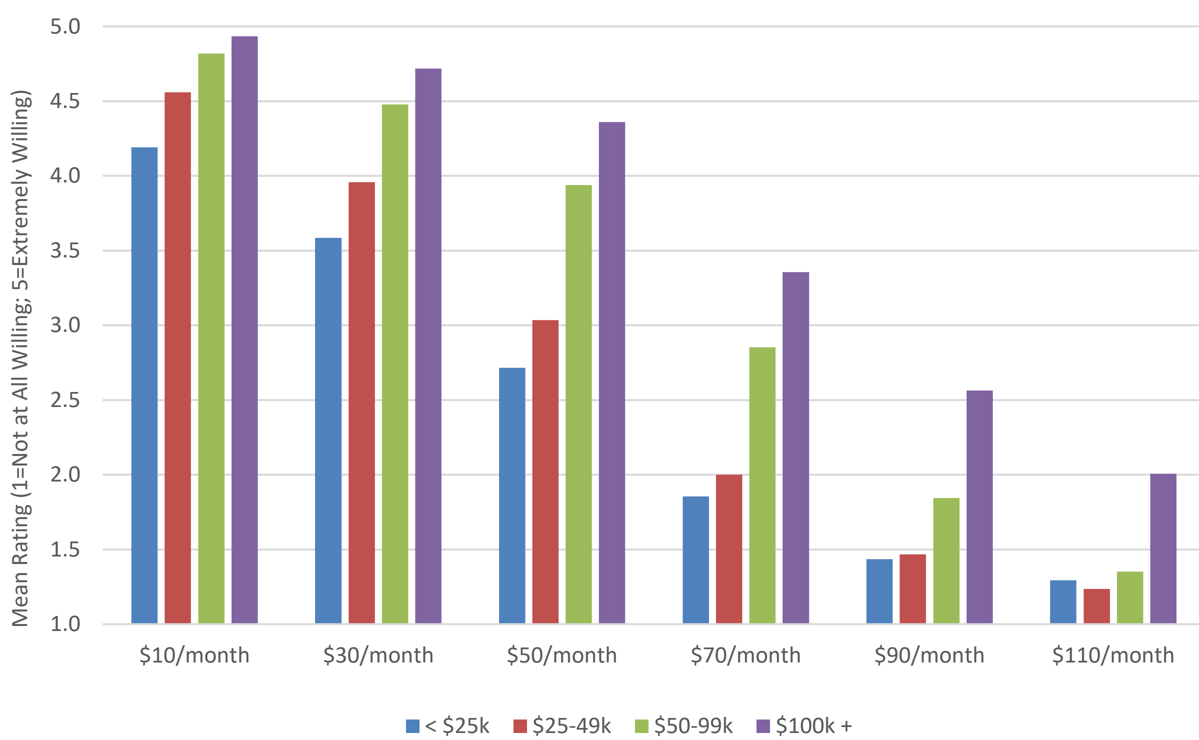


Respondents' willingness to purchase 1 Gbps internet service is high at $10 per month (4.6 mean), but it drops considerably as the price increases. The mean rating falls to 4.3 at a price point of $30 per month, 3.6 at a price point of $50 per month, and 2.7 at a price point of $70 per month (slightly to moderately willing). Respondents would only be slightly willing to switch for price points of $90 per month or $110 per month.

From another perspective, 88 percent of respondents are extremely willing to purchase 1 Gbps internet for $10 per month, dropping to 70 percent at $30 per month, 47 percent at $50 per month and 20 percent at $70 per month. Just 9 percent strongly agreed at a price point of $90 per month, and 5 percent strongly agreed at a price point of $110 per month.

The willingness to purchase high-speed internet service is also correlated with some demographic characteristics of the respondents, including household income (see Figure 88). The likelihood of purchasing high-speed internet tends to increase as household income increases.

Figure 88: Willingness to Purchase 1 Gbps Internet Service by Household Income

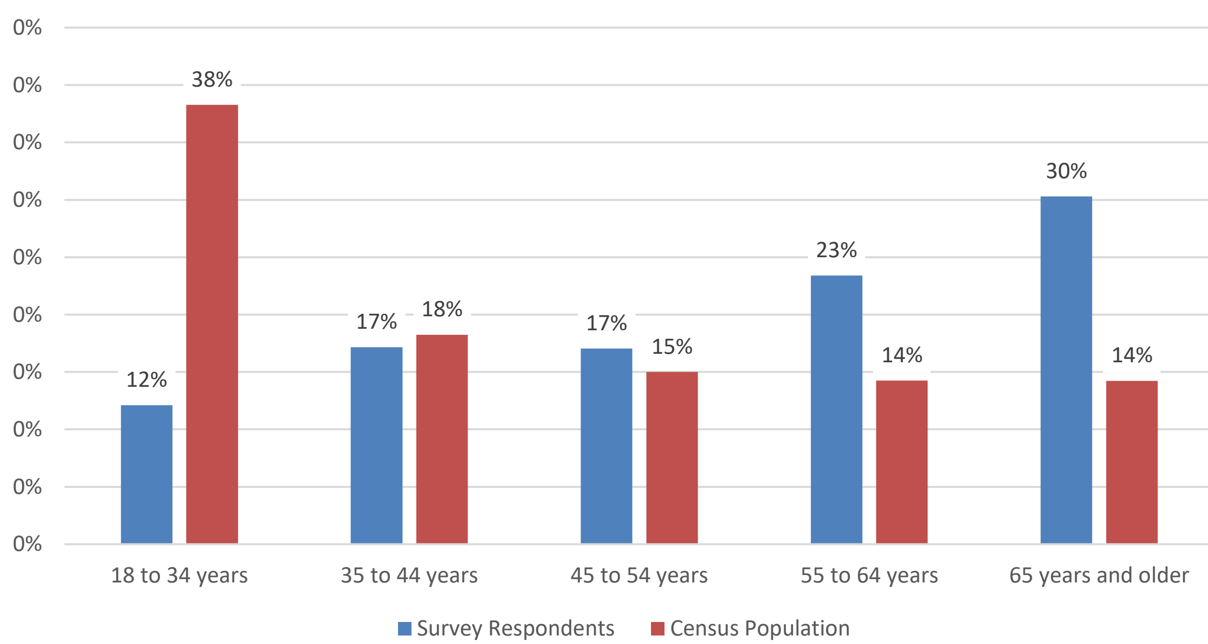


4.3.7 Respondent information

Basic demographic information was gathered from survey respondents and is summarized in this section. Several comparisons of respondent demographic information and other survey questions were provided previously in this report.

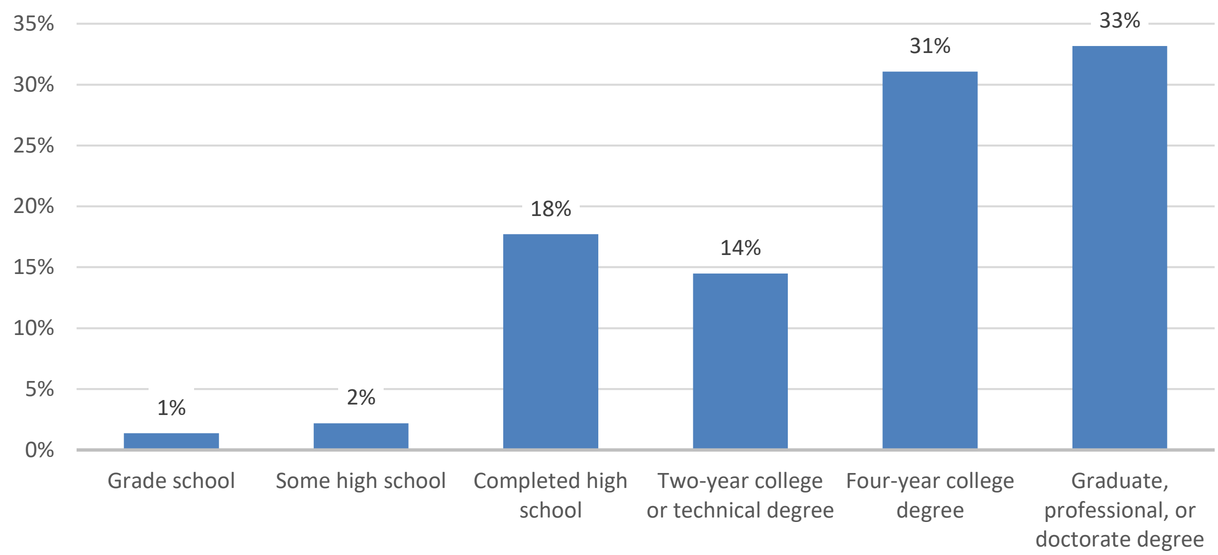
As indicated previously in Figure 1 regarding age-weighting, disproportionate shares of survey respondents were in the older age cohorts relative to the area's adult population as a whole (see Figure 89). Similarly, the data were weighted to account for differences in response by household income and presence of children in the household. The weighted survey results presented in this report are adjusted to account for these differences and to provide results that are more representative of the area's population, as discussed previously.

Figure 89: Age of Respondents and City of Dallas/DISD Adult Population



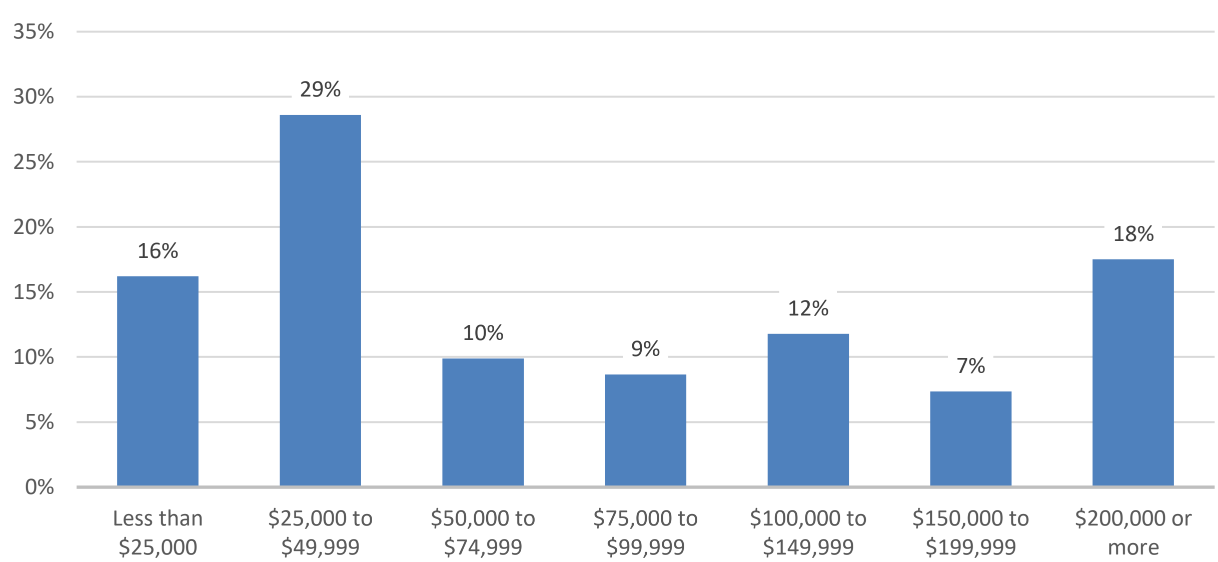
The respondents' highest level of education attained is summarized in Figure 90. Most respondents have a four-year college degree (31 percent) or a graduate, professional, or doctorate degree (33 percent). One-fifth of respondents have a high school education or less.

Figure 90: Education of Respondent



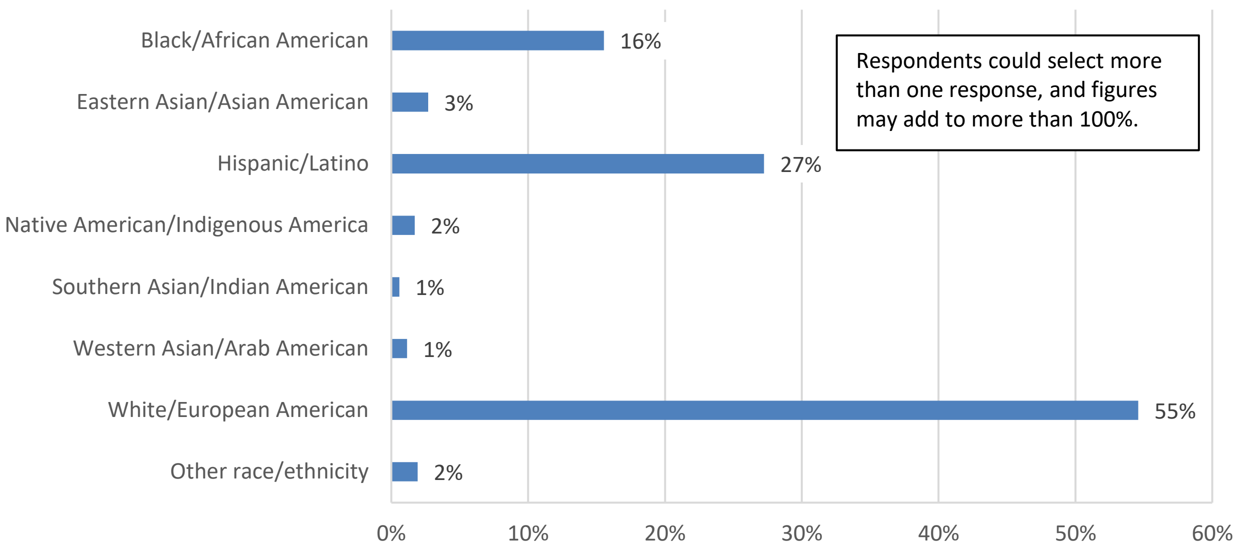
Survey data were weighted to correspond to the income distribution in the population (City of Dallas used as a proxy for market area). Forty-five percent of respondents earn under $50,000 per year, and 55 percent earn over $50,000 per year (see Figure 91).

Figure 91: Annual Household Income



As illustrated in Figure 92, 55 percent of respondents are White/European American. More than one-fourth (27 percent) of respondents are Hispanic/Latino, and 16 percent are Black/African American.

Figure 92: Race/Ethnicity



Respondents were asked to indicate the number of adults and children in their household. More than one-half of households have two members, and 25 percent have three or more members. Just 23 percent of respondents live alone (see Figure 93). Three in 10 respondents have children living in the household (see Figure 94).

Figure 93: Total Household Size

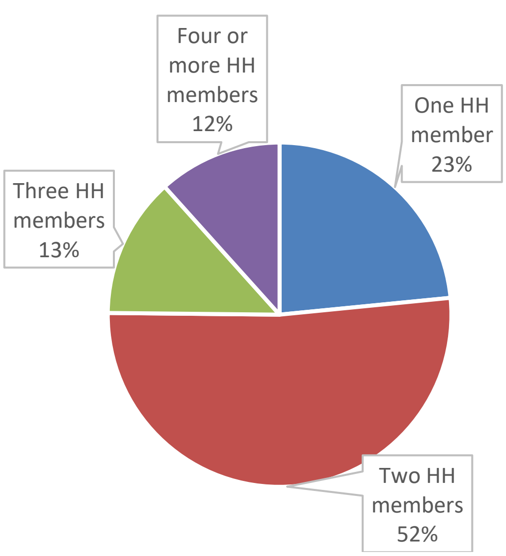
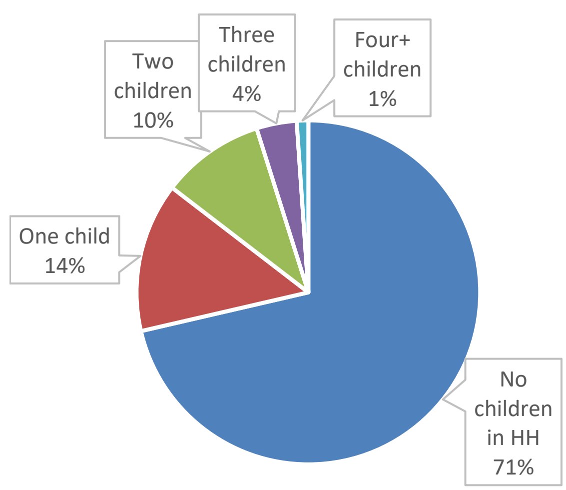
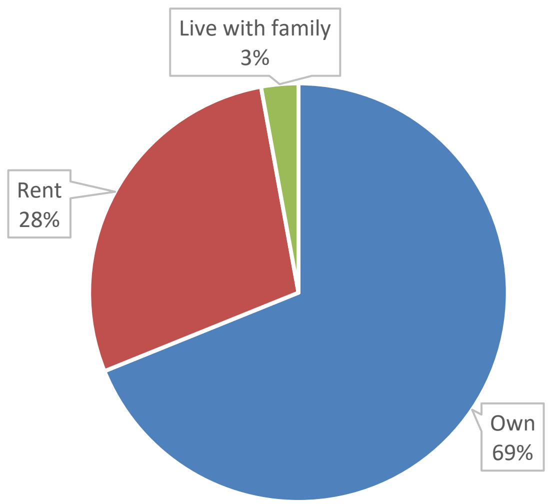


Figure 94: Number of Children in Household



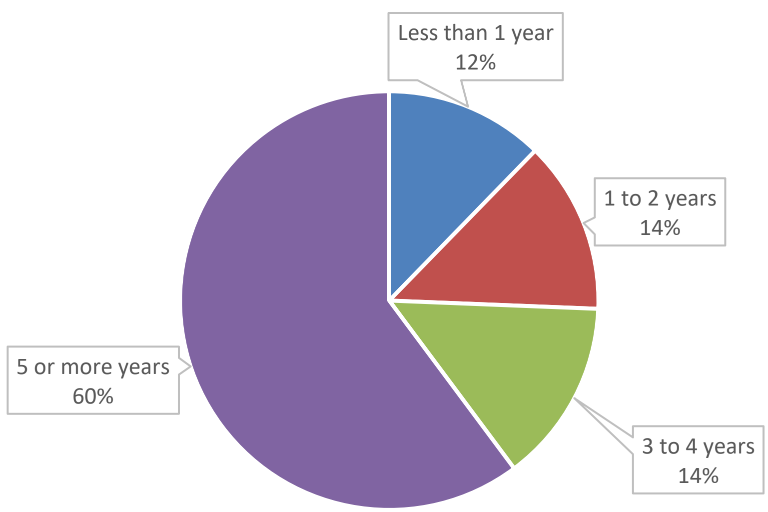
Most respondents (69 percent) own their residence, while 28 percent rent and 3 percent live with family (see Figure 95).

Figure 95: Own or Rent Residence



Six in 10 respondents have lived at their current residence for five or more years. Another 28 percent have resided at the home for one to four years, while 12 percent have lived at the residence for less than one year (see Figure 96).

Figure 96: Number of Years Lived at Current Residence



5 New wireless infrastructure could be a partial solution to broadband gaps in Dallas: Evaluation and recommendations regarding wireless pilots and expansion

In this section, we provide an introduction to wireless connectivity, an overview of the wireless broadband pilot projects DISD launched at one high school, and that the City of Dallas launched in several neighborhoods, an exploration of the feasibility of using wireless infrastructure to close the broadband gaps in Dallas, and a recommendation that the City continue to explore its options for funding and building its own backbone fiber network. On the latter point, CTC's engineers developed a candidate design and cost estimates for a full-scale network, based around neighborhood characteristics and prioritization.

5.1 Introduction to fixed wireless network connectivity

Broadband speeds in compliance with the FCC's definition (i.e., 25 Mbps download, 3 Mbps upload) are now more technically feasible using fixed wireless networks than in the past, due to increased available spectrum and new wireless technologies.

A fixed wireless connection may be a desirable solution if cable or fiber is not available or cost-effective. If adequate care is taken in the design such that the network is not overloaded and uses spectrum capable of broadband speed, subscribers will enjoy high-quality performance, sufficient for applications such as Zoom.

5.1.1 Fixed wireless spectrum and architecture

Fixed wireless networks typically use the following spectrum and associated frequencies:

Table 23: Fixed Wireless Spectrum

Spectrum	Frequency Band
TV White Space (TVWS)	500 MHz
Unlicensed (including Wi-Fi)	900 MHz, 2.4 GHz, and 5 GHz
Educational Broadband Service (EBS)	2.5 GHz
Citizens Broadband Radio Service (CBRS)	3.5 GHz

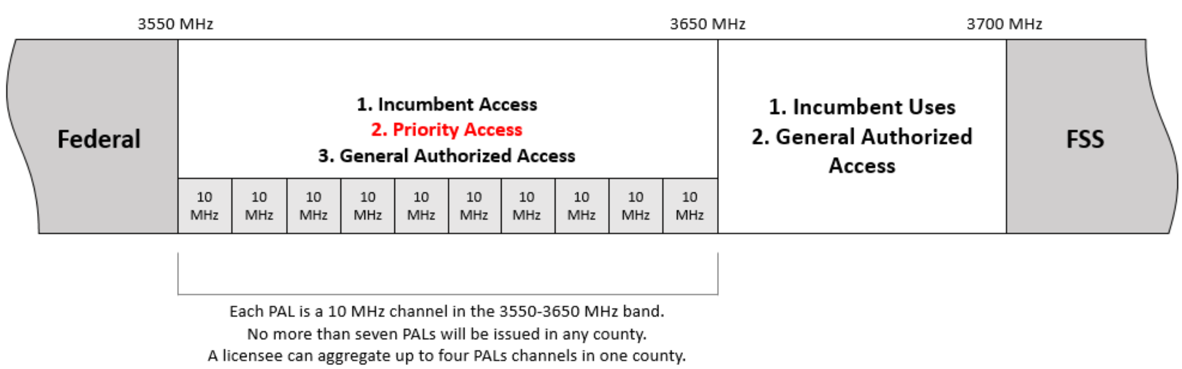
Fixed wireless broadband is delivered via access point antennas mounted on towers, rooftops, or poles to a subscriber antenna. Subscriber antennas can be located indoors or outdoors depending on the distance to the access point and the amount of "clutter" between the subscriber antenna and the access point. Outdoor antennas may be attached to a building or a mast on the premises (Figure 97).

Figure 97: Sample Indoor and Outdoor Customer Antenna Configurations for a Fixed Wireless Network

As one example of fixed wireless technology,[21] Citizens Broadband Radio Service (CBRS) is a band of spectrum in the 3.5 GHz range that was authorized for both licensed and unlicensed use by the FCC in 2015. Extending between 3550 MHz to 3700 MHz, CBRS provides spectrum to a broad audience of potential users, from government entities to small businesses. The FCC has divided access to the CBRS band into three tiers with different levels of interference protection. Access to the CBRS band is managed by a cloud-based dynamic frequency coordination system called a Spectrum Access System (SAS).

Access is divided into three tiers: Incumbent Access, Priority Access [Licenses] (PAL), and General Authorized Access (GAA) and is managed by the SAS. Each Tier spans the ten 10 MHz channels; the remaining spectrum is available for incumbent uses and GAA (Figure 98).

Figure 98: CBRS Tiers (Source: FCC)



[21] We have focused on CBRS because it is the band DISD used for the Lincoln High School pilot.

- Tier 1 – Incumbent Access grants access to the 3550 MHz to 3650 MHz band to existing license holders, primarily U.S. Navy radar systems and commercial fixed satellite stations.[22] Users in Tier 1 have the highest priority for their licensed frequencies and have a GSA of 35 miles. The SAS continuously monitors the channels and will prioritize a Tier 1 transmission over a Tier 2 or Tier 3 transmission on the Tier 1 incumbent's frequency.[23]

- Tier 2 – Priority Access channels were auctioned off as through competitive bidding. PAL licenses were granted for 10 MHz channels in the 3550 to 3650 MHz band in individual counties (as opposed to the 35-mile GSA that incumbents have) and must be renewed every 10 years. A total of 70 MHz, and thus seven PALs, are available in each county; however, no single licensee may operate more than 40 MHz (four PALs) in a single county. The SAS will prioritize a Tier 2 transmission over a Tier 3 transmission on the Tier 2 frequency licensed to that provider.

- Tier 3 – General Authorized Access (GAA) allows open, unlicensed access to the full CBRS band. This spectrum is available for use by anyone using certified equipment and who has registered with the SAS. However, Tier 3 users have the lowest priority of the three Tiers and are granted access on a first-come, first-served basis.

As noted, the SAS coordinates use of the band, ensuring Tier 2 and Tier 3 users do not interfere with incumbents. The SAS is responsible for databasing spectrum users and prioritizing and granting access requests based on users' access Tiers and the spectrum load of a given area. As CBRS usage grows, the SAS will be responsible for efficiently managing the user load to ensure access rules are enforced and interference is minimized.

In late January 2020, the FCC authorized full commercial deployment of OnGo[24] service in the 3.5 GHz CBRS band. This allows OnGo-certified antennas and devices to use the band as General Authorized Access (GAA) by unlicensed users. As PAL holders build out their networks, the SAS will give PAL licensees priority on the spectrum they have been allocated. In areas where all of the PAL holders make use of their channels, GAA users will only be able to share 80 MHz of the band. In Dallas, the PAL licensees are AT&T, Charter, and Dish Network.

The SAS monitors the spectrum through the internet and provides a temporary license to that spectrum in its area to a user. This temporary license must be renewed at regular intervals. The

[22] "What is CBRS?" *Fierce Wireless*, June 23, 2020, https://www.fiercewireless.com/private-wireless/what-cbrs#:~:text=The%20incumbent%20tier%20is%20reserved,as%20commercial%20fixed%20satellite%20stations. In Georgia, Navy radar systems may potentially be activated from time to time at Kings Bay Naval Submarine Base inland of the eastern coast, and the Naval Reserve training center on the western border with Alabama.

[23] There also exist grandfathered users who had been using this band before CBRS was created, but these users were supposed to have migrated to GAA in 2020.

[24] OnGo is a brand name that represents the networks and devices in the CBRS band.

SAS checks its national database and verifies the user's access priority (Tier). In an extremely congested situation where spectrum channels may not be available, the SAS will reduce or revoke access to existing users to accommodate a new request from a higher Tier user, with the Tier 1 users having the highest priority. Because the CBRS band is in the early days of use, there is no public record of congestion or spectrum availability, but anecdotal reports in urban and rural areas are reporting the ability to access GAA spectrum.

Wi-Fi uses the 2.4 and 5 GHz bands. It is an unlicensed service and is subject to the FCC's rules on unlicensed spectrum, which require that users use equipment that complies with limits on power levels and other parameters, use equipment that is type-certified by the FCC, and accept all interference from other permitted users of the spectrum. Wi-Fi originated as a technology to eliminate the use of cables in indoor local-area networks, and this initial vision of indoor use still imposes limits to its use over wide outdoor areas. Though the technology has improved in performance and has expanded to more spectrum as authorized by the FCC (including emerging "Wi-Fi 6" expanding beyond the prior upper bounds of the 5 GHz band), the power limits keep the range at hundreds of feet, and the combination of power limits and the propagation of the spectrum bands make it challenging for outdoor signals to effectively provide high-quality service indoors, and vice versa.

5.1.2 Fixed wireless network characteristics and considerations

Most fixed wireless network solutions require the antenna at the subscriber location to be in or near the line-of-sight of the base station antenna. Line-of-sight can be especially challenging in in areas where multiple tall buildings or trees can interfere with the signal. Moreover, the quality of line of sight can vary seasonally, with the variations in density of foliage.

As a result, wireless internet service providers (WISP) and other network operators often need to lease space on rooftops, or at or near the top of radio towers; even then, some customers may be unreachable without the use of additional repeaters. Climate conditions like rain and fog can also impact the quality of service.

When designing and deploying a fixed wireless network, there is a tradeoff in spectrum between capacity and the ability to penetrate obstructions such as clutter and terrain. Higher frequencies have wider channels and are therefore able to provide more capacity. However, higher frequencies are those most easily blocked by obstructions.

Wireless equipment vendors offer a variety of point-to-multipoint and point-to-point solutions. Point-to-multipoint is more suited to a residential or small business network while large or medium-sized business connections and backbone connectivity between wireless sites would use a point-to-point solution. Point-to-point connectivity enables dedicated bandwidth needed for these applications, but at a higher cost per user than a point-to-multipoint design. Both Dallas pilot networks were designed for residential and small business use and thus use point-to-multipoint technology.

5.2 DISD educational network pilot at Lincoln High School

With the move to distance learning due to the Covid-19 pandemic, the accessibility of broadband connectivity in students' homes has become a paramount element to the quality of their education. Students who are unable to receive broadband connectivity due to lack of service or high costs are at a disadvantage in their education.

To explore options for meeting students' broadband needs, DISD developed a pilot concept using CBRS GAA tier spectrum (which is open access and has a low cost of deployment), radios located at DISD buildings (to avoid facility lease fees), and fiber connectivity to DISD's network.

In late 2020 and early 2021 DISD began to pilot an educational network to provide broadband service to student households located near Lincoln High School. BearCom, in partnership with Motorola, installed an antenna and related radio equipment near the school and, in the first months, about 40 participating student households living about a half-mile from the school were provided indoor Wi-Fi routers (also called customer premises equipment, or CPE) to deliver service within their homes. The first phase included indoor CPE equipment with Wi-Fi and USB interfaces, capable of connecting to DISD-provided Chromebooks and other Wi-Fi-based devices.

The pilot user devices are all provided to users by DISD. Therefore, at this stage, all makes and models of devices are provided by DISD according to their selection, and only DISD families authorized by DISD receive equipment or are allowed to use the network. Because the equipment is uniquely identifiable through serial number, DISD is able to identify particular user devices on the network and their usage. DISD is also able to monitor and limit network usage by user. While in the future, smart phones and other wireless devices may have standard CBRS technology interfaces, these still will require SIM cards or digital certificates to access the DISD network and will be uniquely identifiable.

Backhaul was provided through the DISD fiber optic network and out to the DISD internet connection. The network core in the first stage was a Motorola hosted LTE evolved packet core. As DISD moved to expand the network to additional schools, it found performance problems in the cloud-based core and worked with BearCom to move to a core located at the DISD data center.

DISD is planning to test different CPE equipment to expand the range of the network and improve performance to homes with more challenging lines of sight. One option is a window-mounted CPE radio that can be installed by the DISD family at a location with the best connection to the network, which then acts as a Wi-Fi hotspot connecting to student devices.

DISD is targeting connecting 5,000 student households at five schools by the end of June 2021 from five schools—Lincoln, Roosevelt and South Oak Cliff High Schools, Dunbar Learning Center, and Rice Learning Center.

5.3 City of Dallas Wi-Fi pilot in priority zones

At approximately the same time as the DISD pilot, the City of Dallas also began a pilot, using Wi-Fi technology from Neo Networks. Locations were selected in 10 priority zones consistent with proximity to City facilities, DISD and City collaborative projects, and areas of limited household connectivity to the internet.

Initial locations are listed below, identified by Council District (CD), and illustrated in Figure 99 below:

1. Martin Weiss Recreation Center: Thibet St. from Martindale to Westmoreland (CD 1)
2. Fire Station #52: Bridlewood from Cockrell Hill to Western Park (CD 3)
3. Beckley Saner Recreation Center: Seevers from Hobson to Elmore (CD 4)
4. Fire Station #23: Iowa from Corinth to Bruck (CD 4)
5. Pleasant Oaks Recreation Center: Greenmound from McCutcheon to McKim (CD 5)
6. Fire Station #32: Toland from Jim Miller to Elva (CD 5)
7. Arcadia Branch Library: N. Justin Ave. from Library to Goodman (CD 6)
8. Fire Station #50: Bluegrass from Keeneland to Furlong (CD 6)
9. Singing Hills Recreation Center: Gillarel Springs from Old Ox to Cul-de-Sac (CD 8)
10. Polk Wisdom Library: Deerwood from Library to S. Polk (CD 8)

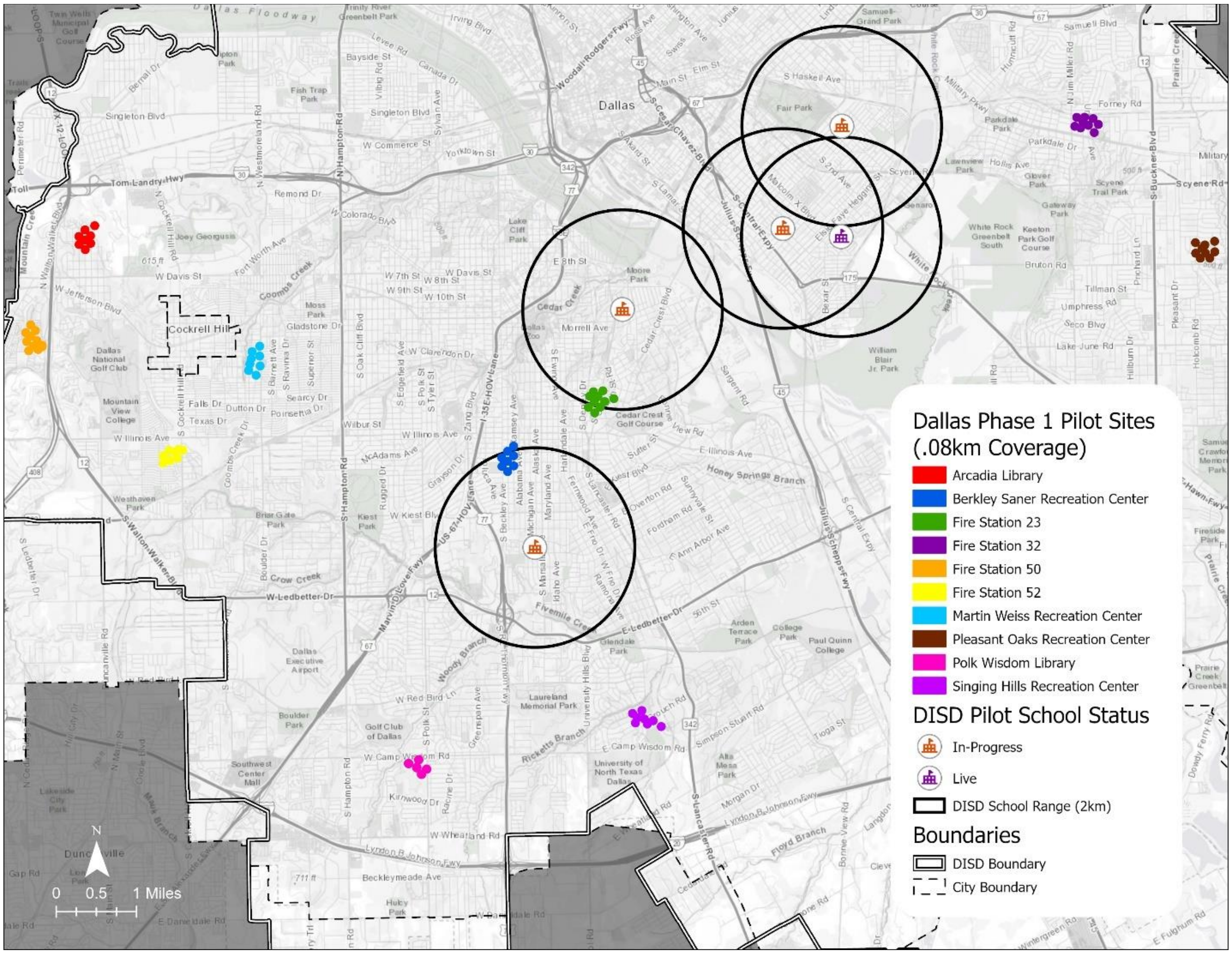
The network is a Wi-Fi wireless mesh network with five to 10 outdoor access points in each of the areas. Access points are mesh routers manufactured by ARRA. Wi-Fi access points are installed on City-owned poles, installed for this purpose. Poles are metal poles built by CommScope , as well as wooden poles in neighborhoods where there are wooden utility poles, and fully integrated solar powered ClearWorld smart poles.

The mesh network is operating on a 5 GHz band using 60-degree directional antennas between the points, with signals from access points to public at 2.4 GHz.

Backhaul to the areas is either with Charter cable modem circuits operating at best effort, usually 600 to 700 Mbps, or mobile broadband connections using Cradlepoint routers. The intent is to upgrade the backhaul to fiber, as the pilot continues. As of the date of this report, all but the Singing Hills location have been moved to the Charter cable modem services.

Devices on the poles are solar-powered, with battery backup. The devices appear to be working with low power draw at the moment, but if equipment is added at the pole, such as other City equipment or additional radios, the backup time may be reduced.

Figure 99: City of Dallas Pilot Locations



Backhaul and pole installation were done to provide a rapid proof of concept; different choices may be made if time permits—such as fiber backhaul and use of Oncor utility poles instead of purpose-built poles.

In this proof-of-concept phase, residents in the area would connect using their own Wi-Fi-enabled devices. Neo conducted an analysis to determine where a minimum level of -70 dBm signal strength would be available, in order to estimate a margin to take into account building penetration.

Speed currently is capped at 50 Mbps downstream, 5 Mbps upstream, for the pilot service. The pilot has not tested network authentication, with the network currently appearing as an open network to any Wi-Fi device in range, and the same login and password used for all users. It also has not yet tested the ability to have different rate limits and parental controls for different users, this functionality relies on separate services not budgeted in the initial implementation.

Neo has not tracked the number of users to connect to the network—the common login and password makes this impossible at the moment. Drive testing or in-home testing have not taken place yet.

According to Neo, availability of the Wi-Fi access points and the backhaul connections has been approximately 98 percent. Issues found in the network so far include susceptibility to the backhaul circuits “locking up” in the event of power failure, requiring the pilot team to manually visit the sites and restart all of the access point devices. The City is addressing this issue by placing uninterruptible power systems (UPS) at the sites with mobile wireless connections, to keep power up and reboot the devices remotely if necessary.

The second pilot was completed by City contractors. Locations were selected in 10 priority zones consistent with the findings of the Mayor’s Task Force on Safe Communities, as well as in strategic lighting zones which take into account factors such as the Market Value Analysis, and areas of racial and ethnically concentrated poverty.

Initial locations are listed below, identified by Council District (CD):

1. Thurgood Marshall Recreation Center: Ariel from Mark Trail to Dove Creek (CD 3, LIA and SLZ),
2. Fire Station #38: Cicero from Wilhurt to Ann Arbor (CD4, LIA, MTF, and SLZ),
3. Eloise Lundy Recreation Center: Denley from Hutchins to Reverend CBT Smith (CD 4, MTF and SLZ),
4. Fire Station #5: Corvette from Bruton to Limestone (CD 5, LIA, MTF, and SLZ),
5. Janie C. Turner Recreation Center: Ezekial from Elam to Hoode (CD 5, LIA, MTF, and SLZ),
6. Mattle Nash Myrtle Davis Recreation Center: Bayside from Hampton to Puget (CD 6, LIA and SLZ),
7. Juanita J. Craft Senior Center: Frazier from Spring to Marshall (CD 7, LIA, MTF, and SLZ),
8. Skyline Library: Symphony from Everglade to Snowbird (CD 7, LIA, partially in MTF, and SLZ),
9. Fire Station #40: Kirnwood from Cul-de-Sac to Cul-de-Sac (CD 8, LIA, MTF, and SLZ),
10. Fire Station #54: Pinebrook from Bonnie View to Strawberry Trail (CD 8, LIA and SLZ).

This pilot included the installation of streetlights with fiber optic installation from adjacent City facilities to wireless access points (WAP) on the streetlights installed on the selected blocks.

5.4 Recommendations for data evaluation and tracking

Both the DISD and City pilots are in process. It is important to continue to use these pilots as an opportunity for evaluating technical and business processes, including:

- Technical performance in actual user situation—with the applications (software) that will actually be used, with a range of likely user hardware (user devices, hotspots, access points, extenders, indoor and window mounted), in the actual environment of use (indoor, in different places in the house), and with the full, envisioned loading of the network
- Business and operational processes, with actual users, connection to network, customer help desk, repair and maintenance processes, installation processes, and interactions with other entities involved (e.g., pole owner, backhaul provider)—both to evaluate feasibility and to estimate the cost to scale and operate a potential full-size network

5.4.1 Technical evaluation

Technical evaluation may start with initial connection and demonstrations but should include development and fulfillment of a detailed test plan that will identify strengths and weaknesses that will enable the City to develop specifications and cost estimates for a network at scale.

A comprehensive technical evaluation test plan includes:

- Numerical performance parameters measured with user equipment—speeds, latency, and jitter
- Range of end-user equipment—laptops, smart phones, tablets, internet of things machines
- Range of environments—in-house, outdoors, in rooms where public and users will be
- Qualitative assessment using actual applications—Zoom, video streaming
- Stress testing to determine scalability—with individual wireless network segments fully loaded, and/or use of traffic generation equipment
- Backhaul configurations—including the use of leased circuits, incorporation of connection through intermediate locations such as City sites, use of routing and switching configuration
- Network management—determining how to best monitor and manage performance, how to provision new users, how to troubleshoot, and how to assign different levels of service and access to different users—verifying operation of network management, provisioning, and authentication tools

- Security—ascertaining the vulnerability of the network to external attempts to shut it down or damage it, physical security of devices, degree of security of information of individual users and warnings and safeguards that need to be provided to users

Tests can be done in a wide range of ways, including using customized versions of the speed test used in Section 3.3. In equipment provided by DISD or the City, scripts can be installed to automatically test the connections at regular intervals.

Wireless technology has great advantages, such as (in many settings) speed to deploy, and great flexibility. However, the flip side is that wireless is significantly less predictable than a wired network because performance changes radically with line of sight and loading. Additionally, technologies like Wi-Fi that are widely available and work off the shelf, need to be adequately equipped with the necessary management and security functions when they are providing a mission critical service or when individuals rely on them as their main internet service—while in carrier network technologies like CBRS these may be included, in Wi-Fi they are often add-ons that need to be added explicitly.

A citywide Wi-Fi model for ubiquitous service is untested and thus represents unknown risks to the City in such areas as execution and operations, until these are demonstrated in the pilot. In particular, we are concerned that Wi-Fi antennas mounted outdoors may not provide consistent service to Dallas residents inside their homes and are concerned that large Wi-Fi mesh networks may not deliver consistent performance if a user is more than a few “hops” from the connection to the internet.

5.4.2 Business evaluation

Operating and sustaining a network can be complex. To the extent the network is operated by internal City and DISD staff, operations will require a standardized procedure to install or activate a user, customer support help desk, and a maintenance team. It will require education of users and an ongoing outreach to the users. It will require staff to access equipment on poles, towers, or rooftops, it will require an ongoing relationship and agreements with pole or facility owners, as well as the operators of backhaul networks. It will require training of staff who handle all of these areas.

There will need to be an evaluation of the likely lifetime of components and the need to replace or upgrade them.

All of the various operational components will need to be specified and assigned either to the appropriate part of the City/DISD or to a contractor or partner. If a responsibility is assigned to a contractor or partner, it needs to be spelled out in a sufficiently detailed way that the work can be bid out competitively.

One of the key parts of the business evaluation should be a complete analysis of the costs of all labor and materials in order to define a business model.

5.5 Candidate wireless design and cost estimates

Starting with the equipment specifications of the DISD pilot at Lincoln High School, we developed five models to estimate the effectiveness and costs of expanding the pilot concept to other parts of the City by adding antennas to the rooftops of additional DISD buildings. In our modeling we used the rooftops of all 282 DISD schools as potential radio locations and determined the maximum number of potential subscribers that could be served under different parameters. (The addition of other publicly owned rooftops and other infrastructure, including that of the city of Dallas and the county, would further extend the potential of the network and improve coverage.)

The first two models are for DISD families. The third, fourth and fifth models are for all City residents. In all models we use DISD rooftops, both because the model is proven in the DISD pilot and because DISD buildings have fiber connections that are necessary to connect the antennas to the internet.

We used the DISD Community Resource Index (CRI), a tool created by the Child Poverty Action Lab, as one tool to help establish prioritization for Model 2; CRI was designed to inform investment decisions and resource allocations because it measures various characteristics of Dallas neighborhoods, such as education, economics, and health.[25] We considered the areas where broadband-level speeds are not available everywhere, and that have seen less investment in fiber by the incumbent providers, for Model 3. We also considered the City of Dallas Office of Equity and Inclusion's Covid-19 risk score data in Model 4; within that framework, Risk 5 areas have the highest risk, followed by Risk 4 and so on.[26] In Model 5 we considered reaching all residents reachable from DISD rooftops in areas with a Community Resource Index (CRI) score under 40.

The five wireless infrastructure models we developed are:

- Model 1: All DISD families are potential subscribers
- Model 2: Only DISD families who can be connected from schools with a Community Resource Index (CRI) score under 40 are potential subscribers

[25] "DISD Community Resource Index," Child Poverty Action Lab, https://childpovertyactionlab.org/disd-cri (accessed May 2021).
[26] Covid-19 risk score description and methodology, Office of Equity and Inclusion, City of Dallas, https://dallasgis.maps.arcgis.com/home/item.html?id=186b98f0fab940118dbd9a4422db7eaa&view=table&sortOrder=desc&sortField=defaultFSOrder#overview (accessed April 29, 2021).

- Model 3: All City residents (DISD families and others) in areas that have seen less existing broadband infrastructure are potential subscribers
- Model 4: All City residents (DISD families and others) in City-designated Covid Risk 5 areas are potential subscribers
- Model 5: All residents (DISD families and others) in Dallas using DISD rooftops in areas with a Community Resource Index (CRI) score under 40

These models were used to estimate the greatest number of eligible households that could be reached using different target areas and selection parameters. These data are intended to help DISD and the City compare options for deploying a wireless network for student households and/or other residents.

5.5.1 RF coverage modeling methodology and assumptions

For the purpose of our analysis, we modeled radio frequency (RF) coverage using CloudRF propagation software. The software was chosen because of its ability to output accurate coverage maps in a GIS layer than can be overlaid on the unserved address points, and therefore identify which of the addresses would be covered by the wireless model. CloudRF uses a sophisticated model that considers terrain and ground clutter such as trees, vegetation, and buildings.

The industry uses a wide range of propagation models used RF analysis. Widely used models include the line of sight (LOS) model, cost 231 model, Okumura Hata model, and Longley-Rice model (also called the Irregular Terrain Model, or ITM).

For our analysis we used ITM, which is the most conservative model and takes into consideration the atmospheric conditions, the ground elevation, the deployment environment, the obstacles between the base and mobile stations, and the ground clutter.

Additional modeling assumptions:

- Channel bandwidths used are 40 MHz for the CBRS GAA band.
- The CBRS band equipment operates at the maximum allowed power.
- 10 dB of fade margin was included. Fade margin is defined as the difference between receiver signal strength and receiver sensitivity. Fade margin accommodates additional miscellaneous losses which might occur.
- 13 dB of loss was assumed due to building material absorption.
- Assumed receiver antenna gain of 8 dB.

- Access point antennas were placed at 60 feet height. We assumed each DISD school rooftop would accommodate a small mounting structure on the main roof level allowing antenna heights to be 60 feet.
- Ground elevation and clutter resolution were 30 meters—therefore this model takes into consideration any obstacles or clutter of up to 30 meters in size.

5GHz modeling assumptions (Model 5 only):

- We assumed that the 5 GHz band can reach the same distance as CBRS, providing greater capacity but within the same coverage area.
- We assumed 80 GHz of bandwidth in the 5 GHz band to provide the additional capacity.
- From a technical perspective, this deployment (5 GHz plus CBRS) can theoretically serve three times the number of addresses as CBRS alone. But to be conservative, we assumed that this deployment would serve only two times the number as CBRS alone.

We based our analysis on the following assumptions:

- We considered all DISD school rooftop locations in our analysis.
- We eliminated those DISD rooftop locations that could not reach 33 or more addresses, because we defined those locations as reaching too few addresses to be cost-effective.
- Assuming a three-sector site, a 40 MHz CBRS channel has the capability to serve 768 addresses with 25/3 Mbps capacity. With 60 percent market penetration, the maximum number of addresses in the service area is 1,280 addresses. A 60 percent penetration was chosen for the model because it is assumed that some number may not be eligible or may have service from other sources (e.g., AT&T or Charter). In Model 5, as noted above we add 5 GHz wireless antennas to serve additional addresses from each rooftop.
- Assumed 64 QAM and 2x2 MIMO for DL and 16QAM and 1x1 MIMO for UL.
- Assumed that for any DISD school rooftop that covers more than 768 addresses the additional number of addresses can be offloaded to neighboring DISD school rooftops, and there is sufficient overlap between all DISD rooftop locations.
- Unit pricing is based on industry pricing from various suppliers.

We note that these are high-level models based on scaling the networks built during the pilot. Because the CBRS technology is new and its use is just beginning—and it is open to other service providers and the public—it is possible that interference with other providers in the future will reduce the performance of the network and/or the number of DISD families and City residents who can effectively be served. We also note that CBRS has not yet been operated in a network that seeks to serve the majority of a large city, and caution that an actual deployment take into account the possible need to place more antennas and/or use other spectrum options in the event of interference or network overload.

5.5.2 High-level coverage and cost estimates by model

The following tables illustrate the estimated capital and operating costs for the models, as well as key parameters for each.

Table 24 summarizes the estimated capital costs for each model.

Table 24: Estimated Fixed Wireless Capital Costs

Model	Number of DISD Rooftops	Homes Served	Capital Cost	Average Cost per Home Served[27]
1: DISD families – All schools	210	74,500	$38,173,800	$854
2: DISD families – schools with CRI < 40	107	44,800	$20,993,280	$781
3: All City residents in areas with less existing broadband infrastructure	148	28,235	$21,870,831	$1,291
4: All City residents in Covid Risk 5 areas	5	774	$893,664	$1,924
5: All residents who can be served from schools with CRI<40	107	106,721	$56,156,064	$877

Note: The capital cost model assumes a 60 percent penetration rate, which is likely in an area with no other broadband option.

[27] Assumes60 percent penetration. Includes $350 per household served for installation and customer premises equipment.

Table 25 summarizes the estimated operating costs for each model.

Table 25: Estimated Fixed Wireless Operating Costs

Model	Number of DISD Rooftops	Homes Served	Annual Cost	Average Cost per Home Served[28]
1: DISD families – All schools	210	74,500	$4,334,500	$97
2: DISD families – Schools with CRI < 40	107	44,800	$2,548,250	$95
3: All City residents in areas with less existing broadband infrastructure	148	28,235	$2,265,725	$134
4: All City residents in Covid Risk 5 areas	5	774	$453,040	$976
5: All rooftops – CRI<40	107	106,721	$8,424,700	$132

Model 4, while having significantly lower capital costs, has higher average distribution costs and operating costs per address compared to Model 1 and 2 due to the cost of the wireless equipment compared to the number of locations that can be served, and the fact that such a small network has few economies of scale. Model 4 served roughly 1 percent of the number of locations that can be served by Model 1 at roughly 3 percent of Model 1's capital costs. However, Model 4's average distribution cost per address is more than three times the cost and the operating cost per address is almost six times that of Model 1's average. Model 5 extends service to all City residents reachable from DISD rooftops in areas with a Community Resource Index (CRI) score under 40.

5.5.2.1 Model 1: All DISD family addresses and all DISD school locations

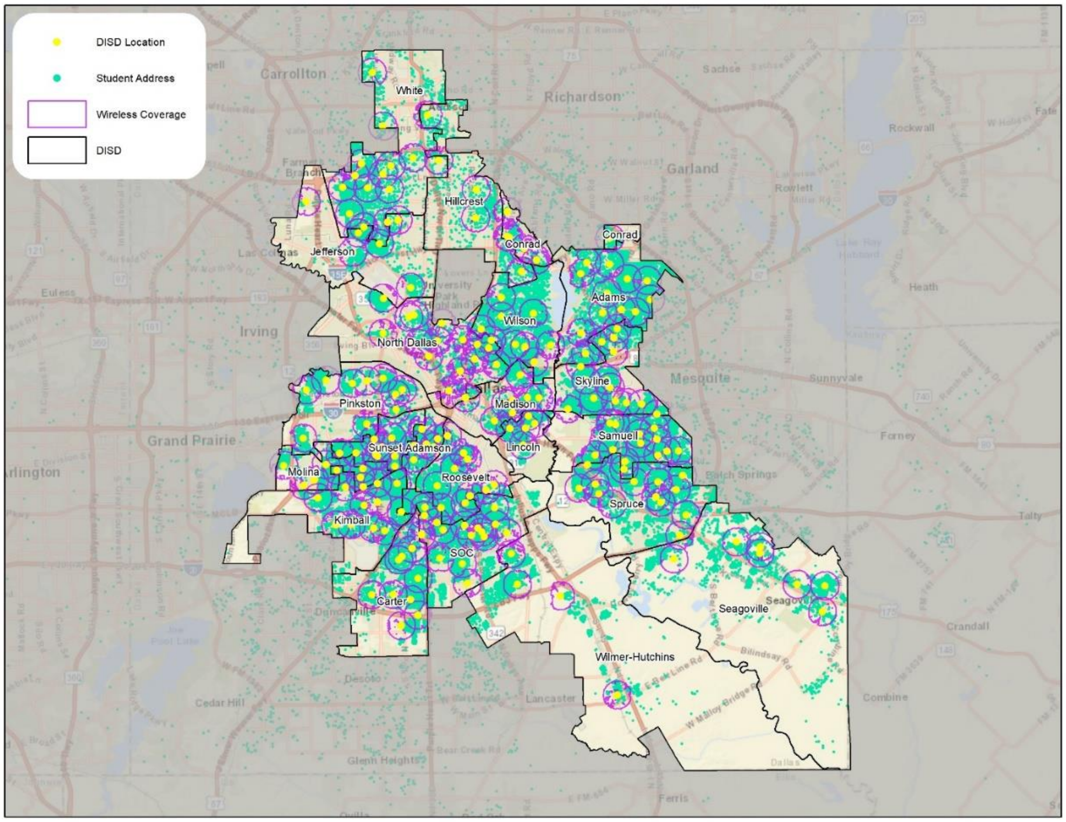
Model 1 seeks to serve as many DISD student families as possible, as broadly as possible across the City. This is the most comprehensive model, and in turn also the most expensive model.

Analyzing DISD family address points, 210 DISD locations were identified to serve at least 33 DISD family addresses each and thus be able to reach more than the minimum number of addresses to justify construction. Base stations and antennas deployed to those 210 DISD locations could collectively deliver service to about 74,500 addresses, or an estimated 76 percent of all DISD family addresses. (Figure 100) Although 21 schools exceeded the optimal 768-user limit on the specified radio equipment, many students live in overlap areas of multiple schools. This may help address any overload of the radio equipment.

[28] Assumes 60 percent penetration.

We also overlaid a map of DHA properties on the Model 1 coverage map and found that 410 of 522 buildings are within the service contours—which corresponds to an additional 2,584 households that could be served by this model.

Figure 100: Model 1 Coverage and DISD Locations



As illustrated in Table 26, Model 1 can serve an estimated 74,500 addresses, or 76 percent of all DISD family addresses in the district.

Table 26: Model 1 Predicted Coverage (All DISD Family Addresses)

Addresses	Estimate
Total DISD family addresses	96,897
Total DISD family addresses served	74,500
DISD family addresses not served	22,397
Percent of addresses served	76%

Table 27 provides a high-level capital cost breakdown for Model 1's distribution network, which would cost approximately $303 per address.

Table 27: Capital Cost Estimate for Model 1

Item	Cost
Network Core	$200,000
Access Point Equipment[29]	$2,362,500
Backhaul Electronics and Networking	$8,400,000
Engineering and Design[30]	$1,076,250
Site Preparation[31]	$10,500,000
Total Distribution Network Costs	$22,538,750
Total Addresses	74,500
Cost per Address (Distribution Network Only)	$303

Table 28 provides the total cost estimate for Model 1 per address at 60 percent penetration (taking into account the customer premises equipment at the home and assuming 60 percent of eligible addresses take the service). The incremental premises cost represents the cost of CPEs and their installation. The total cost, including the distribution network and CPEs, would be an estimated $854 per address.[32]

Table 28: Total Cost Estimate for Model 1 at 60 Percent Penetration Rate

Item	Cost
Number of addresses at 60% penetration	44,700
Total cost (60% penetration)	$38,173,800
Total cost per unserved location (60% penetration)	$854

5.5.2.2 Model 2: All DISD family addresses and DISD school locations with CRI<40 and their feeders

Model 2 provides service to all DISD families served by schools with a CRI score under 40. While this model still uses the entire district as its target area, Model 2 may allow DISD to focus its resources on serving students in greater need.

Analyzing DISD family address points, 107 DISD locations (with CRI<40 and their feeders) were identified to serve at least 33 DISD family addresses each. Base stations and antennas deployed to those 107 DISD locations could deliver service to about 44,000 addresses, an estimated 46 percent of DISD family addresses. Eleven schools exceeded the optimal 768-user limit on the

[29] Assumes an average access point cost of $3,750, with a buffer to reflect the variability of pricing by model.
[30] Calculated as 10 percent of the cost of access point equipment and backhaul electronics and networking.
[31] Includes site walks for candidate selection, preparation of structural drawings, and other typical costs.
[32] Cost per address is higher here than in Model 2 due in part to the proximity and clustering of served locations around available rooftops where access point antennas will be mounted.

radio equipment; however, many students live in overlap areas of many schools. This may help address any overload of the radio equipment. The following map illustrates the model.

Figure 101: Model 2 Coverage and DISD Locations

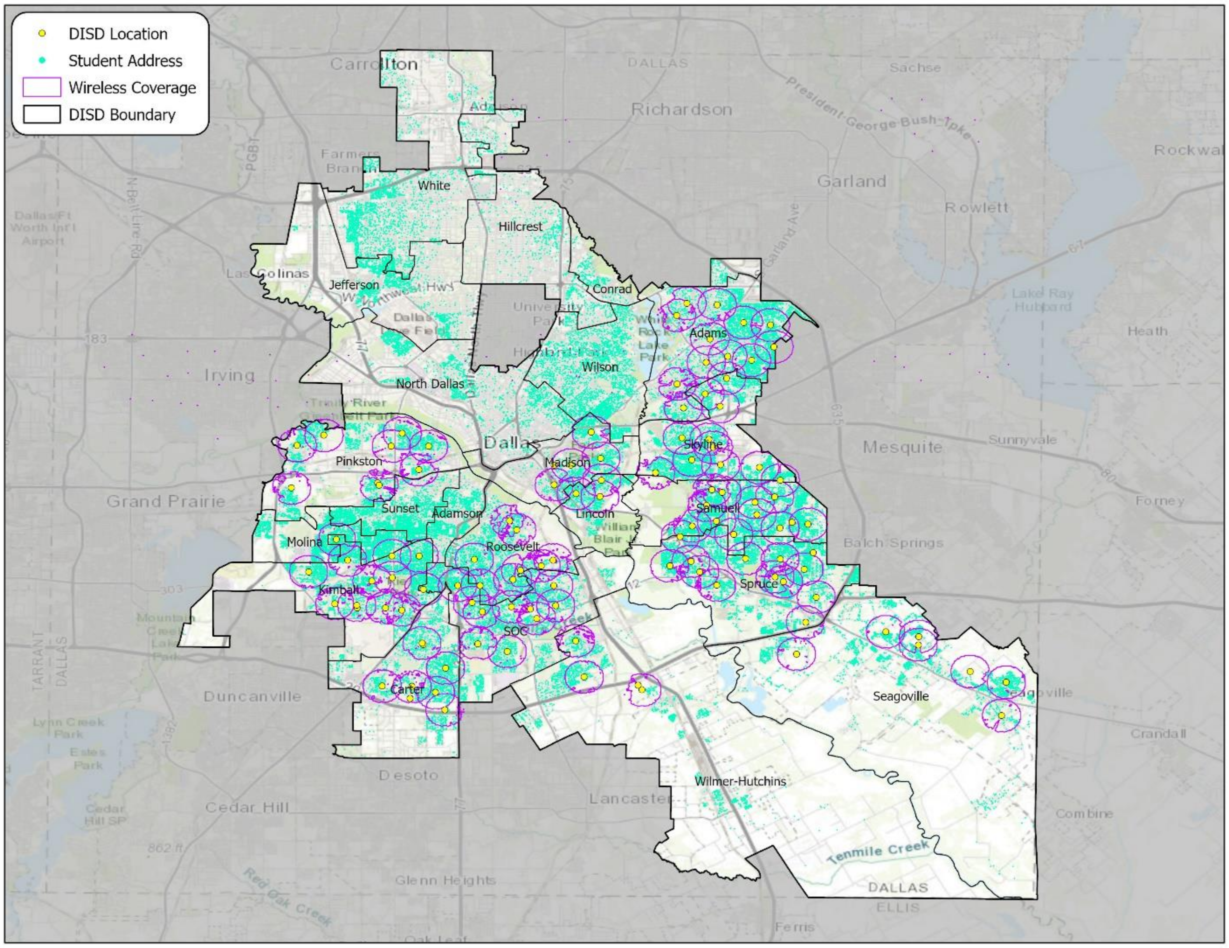


Table 29 indicates the coverage of all DISD family addresses. Model 2 can serve an estimated 44,000 addresses, or 46 percent of all DISD family addresses.

Table 29: Model 2 Predicted Coverage (All DISD Family Addresses)

Addresses	Estimate
Total DISD family addresses	96,897
Total DISD family addresses served	44,800
DISD family addresses not served	52,097
Percent of addresses served	46%

Table 30 provides the high-level capital cost breakdown for Model 2's distribution network. It costs approximately $259 per address.

Table 30: Capital Cost Estimate for Model 2

Item	Cost
Network Core	$200,000
Access Point Equipment	$1,203,750
Backhaul Electronics and Networking	$4,280,000
Engineering and Design	$548,375
Site Preparation	$5,350,000
Total Distribution Network Costs	$11,582,125
Total Addresses	44,800
Cost per Address (Distribution Network Only)	$259

Table 31 provides the total cost estimate for Model 2 per address at 60 percent penetration. The total cost, including the distribution network and CPEs, would be an estimated $781 per address.

Table 31: Total Cost Estimate for Model 2 at 60 Percent Penetration Rate

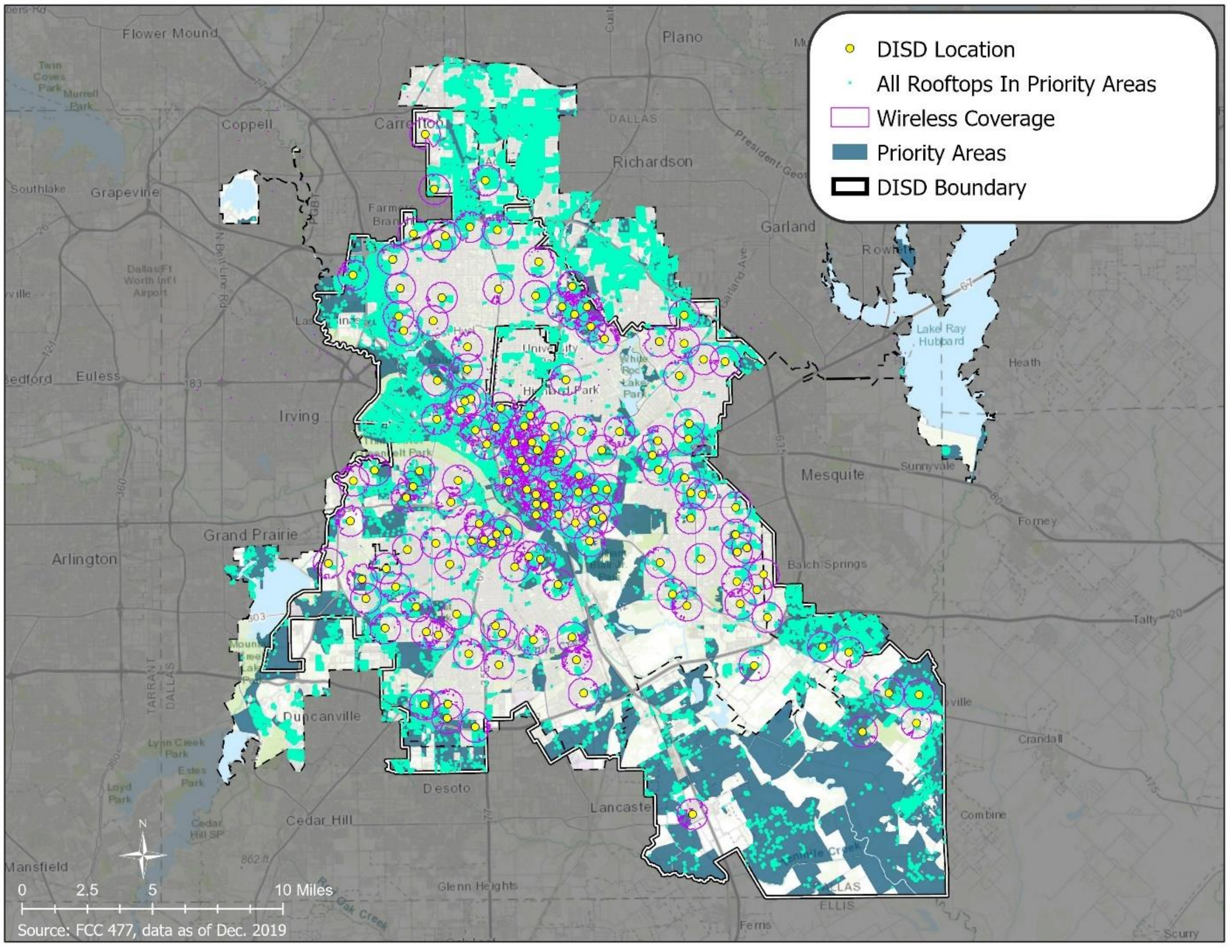
Item	Cost
Number of addresses at 60% penetration	26,880
Total cost (60% penetration)	$20,993,280
Total cost per unserved location (60% penetration)	$781

5.5.2.3 Model 3: All City residents in areas with less existing broadband infrastructure and all DISD school locations

Model 3 provides service to all City residents in areas with less existing broadband infrastructure. We used Microsoft's open use building footprint dataset[33] to estimate the number and location of all addresses within these areas; 148 DISD locations were identified to serve at least 33 addresses each. Base stations and antennas deployed to those 148 DISD locations could deliver service to about 28,235 addresses, an estimated 40 percent of all addresses in these areas. Three schools exceeded the optimal 768-user limit on the radio equipment; however, many students live in overlap areas of many schools. This may help address any overload of the radio equipment. The following map illustrates the model.

[33] https://blogs.bing.com/maps/2018-06/microsoft-releases-125-million-building-footprints-in-the-us-as-open-data

Figure 102: Model 3 Coverage and DISD Locations



The table below indicates the coverage of all addresses in areas with less existing broadband infrastructure.

Table 32: Model 3 Predicted Coverage (All Addresses in Areas With Less Broadband Infrastructure)

Addresses	Estimate
Total addresses	70,393
Total addresses served	28,235
Addresses not served	42,158
Percent of addresses served	40%

The table below shows the high-level capital cost for Model 3's distribution network. It costs approximately $565 per address.

Table 33: Capital Cost Estimate for Model 3

Item	Cost
Network Core	$200,000
Access Point Equipment	$1,665,000
Backhaul Electronics and Networking	$5,920,000
Engineering and Design	$758,500
Site Preparation	$7,400,000
Total Distribution Network Costs	$15,943,500
Total Addresses	28,235
Cost per Address (Distribution Network Only)	$565

The table below provides the total cost estimate for Model 3 per address at 60 percent penetration. The total cost, including the distribution network and CPEs, would be an estimated $1,291 per address.

Table 34: Total Cost Estimate for Model 3 at 60 Percent Penetration Rate

Item	Cost
Number of addresses at 60% penetration	16,941
Total cost (60% penetration)	$21,870,831
Total cost per unserved location (60% penetration)	$1,291

5.5.2.4 Model 4: All Covid Risk 5 addresses and all DISD school locations

Because this model seeks to reach all families in the target areas, we used Microsoft's open use building footprint dataset[34] to estimate the number and location of all addresses within the Covid Risk 5 areas. Five DISD locations were identified, serving at least 33 addresses each inside Covid Risk 5 areas. The schools utilized in this model are:

- Barack Obama Male Leadership Academy
- South Oak Cliff High School
- A. Maceo Smith New Tech High School
- Clara Oliver Elementary School
- J. P. Starks Math, Science and Technology Vanguard

[34] https://blogs.bing.com/maps/2018-06/microsoft-releases-125-million-building-footprints-in-the-us-as-open-data

Base stations and antennas deployed to those five DISD locations could deliver service to an estimated 720 addresses in Covid Risk 5 areas. We also found the same locations could serve an estimated 54 addresses in Covid Risk 4 areas. The following map illustrates the model.

Figure 103: Model 4 Coverage and DISD Locations

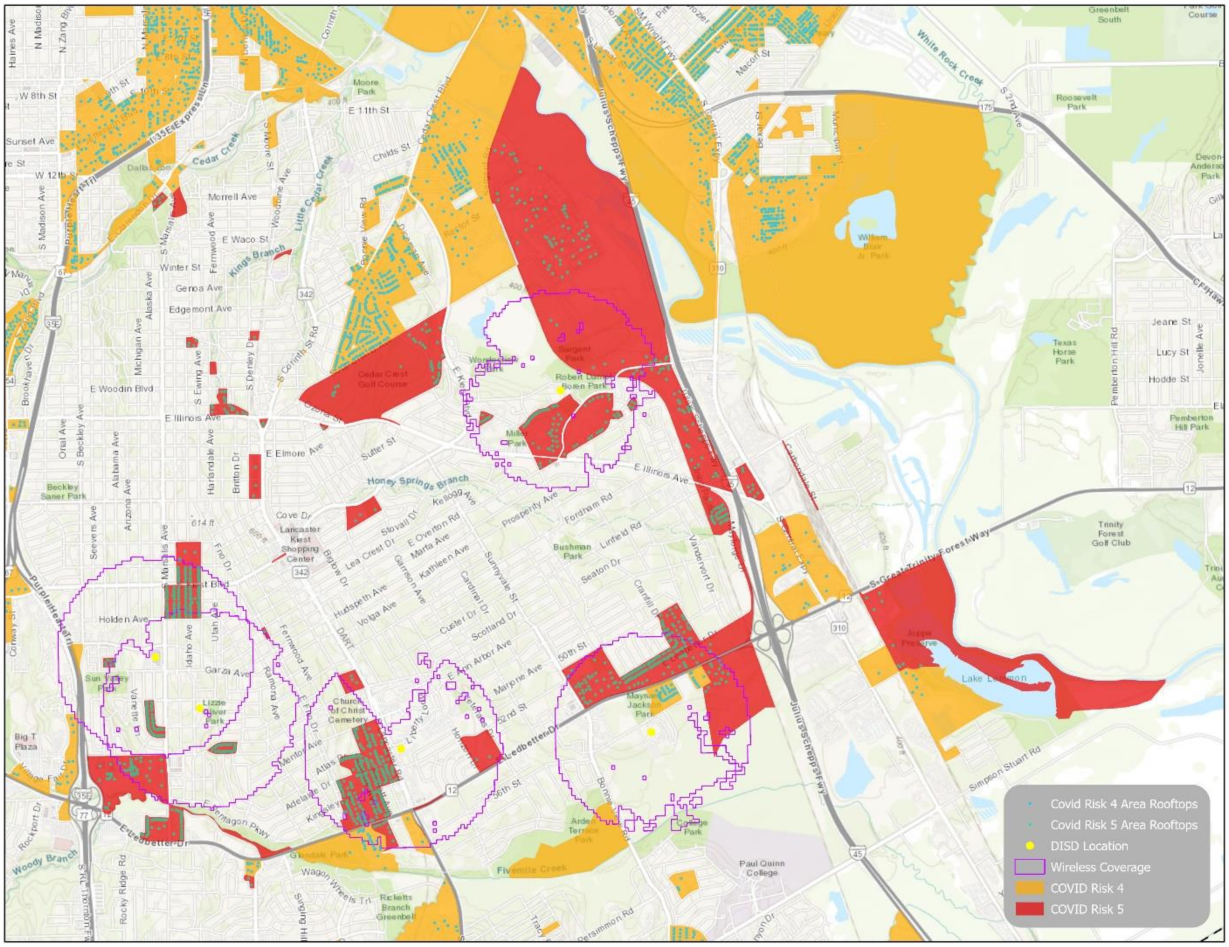


Table 35 provides the high-level capital cost breakdown for Model 4's distribution network. It would cost an estimated $946 per address.

Table 35: Capital Cost Estimate for Model 4

Item	Cost
Network Core	$200,000
Access Point Equipment	$56,250
Backhaul Electronics and Networking	$200,000
Engineering and Design	$25,625
Site Preparation	$250,000
Total Distribution Network Costs	$731,875
Total Addresses	774
Cost per Address (Distribution Network Only)	$946

Table 36 provides the total cost per address for Model 4 at 60 percent penetration. In this model, the total cost, including the distribution network and CPEs, would be an estimated $1,926 per address.

Table 36: Total Cost Estimate for Model 4 at 60 Percent Penetration Rate

Item	Cost
Number of addresses at 60% penetration	464
Total cost (60% penetration)	$893,664
Total cost per unserved location (60% penetration)	$1,926

5.5.2.5 Model 5: Reaching the largest number of DISD and other households using DISD locations in areas with CRI<40

Model 5 provides service to a large number of addresses (students and non-students) within Dallas city boundaries using the rooftops of all DISD locations in areas with a CRI score under 40.

For this model, to serve more users, we added additional capacity using the 5 GHz unlicensed band and assumed the coverage ring for 5 GHz band would be same as CBRS. We also assumed that channel size for 5 GHz is 80 MHz, double that of CBRS.

Base stations and antennas deployed to those 107 DISD locations could deliver service to about 106,721 addresses, an estimated 36 percent of all the addresses.

We are assuming that 50 percent of the total addresses would be served by CBRS with indoor customer premises equipment. The remaining 50 percent of addresses would be served using 5 GHz band, with outdoor antennas. This hybrid model is necessary in order to accommodate a larger number of households from each rooftop.

Figure 104 illustrates the model.

Figure 104: Model 5 Coverage and DISD Locations

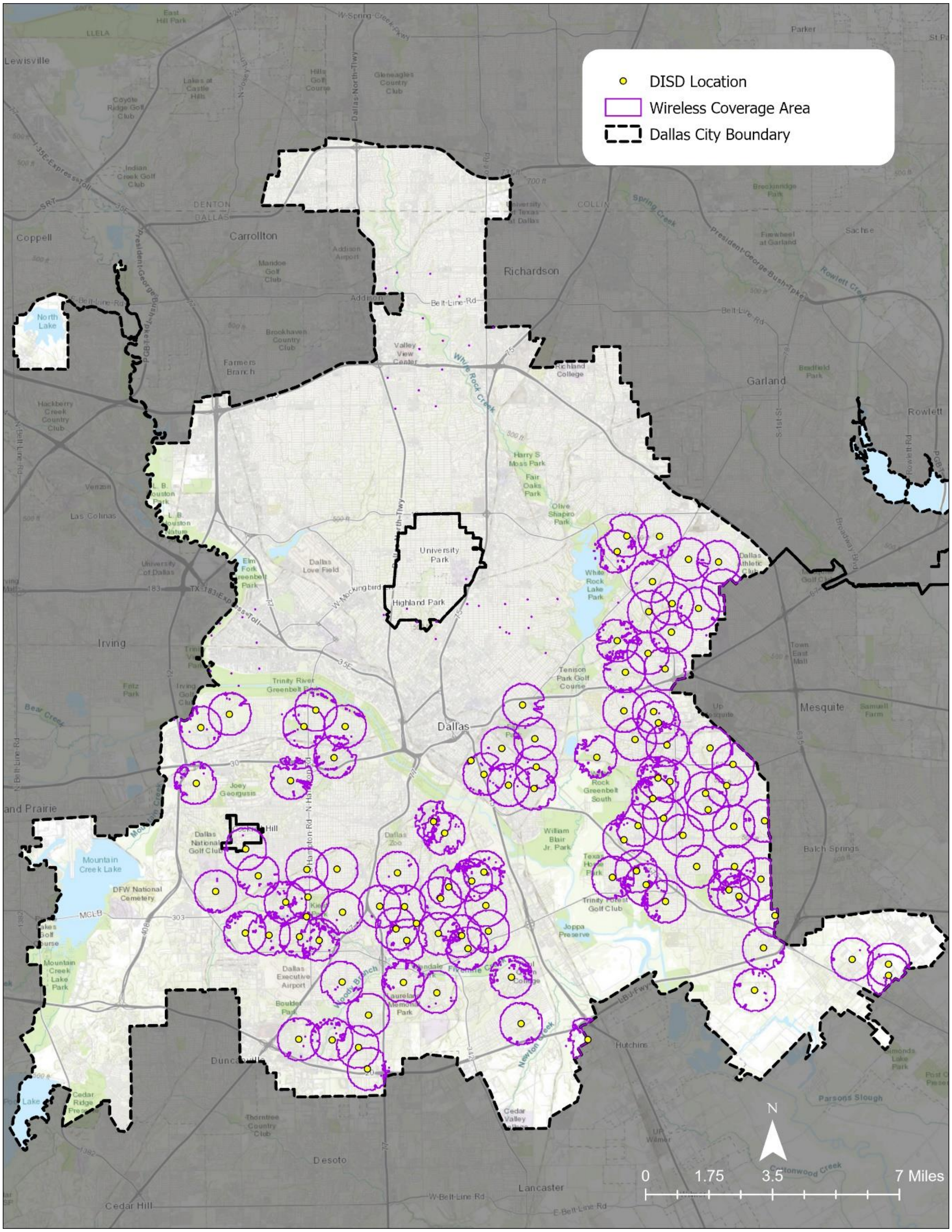


Table 37 indicates the coverage of all addresses. Model 5 can serve an estimated 106,721 addresses, or 36 percent of the addresses in the City.

Table 37: Predicted Coverage (All Addresses)

Addresses	Estimate
Total addresses	295,242
Total addresses served	106,721
Addresses not served	188,521
Percent of addresses served	36%

Table 38 provides the high-level capital cost breakdown for Model 5's distribution network. It costs an estimated $121 per address.

Table 38: Capital Cost Estimate for Model 5

Item	Cost
Network Core	$200,000
Access Point Equipment	$2,407,500
Backhaul Electronics and Networking	$4,280,000
Engineering and Design	$668,750
Site Preparation	$5,350,000
Total Distribution Network Costs	$12,906,250
Total Addresses	106,721
Cost per Address (Distribution Network Only)	$121

The total cost, including the distribution network and CPEs, would be an estimated $877 per address (Table 39).

Table 39: Total Cost Estimate for Model 5 at 60 Percent Penetration Rate

Item	Cost
Number of addresses at 60% penetration	64,032
Total cost (60% penetration)	$56,156,064
Total cost per unserved location (60% penetration)	$877

5.5.2.6 Assumptions underpinning estimated capital and operating costs

Capital cost trends for these five models were consistent with the number of locations served. This is due both to the cost of DISD rooftops and the cost of the CPE for each location. Our analysis makes the following assumptions:

- All served addresses require subscriber equipment. All the subscriber equipment was assumed to be indoor or outdoor (just for Model 5).
- Service will be used by 60 percent of the served locations (i.e., 60 percent penetration).
- Indoor CPE cost is approximately $350
- Outdoor CPE cost is approximately $1000
- DISD rooftop radios will be configured with three sectors.
- Backhaul is provided by fiber optic cabling where it already exists and 11 GHz microwave links otherwise.
- Engineering and design costs include propagation studies, RF path analysis for point-to-point connections, structural analysis, construction plans, and permits. This cost is estimated to be 10 percent of the distribution network costs.
- Site preparation costs include preliminary equipment dimensioning, power needs, shelter requirements, RF suitability, switches, escorts, lease negotiations, and permitting. Actual costs will vary, but the average is approximately $50,000.
- Core network estimates include core network equipment for each solution to manage functions such as authentication, billing, security, and connection to the internet. We estimate $200,000 for costs of equipment and its setup.

Our operating cost estimation considers maintenance and estimated equipment replacement for the distribution equipment at the sites and core. Regular maintenance includes any adds, moves, and changes required. Electronics may need to be replaced at five- to 10-year intervals due both to technological obsolescence and wear and tear—and unlike a fiber network, the electronics comprise almost all of the capital cost of the network, thus significantly increasing the operational cost as a fraction of the total cost of operations. Our model also considers CPE replacement at 10 years, amortizing the cost annually.

We also considered staffing to operate the network including program and network management, network technician and technician training, help desk/customer service, portal/application/access management, general counsel, and some business administration roles for billing and other duties. Staffing requirements were scaled for each of the counties based on the number of estimated towers and users. The model also includes insurance and minimal office expenses.

By utilizing the rooftops of schools DISD already owns, it can avoid paying costly space leasing costs to deploy three sectors of antennas at each site, which could cost approximately $36,000 per site per year.

5.6 Recommendation: If the City deploys wireless services for low-income residents, it should do so at minimal or no cost to users

If the City decides to deploy a wireless service to partially fill its broadband gaps, we recommend a free, rather than paid, service for a number of reasons. First, offering free service entails less operating cost and complexity than a paid service with respect to sales, marketing, billing, collections, and other elements of paid broadband service. Second, given the significant cost barriers associated with low adoption of broadband, a free service has potential for far greater impact than a paid service.

We anticipate that a free service would be provided on a "best effort" basis, without particular service level guarantees, but the program would still necessitate certain operations support to deliver a reliable service and ensure the overall technical success of the initiative.

6 A City-owned fiber optic backbone network would deliver considerable value

Proposed City-owned fiber would greatly benefit City operations and provide the ancillary benefit of supporting digital equity efforts. We recommend the City continue the analysis already underway, taking into account the availability of funds and the nature and geographic distribution of its current and future networking needs.

We further recommend the City develop and refine a “hybrid” approach, with City-driven dark fiber likely a key element of the core and connectivity to many City sites and neighborhoods. In this approach, we envision a mixture of City-built fiber and managed fiber network services at the edge (accompanied by City and other wireless technologies). Approaches such as fiber lease could also be used where high capacity is needed and where it can be cost-effectively provided (but where the flexibility and capability of City-driven fiber is not as necessary).

The current City plan is to start with a fiber backbone between hub points that include key public safety and library locations, with the first stage likely comprising approximately 100 miles. Recently, the City has expanded this concept to a 180-mile network that provides a backbone and links approximately 100 City facilities, as well as approximately 100 locations that address the digital divide and provide Internet of Things connectivity along the route. Compared to acquiring the same fiber through leased services, this project could provide significant long-term operational savings. It would bring fiber to many City buildings, support public safety applications, and, with strategic routing, provide a strong foundation for future digital equity efforts (by bringing fiber into areas that have seen lower levels of fiber investment by private providers).

This section presents a high-level analysis of the City’s efforts so far in planning a fiber network and considers the City’s costs for its current leased services, the cost of building and operating the infrastructure, the value of controlling a fiber asset, and the availability of spare capacity that could assist with economic development.

6.1 The City’s planning efforts to date

Over the past few years, the City developed a plan to align its anticipated future enterprise communications needs with technology investment. The City identified the growing need for video as a main bandwidth driver—driving the need for capacity as well as requirement for quality of service and security (i.e., dedicated circuits, not those shared with the public internet or an intranet).

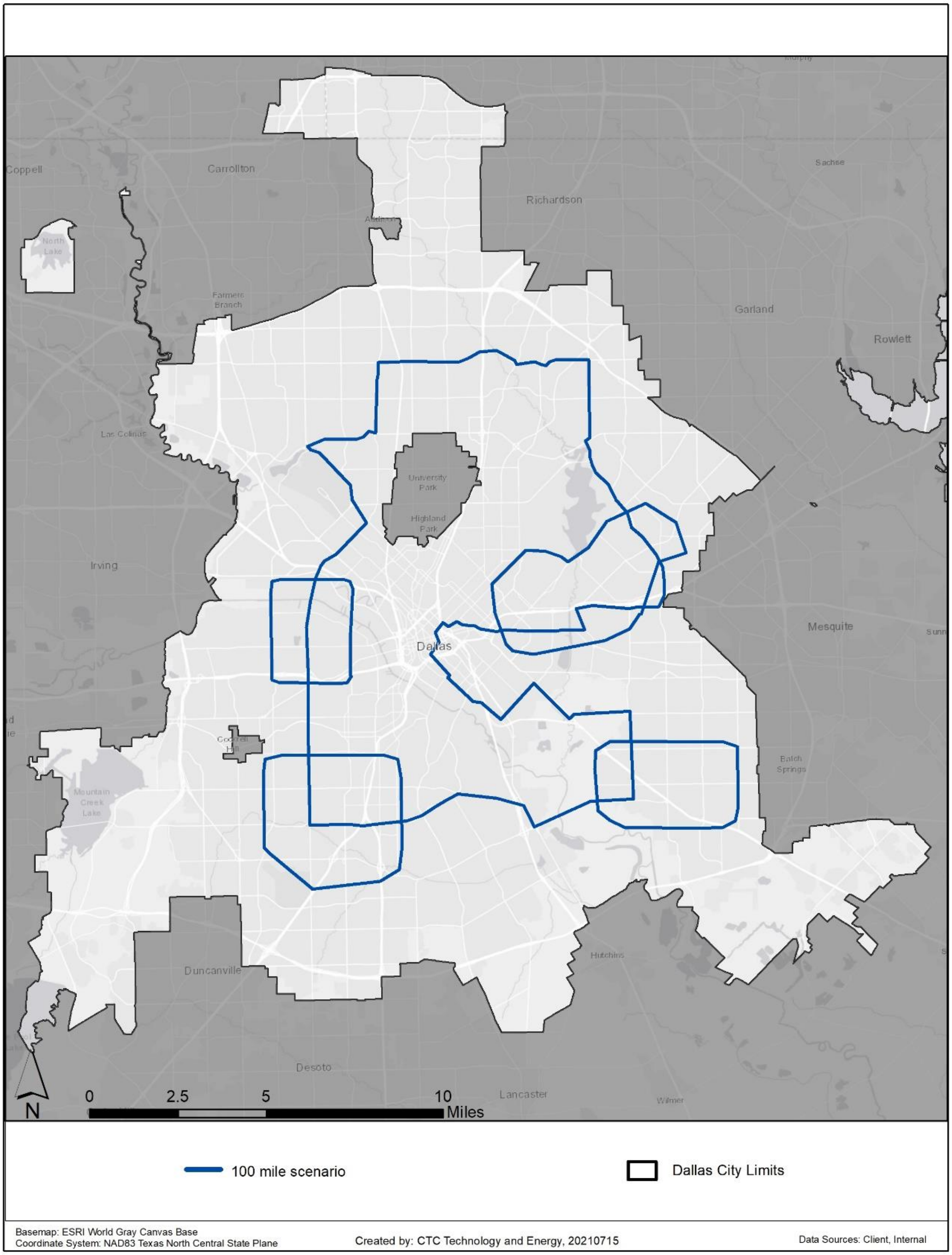
As an example, the City has seen growing demand for interactive video between City locations and from City locations to the internet. The City has also seen a growing need for storing and managing body camera data and anticipates a future need to transfer live video from police in the field.

The City's current practice is for video to be stored in a distributed way because storage in centralized data centers would require high-cost network transport in the core network. Accordingly, the main value of a City-owned fiber backbone would be in that core network, where connections aggregate from the core and distribution sites to the City's two data centers (i.e., City Hall and the former IBM data center). Connectivity to individual sites may continue as a hybrid of City fiber and leased services, based on analysis of upfront and monthly costs; business case and prioritization need to be considered on a case-by-case basis.

Furthermore, the City is beginning to establish Wi-Fi service in neighborhoods to address the digital divide and provide connectivity to City devices such as CCTV (Section 5.3). These areas are currently connected using a range of managed services but can be significantly improved and scaled up using direct City fiber connections, which would improve the performance of the services and provide more flexibility in how devices can be connected.

Figure 105 illustrates one conceptual model of a 100-mile fiber backbone. This design consists of one primary loop totaling 58 miles and four loops to extend further from the city center. With increased fiber mileage, any given location in the City is closer to the fiber, and more locations and applications can be connected.

Figure 105: City of Dallas Fiber Backbone and Rings: a Potential 100-Mile Design



6.2 Building 180 miles of fiber would cost approximately $25 million but could provide significant long term savings as compared to leased services

Recently the City has been exploring the concept of building 180 miles of fiber, which, compared to a 100-mile network, would go significantly farther toward meeting City and digital equity needs. At the request of the City, CTC conducted a financial analysis of building 180 miles of fiber. As we describe below, constructing and connecting 180 miles of fiber would cost approximately $25 million and then entail ongoing operating costs of about $2 million per year (Table 40).

Table 40: Estimated Costs of 180 Miles of Fiber

Item	Cost
Fiber Optic Outside Plant (OSP) Construction	$22,500,000
Network Hardware	$2,000,000
Network Integration and Testing	$500,000
Total Capital Costs	**$25,000,000**
Annual Operating Costs	**$2,000,000**

The City informed us that current pricing for dedicated 10 Gbps transport from AT&T, the City's primary network provider, is $18,000 per month. The City's current vision is that many times this level of capacity will be needed in the coming years for the core network connecting approximately 10 locations that act as aggregation points in the network. Moving out from the 10 locations to approximately 200 facilities, the bandwidth need decreases—so the business case for those connections will depend on the individual site's demand or the demand in that geographic area.

The City analyzed separate use cases, centered around video, to explore the potential costs and benefits of fiber deployment in comparison to leased transport:

- In the first use case—a conservative estimate—30 libraries, each with a projected 1 Gbps capacity need, will have three 10 Gbps circuits in the core, and from the core sites back to the data centers. At current lease fees, that portion of the core data transport would cost more than $50,000 per month for libraries alone.
- In the second use case, centered around Dallas Police Department officers' body-worn cameras, uploading stored camera data (and, in the future, transmitting video in real time in a proactive approach) would require high quality of service, high availability, and high security. Each site would need 1 Gbps or more. With 30 sites, the City would need more than three 10 Gbps circuits in the core—leading to a leased transport cost significantly more than $50,000 per month.

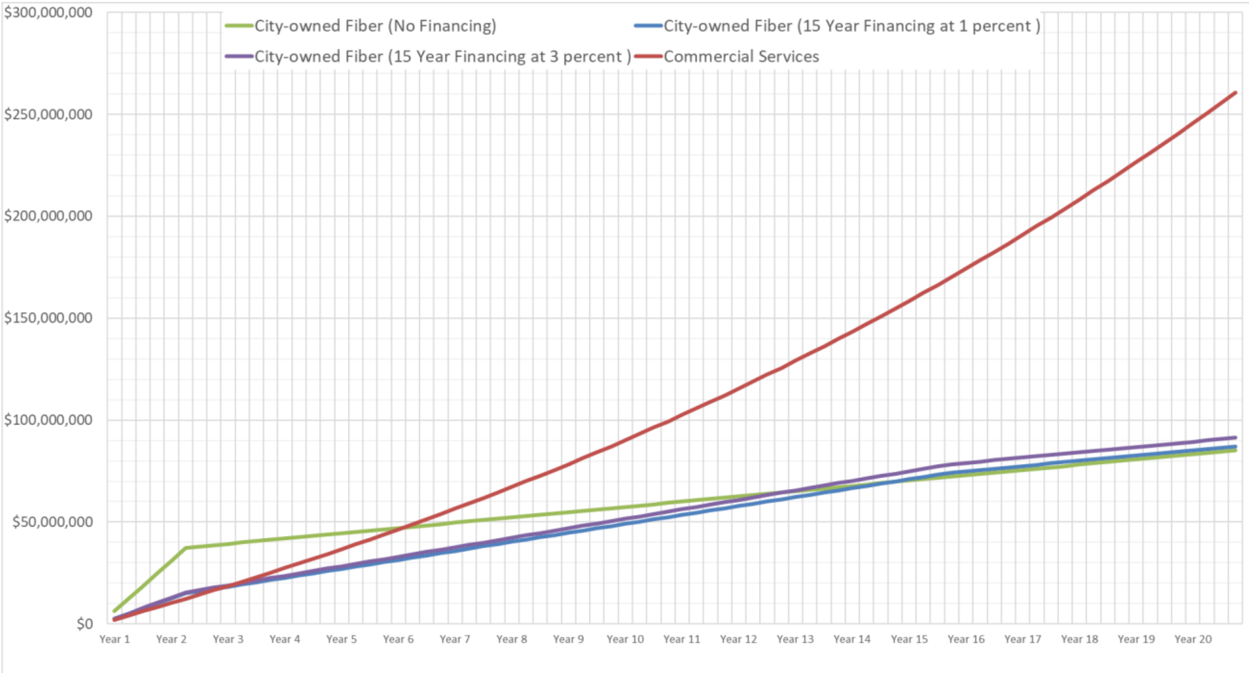
If the City were to consider connecting 200 sites with similar level needs across all agencies, it would need 20 or more 10 Gbps circuits, which would cost $360,000 per month or more than $4 million annually in lease fees for the core alone.

Furthermore, if the City were to connect 100 additional City sites directly to fiber, taking into account expected growth, it would offset the cost of 100 circuits of switched Ethernet service, a total of $164,300 per month, or an additional $2 million per year. Adding 100 further outdoor digital divide and Internet of Things locations would double that amount to $4 million per year. Including the services on the ring, the total offset service amount is approximately $8 million per year.

By comparison, if fiber construction cost $125,000 per mile on average, a 180-mile backbone network (including about five miles of building-entry and lateral fiber to the sites and digital divide locations) would cost $22.5 million. Additionally, network electronics for 10 key hub sites 100 City sites, and 100 digital divide sites (not including wireless equipment or IoT devices) would be approximately $2 million, plus $500,000 for integration and testing. Given a conservative operating cost estimate (including fiber maintenance, location of underground utility lines, incremental staffing, and equipment replacement costs) of approximately 4 percent of construction costs annually ($2.5 million), the City's five-year total cost of operation would be an estimated $37.5 million. The 10-year costs would be approximately $50 million—or less than the cost of seven years of leased backbone networking services.

Figure 106 illustrates models of the cumulative cost of City-owned fiber operated by the City, as described above, under three separate models of City funding (no financing, 15-year financing at 1 percent, and 15-year financing at 3 percent) and compares them on a year-by-year basis to the expected cost of the leased backbone services. The commercial services are assumed to start with twenty 10 Gbps circuits and 200 1 Gbps circuits at the current price and are expected to scale as needs grow (likely including 40 Gbps and 100 Gbps circuits over the course of years) and therefore the approximation is that these costs stay the same. The "no financing" model costs the same as the commercial services after six years, then is significantly less. The financed models track closely to the commercial services costs for the first two years, after which they are also significantly less costly than the commercial service model.

Figure 106: Cost Scenarios for 180 Miles of City Fiber



Constructing this network would also mean having City-owned fiber present throughout the City, including in and near neighborhoods where broadband-level speeds are not available everywhere, and that have seen less investment in fiber by the incumbent providers. Very few parts of the City would be more than one mile from the fiber, and the majority would be significantly closer. In theory, this fiber could be used to broaden service options or allow the City to deliver Wi-Fi or fixed wireless services to residents, akin to the school-based wireless concepts outlined in this report.

Making a detailed determination of the "right" amount of City fiber, choosing among hundreds of potential sites to be connected, and assessing of the appropriate construction timeline is beyond the scope of this analysis. But even the highest-level estimate indicates that an institution with needs that grow into and beyond multiple 10 Gbps transport circuits will outgrow the current model of managed Ethernet network services and make City-owned fiber more competitive.

Further, a City-driven model, if pursued, can and should have excess capacity, since the cost of building the fiber strands for the City's needs is roughly the same as for a network with twice or four times that capacity (given the relatively low cost of the fiber itself). That excess capacity can be used to enable the City's network growth (especially in evolving technologies like internet of things and connecting field and advanced transportation electronics), as well as the City's current need for securely connecting traffic signal devices, and SCADA networks, economic development, and potential fiber leases to recoup some of the build costs.

It bears noting, too, that managed network services (as currently purchased by the City) and City-owned fiber are not the only options for the City. Other options include leasing fiber and conduit from entities that have built fiber in the City, such as UPN, Zayo, and Crown Castle. The cost of fiber lease may be significantly less over time than purchasing a 10 Gbps or other high-speed circuit and could provide that level of capacity, and thus can provide the high speeds needed in the core with a much lower total cost than managed services or fiber construction. That said, a fiber lease would not provide the City with a durable asset of its own, and it would also not provide additional capacity for economic development or revenue creation.

Building 180 miles of fiber can a step toward deeper expansion of City fiber into Dallas neighborhoods. We recommend an architecture that adds additional fiber in rings that connect to the initial backbone, starting with neighborhoods that are the least served by broadband and those with the greatest need for connecting City infrastructure, such as buildings and devices such as police and traffic cameras, traffic signal controllers, and City efforts to address the digital divide. The outcome could be that Dallas residents, especially those in underserved areas, will be close to City fiber.

6.3 Off-the-balance-sheet benefits of a middle-mile fiber network

Another business case consideration is the value the City would derive from having its own fiber, and no longer being restrained by scarce bandwidth (or the high cost of leasing the bandwidth and redundancy necessary to support critical government services). With a middle-mile backbone fiber network the City would be able to meet their future needs as they emerge, and scale to greater speeds without needing to wait to be able to afford the additional bandwidth. Middle-mile fiber offers a mechanism to mitigate the risk that future demands will exceed the capacity of affordable services and contain the associated exposure to unknown future costs.

This is not to say that leased circuits lack any benefits; they do. For example, leased circuits do not require internal staff or contractors to maintain physical fiber optic outside plant; their upfront costs are lower than constructing fiber; and the time to deployment can be shorter.

Leasing, however, has critical disadvantages that make it much less desirable than City-owned and operated fiber, particularly with respect to scalability, network security, continuity of operations, and support of public safety and emergency support services:

- Leased services and fiber infrastructure do not offer total control and management over the network;
- Commercial providers may not allow for direct evaluation of the reliability or availability of a leased circuit, because critical information required for this analysis is generally considered by commercial carriers to be proprietary and confidential;

- Leased services are not independent of the networks used by the public, and are therefore less secure and reliable; and
- Leased services and fiber infrastructure generally cannot offer the customer complete control of network security between end points.

Each of these items is addressed in detail below.

6.3.1 Ownership provides control over facilities and management

A network built upon leased network services obtained from a service provider cannot provide the control and management that is available in network that is owned end-to-end by the City.

Leased network services are in essence a “black box” in terms of control and management. The customers are forced to rely on the provider to maintain and operate the core equipment supporting a leased service (these tasks include configuring the equipment, monitoring the hardware and physical infrastructure, and performing routine maintenance).

The City’s internal connectivity requirements includes video, voice, and data communications. Both voice and video services usually require dedicated bandwidth. Two-way voice and video services require dedicated bandwidth and very predictable transmission delay properties.

In other words, linking two-way radio communications systems or supporting videoconferencing or Voice-over-IP (VoIP) services requires the ability to manage bandwidth across the entire network. Although this functionality can be provisioned on the edge device when using a managed service provider for connectivity, if the City owns and operates its own fiber network, it will have control and capability to increase bandwidth based on its time frame (which will in turn allow the City to properly plan for integration of new applications without an increase in cost for provisioning of new bandwidth). Further, it offers the ability to implement advanced Quality of Service (QoS) mechanisms that are enforced on a network-wide, end-to-end basis.

Under the leased model, each customer must request (and pay for) the private company to make changes in the core of the network for a new application, increase bandwidth, or to implement new policies for enhanced QoS. As an example, Comcast generally offers three tiers of QoS for its Metro Ethernet service offering: “Basic,” “Priority,” and “Premium”—meaning that in the event of congestion in the Comcast network, certain customers’ traffic will have priority over others, and some packets of data may get intentionally discarded by the network switches and routers where the congestion is occurring. This may have minimal impact to standard web-browsing, or even large file transfers over the network where periodic slowdowns can be tolerated, but it may mean dropped calls, unintelligible audio, and/or choppy or frozen video where VoIP and videoconferencing are concerned.

Under the leased model, the City is also not able to control who manages and maintains the core of the network. The knowledge, skill set, and security background of those operating the network is often beyond the control of the City.

With a private fiber optic network, each piece of the communications network is controlled and managed by the City, which may choose to operate the network on its own with internal staff, or outsource the operations to a contractor. Many major American cities (e.g., New York, Boston, Atlanta, Washington, D.C.), large counties, and municipal electric utilities own and operate extensive fiber optic networks. Either way, choices regarding the management of the network stay in the hands of the City—not the cable company or the phone company.

6.3.2 Ownership facilitates high-availability and reliability

The "availability" of a communications link is derived from the probability of a failure within the network between two points and the amount of time it takes to repair a problem. In a leased circuit network, the end user is not aware of all of the potential risks to availability of the network. Several key factors that affect availability, but which generally cannot be determined by the customer of leased services, include:

- Physical diversity in the outside cable plant paths
- Physical diversity in the building entrances
- Physical redundancy in the networking equipment
- Ensuring network equipment is properly configured and regularly tested to take advantage of hardware and link redundancy
- Redundancy for power and HVAC systems necessary to support network electronics
- How many facilities the circuit crosses between endpoints
- Whether the plant is located underground or aerial
- Who has access to the core networking equipment and plant
- The core equipment's age and maintenance
- How the system is monitored and maintained
- The single points of failure in the communications link

Many of the factors can be approximated or relative numbers may be obtained from the leased circuit provider; however for critical services impacting costly business functions or public safety, the approximations and availability estimates from leased network services may not meet the availability requirements of critical traffic network. In the case of physical architecture issues, such as the physical routes of cabling, approximations are not sufficient, and detailed maps are usually considered proprietary and confidential to a commercial provider.

In addition, lessees are subject to the provider's schedule for repair and maintenance of the circuit. Although it may be possible to include provisions in the service level agreement (SLA) for special priority service restoration, it is possible that a provider may not be able to adhere to SLAs during major disaster events, or SLAs may specifically exempt the carrier from meeting their normal obligations during these events. Further, there may be no way to ensure that a leased circuit for a critical site is the first link to be repaired during a major disaster.

A similar problem can arise in both scheduled and unscheduled maintenance of a leased circuit. The timing of these maintenance windows may not correspond to convenient downtimes for the customer. In a City-owned fiber network, maintenance downtimes can be coordinated to minimize impact, and the City can prepare for an outage by adapting operational procedures.

SLAs often guarantee availability and repair time, but typically are not reliable in the event of a major disaster. In addition, service providers usually rely on credits against service fees to compensate for network outages to the network—an unacceptable solution in the case of public safety, where cash cannot compensate for lost service. In other words, SLAs are incentive management frameworks, not actual guarantees against downtime, and SLA providers therefore have a financial interest in prioritizing commercial clients where the loss in compensated credits would be greater, thereby potentially delaying service restoration for public and government clients.

6.3.3 Private fiber networks offer independence from public networks

A privately owned communications network does not rely on physical infrastructure, equipment, or other resources that also carry public traffic for residents and businesses. Shared resources are used by a managed network service provider to reduce their cost by taking advantage of the statistical nature of packet-based data. In other words, commercial carriers intentionally oversubscribe the capacity of their networks to minimize costs (maximize profits), because all of their customers are not likely (statistically speaking) to simultaneously use their services to full capacity all of the time. The advantage of an independent network is that increases in public traffic on the network or public network outages do not impact privately-owned networks.

Only a network provisioned with no oversubscription can guarantee that there is always sufficient capacity to meet maximum demand of all users and applications simultaneously, rather than provisioning based on average utilization. This is less cost-effective for a commercial provider, and tends to drive costs upwards for "dedicated" services. Some leased managed services incur charges on a metered basis for the bandwidth that is used. Typically, these services are only cost-effective when institutions have a specific understanding of their applications' bandwidth requirements. A City-owned fiber network will provide a more reliable, higher capacity, flexible network infrastructure because it is designed to support a broad range of initiatives, and can easily and seamlessly scale to meet new bandwidth requirements.

As is the case in many major public safety incidents, public networks like the Public Switched Telephone Network (PSTN) and the Internet are often overloaded by the amount of traffic on the network. This can lead to busy signals on the PSTN and a lack of connectivity on the Internet. Privately owned networks typically do not experience the same traffic increases, and can be designed to handle any expected traffic increase during a major incident.

A private fiber network can prioritize bandwidth both in the core and at the edge. This capability allows the City to prioritize by location and to preempt all traffic other than for the most critical services, if necessary. More importantly, the fiber infrastructure can be allocated so that sensitive traffic always has dedicated capacity, because capacity can be readily scaled as needed for other applications.

6.3.4 Fiber ownership offers control over network security

Implementation of network security on a leased circuit typically occurs at the edge of the network. Many leased network customers use end-to-end encryption to securely transmit data over networks that share infrastructure with other customers. On a privately-owned fiber network, the owner(s) can control end-to-end security throughout the network infrastructure. Traffic can be segmented among different user groups and provide more robust security without necessarily needing to rely on more costly, often performance degrading encryption technologies.

In addition to data security, a privately owned network will allow the City control over network security. This includes:

- Access to facilities and networking rooms
- Passwords to edge equipment and firewalls
- Network access and authentication
- Monitoring of networking rooms, including security alarms, surveillance cameras, etc.
- Equipment placement and provisioning

7 Dallas is home to digital equity initiatives—and strategic development of existing and new programs can address remaining needs

The City, DISD, and other nonprofits and stakeholders are actively engaged in addressing issues of digital equity. A wide range of entities provide a variety of relevant support services, including device rentals and digital skills training. Additionally, certain low-cost and subsidy programs can help ease the burden of the monthly cost of broadband service for some eligible households.

In the sections below we summarize the existing range of programs in the Dallas area that offer reduced-cost broadband service and access to devices and training and make recommendations about potential ways to build on these efforts (Section 7.5).

At the outset we note that digital equity has four elements:

- **Access**: broadband infrastructure exists, and reliable high-speed broadband plans are available for purchase
- **Affordability:** broadband service is not only available but can be obtained at reasonable prices by all
- **Devices:** residents own or have access to well-functioning, up-to-date computers—and have the capacity to maintain and replace these devices if needed.
- **Skills:** residents are able to make full use of computers and online resources, and thus are able to use these tools to communicate, work, learn, attend medical appointments, and so on—and avoid online harms.

As noted in other sections of this report, the Dallas area is generally served by broadband, so digital equity challenges therefore are mainly (but not exclusively) in the areas of affordability, device access, and skills in using broadband and computers.

7.1 Achieving affordability: A review of the existing low-cost and subsidy programs available in the Dallas market

Two low-cost internet programs are available from ISPs in the Dallas market for qualifying low-income households. However, and for a variety of reasons, a relatively small percentage of potentially eligible Dallas-area residents are making use of these programs. Federal subsidies for monthly broadband service also are available to eligible households—including one program that launched in May 2021 as this report was being written.

7.1.1 Spectrum Internet Assist

Charter offers a low-cost internet program, Spectrum Internet Assist, that individuals can choose to apply for and participate in at the household level—but it comes with an application process.

We note during our analysis of mail survey responses that use of this program appears low, as we reiterate later in this section.

Spectrum Internet Assist[35] offers 30 Mbps (download)/4 Mbps (upload) service and antivirus software for $17.99 per month plus taxes and fees, with an option to rent a router for an additional $5 per month. There are no contracts required for Spectrum Internet Assist service. Individuals must apply for Spectrum Internet Assist and meet its eligibility requirements to enroll. To qualify, a member of the household must participate in the National School Lunch Program (NSLP), the Community Eligibility Provision (CEP) of the NSLP, or Supplemental Security Income (SSI), and must not be a current Spectrum subscriber.

Because of the individual eligibility requirements, Charter does not offer the option for cities to purchase Spectrum Internet Assist subscriptions on a bulk basis. However, Charter does often offer cities the option to bulk-purchase basic broadband subscriptions (as opposed to the Internet Assist product) on behalf of residents. This is typically done to provide service to all units of a public housing or subsidized housing complex. The details and subscription prices would be the subject of negotiation between the City (or its housing agency) and Charter. A bulk-purchase service would not be subject to any individual eligibility requirements.

7.1.2 AT&T Access

Like Charter, AT&T offers a low-cost broadband service—known as Access from AT&T.[36] Qualifying customers receive broadband service at speeds up to 25 Mbps (download) for up to $10 per month, with those that have slower service available paying less per month. Customers receive the maximum speed available at their address, up to 25 Mbps. The speed available also determines the monthly data allowance of either 150 GB or 1 TB. Customers are charged an additional $10 each time they exceed the data allowance by 50 GB or less.

Households in Dallas have in the past been eligible for the Access program if a member participates in the Supplemental Nutrition Assistance Program (SNAP). As part of its Covid-19 response, AT&T expanded eligibility for the Access program to include households with income 135 percent or less than the federal poverty line, as well as households participating in the National School Lunch or Head Start programs. It also waived data overage fees for non-DSL customers. These Covid-19 response measures are only slated to be in effect through June 30, 2021.

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[35] "Spectrum Internet Assist," Charter Communications, https://www.spectrum.net/support/internet/spectrum-internet-assist/ (accessed February 2021).
[36] "Access from AT&T," AT&T, https://www.att.com/internet/access/ (accessed May 11, 2021).

7.1.3 Lifeline

The Lifeline program was created by Congress (and is administered by the FCC's Universal Service Administrative Company) with the purpose of making service more affordable by providing a modest subsidy—$9.25 per month with an additional $25 per month available for those who live on Tribal lands[37]—to telecommunications carriers for service to lower-income members of the community. Adoption rates for this program remain low—around 20 percent—but, as we discuss below, the program's impact could potentially be maximized with City and DISD support.

Challenges of the Lifeline program include community awareness and the application and eligibility verification processes. A critical effort from the City and DISD would include outreach and education for eligible families to provide information about the program, as well as resources to assist with the enrollment process. Ideally support would be provided in partnership with established, trusted community organizations that are already accustomed to providing resources of this nature.

7.1.4 Emergency Broadband Benefit Program

The Consolidated Appropriations Act established the $3.2 billion Emergency Broadband Benefit Program.[38] This program is administered by the FCC and is designed to provide a broadband subsidy for eligible households that will appear as a discount on their monthly bills. While similar in this regard to the Lifeline program, this program offers a much more robust discount: The FCC will reimburse ISPs up to $50 per month per eligible household, or $75 per month for households on Tribal lands. Notably, this program also subsidizes the cost of a laptop, desktop computer, or tablet for each eligible household; ISPs can be reimbursed up to $100 for a connected device, as long as they charge the recipient no more than $50 for it.

The law states the program can run six months beyond the end of the Covid-19 public health emergency, but that is only if the funding is sufficient to cover the ISPs' charges for all of the participants. The program began accepting applications[39] on May 12, 2021, and it is anticipated that the $3.2 billion allocated to the program will provide less than a year of funding. Congress could appropriate future funds to keep the program operating, though it is unlikely the political will exists to make the program permanent.

Because the benefits available through the Emergency Broadband Benefit Program are so significant for consumers, this program stands to serve as an impactful broadband adoption plan.

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[37] "Additional Support for Tribal Lands," Universal Service Administrative Company, https://www.lifelinesupport.org/additional-support-for-tribal-lands/ (accessed May 13, 2021).
[38] Emergency Broadband Benefit Program Report and Order, Federal Communications Commission, https://docs.fcc.gov/public/attachments/FCC-21-29A1.pdf (accessed May 13, 2021).
[39] The Universal Service Administrative Company (USAC), https://getemergencybroadband.org/ (accessed May 12, 2021).

While the program will provide welcome financial relief for families that have been paying for broadband service throughout the pandemic, it will also create opportunities for many low-income families to subscribe to a home broadband service for the first time.

However, the way the program's rules are structured put significant burden on families to prove their eligibility and ensure their subsidy is appropriately applied. The FCC defines eligibility for the program broadly as a household in which at least one member meets one of the following criteria:

- "Has an income that is at or below 135 percent of the Federal Poverty Guidelines or participates in certain assistance programs, such as SNAP, Medicaid, or Lifeline;
- Approved to receive benefits under the free and reduced-price school lunch program or the school breakfast program, including through the USDA Community Eligibility Provision in the 2019-2020 or 2020-2021 school year;
- Received a Federal Pell Grant during the current award year;
- Experienced a substantial loss of income due to job loss or furlough since February 29, 2020, and the household had a total income in 2020 at or below $99,000 for single filers and $198,000 for joint filers; or
- Meets the eligibility criteria for a participating provider's existing low-income or Covid-19 program."[40]

Participating ISPs will be able to verify household eligibility in one of three ways:

1. Based on the National Verifier or the National Lifeline Accountability Database
2. Based on a school's verification of a household member's participation in the National School Lunch Program or the School Breakfast Program
3. Based on the ISP's "alternative verification process" (which must be deemed sufficient by the FCC "to avoid waste, fraud, and abuse")

The program's rules raise concern that there will be significant burden on families to prove their eligibility and ensure their subsidy is appropriately applied. For instance, families will need to call their provider to ask for service and determine how to apply the subsidy. This is not an insignificant burden for the families this subsidy is intended to help, nor is the potential financial risk to those families (i.e., that they might be responsible for charges if the subsidy is not accurately applied) a minor point.

[40] "Emergency Broadband Benefit," Federal Communications Commission, https://www.fcc.gov/broadbandbenefit (accessed May 13, 2021).

7.2 Achieving access: A review of existing City and DISD digital equity initiatives

The City of Dallas and DISD have undertaken a variety of digital equity initiatives related to broadband access and affordability, device access, and digital skills training.

7.2.1 Internet for All Coalition builds community-wide digital equity strategy

The Internet for All Coalition is responsible for the Internet for Dallas program, which aims to provide access to high-speed reliable internet and devices for all households in Dallas. It is a collaborative effort of more than 40 organizations across the Dallas area, including those from local school districts, Dallas College, the City of Dallas, the City of Grand Prairie, Region 10, community- and faith-based organizations, Dallas County, and local funders. Due to the coalition's diverse and inclusive make-up, it is well positioned to carry out a variety of programs to help increase connectivity and access.

In addition to its efforts to help ensure connectivity, the Internet for All Coalition is a helpful resource for students and families to learn how to:

- Access free and discounted service and devices
- Advocate for the service and speed you need for online learning
- Identify the best internet connectivity solutions for residents[41]

The coalition has several resources for persons of all ages. These resources include information and support with telehealth, job training, finding employment through the internet, and continuing education programs.

7.2.2 Digital Navigators program helps residents access internet subscriptions, devices, and training opportunities

Digital Navigators is a grant program currently offered by the City with the goal of helping to address digital equity problems in Dallas. The program offers grants to non-profits seeking to support low-income families (making less than 80 percent of area median income) with resources for internet access, hardware, and literacy programs.

Non-profits seeking to serve as navigator organizations are required to fill out applications to the City. The City has so far provided grants to two nonprofit organizations to enable those organizations to serve as "digital navigators" in the community. The first is the League of United Latin American Citizens National Educational Service Center (LNESC), which received a $110,956 grant to serve residents in key ZIP codes across the City. The other grant recipient, Southern

[41] "About Internet for Dallas," Internet for Dallas, http://www.internetfordallas.org/about.php (accessed April 27, 2021).

Dallas Progress Community Development, received an award of $25,000 and focused its efforts specifically on the 75216 ZIP code in southern Dallas.

The navigator program is fairly comprehensive in that it seeks to address not only concerns about affordability but skills and equipment gaps as well. According to the City's guidelines for applicant the "navigators" or award recipients must:

- Discuss with each client their home internet access or need for home internet access, technology experiences, and their devices.
- Assess their clients' access to technology, current digital skill level pertaining to what they need to accomplish the plan, connectivity needs, and internet use priorities.
- Advise clients about free or affordable home internet service options for which they may qualify, assist clients to apply for services they choose and support their efforts to secure service.
- Advise clients about sources of affordable computers or other internet-connected devices for which they may qualify and support their efforts to acquire appropriate devices and where they can get help for repair.[42]

7.2.3 The City's purchase of laptops and hotspots make devices more accessible

The City of Dallas has purchased approximately 1,500 laptops and related equipment for distribution in the community. Of the total devices purchased, 1,300 will be distributed to the Dallas Public Library system and 200 will be distributed to Parks and Recreation centers across the City.

In addition, the Dallas Public Library system currently has 900 hotspots available for circulation, with 75 percent of them being used at any given time. The Library's FY 2021 budget includes the purchase of an additional 2,100 hotspots.[43] The Library allow residents to borrow laptops and hotspots together. City officials believe that despite these expanded efforts, there remains a great unmet demand for these devices.

7.2.4 Texas Education Agency matching funds support the purchase of devices and home internet for students

The Texas Education Agency (TEA) received $200 million in federal CARES Act funding for the purchase of devices and home internet solutions to enable remote learning for students who

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[42] "Request for Applications (RFA): Project Title: Office of Resilience – Digital Navigators (Buyer Solicitation Number: BS20-00014266)," City of Dallas.

[43] "Dallas Public Library expands hotspot lending program to meet stay-at-home needs," City of Dallas, News Release, http://www.dallascitynews.net/dallas-public-library-expands-hotspot-lending-program-meet-stay-home-needs (accessed May 24, 2021).

lacked connectivity for the 2020-21 school year. The TEA established two main reimbursement programs: the Operation Connectivity Prior Purchase Reimbursement Program (PPRP) and the Operation Connectivity Bulk-Purchase Local Match Reimbursement Program (LMRP).[44] The PPRP funds local education agencies' technology-related purchases made to better serve students and staff during the Covid-19 pandemic. The LMRP focuses on the facilitation of online/distance learning.

These local education agencies are eligible for additional matching funds if they receive funding from their city or county's Coronavirus Relief Fund budget. The TEA will increase its match by $1 for every dollar of local Coronavirus Relief Fund money that local education agencies receive, for up to 25 percent of the total expenditure. The amount allocated to cities were calculated based on the number of students in the Free and Reduced Lunch program in each independent school district.

The allocation to DISD, however, was not calculated using the same formula, but instead was a flat amount determined based on other investments that the City is making in partnership with DISD related to the digital divide. In addition, the end date for the funding of CRF (which is funding PPRP) is December 31, 2021,[45] making this program unsustainable in the long run unless an alternative funding source is established.

7.2.5 DISD's purchase of mobile hotspots supports student connectivity

In March 2020, DISD's board of trustees unanimously approved $2.5 million in funding for the purchase of more than 10,000 hotspots. This program was undertaken in response to a survey of 18,000 DISD families which showed almost 30 percent of families do not have internet access.[46]

Families can request these devices through their school's page on the DISD website and are able to rent them for the school year. The hotspots officially are a part of DISD's long-range plan for technology which attempted to provide a laptop or tablet to every DISD secondary student. There are already plans by the Dallas Education Foundation, the nonprofit philanthropic arm of DISD, to fundraise with the private sector in order to purchase more hotspots.

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[44] "Coronavirus relief Fund (CRF) reimbursement programs," Texas Education Agency, https://tea.texas.gov/finance-and-grants/grants/coronavirus-relief-fund-crf-reimbursement-programs (accessed April 27, 2021).

[45] "Coronavirus relief Fund (CRF) reimbursement programs," Texas Education Agency, https://tea.texas.gov/finance-and-grants/grants/coronavirus-relief-fund-crf-reimbursement-programs (accessed April 27, 2021).

[46] "Trustees approve purchase of more than 10,000 hotspots for students to help close digital divide," Dallas Independent School District, https://thehub.dallasisd.org/2020/03/26/dallas-isd-approves-2-5-million-to-help-close-digital-divide/ (accessed May 13, 2021).

7.2.6 Signal extender initiative expands access to free Wi-Fi

One of the actions or programs undertaken by the City of Dallas in response to the Covid-19 pandemic has been the installation of Wi-Fi signal extenders at several public libraries. The initial rollout of the program utilized the Dallas West, Highland Hills, Paul Laurence Dunbar-Kiest and Prairie Creek libraries.[47] The signal extenders were donated to the City by Cisco and allow a Wi-Fi signal to be extended up to 300 feet outside of the building. This did not generally extend coverage to nearby residential homes but provided a limited area of service around the library. Additionally, Cisco donated two monitors that can be used for video conferencing, virtual tours, telehealth appointments, and other applications.

These programs are promising, with staff at the Prairie Creek location reporting an increase in overall Wi-Fi usage at their location. Many of the libraries are located in areas having low rates of broadband use.[48]

7.3 Dallas organizations active in digital equity

In addition, there are several independent nonprofits and other organizations that are active in digital equity initiatives throughout Dallas.

7.3.1 Dallas Innovation Alliance (DIA)

The Dallas Innovation Alliance is a coalition from the City of Dallas including corporations, civic and NGO organizations, academic organizations, and private individuals who are "invested in Dallas' continued evolution as a forward-thinking, innovative, 'smart' global city."[49] The alliance has several efforts underway. The first of these involves implementing a smart city strategy focused on the West End in Central Dallas.[50] The initial project was launched in 2017 in partnership with AT&T and included elements like smart water meters, pedestrian sensors, public Wi-Fi, and digital infrastructure nodes.[51]

DIA is also responsible for the Mobile Learning Lab, a converted school bus that has been turned into a large-scale mobile hotspot and classroom. The bus offers free Wi-Fi in a limited area around

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[47] "How hot spots are bridging southern Dallas' digital Divide during the coronavirus pandemic," Cooper, B., *The Dallas Morning News*, https://www.dallasnews.com/news/public-health/2020/08/28/how-hot-spots-are-bridging-southern-dallas-digital-divide-during-the-coronavirus-pandemic/ (accessed April 27, 2021).

[48] "How hot spots are bridging southern Dallas' digital Divide during the coronavirus pandemic," Cooper, B., The Dallas Morning News, https://www.dallasnews.com/news/public-health/2020/08/28/how-hot-spots-are-bridging-southern-dallas-digital-divide-during-the-coronavirus-pandemic/ (accessed April 27, 2021).

[49] "Mobile Learning Lab," Dallas Innovation Alliance, http://www.dallasinnovationalliance.com/mll (accessed May 13, 2021).

[50] "Phase one: The West End," Dallas Innovation Alliance, http://www.dallasinnovationalliance.com/projects (accessed April 27, 2021).

[51] "Phase one: The West End," Dallas Innovation Alliance, http://www.dallasinnovationalliance.com/projects (accessed April 27, 2021).

the bus (i.e., a radius of approximately 300 to 500 feet).[52] The lab also offers furniture and umbrellas to help ensure participants are able to use the Wi-Fi in relative comfort. In addition to the Wi-Fi, the Mobile Learning Lab offers classes to help improve digital literacy. DISD, using similar technology, has deployed eight additional buses.[53]

7.3.2 Comp-U-Dopt

Comp-U-Dopt is a national non-profit which seeks to provide technology and education to underserved youths throughout the country. They accomplish this by providing free computers and associated devices to low-income families. The devices are then distributed through "computer drive-thrus" like the one Comp-U-Dopt established in North Dallas.[54] Comp-U-Dopt will also soon operate a lottery to provide devices to pre-registered applicants. The City of Dallas has also been in talk with Comp-U-Dopt over the possibility of donating City computers for distribution in the Dallas area.

In addition to its primary purpose of providing free computers, Comp-U-Dopt offers a variety of youth digital literacy courses designed for all age categories.[55] The programs for younger children focus on STEM and coding programs to help increase overall technical skills. High schoolers focus on coding, computer building, and drones to learn higher level skills that are both practical and marketable. All high school participants are given a refurbished laptop they can keep after the program ends.

7.4 A sample of digital equity programs and strategies in other cities

Dallas, the DISD, and other partners are fortunate to have established the Internet for All coalition and created a range of digital equity programs. As Dallas seeks to augment its efforts, the experiences of other municipalities may prove useful.

In CTC's work with other cities, we have identified best-practice strategies used to create more digitally inclusive communities. The following points highlight some of the lessons these practitioners have learned about what strategies have the greatest impact, what hurdles are likely to arise, and what kind of roles City government is best suited to play in the digital equity ecosystem:

- Community organizations already working with target populations are best suited to assist in overcoming barriers to broadband adoption

[52] "Mobile Learning Lab," Dallas Innovation Alliance, http://www.dallasinnovationalliance.com/mll (accessed May 13, 2021).
[53] "Mobile Learning Lab," Dallas Innovation Alliance, http://www.dallasinnovationalliance.com/mll (accessed May 13, 2021).
[54] Comp-U-Dopt, https://www.compudopt.org/dallas (accessed April 27, 2021).
[55] Comp-U-Dopt, https://www.compudopt.org/dallas (accessed April 27, 2021).

- A digital equity agenda is most likely to succeed when it is integrated and connected to other City goals
- City staff can play an important role in helping develop an evaluation framework and data collection system at a citywide or regional level
- Only a fraction of potentially eligible households makes use of discounted internet offerings, both because of a lack of awareness and the difficulty involved in navigating the sign-up process
- Regular community assessments allow City staff to reset priorities in light of shifts in barriers to adoption
- A digital equity agenda needs a champion in a leadership position to encourage cross-departmental collaborations and pursue philanthropic donations
- Digital inclusion coalitions can delegate responsibilities to community organizations, but should define performance metrics and establish accountability mechanism to ensure progress
- Bad credit has become a significant barrier to broadband adoption

The following sections describe some of these key findings in more detail.

7.4.1 Coalitions are key drivers of change in other cities

As a recent Benton Institute report[56] noted, coalitions are critically important to engage stakeholders and drive change. In Dallas, the Internet for All Coalition represents an important platform for addressing broadband challenges in the metropolitan area. Although Dallas stakeholders may already be aware of other such coalitions, other examples include the Digital Inclusion Alliance San Antonio (DIASA),[57] which is cultivating and promoting public policies and initiatives that prioritize digital equity; the Portland Digital Inclusion Network,[58] a coalition of community organizations interested in raising awareness about digital equity barriers and developing solutions to bridging the digital divide; and the Digital Empowerment Community of Austin, a network of community stakeholders in Austin, TX, working on different facets of the digital equity issues there.[59]

A City government or school district is well suited to implementing some solutions, especially on tasks involving infrastructure improvements, staffing, and programs. But they cannot alone

[56] https://www.benton.org/sites/default/files/growinghealthy_ecosystems.pdf
[57] https://digitalinclusionsa.org/
[58] https://www.portlandoregon.gov/oct/73860
[59] http://austintexas.gov/page/digital-empowerment-community-austin

address all challenges related to digital equity, particularly not all relating to connecting residents with subsidy programs, providing devices, assisting with device maintenance and updates, and helping people develop better computer skills. Coalition could be charged with proposing ways to accelerate other initiatives and also to find alternate sources of funding – such as from foundations, as noted below.

7.4.2 Examples of digital equity funds in Seattle, Austin, and Boston

Modest grant funding streams from the City can be leveraged by community organizations for considerable impact. For example, Seattle has used a technology matching fund since 1997 to support local organizations working to close the digital divide.[60] The fund's annual budget has grown to $320,000; it supports an average of 12 organizations per year.

Inspired by Seattle's program, the City of Austin launched its Grants for Technology Opportunities Program in 2001.[61] Similarly, the City of Boston began offering $35,000 in grants through its digital equity fund[62] in 2017 and expanded it to $100,000 annually in 2019. The fund of moderate amount could help support many of the strategic recommendations made, whether by this report or by stakeholders in the City who have an excellent understanding of the problems and connections with the affected families. And the process of vetting and awarding grant applications will help the City and other stakeholders understand the evolving nature of the problem and maintain good working relationships.

7.4.3 Foundation engagement accelerates efforts in Cleveland

Engaging with local foundations and other philanthropic entities can potentially help broaden the funding base for digital equity initiatives. A number of potential project types could be suitable for foundation funding, such as:

- Providing laptops, Chromebooks, and other devices to low-income residents or others who have devices in poor condition
- Establishing resource centers where members of the community can access devices, high-speed internet, and training/mentoring
- Providing funding for community outreach specialists to help older residents or others in need to learn basic digital skills

A model for a foundation role emerged recently in Cleveland, where the Cleveland Foundation, Cuyahoga County, and T-Mobile partnered to launch the Greater Cleveland Digital Equity Fund.[63]

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[60] https://www.seattle.gov/tech/initiatives/digital-equity/technology-matching-fund
[61] https://www.austintexas.gov/department/grant-technology-opportunities-program
[62] https://www.boston.gov/innovation-and-technology/digital-equity-fund
[63] https://www.clevelandfoundation.org/news_items/digital-equity-fund/

The fund was initially launched with $3 million in commitments intended to address immediate and long-term needs involving access, computing devices, skills, and technology support.

The George Gund Foundation gave an additional $1 million grant to support digital needs—such as hotspots and laptops—for K-12 students in the Cleveland Metropolitan School District and others who lack broadband access and devices to learn remotely during the pandemic.

T-Mobile committed to providing 7,500 unlimited data hotspots and $1 million of in-kind equipment donations, while other local organizations will provide up to 10,000 computers and ongoing support to area students.

7.4.4 Digital equity guides and resources

The following guidebooks and resource pages may help individuals and organizations pursuing digital equity to learn what is working in other communities and develop their own plans of action.

National Digital Inclusion Alliance's (NDIA'S) Discount Internet Guidebook offers a guide for digital inclusion practitioners wanting to help their community find affordable home broadband service. It describes large ISPs affordable broadband options and explains how eligible households can sign up.

Digital Inclusion Coalition Guidebook reports on lessons learned from six established community-wide digital inclusion coalitions in an effort to help local communities implement their own digital inclusion coalition.

Digital Inclusion Start-Up Manual provides guidance for communities looking to increase access and use of technology in disadvantaged communities through digital literacy training, affordable home broadband, affordable devices, and tech support. The guidebook was updated in September 2020 to reflect best practices around Digital Inclusion programming in the age of COVID-19.

NDIA's Resource Page includes link to strategy guides, local government plans and reports, sources of data and research on the digital divide.

National Collaborative for Digital Equity's (NCDE's) Guide to CRA Grantmaking for Digital Equity and Economic Inclusion offers a detailed description of how banks can meet Community Reinvestment Act (CRA) obligations through investments in digital equity.

NCDE's Digital Equity Resource Page provides links to sources of free and low-cost broadband, devices, apps, software, and technical support, as well as other digital literacy, education, and professional development resources.

Consortium for School Networking's Digital Equity Toolkit details strategies that school systems are successfully using to narrow the "homework gap" in their communities, as well as guidance on how these steps can integrate with broader digital inclusion efforts.

HUD's ConnectHome Playbook provides a step by step guide for building a digital equity initiative, lessons from 28 pilot projects, and tips for how ConnectHome partners can help families in HUD-assisted housing overcome some barriers to adoption.

7.5 Recommendations for expansion or creation of digital equity initiatives in Dallas

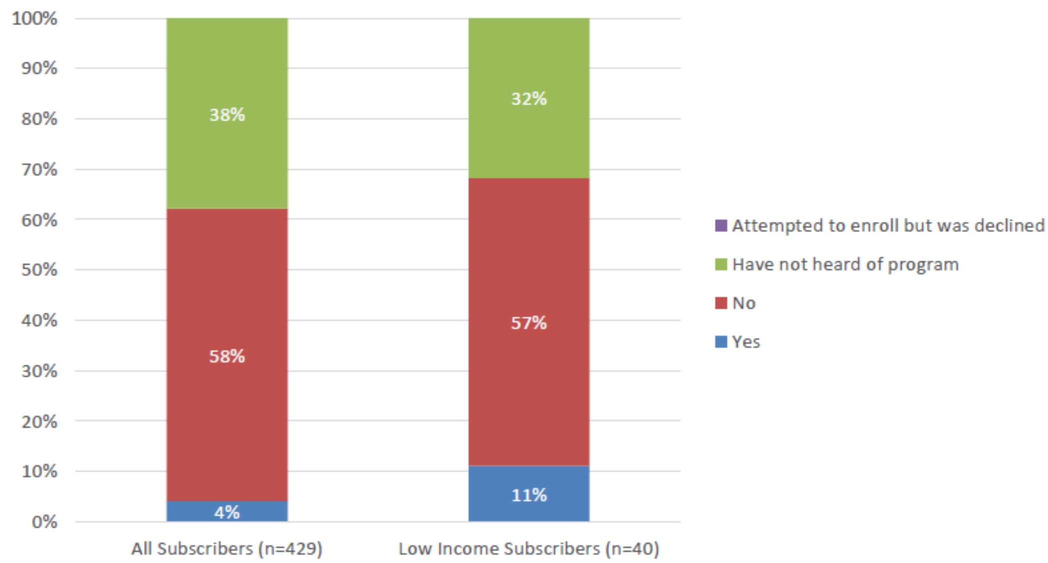
The extensive efforts by both the City and DISD—as well as the two entities' partnership around these issues—have made Dallas a burgeoning national leader in advancing digital equity. CTC recommends the strategic expansion of existing initiatives and introduction of new efforts to address persistent digital equity gaps in Dallas.

7.5.1 Recommendation: Expand the Digital Navigators program across systems to maximize participation in low-cost programs and federal subsidy programs

Charter's Spectrum Internet Assist program, AT&T's Access program, the federal government's Lifeline and Emergency Broadband Benefit programs, and the new Emergency Connectivity Fund offer opportunities for qualifying residents to receive subsidies, low-cost, or discounted broadband services. But each program has its share of hurdles that make enrollment challenging, and participation rates have historically been low.

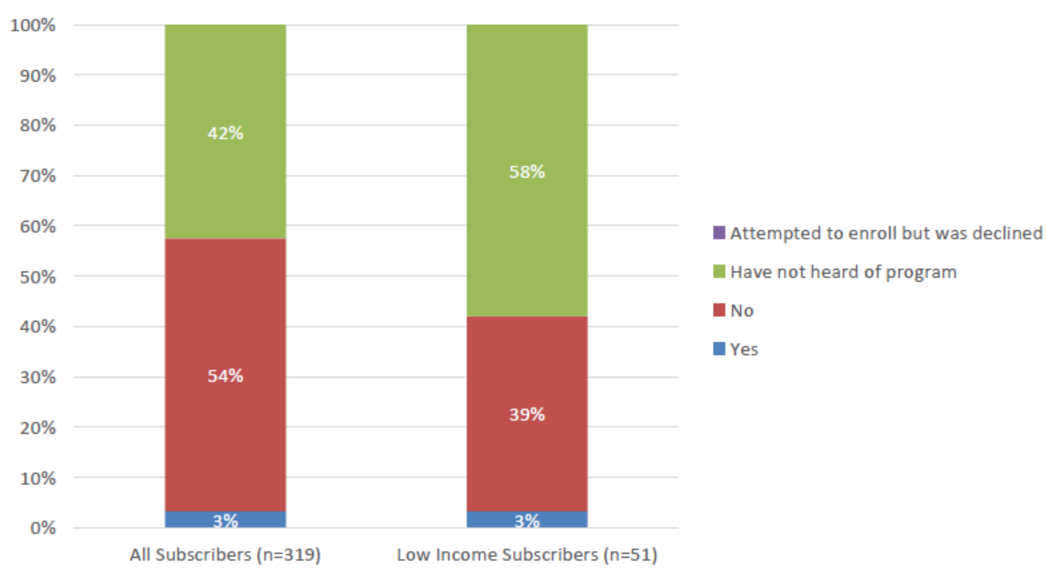
The survey data show that these programs are extremely underutilized in Dallas. As illustrated in Figure 107, just 4 percent of all AT&T customers are enrolled in the ISP's Access program for low-income households. Eleven percent of customers earning under $25,000 per year said they are enrolled in the program.

Figure 107: Enrolled in AT&T's Access Program



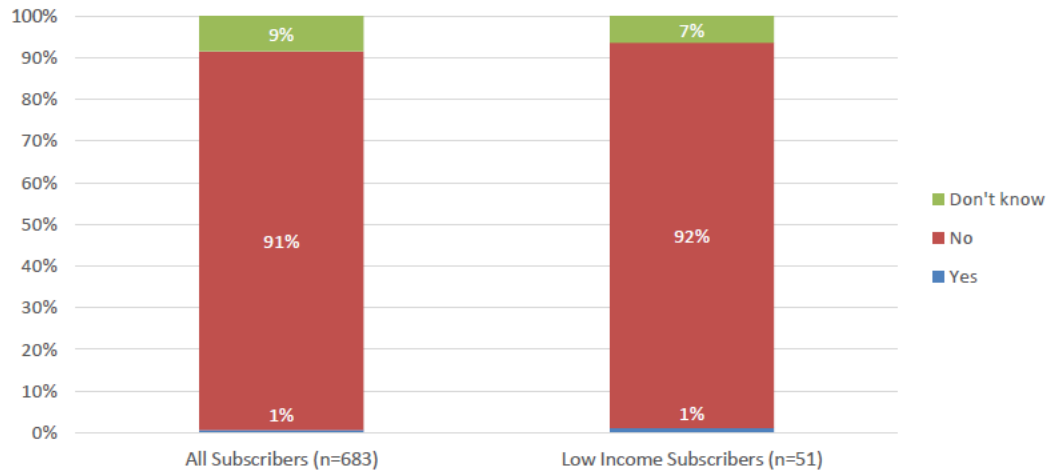
As illustrated in Figure 108, just 3 percent of all Spectrum customers and low-income customers are enrolled in the ISP's Internet Assist program for low-income households. Four in 10 customers earning under $25,000 said they had not heard of the program.

Figure 108: Enrolled in Spectrum's Internet Assist Program



Just 1 percent of low-income subscribers (earning under $25,000 per year) receive the $9.25 subsidy under the FCC's Lifeline program, and 7 percent are unsure whether they receive the subsidy. Most households are not receiving the subsidy (see Figure 109).

Figure 109: Receive $9.25 Subsidy Under FCC's Lifeline Program



CTC recommends the City take a series of steps to alleviate the barriers to enrollment in all three programs by expanding the piloted Digital Navigators program. Additionally, a partnership between the Digital Navigators and DISD to undertake this effort could increase awareness about the programs and educate residents about eligibility and program benefits. Such a strategy would leverage existing City efforts to maximize the impact of existing, long-standing programs that are available to a large number of residents.

In terms of the Emergency Broadband Benefit Program, the Digital Navigators could seek to maximize the participation of families in this new FCC program—and the amount of federal subsidy funds coming to residents. The Digital Navigators can use its existing structure to help families understand and navigate the process. The Navigators might even connect families to ISPs to facilitate their enrollment. This will require coordination with the FCC to understand the criteria the FCC will apply for determining the broader eligibility criteria in the federal subsidy program, and to communicate those criteria and any documentation requirements to eligible families.

The Digital Navigators program may also want to consider providing call center support to help smaller ISPs and residents understand and navigate the program, ensure ISPs get qualified by the FCC to participate, and then to determine that families are eligible. This approach would take some of the burden off smaller ISPs. For big ISPs, this is a relatively easy chore; they have access to the federal Lifeline verifier, as well as their own low-income programs.

In addition, the Digital Navigators could continue to provide support for enrollment in the federal Lifeline program as well as Spectrum Internet Assist and AT&T Access. Such an initiative builds on the work and success of the program to date, while leveraging the opportunities presented by incumbent ISPs and the federal government.

In our experience, a call center staffed by three people could assist approximately 8,000 families per year; the number aided by three staff members could be higher or lower based on demand for the service and the ease or difficulty in connecting families with the relevant programs.

The table below estimates the costs of staffing, marketing, and operations for a call center and related communications efforts to increase community awareness of these opportunities. The first section provides Year One costs; the second section provides annual costs for the initiative in subsequent years. The numbers are based on CTC's experience with similar initiatives.

Table 41: Estimated Initiative Budget – Providing Resources to Help Residents Enroll in Low-Cost and Subsidy Programs[64]

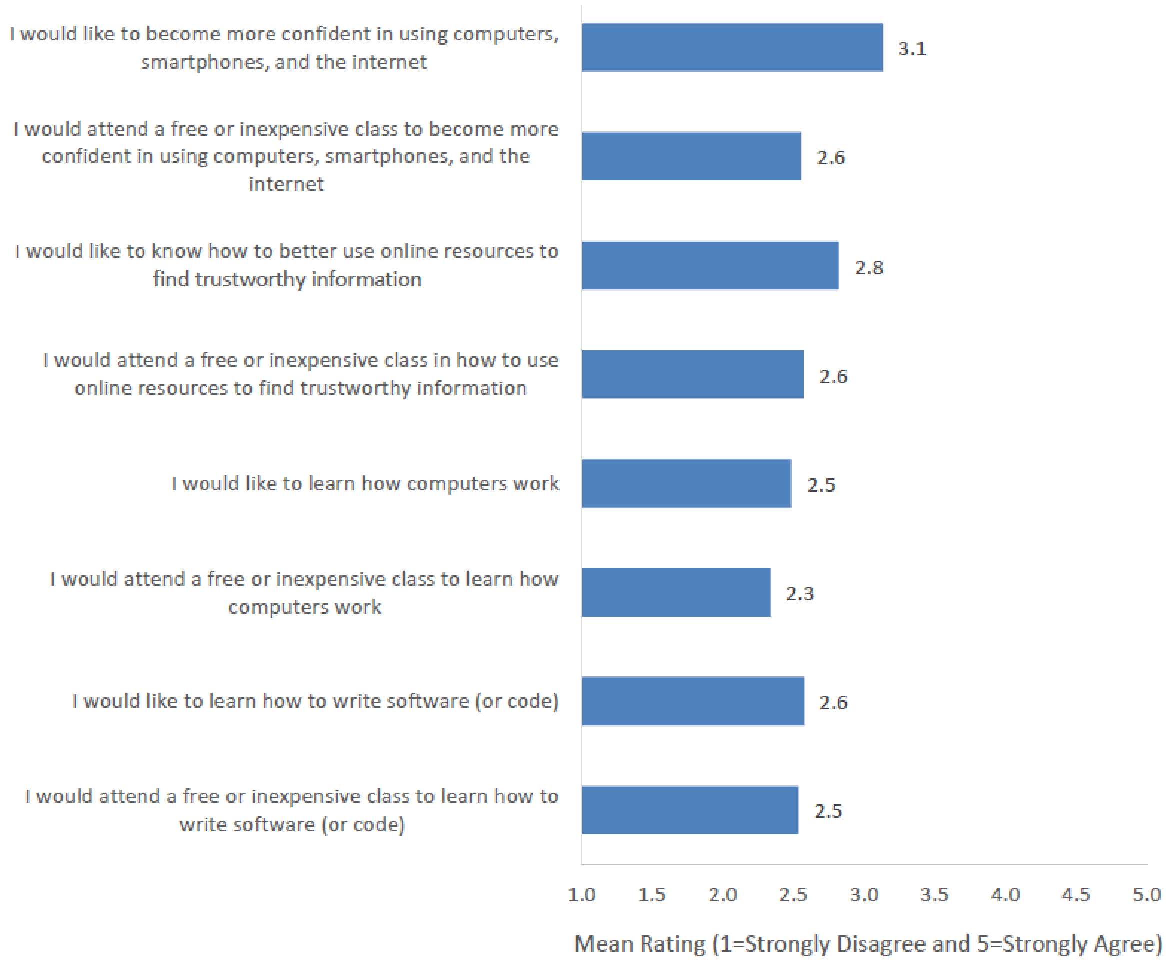
Year One	**Budget**
Creation and distribution of informational materials such as web pages, fliers, inserts, and mailers	$20,000
Call center technology and software licenses	$20,000
Three full-time call center staff ($40 hourly rate)	$249,600
Total	**$289,600**
Estimated cost per household if 8,000 households are assisted	*$36*
Subsequent Years	**Budget**
Creation and distribution of fliers, inserts, and mailers	$5,000
Maintenance of call center and equipment	$10,000
Three full-time call center staff, based on an hourly rate of $40	$249,600
Annual Costs for Year Two Onward	**$264,600**
Estimated cost per household if 8,000 households are assisted	*$33*

7.5.2 Recommendation: Fund the expansion of digital skills training offered through the Digital Navigators program

In addition to access to robust and affordable broadband, residents require digital skills in order to fully take advantage of the opportunities that come with a broadband connection. The survey data show there is moderate interest among respondents in becoming more confident in using computers, smartphones, and the internet, or in using online resources to find trustworthy information, and slightly less interest in attending a free or inexpensive class about these topics.

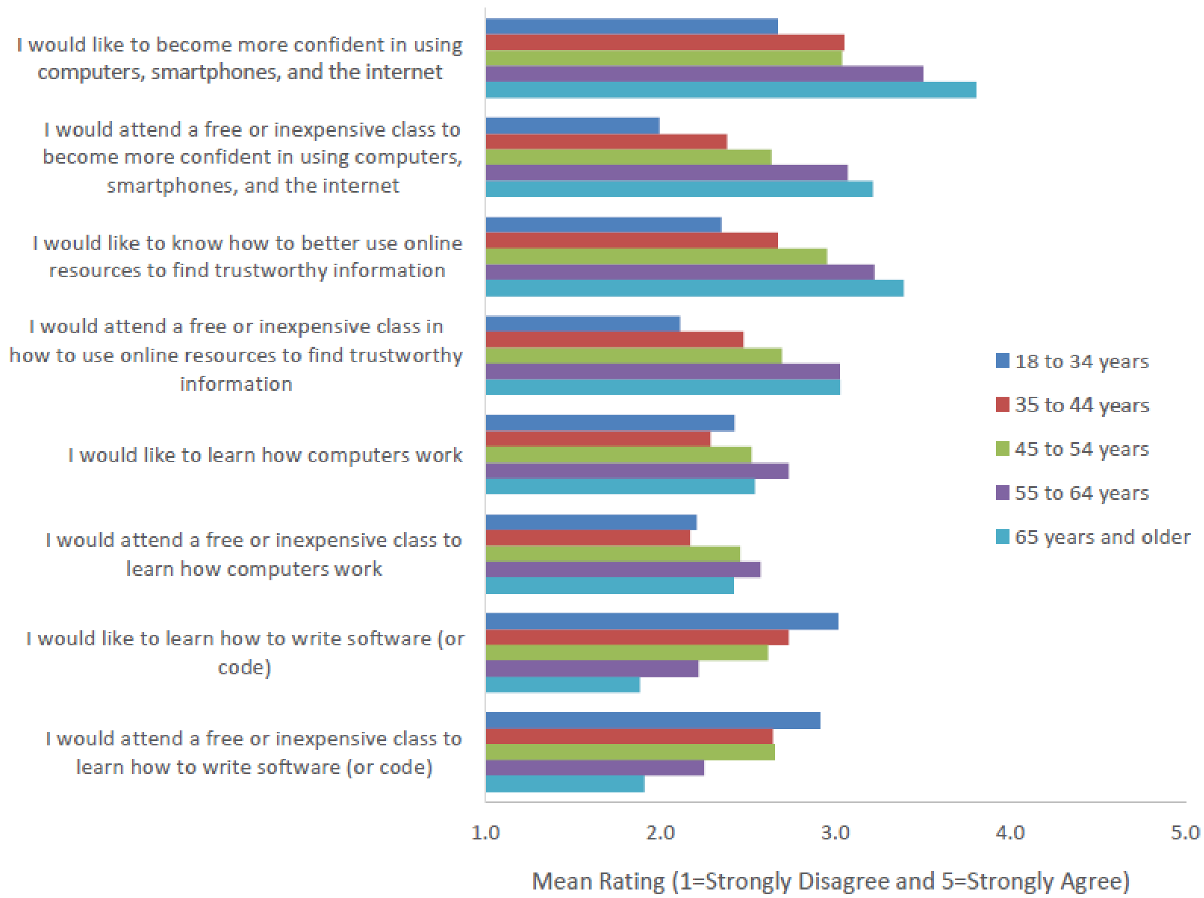
[64] Numbers are derived from CTC's experience designing and operating call centers to support broadband subsidy programs on behalf of state government entities.

Figure 110: Agreement with Statements About Training Related to Computers and the Internet



Interest in training varies significantly by age of respondent. As illustrated in Figure 111, those ages 55 and older expressed greater interest in becoming more confident in using computers and related technology and in learning how to better use online resources, as well as attending a class about these topics, compared with younger respondents. Those under age 35 are more likely than older respondents to agree they would like to learn how to write code or to take a class about this topic.

Figure 111: Agreement with Statements About Training by Respondent Age



If funding allows, Dallas could build upon its successful Digital Navigators program to continue to support community organizations with the capacity needed to enable digital skills training initiatives. The short, one-month duration of the program has been identified as a challenge. Additional funding for the Digital Navigators program would allow current service providers to expand their digital skills training initiatives and would allow for the City to support additional organizations in providing such training, especially those that serve senior residents. Table 42 describes the estimated budget for training 5,000 residents.

Table 42: Estimated Budget for Digital Navigators Training Program

Category	Budget
Training cost per student	$200
Estimated cost if 5,000 residents are assisted	*$1,000,000*

Community-based groups in Dallas are well-positioned to offer direct support services to residents. Supporting these established organizations would be an effective and efficient way for the City to enable digital skills training programs and device distribution efforts that meet residents' needs. Potential grantees include community centers, senior-serving organizations, health care centers, neighborhood organizations, faith-based organizations, immigrant support organizations, and organizations that provide support to those experiencing homelessness. These community-based groups are often well- positioned to offer direct support services to residents but are typically resource-strapped and lack the capacity to offer additional programs.

7.5.3 Recommendation: Purchase devices and fund the expansion of digital skills training and device recycling

While the availability of internet-enabled devices is relatively high in households with internet access, there are variations in device ownership based on age and household income, as seen in Figure 112 and Figure 113.

Figure 112: Devices Available in the Home by Respondent Age

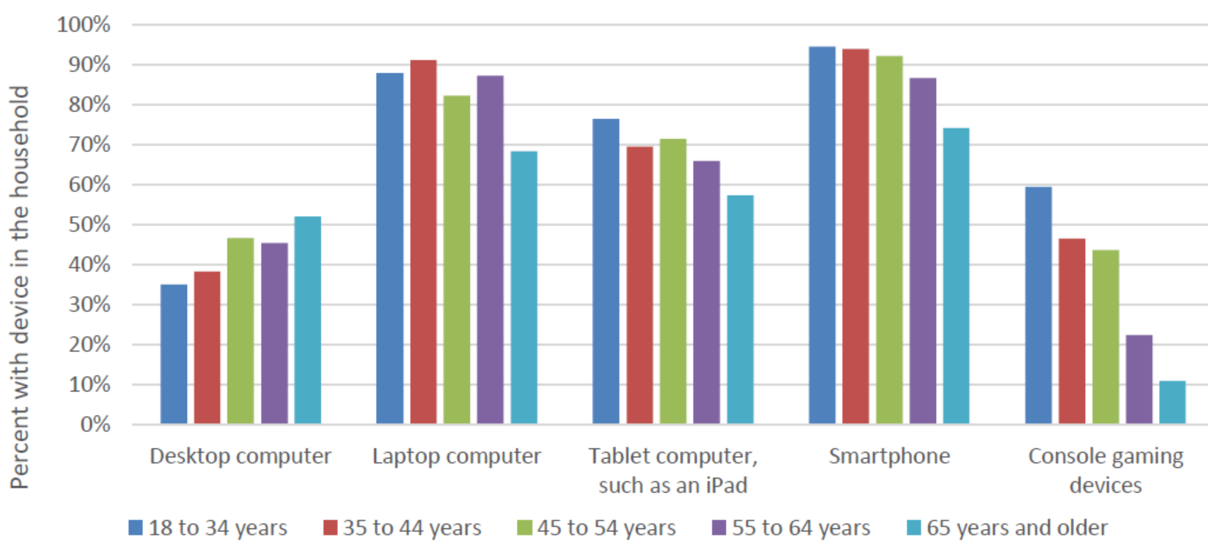
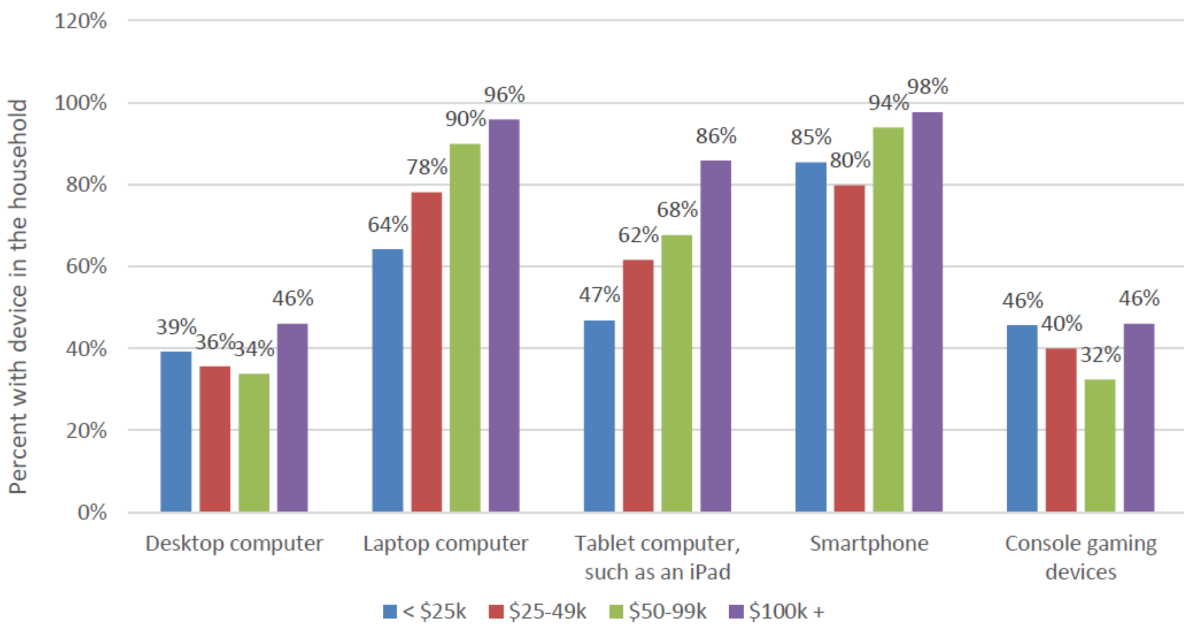


Figure 113: Devices Available in the Home by Household Income



Additionally, one-fourth of internet subscribers earning under $25,000 experience issues at least weekly with their primary computer becoming inaccessible or unusable (see Figure 114). Three in 10 low-income respondents said it would take one to six months to replace a lost or damaged computer, and another 30 percent said they would not be able to replace it (see Figure 115).

Figure 114: How Often Computer Becomes Unusable by Household Income

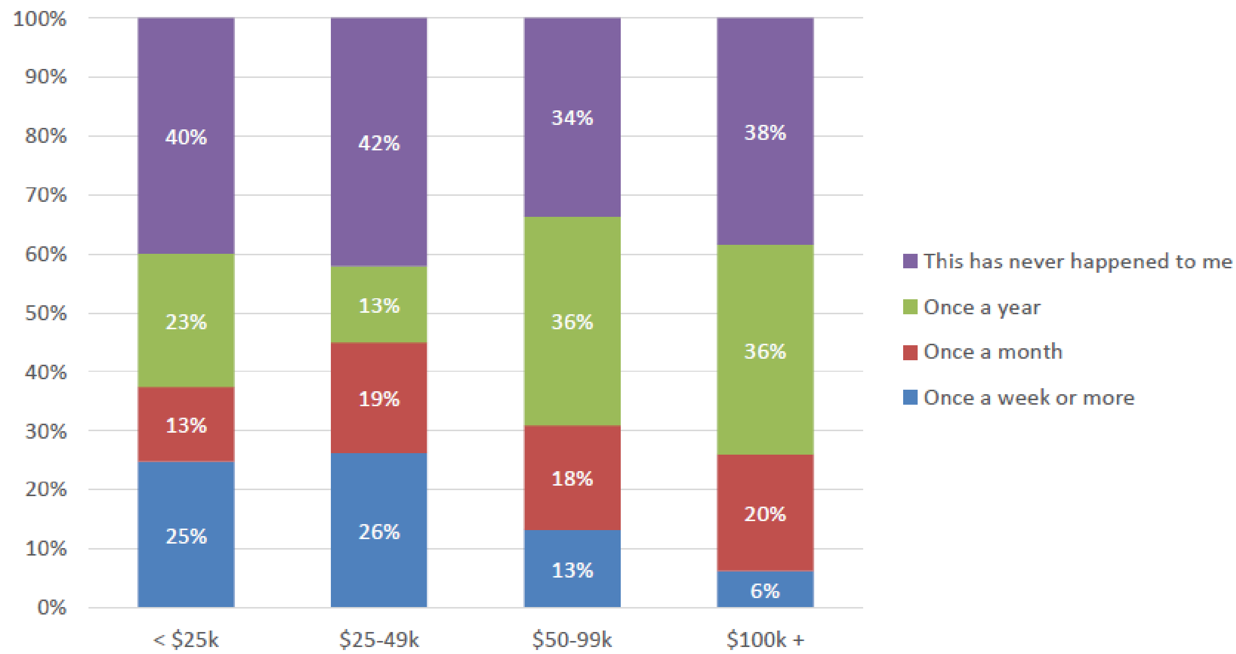
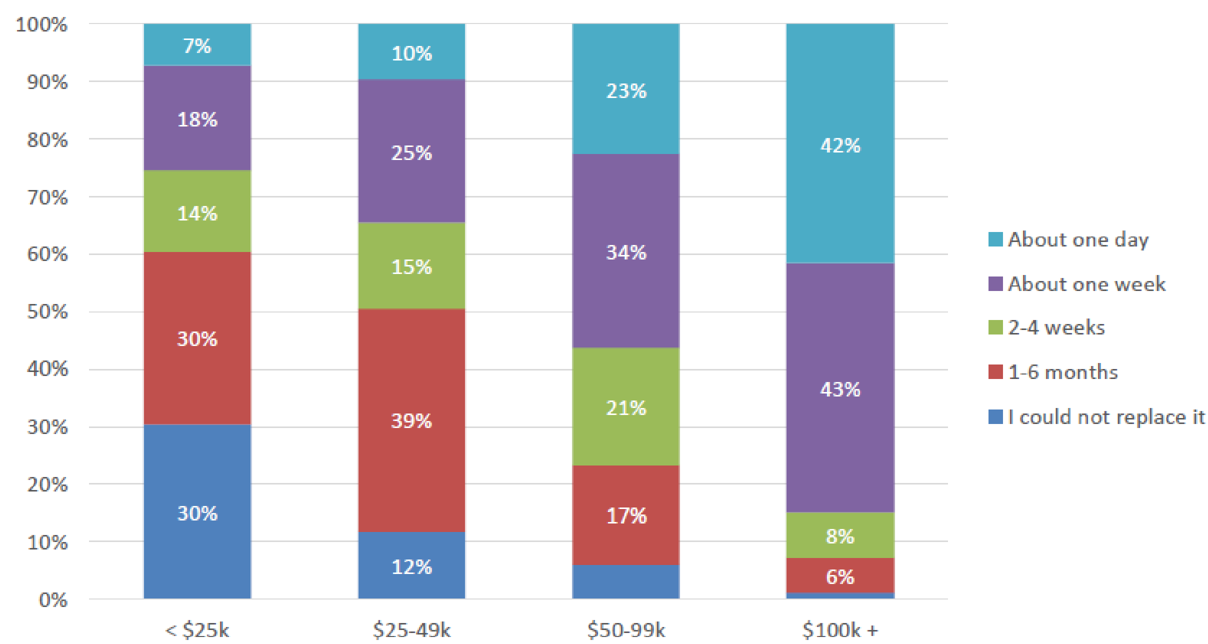


Figure 115: When Could Replace Computer by Household Income



The City or DISD could forge partnerships with, or replicate programs offered by, organizations such as Comp-U-Dopt, PCs for People, Tech Soup, and Tech Goes Home. These organizations have a variety of successful and scalable models for reselling, refurbishing, or offering new laptops and other devices and training to partner organizations.

Given the availability of funds for efforts such as this, we recommend the City purchase new devices at a far larger scale to address Dallas residents' immediate challenges. A one-time purchase of new computers for the roughly 65,000 households that lack a computer[65] would cost approximately $13 million (Table 43).

Table 43: Estimated Budget for One-Time Device Purchase Program

Category	Budget
Obtain 65,000 devices (based on 2019 American Community Survey data that 12.8% of Dallas households lacked a computer)	$13,000,000
Total	**$13,000,000**
Estimated cost per household	*$200*

7.5.4 Recommendation: DISD should prepare for procurement of home-based services under Emergency Connectivity Fund

The Emergency Connectivity Fund represents a significant opportunity for DISD to apply for federal funding to offset the costs of its efforts to ensure all unserved students have broadband access for the coming school year. Importantly, federal reimbursement from the Emergency Connectivity Fund could dovetail with a bulk-purchase of services from Charter or AT&T for unserved DISD families.[66]

As an estimate of the number of DISD households lacking broadband, we consider wireless infrastructure Model 2 (see Section 2.2), which aims to serve the 45,000 student households at schools with low CRI scores. If we estimate that a bulk purchase price might be around $20 per household per month, DISD could potentially facilitate the provision of broadband to those families for about $10.8 million per year—reimbursed by the Emergency Connectivity Fund in the first year to the extent a student is not currently connected. (While there has been some discussion in Washington of continued subsidy, we would not assume that ECF will continue to pay in future years.)

By way of background, the FCC's E-rate program has previously subsidized broadband service to schools and libraries. As we describe in Section 8.2.3, the American Rescue Plan Act included a $7.2 billion appropriation to create the Emergency Connectivity Fund, which extends E-rate support to reimburse schools and libraries for providing equipment and connectivity services to

[65] "Quick Facts: Dallas city, Texas," U.S. Census Bureau, https://www.census.gov/quickfacts/fact/table/dallascitytexas/PST045219 (accessed June 2021).

[66] Charter offers bulk-purchase option for entities such as cities or school districts to purchase internet services for residents. In February, Charter responded to a Region 10 ESC request for proposals (RFP) with an offer to provide 50 Mbps service for $29.99 monthly per household, which would be reduced to $24.99 if 3,000 or more subscribers were added.

K-12 students *at their homes and other locations*. All schools and libraries that are eligible for E-rate are also eligible for the Emergency Connectivity Fund program

The FCC issued rules for the Emergency Connectivity Fund in early May 2021.

The FCC issued rules for the Emergency Connectivity Fund in early May 2021. Priority is given to students and library users who will be unserved by broadband in this school year. The first application window has passed, but a second ECF application window will be open from Sept 28, 2021, to October 13, 2021, for the current school year (specifically for July 1, 2021, to June 30, 2022). ECF will allow for reimbursement retroactively for qualified expenses within this period.

This program will pay 100 percent of a school or library's "reasonable" costs for mobile hotspots (up to $250 each), connected devices (up to $400 per device), and services; it will not cover the cost of infrastructure construction. Wi-Fi hotspots for school buses are allowed—and present an option for delivering service beyond individual homes.

In terms of services purchased with Emergency Connectivity Fund money, the FCC does not specify a minimum definition of broadband (such as the 25 Mbps download and 3 Mbps upload requirement for some other programs); rather, it requires the connection be sufficient to enable remote learning, which includes videoconferencing. As mentioned above, if DISD were to negotiate a bulk purchase of Charter or AT&T services to connect unserved students, that contract could be eligible for reimbursement—likely within a range of $10 to $25 per month per user.[67]

Unlike the standard, rigorous E-rate procurement process, the Emergency Connectivity Fund will require participating school districts to verify and self-certify that beneficiaries are not also receiving benefits under other federal programs such as the FCC's Emergency Broadband Benefit Program subsidy. DISD and other school districts that tap into this funding source should develop a rigorous process and document every step, so as to be prepared for a potential future audit of its participation.

7.5.5 Recommendation: Evaluate bulk purchase of service for unserved residents

If the City were to consider a bulk-purchase of services for unserved residents, the annual costs could be considerably higher than a bulk-purchase program only for DISD families—depending on the scope of the subsidy effort (Table 44).

According to the Census, as of the American Community Survey for 2019, only 76.6 percent of Dallas' 513,000 households had a broadband internet subscription. We thus estimate 23.4

[67] "How the FCC Will Help Schools and Libraries Bridge the Digital Divide," Benton Institute for Broadband & Society, May 13, 2021, https://www.benton.org/blog/how-fcc-will-help-schools-and-libraries-bridge-digital-divide (accessed May 24, 2021).

percent of households, or 120,000, lack a broadband subscription. Assuming a bulk purchase price of $20 per month, subsidizing service to those households would cost $28.8 million annually.

Alternatively, if the City were to bulk-purchase service for the estimated 56,000 households in poverty, its annual cost would be an estimated $13.4 million.

Table 44: Estimated Alternative Annual Budget for Ongoing Broadband Connectivity Subsidy Program

Alternative Proposed Criteria for Eligibility	Estimated Number of Eligible Households	Total Annual Budget
Households without a broadband internet subscription as of 2019 (American Community Survey)	120,000	$28.8 million
Households in poverty as of 2019 (American Community Survey)	56,000	$13.4 million
Estimated annual cost per household	*$240*	

8 Summary of grant and other funding opportunities

Recent federal actions have led to an unprecedented amount of available broadband funding. Both the Consolidated Appropriations Act and the American Rescue Plan Act created new broadband funding opportunities, and the latter included a sizeable appropriation for the Department of Commerce's Public Works and Economic Adjustment Assistance Program—which continues to be one of the most promising sources of funding for broadband projects in urban communities such as Dallas.

As we were writing this report, the federal government released preliminary guidance and rules on many of these programs—which represent the biggest tranche of broadband funding ever appropriated by Congress. It is important to understand the funding landscape is shifting in real time. As we describe below, for example, initial guidance from NTIA indicates the agency has added project eligibility restrictions that were not part of the statutory language that created one of the new funding programs.

The following sections describe these opportunities and our initial assessment of their feasibility for the City and DISD based on our analysis of the legislation, notices of funding opportunity (NOFO), and other guidance released so far.

8.1 Broadband funding in the 2021 appropriations package

The federal appropriations bill[68] signed into law on December 27, 2020, includes several funding streams for broadband, including a subsidy program to offset the cost of monthly internet service for low-income households, administered by the FCC, and three distinct grant programs to build new broadband infrastructure and purchase services, managed by NTIA.[69]

While the funds for NTIA's programs and the initial statutory requirements were included in the legislation, the program details were released later. The initial statutory program structures and eligibility requirements are described below. The FCC has released the full rules for the Emergency Broadband Benefit, which are described here and also discussed in Section 7.1.4.

8.1.1 Broadband Infrastructure Program (Department of Commerce)

NTIA released a notice of funding opportunity (NOFO) on May 19, 2021, for the Broadband Infrastructure Program—what the Consolidated Appropriations Act referred to as the Promote

[68] "Consolidated Appropriations Act, 2021," U.S. Congress, December 21, 2020, https://rules.house.gov/sites/democrats.rules.house.gov/files/BILLS-116HR133SA-RCP-116-68.pdf (accessed May 10, 2021).

[69] One of the three programs, the Tribal Broadband Connectivity Program, is not included here because of Dallas' lack of Tribal lands.

Broadband Expansion Grant Program. [70] The funding window for submission of grant applications closed on August 17, 2021.

But the City of Dallas had little to no chance of being funded under this program, for two reasons. First, the program prioritizes unserved areas. Second, the fund is only $288 million for the entire country—and large numbers of more-eligible rural jurisdictions applied for the funds.

According to the appropriations bill, the Broadband Infrastructure Program will fund grants from NTIA to provide fixed service that delivers at least 25/3 Mbps, with priority given to projects that deliver 100/20 Mbps.

8.1.2 Connecting Minority Communities Pilot Program (Department of Commerce)

The Connecting Minority Communities Pilot Program[71] will provide $285 million in grant funding to eligible recipients to purchase broadband or eligible equipment, or to hire and train IT personnel. The program will be administered by NTIA. The application window has opened, and applications are due on December 1.

This nascent program represents an opportunity for several institutions in Dallas to pursue funding to support instruction and remote learning capabilities, with priority placed on serving students that meet certain criteria to indicate need.

Entities eligible to receive grants through this program include:

- Historically Black colleges and universities (HBCUs)
- Tribal colleges and universities (TCUs)
- Hispanic-serving institutions (HSIs)
- Other minority serving institutions (MSIs)
    - Alaska Native-serving institution (ANSI)
    - Native Hawaiian-serving institution (NHSI)
    - Predominantly Black institutions (PBI)
    - Asian American and Native American Pacific Islander-serving institution (AANAPISI)
    - Native American-serving, nontribal institution (NASNTI)

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[70] "Consolidated Appropriations Act, 2021," U.S. Congress, December 21, 2020, https://rules.house.gov/sites/democrats.rules.house.gov/files/BILLS-116HR133SA-RCP-116-68.pdf (accessed May 10, 2021).

[71] "Consolidated Appropriations Act, 2021," U.S. Congress, December 21, 2020, https://rules.house.gov/sites/democrats.rules.house.gov/files/BILLS-116HR133SA-RCP-116-68.pdf (accessed May 10, 2021).

- A consortium led by an HBCU, TCUs, HSIs or MSI, with minority business enterprises and/or nonprofit organizations in the anchor community

Entities in Dallas that are eligible to apply for this program include the following:

- Dallas Nursing Institute (PBI)
- El Centro College (HSI)
- Mountain View College (HSI)
- Paul Quinn College (HBCU)
- Richland College (AANAPISI & HSI)
- University of North Texas at Dallas (HSI)

For higher education recipients, grants are intended to support instruction and learning, including remote learning. For minority business enterprises and nonprofits, grants are intended to support the operation of the organization. Educational institutions that receive a grant to support student connectivity must prioritize students that:

- Are eligible to receive the Pell Grant
- Receive need-based financial aid from the federal government, state, or the institution
- Qualify for the FCC's Lifeline program
- Earn less than 150% of the federal poverty line
- Have been approved to receive unemployment insurance since March 1, 2020

Eligible equipment includes Wi-Fi hotspots; modems, routers, or combined modem/routers; laptops, tablets, or similar internet-connected devices; and any other equipment used to provide broadband.

8.1.3 Emergency Broadband Benefit Program (Federal Communications Commission)

As we describe in Section 7.1.4, the Appropriations Act established a $3.2 billion Emergency Broadband Benefit Program,[72] housed within the FCC, to provide a monthly discount to eligible households for broadband service. This program pays a subsidy directly to eligible residents (in the form of a credit on their ISP's bill), so the City and DISD's role would be limited to encouraging and enabling residents to enroll.

Service providers must elect to participate in the program, and do not need to be considered eligible telecommunications carriers (ETC) by the FCC. While ETCs are automatically eligible to

[72] "Consolidated Appropriations Act, 2021," U.S. Congress, December 21, 2020, https://rules.house.gov/sites/democrats.rules.house.gov/files/BILLS-116HR133SA-RCP-116-68.pdf (accessed May 10, 2021).

participate in the program, providers that are not ETCs will receive an expedited approval process for participation from the FCC.

Participating providers may verify household eligibility in one of three ways:

1. Based on the National Verifier or the National Lifeline Accountability Database
2. Based on an alternative method that is deemed sufficient by the FCC
3. Based on a school's determination of participation in the National School Lunch Program or the School Breakfast Program

Eligible households receive a monthly discount on broadband service of up to $50 (or $75 for households on Tribal lands). If the monthly cost to the household exceeds $50, the household is responsible for the difference. Providers cannot charge households for the discount amount, nor can they require a household to pay an early termination fee if the household entered into a contract in order to receive the service. Additionally, households cannot be subject to a waiting period to receive service based on having previously received service from the provider.

To enact the benefit, a household must either apply through the Universal Service Administrative Company (USAC) or contact its provider and inquire about eligibility. If the household is eligible, the participating provider applies the discount to the household's bill, and then requests to be reimbursed by the FCC. Providers may also be reimbursed up to $100 for providing one connected device to a household if the provider charges the household between $10 and $50 for the device.

8.2 Broadband funding in the American Rescue Plan Act

President Biden signed the American Rescue Plan Act into law on March 11, 2021. Included in the $1.9 trillion package is significant funding that can be used to support expansion of broadband infrastructure. The key broadband-related provisions include the following funds.

8.2.1 Coronavirus State and Local Fiscal Recovery Fund (Department of the Treasury)

The U.S. Department of the Treasury has released interim final rules for the Coronavirus State and Local Fiscal Recovery Funds program.[73] Established in ARPA, this program will distribute $350 billion in emergency funding to eligible state, local, territorial, and Tribal governments. Treasury has allocated about $350 million to Dallas.[74]

[73] "Fact Sheet: The Coronavirus State and Local Fiscal Recovery Funds Will Deliver $350 Billion for State, Local, Territorial, and Tribal Governments to Respond to the COVID-19 Emergency and Bring Back Jobs," U.S. Department of the Treasury, May 10, 2021, https://home.treasury.gov/system/files/136/SLFRP-Fact-Sheet-FINAL1-508A.pdf.

[74] "Allocation for Metropolitan Cities," U.S. Department of the Treasury, page 24, https://home.treasury.gov/system/files/136/fiscalrecoveryfunds-metrocitiesfunding1-508A.pdf (accessed May 14, 2021).

The State and Local Fiscal Recovery Fund includes broadband spending as an eligible use, but not a primary focus. (The Treasury-managed, $10 billion Coronavirus Capital Projects Fund is primarily for broadband projects; see Section 8.2.1 for more details.)

The Local Fiscal Recovery Funds program may be Dallas' most viable source of broadband funding because the City will control the funds.

In brief summary, Congress created this program's $350 billion allocation with no limitations on how it could be spent on broadband. When Treasury announced its interim final rules, however, those guidelines included new restrictions that were not part of the authorizing legislation. The interim rules said the Local Fiscal Recovery Funds should not be targeted for areas where there is "reliable" 25/3 Mbps broadband service. Treasury has since clarified that these funds can be used in areas that already have 25/3 if the funds are primarily targeted for areas where 25/3 is not available.

Based on the legislation that created it, this program will fund broadband deployments and digital equity strategies designed to facilitate such connectivity and has been designed to enable states and localities "to identify the specific locations within their communities to be served and to otherwise design the project" to fit their needs.[75] Treasury provided interim rules establishing certain minimum requirements on how recipients can use funds for broadband deployments;[76] it also provided suggestive guidance about the range of digital equity projects that can use program funds. Key guidance includes the following:

- **Infrastructure projects must support 100 Mbps symmetrical speeds unless geographical, topographical, or fiscal constraints make it impractical.** For the purposes of the Fiscal Recovery Funds, Treasury's approach to broadband infrastructure matches some of the most forward-thinking states' broadband grant programs. In its interim rules, Treasury expects the funds to be used on broadband deployments that are capable of at least 100/100 Mbps speeds, to address Americans' modern communications needs. The program also strongly suggests that projects focus on fiber deployments, because fiber has the capability of affordably meeting the steady annual increase in broadband capacity demands faced by our nation's networks.

  The interim rules also outline a scenario in which symmetrical 100 Mbps service may be considered "impractical due to geographical, topographical, or financial constraints,"[77]

[75] "Coronavirus State and Local Fiscal Recovery Funds, Interim Final Rule," Department of the Treasury, 31 CFR Part 35, RIN 1505-AC77, released May 10, 2021, page 71, https://home.treasury.gov/system/files/136/FRF-Interim-Final-Rule.pdf. Interim Final Rules, "Interim Final Rules."

[76] "Coronavirus State and Local Fiscal Recovery Funds Frequently Asked Questions," pages 11-12, U.S. Department of the Treasury.

[77] Interim Final Rules, page 75, U.S. Department of the Treasury.

and in that case, require projects to provide 100/20 Mbps service with the ability to scale to 100 Mbps symmetrical. This appears to be a concession to incumbent cable providers who can cost-effectively extend to unserved locations from their current network footprint and are on a roadmap to symmetric speeds. Most cable companies have implemented DOCSIS 3.1—and while they currently limit upstream to 35 to 50 Mbps, field upgrades would allow them to deliver gigabit speeds upstream and would also put them on a long-term roadmap to DOCSIS 4.0's 10/6 Gbps capability.

- **Projects must address areas that lack 25/3 Mbps.** The interim final rules state that projects will be expected to address unserved and underserved areas, defined as those that do not yet have access to speeds of at least 25/3 Mbps. The manner in which this goal is phrased suggests wide latitude in designing projects—as long as they also address unserved locations.

- **Projects are encouraged to prioritize affordability as well as local broadband solutions.** After noting that the U.S. has some of the most expensive broadband service in the world,[78] the program's interim rules place special emphasis on ensuring that the resulting broadband service provided over the funded network is affordable. The "Treasury also encourages recipients to prioritize support for broadband networks owned, operated by, or affiliated with local governments, non-profits, and co-operatives—providers with less pressure to turn profits and with a commitment to serving entire communities."[79]

- **Projects are encouraged to prioritize last-mile connectivity.** While Treasury underscores this, states and localities are not precluded from setting their own priorities, and other initiatives that could improve affordability by investing in capacity bottlenecks such as middle-mile or data center builds could be funded.

- **Rural Digital Opportunity Fund (RDOF) results likely will not affect funding eligibility.** The interim rules encourage recipients to avoid funding projects that will serve a location with an existing agreement "to build reliable wireline service with minimum speeds of 100 Mbps download and 20 Mbps upload by December 31, 2024."[80] In other words, fixed wireless and satellite commitments (such as SpaceX) funded with federal dollars will not be considered ineligible. And because 2024 represents the third year of RDOF, at which point no RDOF winner will yet be obligated to serve a specific area, RDOF-funded wireline

[78] "Even in areas where broadband infrastructure exists, broadband access may be out of reach for millions of Americans because it is unaffordable, as the United States has some of the highest broadband prices in the Organisation for Economic Co-operation and Development (OECD)." Interim Final Rules, page 70, U.S. Department of the Treasury.
[79] Interim Final Rules, pages 76-77, U.S. Department of the Treasury.
[80] Interim Final Rules, page 76, U.S. Department of the Treasury.

areas are also not considered. Unless a winner made written commitments separately (for example, through a state grant application) for completing a build before this date, planners can largely disregard RDOF when evaluating projects for funding under this specific allocation.

- **Infrastructure projects are expected to meet strong labor standards.** This includes project labor agreements, community benefit agreements, and wages at or above the prevailing rate with local hire provisions. Treasury notes it will release additional guidance related to workforce reporting requirements at a later date, but expect fair (high) wage provisions, benefits, and local sourcing as key components.

- **Projects can address a wide array of broadband-related concerns.** In addition to infrastructure, these State and Local Fiscal Recovery Fund dollars can also be used for an array of other initiatives that respond to the public health and economic impacts of the pandemic. While Treasury leaves the door open for a wide variety of fundable initiatives, it offers the general guidance that recipients should "identify a need or negative impact of the Covid-19 public health emergency and, second, identify how the [proposed] program, service, or other intervention addresses the identified need or impact."[81]

- **Allocations from these funds can be leveraged as matches for other broadband grant opportunities.** Because these funds are considered locally administered, if you are already targeting a federal grant or state grant opportunity that requires matching funds, the Recovery Funds can be leveraged for that purpose.

8.2.2 Coronavirus Capital Projects Fund (Department of the Treasury)

The Treasury Department has released only initial information regarding its pending rules for the $10 billion Coronavirus Capital Projects grant fund. Final rules have yet to be released as of the writing of this report.

ARPA defined this program without using the word "broadband"—noting that funds were to be used for "capital projects directly enabling work, education, and health monitoring, including remote options, in response to the public health emergency." A brief statement posted by Treasury in early May makes clears that the program "allows for investment in high-quality broadband." [82]

[81] Interim Final Rules, page 10, U.S. Department of the Treasury.

[82] The interim rules for the funds show that Treasury intends to favor fiber optic investments, and to target symmetrical 100 Mbps service where feasible—which could indicate one aspect of what Treasury considers "high quality."

The statement further notes that proposed projects "must be critical in nature, providing connectivity for those who lack it." We do not know how Treasury will define "unserved" in its final rules.

The Capital Projects Fund is separate and distinct from the $350 billion State and Local Fiscal Recovery Funds program (see Section 8.2.1).[83] The former is intended only for broadband; the latter can be used for broadband—but is also intended to support infrastructure and other initiatives. That said, Treasury's statement makes it clear that Treasury sees the Capital Projects Fund as complementary to the State and Local Fiscal Recovery Funds when it comes to broadband.

The Capital Projects Fund is not a competitive-application program; states will receive a fixed allocation from this fund. Treasury's current guidance note that states will be asked to submit proposals on how the Capital Projects Fund allocations should be used. Until we have more defined rules, Treasury's guidelines indicate that recipients will have wide discretion for determining how to identify worthy projects.

That means, for example, that the City could propose to inject all funding from the Capital Projects Fund into its current programs with alignment to overall program guidelines on timing and purpose of expenditure.

We note that overbuilding is not a program goal. It is not clear what the final Capital Projects Fund rules will be, but Treasury's statement emphasizes the need to demonstrate bringing critical connectivity to those who do not currently have it. The companion State and Local Fiscal Recovery Funds also disincentivize overbuilds.

In other words, the Capital Projects Fund does not seem—according to the brief statement released—to be designed to create more affordable service options by increasing competition (such as by building new infrastructure in an area that already has high-speed wireline service). Similarly, it likely will not help the City improve broadband infrastructure in collaboration with an incumbent cable provider.

8.2.3 Emergency Connectivity Fund (Federal Communications Commission)

As we describe in detail in Section 7.5.4, DISD is well-positioned to apply for funding under this new program.

The FCC's E-rate program has previously subsidized broadband service to schools and libraries. The American Rescue Plan Act included a $7.2 billion appropriation to create the Emergency

[83] For more details, see our analysis here: https://www.ctcnet.us/blog/initial-guidance-and-analysis-treasury-announces-preliminary-guidance-for-broadband-projects-funded-by-the-350b-coronavirus-state-and-local-fiscal-recovery-funds/

Connectivity Fund, which extends E-rate support to reimburse schools and libraries for providing equipment and connectivity services to K-12 students at their homes and other locations. All schools and libraries that are eligible for E-rate are also eligible for the Emergency Connectivity Fund program.

The FCC issued rules for the Emergency Connectivity Fund in early May 2021. Priority is given to students and library users who will be unserved by broadband in this school year. The first application window has passed, but a second ECF application window will be open on Sept 28, 2021, to October 13, 2021, for the current school year (specifically for July 1, 2021, to June 30, 2022). ECF will allow for reimbursement retroactively for qualified expenses within this period.

8.3 Public Works and Economic Adjustment Assistance Program (Department of Commerce)

This program is a rebrand of the previous Economic Development Administration (EDA) Program and is designed to address needs in economically distressed areas. While the agency does not receive many broadband applications, this can actually be a strategic advantage for communities that can show broadband is needed as an element of their economic development plan. While it focuses on distressed communities, especially those that have experienced plant or base closures, an addendum was added on May 7, 2020, to announce additional funding through the CARES Act to support recovery of communities adversely affected by Covid-19. Funding requests that target recovery from Covid-19 distress are intended to be flexible and spent quickly and are not subject to the regular economic distress requirements. ARPA also allocated $3 billion in additional funding to the program through September 2022.

Eligible entities include city, township, county, or special district governments; state governments; federally recognized Tribal governments; nonprofits, aside from institutions of higher education; private institutions of higher education; and public and state-controlled institutions of higher education.

Regular program rules require the community to qualify as distressed for a project to be eligible. Criteria for eligibility is established by providing "third-party data that clearly indicate that the region is subject to one (or more) of the following economic distress criteria: (i) an unemployment rate that is, for the most recent 24-month period for which data are available, at least one percentage point greater than the national average unemployment rate; (ii) per capita income that is, for the most recent period for which data are available, 80 percent or less of the national average per capita income; or (iii) a "Special Need," as determined by EDA."

Note that the EDA has determined that the economic impact of the coronavirus pandemic constitutes a "special need," and has extended eligibility to all communities if applying for coronavirus related funding. Applicants must still explain in their applications how their project would "prevent, prepare for, and respond to" to coronavirus, or respond to "economic injury as a result of the coronavirus," and the level of distress of the community is still a factor in application competitiveness.

Building, designing, or engineering infrastructure and facilities to advance economic development strategies, or planning efforts to implement such solutions, are all considered eligible costs for this program. Grant awards vary with a minimum of $100,000, and a maximum of $30 million. However, the trends in awards since April 2020 have shown awards closer to an average of $3 million.

Grants typically covers up to 50 percent of project costs, but the maximum allowable investment rate can increase if other economic factors are met. For projects that constitute a special need (such as the coronavirus), the EDA will determine the maximum award percentage, not to exceed 80 percent of project costs. Funds from other federal financial assistance awards may be considered matching only if authorized by statute and approved by the EDA.

A Community Economic Development Strategy (CEDS) must be in place for the intended project area and must discuss the need for broadband. The applicant must demonstrate support of the project by the business community.

Appendix A: Internet usage survey instrument

The City of Dallas and Dallas Independent School District distributed a version of the attached survey in December 2020. The document below is the English-language version of the survey; the survey instrument mailed to residents was printed in both English and Spanish.

City of Dallas

and

Dallas Independent School District

Internet Usage Survey

DALLAS
INDEPENDENT SCHOOL DISTRICT

December 2020

Even if you do not have home internet service, please complete this survey form and return to us. Your opinions, experiences, and information are important to us. If you need help completing this survey in your language, please email officeofresilience@dallascityhall.com or rebsanchez@dallaisd.org or call 972-925-5671.

The City of Dallas, together with the Dallas Independent School District, is sending you this survey to help develop strategies to improve internet accessibility and affordability—and to ensure that residents have the skills needed to make the most effective use of broadband. *The information gathered will not be used to sell you anything.* Your responses will be kept strictly confidential.

How long will the survey take?
This survey should take approximately 15 minutes to complete.

What is the due date to complete the survey?
Please return your completed form in the enclosed postage-paid envelope by **December 31, 2020**.

What if I have questions about the survey?
If you have questions, please contact:

Liz Cedillo-Pereira
Chief of Equity and Inclusion, City of Dallas
Email: officeofresilience@dallascityhall.com

Rebecca Sanchez
Director, IT Business Services, Dallas Independent School District
Email: rebsanchez@dallaisd.org

City of Dallas Covid-19 Hotline
Phone: 214-670-INFO (4636).

Please also conduct a speed test of your home or mobile broadband service.

To do so, please visit https://speedsurvey.dallas.gov/, answer the brief questions, and conduct the speed test.

Thank you in advance for your participation!

☐ INTERNET USE AND DEVICES

Do you use the internet (also known as "going online") at all on any computer or phone from any location (e.g. home, work, coffee shop, library, friend's house, etc)?

- ☐ Yes **(Please skip to Question 0)**
- ☐ No

Thinking about the reasons why you do NOT ever use the internet, please indicate how much you agree or disagree with the following statements *(please circle your response for each statement, where 1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree)*

Aspect	*Strongly Disagree*				*Strongly Agree*
(a) An internet connection is too expensive	1	2	3	4	5
(b) I am concerned about my safety and privacy	1	2	3	4	5
(c) I am not interested	1	2	3	4	5
(d) I don't need to go online because I have someone who will do it for me	1	2	3	4	5
(e) I have no one to teach me how to go online	1	2	3	4	5
(f) I do not have a computer or other device for using the internet	1	2	3	4	5
(g) Using the internet is too difficult	1	2	3	4	5

How important are the following services to your household? *(please circle your response for each aspect, where 1=Not at all important, 2=Slightly important, 3=Moderately important, 4=Very important, 5=Extremely important)*

Aspect	*Not at all important*				*Extremely important*
(a) Internet connection (any speed)	1	2	3	4	5
(b) High-speed internet connection	1	2	3	4	5
(c) Cable television service	1	2	3	4	5
(d) Free broadcast TV from an antenna	1	2	3	4	5
(e) Satellite television service	1	2	3	4	5
(f) Fixed (land-line) telephone service	1	2	3	4	5
(g) Cellular/mobile telephone service	1	2	3	4	5
(h) Free public Wi-Fi service	1	2	3	4	5

If you use the internet in your home, who is your primary internet service provider? *(✓ only one)*

- ☐ Do not have internet service (home internet or cellular/mobile) **(Please answer Question 0 and then skip to Question 0)**
- ☐ AT&T (wired service—fiber or DSL) **(Please answer Question 0 and Question 0)**
- ☐ Frontier
- ☐ Spectrum **(Please answer Question 0)**
- ☐ Rise Broadband
- ☐ TierOne
- ☐ NextLink
- ☐ Argon Technologies
- ☐ Dish Network
- ☐ HughesNet
- ☐ ViaSat
- ☐ AT&T wireless (mobile service)
- ☐ Verizon wireless (mobile service)
- ☐ T-Mobile/Sprint, also called "New T-Mobile" (mobile service)
- ☐ Mobile Wi-Fi hotspot provided to me by a school, library or other entity
- ☐ Other (Please specify:________________________)

(If you do not have internet service) What is your main reason for not purchasing home internet service? *(✓ only one)*

- ☐ No good internet service is available at our location
- ☐ No internet-enabled devices in our home
- ☐ No interest or need for the internet
- ☐ Can get internet access at another location
- ☐ Privacy and security concerns
- ☐ Cost of internet service is too high
- ☐ Don't know how/not skilled enough to use the internet
- ☐ Cellular/mobile data service meets our needs
- ☐ Other ______________________

If your home internet service provider is AT&T, is the service DSL or fiber? (If you aren't sure, check if your Wi-Fi router is connected to a phone jack. If it is, you have DSL service.) *(✓ only one)*

- ☐ DSL (my router is connected to a phone jack)
- ☐ Fiber (my router is not connected to a phone jack)
- ☐ Unsure

If you are an AT&T customer, are you enrolled in AT&T Access, which provides $10 home internet service and other benefits to eligible low-income subscribers?

- ☐ Yes
- ☐ No
- ☐ I have not heard of this program until now
- ☐ I attempted to enroll in this program but was declined
- ☐ I am not an AT&T customer

If you are a Spectrum customer, are you enrolled in Spectrum Internet Assist, which provides $14.99 home internet service and other benefits to eligible low-income subscribers?

- ☐ Yes
- ☐ No
- ☐ I have not heard of this program until now
- ☐ I attempted to enroll in this program but was declined
- ☐ I am not a Spectrum customer

Do you receive a $9.25 subsidy on either a wireline or wireless broadband service under the FCC's "Lifeline" program, which is available to eligible low-income subscribers?

- ☐ Yes
- ☐ No
- ☐ Don't know

How many personal computing devices (desktop/laptop computers, tablets, smartphones, console gaming devices) are used in your household?

- ☐ 1 or 2
- ☐ 3 or 4
- ☐ 5 or more
- ☐ I do not have any personal computing devices in my home

What devices are available for use in your home? Check all that apply, but only for device or devices that are in good working order.

- ☐ Desktop computer
- ☐ Laptop computer
- ☐ Tablet computer, such as an iPad
- ☐ Smartphone
- ☐ Console gaming devices

Thinking about the computer you primarily use (desktop, laptop or tablet computer), about how often does it become inaccessible or unusable for any reason?

- ☐ Once a week or more
- ☐ Once a month
- ☐ Once a year
- ☐ This has never happened to me

Thinking about the computer you primarily use (desktop, laptop or tablet computer), if it were lost or damaged beyond repair, how long do you think it would take you to replace it?

- ☐ I could not do so in the foreseeable future
- ☐ 1-6 months
- ☐ 2-4 weeks
- ☐ About one week
- ☐ About one day

Please estimate how much your household pays PER MONTH for your *home* internet service (not including television or phone service).

- ☐ $0- $10
- ☐ $11 to $20
- ☐ $21 to $40
- ☐ $41 to $60
- ☐ $61 to $80
- ☐ $81 to $100
- ☐ $101 to $120
- ☐ More than $120

How often do you and anyone in your household use your primary home internet connection for: *(please circle your response for each activity)*

Home Internet Activity	*Never*	*Occasionally*	*Frequently*
(a) Listening to music (streaming)	1	2	3
(b) Watching movies, videos, or TV	1	2	3
(c) Playing online games	1	2	3
(d) Connecting to work	1	2	3
(e) Using social media	1	2	3
(f) Shopping online	1	2	3
(g) Running a home business	1	2	3
(h) Accessing educational resources	1	2	3
(i) Accessing government information	1	2	3
(j) Accessing medical services	1	2	3
(k) Banking or paying bills	1	2	3
(l) Accessing home security/other “smart home” devices	1	2	3
(m) Accessing cloud-based file storage and sharing	1	2	3

☐ COVID-19 PANDEMIC AND INTERNET USE

Thinking about your activities BEFORE the Covid-19 pandemic, how frequently did you use the internet at various times in your home? *(please circle your response for each timeframe, where 1=never, 2=less than monthly, 3=at least monthly, 4=at least weekly, and 5=at least daily)*

Time of Day	Never	Less Than Monthly	Monthly	Weekly	Daily
(a) Early morning (6 a.m. – 9 a.m.)	1	2	3	4	5
(b) Midmorning (9 a.m. – noon)	1	2	3	4	5
(c) Early afternoon (noon – 3 p.m.)	1	2	3	4	5
(d) Late afternoon (3 p.m. – 6 p.m.)	1	2	3	4	5
(e) Evening (6 p.m. – 9 p.m.)	1	2	3	4	5
(f) Night (9 p.m. – midnight)	1	2	3	4	5

Now, thinking about your activities DURING the Covid-19 pandemic, how frequently have you been using the internet at various times in your home? *(please circle your response for each timeframe, where 1=never, 2=less than monthly, 3=at least monthly, 4=at least weekly, and 5=at least daily)*

Time of Day	Never	Less Than Monthly	Monthly	Weekly	Daily
(a) Early morning (6 a.m. – 9 a.m.)	1	2	3	4	5
(b) Midmorning (9 a.m. – noon)	1	2	3	4	5
(c) Early afternoon (noon – 3 p.m.)	1	2	3	4	5
(d) Late afternoon (3 p.m. – 6 p.m.)	1	2	3	4	5
(e) Evening (6 p.m. – 9 p.m.)	1	2	3	4	5
(f) Night (9 p.m. – midnight)	1	2	3	4	5

Thinking about your normal habits BEFORE the Covid-19 pandemic, how often did you use the internet in the following locations on average? *(please circle your response for each timeframe, where 1=never, 2=less than monthly, 3=at least monthly, 4=at least weekly, and 5=at least daily)*

Location	Never	Less Than Monthly	Monthly	Weekly	Daily
(a) At my home	1	2	3	4	5
(b) At the home of a friend or family member	1	2	3	4	5
(c) At work	1	2	3	4	5
(d) Inside a school or a college/university building	1	2	3	4	5
(e) Inside a coffee shop or other private business	1	2	3	4	5
(f) Inside a library	1	2	3	4	5

(g) Inside other public buildings such as a municipal office or senior center	1	2	3	4	5
(h) At any outdoor public spaces (including outside any of the above locations) using free Wi-Fi	1	2	3	4	5

Now, thinking about how you have been using the internet DURING the Covid-19 pandemic, how often do you use the internet in the following locations on average? *(please circle your response for each timeframe, where 1=never, 2=less than monthly, 3=at least monthly, 4=at least weekly, and 5=at least daily)*

Location	Never	Less Than Monthly	Monthly	Weekly	Daily
(a) At my home	1	2	3	4	5
(b) At the home of a friend or family member	1	2	3	4	5
(c) At work	1	2	3	4	5
(d) Inside a school or a college/university building	1	2	3	4	5
(e) Inside a coffee shop or other private business	1	2	3	4	5
(f) Inside a library	1	2	3	4	5
(g) Inside other public buildings such as a municipal office or senior center	1	2	3	4	5
(h) At any outdoor public spaces (including outside any of the above locations) using free Wi-Fi	1	2	3	4	5

Thinking about how often you engaged in various internet activities BEFORE the Covid-19 pandemic, how often did you engage in the following activities? *(please circle your response for each timeframe, where 1=never, 2=less than monthly, 3=at least monthly, 4=at least weekly, and 5=at least daily)*

Internet activity	Never	Less Than Monthly	Monthly	Weekly	Daily
(a) Telework/working from home	1	2	3	4	5
(b) Telemedicine/doctor appointments	1	2	3	4	5
(c) Do homework	1	2	3	4	5
(d) Attend online classes	1	2	3	4	5
(e) Homeschool	1	2	3	4	5

Now, thinking about how often you have been engaging in various internet activities DURING the Covid-19 pandemic, how often do you engage in the following activities? *(please circle your response for each timeframe, where 1=never, 2=less than monthly, 3=at least monthly, 4=at least weekly, and 5=at least daily)*

Internet activity	Never	Less Than Monthly	Monthly	Weekly	Daily
(a) Telework/working from home	1	2	3	4	5
(b) Telemedicine/doctor appointments	1	2	3	4	5
(c) Do homework	1	2	3	4	5

(d) Attend online classes	1	2	3	4	5
(e) Homeschool	1	2	3	4	5

What is the current education level of those using your internet connection in your household? *(✓ all that apply)*

- ☐ Preschool (early childhood)
- ☐ Primary (kindergarten – Grade 8)
- ☐ Secondary (Grades 9 – 12)
- ☐ Post-Secondary (Technical/vocational training, college, etc.)
- ☐ Graduate (Graduate, post-graduate, professional degree)
- ☐ Continuing or Adult Education/Professional Development
- ☐ Other ____

At peak usage times in your household DURING the Covid-19 pandemic, how many people need to be online for work, school, and other activities at the same time?

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5 or more

☐ COMPUTER AND INTERNET SKILLS

Please indicate how much you disagree or agree with the following statements regarding your skills using computers and the internet. *(please circle your response for each statement, where 1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree)*

Skill	*Strongly Disagree*				*Strongly Agree*
(a) I know how to upload content (such as videos, photos, music) to a website	1	2	3	4	5
(b) I know how to adjust my privacy settings online, such as on Facebook or other sites	1	2	3	4	5
(c) I know how to bookmark a website or add a website to my list of favorites	1	2	3	4	5
(d) I know how to identify false or misleading information online and find credible sources of information	1	2	3	4	5
(e) I know how to manage my own personal profile on Facebook or other social network site	1	2	3	4	5

Skill	*Strongly Disagree*				*Strongly Agree*
(f) I know how to create and manage my own personal website	1	2	3	4	5
(g) I know how to recognize and avoid a phishing scam	1	2	3	4	5
(h) I know how to create my own content (such as videos, photos, music) using computers and the internet	1	2	3	4	5
(i) I know how to access my bank account online to perform tasks such as paying bills or depositing checks with my phone	1	2	3	4	5
(j) I feel confident in my ability to troubleshoot issues with technology when they arise	1	2	3	4	5
(k) I know how to purchase groceries and food online	1	2	3	4	5
(l) I know how connect with my doctor or other medical support online	1	2	3	4	5

Please indicate how much you disagree or agree with the following statements about your interest in opportunities to obtain training related to computers and the internet. *(please circle your response for each statement, where 1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree)*

Statement	*Strongly Disagree*				*Strongly Agree*
(a) I would like to become more confident in using computers, smartphones, and the internet	1	2	3	4	5
(b) I would attend a free or inexpensive class to become more confident in using computers, smartphones, and the internet	1	2	3	4	5
(c) I would like to know how to better use online resources to find trustworthy information	1	2	3	4	5
(d) I would attend a free or inexpensive class in how to use online resources to find trustworthy information	1	2	3	4	5

Statement	*Strongly Disagree*				*Strongly Agree*
(e) I would like to learn how computers work	1	2	3	4	5
(f) I would attend a free or inexpensive class to learn how computers work	1	2	3	4	5
(g) I would like to learn how to write software (or "code")	1	2	3	4	5
(h) I would attend a free or inexpensive class to learn how to write software (or "code")	1	2	3	4	5

☐ TECHNOLOGY FOR MINOR CHILDREN

Are you the parent, legal guardian or primary caregiver for any child or grandchild under the age of 18 (minor child)?

☐ Yes

☐ No **(Please skip to Question 0)**

This next set of questions asks about how minor children under your care are able to make beneficial use of technology. If you are a legal guardian of a minor child still in school, these questions also apply to you. *(please circle your response for each statement, where 1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree)*

Skill	*Strongly Disagree*				*Strongly Agree*
(a) I feel that children or grandchildren under my care cannot complete their homework because they do not have access to the internet	1	2	3	4	5
(b) I feel that children or grandchildren under my care cannot complete their homework because they do not have access to computers	1	2	3	4	5
(c) I feel that my computer skills are good enough to help children or grandchildren under my care complete their homework	1	2	3	4	5
(d) The children or grandchildren under my care have good enough computer skills to complete their homework on their own	1	2	3	4	5
(e) The children or grandchildren under my care are learning computer skills at school that will prepare them for the future	1	2	3	4	5
(f) The children or grandchildren under my care access the internet at a public or school library	1	2	3	4	5
(g) The children or grandchildren under my care can safely access public libraries	1	2	3	4	5
(h) I learn computer or internet skills from family members	1	2	3	4	5

This next set of questions asks about the skills you or children under your care possess to avoid or minimize online risks. If you are a legal guardian of a minor child still in school, these questions also apply to you. *(please circle your response for each statement, where 1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree)*

Risk	*Strongly Disagree*				*Strongly Agree*
(a) I feel that my children or grandchildren have the skills to detect and avoid false or misleading information online	1	2	3	4	5
(b) I feel that my children or grandchildren are able to avoid online bullying by peers	1	2	3	4	5
(c) I feel that my children or grandchildren are able to get help dealing with online bullying by peers if it does occur	1	2	3	4	5
(d) I feel that my children or grandchildren are able to effectively detect and avoid online financial scams or predators	1	2	3	4	5
(e) I feel that my children or grandchildren are able to avoid exposure to graphic violence or pornography online	1	2	3	4	5
(f) I feel that my children or grandchildren are able to get help if they are exposed to graphic violence or pornography online	1	2	3	4	5
(g) I feel that I am aware of the extent to which my children or grandchildren is exposed to any of the above types of risks or content	1	2	3	4	5
(h) I feel that I have the time and skills to protect my children or grandchildren from the above risks and content	1	2	3	4	5

☐ INTERNET FOR JOBS/CAREERS

Does someone in your household have a home-based business or plan to start a home-based business in the next three years?

☐ Yes, I/we already have a home-based business
☐ Yes, I/we plan to start one in next three years
☐ No

How important is high-speed internet access for: *(please circle your response for each aspect, where 1=Not at all important, 2=Slightly important, 3=Moderately important, 4=Very important, 5=Extremely important)*

Aspect	*Not at All Important*				*Extremely Important*	*N/A*
(a) Working from home (teleworking)	1	2	3	4	5	6
(b) Planned/existing home-based business	1	2	3	4	5	6

☐ OPINIONS ABOUT BROADBAND SERVICE

Please indicate to what extent you disagree or agree that the City or DISD should do the following: *(please circle your response for each statement, where 1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree)*

Aspect	*Strongly Disagree*				*Strongly Agree*
(a) Help ensure that all residents have access to affordable broadband internet services	1	2	3	4	5
(b) Help ensure that all students have access to affordable broadband internet services	1	2	3	4	5
(c) Help ensure that all residents know how to make effective use of the internet	1	2	3	4	5
(d) Provide free access at home to internet-based educational resources for economically disadvantaged students	1	2	3	4	5
(e) Provide free Wi-Fi in public areas	1	2	3	4	5

Consider at what price levels you would be willing to purchase extremely fast internet service (1 gigabit per second). This speed can handle multiple high-definition video streams at the same time or transmit large video or other files near-instantaneously. How willing would be to do so for the following monthly price? *(please circle your response at each price level, where 1=Not at all willing, 2=Slightly willing, 3=Moderately willing, 4=Very willing, 5=Extremely willing)*

Monthly Price	*Not at all Willing*				*Extremely Willing*
(a) $10 per month	1	2	3	4	5
(b) $30 per month	1	2	3	4	5
(c) $50 per month	1	2	3	4	5
(d) $70 per month	1	2	3	4	5
(e) $90 per month	1	2	3	4	5
(f) $110 per month	1	2	3	4	5

☐ INFORMATION ABOUT YOU

The following questions will help describe the total group of survey respondents. Your individual information will not be reported separately—it will be reported only as a part of a larger group to help ensure that the respondents are a representative sample of the residents of the DISD.

Which of the following best describes your age?

- ☐ 18 to 34 years
- ☐ 35 to 44 years
- ☐ 45 to 54 years
- ☐ 55 to 64 years
- ☐ 65 years and older

What is the highest level of education you have completed?

- ☐ Grade School
- ☐ Some high school
- ☐ Completed high school
- ☐ Two-year college or technical degree
- ☐ Four-year college degree
- ☐ Graduate, professional, or doctorate degree

What is your approximate annual household income?

- ☐ Less than $25,000
- ☐ $25,000 to $49,999
- ☐ $50,000 to $74,999
- ☐ $75,000 to $99,999
- ☐ $100,000 to $149,999
- ☐ $150,000 to $199,999
- ☐ $200,000 or more
- ☐ Prefer not to answer

What is your race/ethnicity? ***(✓ all that apply)***

- ☐ Black/African American
- ☐ Eastern Asian/Asian American
- ☐ Hispanic/Latino
- ☐ Native American/Indigenous American
- ☐ Southern Asian/Indian American
- ☐ Western Asian/Arab American
- ☐ White/European American
- ☐ Other (please specify): ______________________

How many people reside in your home (adults and children)?

Adults (including yourself)	Children age 18 and younger
☐ 1	☐ None
☐ 2	☐ 1
☐ 3	☐ 2
☐ 4 or more	☐ 3
	☐ 4 or more

Do you own or rent your residence?

- ☐ Own
- ☐ Rent
- ☐ Live with family
- ☐ Other: ______________________

How long have you lived at your current address?

- ☐ Less than 1 year
- ☐ 1 to 2 years
- ☐ 3 to 4 years
- ☐ 5 or more years

Thank you for completing this survey!

Appendix B: Glossary of basic broadband terms

Broadband – High-speed internet access that is always on and is faster than dial-up access. In 2015, the FCC updated the legal definition of broadband to refer to services providing at least 25 Mbps download and 3 Mbps upload.

Cable – Also called cable modem service. Broadband service that is faster than DSL, is delivered over the same "coaxial cable" that brings cable TV into a home. The most state-of-the-art cable systems can deliver very fast service—up to 1 gigabit per second (Gbps) in some places.

CPE – Customer premises equipment; the electronic equipment installed at a broadband subscriber's home or business.

DSL – Digital subscriber line, an older internet service delivered over copper telephone lines. In areas where the telephone company offers DSL, the service is available to homes and businesses that are within a certain distance from the phone company's local facility. DSL is the slowest of the internet services delivered over wires.

Fiber – Also called fiber optic, fiber-to-the-home, or fiber-to-the-premises (FTTP). The fastest broadband technology available. Like coaxial cables, fiber optic cables are attached to utility poles or installed underground, then connected to a subscriber's home. Fiber can deliver 1 Gbps now, though fiber ISPs typically offer multiple service levels at lower speeds and costs. Developing fiber technologies will enable 10 Gbps or faster service.

Fixed wireless – Internet service delivered over the air from an ISP's nearby antenna to a fixed antenna mounted at the customer's home or business. The antenna at the customer's location connects to a small router device, which then emits a Wi-Fi signal that's available to any devices in the house. Fixed wireless is often an option in areas where ISPs have not constructed wires to users' homes.

ISP – Internet service provider; an organization that provides services enabling customers to connect to the internet.

Mobile wireless – Internet service delivered over the air from an internet service provider's (ISP) nearby antenna to a user's cell phone or to another mobile device (like a tablet or laptop) that has a wireless card. Mobile wireless service is unique in that it follows the user virtually anywhere they go. Users typically pay for mobile wireless service on a per-device basis.

Wi-Fi – A networking technology by which computers and other devices transmit data wirelessly.

Appendix C: Summary cost tables

Table 45: Estimated 100-Mile Fiber Ring Costs

Item	Cost
Fiber Optic Outside Plant (OSP) Construction	$12,500,000
Network Hardware	$800,000
Network Integration and Testing	$200,000
Total Capital Costs	**$13,500,000**
Annual Operating Costs	**$1,000,000**

Table 46: Estimated Fixed Wireless Costs

Model	Households Served	One-time Capital Cost	One-time Capital Cost per Household	Annual Operating Cost	Annual Operating Cost per Household
1: DISD families at all schools	74,500	$38,175,000	$650	$4,858,000	$65
2: DISD families at schools with CRI of less than 40	44,800	$20,992,000	$610	$2,816,000	$63
3: All City residents in areas with less existing broadband infrastructure (see Figure 1)	28,235	$21,880,000	$915	$2,266,000	$81
4: All City residents in Covid Risk 5 areas	774	$894,000	$1,310	$280,000	$361

Table 47: Estimated Initiative Budget – Providing Resources to Help Residents Enroll in Low-Cost and Subsidy Programs[84]

Year One	**Budget**
Creation and distribution of informational materials such as web pages, fliers, inserts, and mailers	$20,000
Call center technology and software licenses	$20,000
Three full-time call center staff ($40 hourly rate)	$249,600
Total	**$289,600**
Estimated cost per household if 8,000 households are assisted	*$36*
Subsequent Years	**Budget**
Creation and distribution of fliers, inserts, and mailers	$5,000
Maintenance of call center and equipment	$10,000
Three full-time call center staff, based on an hourly rate of $40	$249,600
Annual Costs for Year Two Onward	**$264,600**
Estimated cost per household if 8,000 households are assisted	*$33*

Table 48: Estimated Budget for Digital Navigators Training Program

Category	**Budget**
Training cost per student	$200
Estimated cost if 5,000 residents are assisted	*$1,000,000*

Table 49: Estimated Budget for One-Time Device Purchase Program

Category	**Budget**
Obtain 65,000 devices[85]	$13,000,000
Total	**$13,000,000**
Estimated cost per household	*$200*

Table 50: Estimated Alternative Annual Budget for Ongoing Broadband Connectivity Subsidy Program

Alternative Proposed Criteria for Eligibility (2019 American Community Survey Data)	**Estimated Number of Eligible Households**	**Total Annual Budget**
Households without a broadband internet subscription	120,000	$28.8 million
Households in poverty	56,000	$13.4 million
Estimated annual cost per household	*$240*	

[84] Numbers are estimates derived from CTC's experience designing and operating call centers to support broadband subsidy programs on behalf of state government entities.
[85] Based on 2019 American Community Survey data that 12.8 percent of Dallas households lacked a computer.