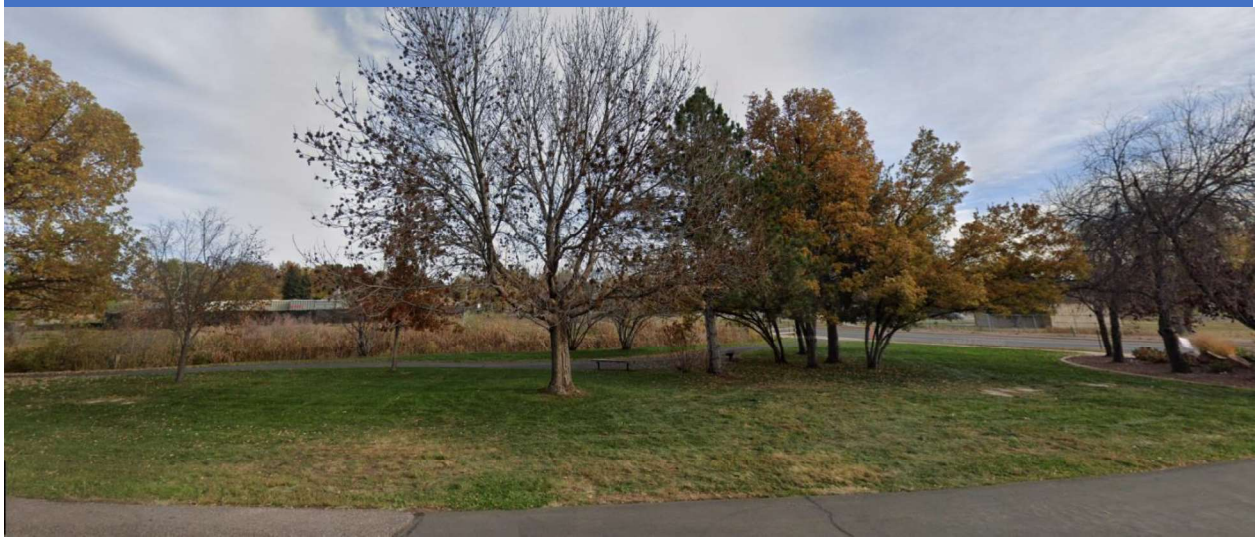
City of Cherry Hills Village

Citywide Cellular Communications & Fiber Study

October 21, 2024



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Section 1: Executive Summary

The Cherry Hills Village Study

The City of Cherry Hills Village is investigating the costs and benefits of various levels of involvement in the management and ownership of future cellular and fiber (broadband) communications within the City, and the infrastructure needs related to these services. Cherry Hills Village is interested in understanding the feasibility of providing improved widespread cellular service throughout the community.

The City desired to create a long-term Vision to address the community's goals for advanced and improved cellular communication. With this Vision defined, the City wanted a plan to provide a strategy for future cellular and broadband improvements including costs. The City understood that it was critical to involve the stakeholders in the visioning process to identify the community's wants and needs.

In April of 2023, City leaders selected HR Green to complete this Citywide Cellular Communications and Fiber Study to address how to best serve the cellular needs of Cherry Hills Village residents and how public and private entities could work together towards a common goal of improving cellular service and fiber (broadband) capability in Cherry Hills Village.

The primary objective of the Study was to make a recommendation as to how to improve cellular service with fiber (broadband) improvements being ancillary. Since the primary focus of this Study was on citywide cellular improvements, **Section 1** through **Appendix C** of this Report documents the cellular part of the Study. **Appendix D** of this Report documents the fiber (broadband) part of the Study.

Approach

The following multi-phase approach was used to complete this Study.

Phase I – Vision

- Assessment of Private Cellular Resources (See **Section 2**)
- Assessment of Private Broadband Resources (See **Appendix D**)
- Cellular Regulatory Review (See **Appendix A**)
- Evaluation of Existing Cellular Conditions (See **Section 2**)
- Evaluation of Existing Fiber Conditions (See **Appendix D**)
- Citizen Cellular Survey (See **Section 3**)
- Citizen Broadband Survey (See **Appendix D**)
- Broadband Market Assessment (See **Appendix D**)
- Vision and Goal Setting Workshops (See **Section 4**)

Phase II - Planning

- Preliminary Cellular Designs and Cost Estimates (See **Section 5**)
- Preliminary Broadband Design and Cost Estimate (See **Appendix D**)
- Conduct Cellular Financial Analysis (See **Section 6**)
- Evaluate Broadband Funding Alternatives (See **Appendix D**)
- Complete Citywide Cellular Communication and Fiber Study (See **Section 8**)

Phase III - Create Public Private Partnerships (P3) Solutions (Executed in parallel with Phase II)

- Explore Public Private Cellular Partnerships (See **Section 7**)

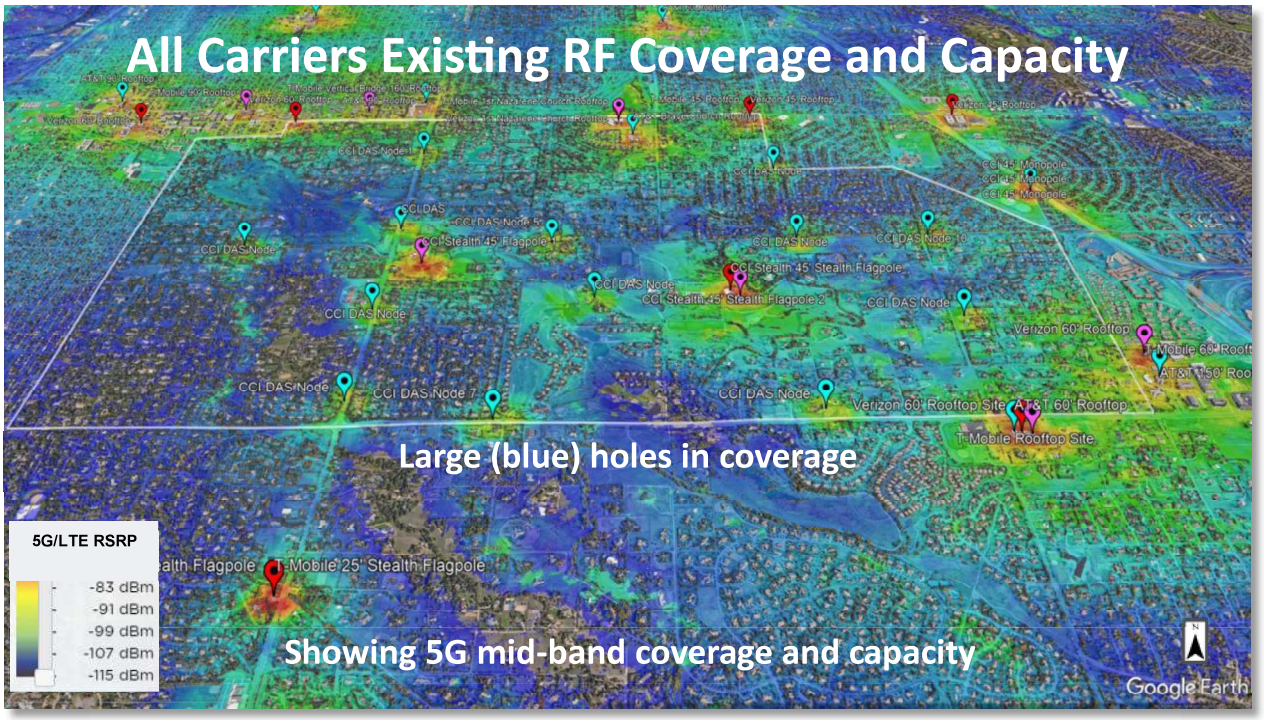
Key Cellular Findings

The following are some of the Key Cellular Findings from the Vision phase of the Study.

Radio Frequency Coverage Evaluation

State-of-the-art Radio Frequency (RF) design tools were used to create robust models of current cellular coverage in the community, based on the access to current carrier locations and services. These models included an assessment of signal strength and capacity based on terrain and tree cover, as well as an evaluation of the current use of 5G low-, mid-, and high-band spectrum in the community.

Shown below is the RF coverage map for all the carriers (AT&T, Dish, T-Mobile, and Verizon). Towers are shown as green, red, and purple thumb tacks. Red areas indicate excellent coverage, and dark blue areas indicate poor coverage. The area outlined in white indicates the Cherry Hills Village city limits.



RF Coverage Key Findings

- The amount of dark blue areas (poor coverage) shown on the RF coverage map in most areas of the City seems to substantiate the feedback the City receives from its citizens regarding poor cellular coverage.
- T-Mobile
  - Decent 5G coverage in low-band, but the assessment indicated poor 5G coverage in mid-band, which does not perform well in stealth antenna enclosures, such as the enclosures used on the two stealth flagpoles.
- Verizon
  - Decent 4G LTE coverage, but the assessment indicated poor 5G coverage in mid-band.
  - Can be addressed with a few well-placed macrocell towers within Cherry Hills Village.

- AT&T
  - Decent 4G LTE coverage, but the assessment indicated poor 5G coverage in mid-band.
  - Can be addressed with a few well-placed macrocell towers within Cherry Hills Village.
- Dish
  - Currently Roaming with T-Mobile and AT&T.

Citizen Surveys

Cherry Hills Village City Council prioritized feedback and input from its citizens regarding the current state of cellular and broadband service. This information is crucial for helping the City identify areas of the greatest need, partner cellular and Internet Service Providers (ISPs) to work with for a given area, and funding opportunities to support any future initiatives. The City welcomed citizen participation as it looked at how the presence of cellular and broadband (internet) services impact the community, and how facilitating cellular and broadband access can meet the City's function of promoting safety, health, and welfare of all members of the community.

Citizen surveys were used to help City decision makers better understand community needs. They helped to determine the community's desire for cellular and broadband services; current market conditions and deficiencies; predicted number of subscribers and optimum monthly cost that subscribers would be willing to pay for the service; stakeholder needs; and what role the government should have, if any, in providing cellular and broadband services. Two surveys were developed, one focused on cellular services, and one focused on broadband services.

Both surveys included a detailed list of questions to capture the data needed. Questions included the composition of the respondent's household, whether they have children, whether they work at home, solely or occasionally, and the age of the respondent. Survey questions also included cellular and broadband upload/download speed, general location of the responding party, and their opinion on what role municipal government should have in providing these services.

The surveys were accessible via a link on the City's website. It is important to note that the surveys included a link to a speed test website. Once on the speed test website, testing was conducted to determine actual upload/download speeds in a manner that could be verified and documented. To obtain the best possible speed test results, the respondent was asked to complete it from their residence.

Both surveys were available from June 5, 2023, to August 4, 2023. The City received 134 responses to the Cellular Survey and 85 responses to the Broadband Survey. The Citizen Cellular Survey results are summarized below. Full details are available in **Section 3**. The summary of the Citizen Broadband Survey results can be found in **Appendix D**.

Citizen Cellular Survey Key Findings

- 134 survey responses were received.
- There was a strong correlation with the RF coverage maps regarding poor coverage.
- Consistently poor speed test results across most cellular carriers.
- Significant dissatisfaction with cellular reliability, speed, and price.
- 86% of respondents support City involvement to fix the cellular issue.

Vision & Goal Setting Workshops

Two vision and goal setting workshops (August 23, 2023, and September 5, 2023) were held to help inform City decision makers regarding the potential future planned cellular and fiber deployment throughout the City. The first workshop was an open house that involved the City Council and residents. The second workshop was with City Council and it explored setting goals and developing the vision of the City as they related to cellular communications and fiber.

The vision and goal setting workshops investigated and provided various scenarios including all feasible public or private ownership options for cellular/fiber construction and implementation, as well as the possibility of leasing conduit and fiber. During the workshops the best practices in other communities that have had experience with leading a broadband effort in their communities were shared.

Prior to the City Council Visioning Session, which took place on Tuesday, September 5, 2023, a multi-part Council Vision Exercise Survey and supporting materials were developed.

The first part of the Council Vision Exercise Survey, the Vision Survey, included questions about the level of importance the Council would rate certain statements regarding cellular and broadband services in the City.

The last part of the Vision Exercise Survey included a weblink to information that presented an overview of the different municipal broadband models. Although these models primarily focus on broadband, they can also be applied to cellular services. Additional information about the broadband models can be found in **Appendix D**.

Some Comments provided at the Open House related to Cellular Service

- "Having trouble connecting with doctors to share important information that needs to be communicated both ways".
- "It becomes a safety situation when parents cannot communicate with kids".
- "Elderly parents live out of state – becomes a problem when their calls cannot be received".
- "In the new hybrid work from home world, unreliable cell service prohibits effective work".
- "Whether a CEO or a new hire, it is uncomfortable, embarrassing, frustrating, and unacceptable to be unable to complete a call".
- Cell coverage is perfect in some homes.
- "City should develop two optional solutions and Council should vote on which one City staff should perfect".
- Citizens would like to volunteer to allow a cell tower to be installed in their yard by one or more carriers.

Key Open House Findings related to Cellular Service

- Generally, attendees shared negative experiences with cellular services within the City.
- Public safety was mentioned as a major concern due to poor cellular coverage.
- Ability to effectively work from home is negatively impacted by unreliable cell service.
- Some attendees shared that they believe the City has a cellular problem, not a broadband problem.
- Individuals from some private sector organizations were in attendance and shared some potential solutions.
- Some attendees volunteered to allow a cell tower to be installed on their property.
- Suggestions were made by some attendees that potential solutions could be shared during the Visioning Session with Council, so Council could decide which solution might work for the City.

Council Vision Exercise Survey Key Fi Executive Summary **ular Service**

- Results mirrored the public perception of the need for improved cellular service.
- Results indicated dissatisfaction with cellular quality in residential areas, public areas, and while driving through the City.

- 80% of Council felt the City should "encourage or enable" improvements in broadband and cellular.

Visioning Session

The goals of the Session were to:

- Provide the City Council the data that had been collected and the feedback from the public.
- Take the feedback and input from the City Council to draft a Vision for the City regarding Cellular Coverage.

The Agenda for the Visioning Session included the following:

- Technology Overview.
- Study Background.
- Cellular Findings.
- Broadband Findings.
- Creating a Council Vision (Included sharing of some possible 5G solutions).
- Discussion & Next Steps.

Key Vision Session Findings related to Cellular Service

After the presentation, the Mayor opened the floor for Council discussion. At the conclusion of the discussion, Council provided the following direction:

- Draft an overall vision for the City related only to cellular coverage. It was decided that fiber and broadband to the home were not to be contemplated except as they relate to cellular service and the infrastructure needed to improve total cellular coverage in the City.
- Continue to investigate larger tower configurations and locations as a possible solution.
- Begin the process of finding possible partners to implement the Vision. Before any final configuration or placement is decided, these partners should be consulted to ensure the towers and their placement are satisfactory to their needs.
- Bring partners forward to the City Council to negotiate formal agreements for cost sharing, infrastructure installation and permitting, provider use agreements, etc.

Based on the data that was collected and the feedback from the public, as well as City Council's discussion and direction, the following Vision Statement and Goals were developed. It is important to note that a Vision and Goals needed to be established prior to the network being designed, which is the next phase of this Study.

Vision Statement and Goals

Vision Statement

Through partnerships and collaboration, the City endeavors to improve cellular coverage throughout its entire jurisdiction. Like water, sewer, and electricity, cellular service has become a necessity. By partnering with infrastructure and service providers the Council strives to improve the health, safety, and welfare of its residents by providing comprehensive cellular coverage throughout the entire City.

Goals

1. Implement a telecommunications solution that provides reliable citywide cell phone coverage, and that providers will utilize.
2. Locate towers on City owned property or rights-of-way, when possible.

3. Ensure that towers do not exceed the maximize height permitted in the City Code. And if needed, provide City Council with the necessary language to modify the code.
4. Engage with potential partners to ensure the designed solution meets all their needs and requirements.
5. Explore all partnership opportunities.
6. Utilize a Request for Expressions of Interest (RFEI) or a Request for Proposal (RFP) process to establish one or more public private partnerships.
7. Explore funding opportunities.

Visioning Session Next Steps

The following next steps were discussed as the Visioning Session concluded. It is important to note that after the Visioning Session, the City authorized Phase III of the Study to be executed in parallel to Phase II of the Study, so the following list of next steps includes tasks from both Phase II and Phase III of the Study.

- Preliminary Cellular Designs & Cost Estimates (Phase II, Task 1)
- Preliminary Fiber Design & Cost Estimate (Phase II, Task 1; see **Appendix D**)
- Conduct Cellular Financial Analysis (Phase II, Task 2)
- Evaluate Broadband Funding Alternatives (Phase II, Task 3; see **Appendix D**)
- Explore Public Private Cellular Partnerships (Phase III, Task 1)
- Complete Cellular Communication/Fiber Study (Phase II, Task 5)

Development of the Preliminary Cellular Designs

Based upon the outcomes and recommendations from the Vision Session with the Council, including the Vision Statement and Goals, the next step in the Study was to complete an evaluation of optional cellular solutions and technologies to determine the best solution for the City. Once that evaluation was completed, then high-level designs (HLDs) of the recommended optional solution(s) were developed that could be used for cost estimating (and possible future detailed design). The HLDs used GIS-based tools.

Leveraging the results of Phase I and the partial results of Phase II, several cellular designs were explored. However, based on the Vision Statement and Goals, three proposed cellular designs were created. These designs were built upon the existing and suggested RF coverage maps by identifying any necessary expansion locations to complete coverage of the community with not only equitable coverage but high-capacity data designs. The three designs created were based on the spectrum owned by each carrier and the type of state-of-the-art telecommunications technology deployed by the carriers. The designs included the creation of RF frequency templates to ensure that future locations will be attractive to potential private sector partners, who each utilize their own spectrum. Additionally, the network designs included the creation of potential pole designs for consideration by City leadership.

Optional Cellular Solutions

There are multiple ways to provide 5G cellular service for a specific area. Mobile operators (Carriers) build networks using a multitude of solutions:

- Macro Radios on Towers or Buildings
- Small Cells
- Distributed Antenna Systems (DAS)
- Internet Mesh Radios on Poles or Buildings
- Direct to Device (D2D) Satellites

Each comes with pros and cons from a technical and business (cost) perspective. Additionally, each solution has its own set of advantages and disadvantages, and they complement each other to provide comprehensive coverage. The choice of which solution to use often depends on the specific needs and characteristics of the area being served.

The following were evaluated for each of the cellular solutions:

- What they are
- How they are used
- Pros and Cons
- Viability for the City of Cherry Hills Village
- Examples
- Numbers and facts

Comparison of Evaluated Technologies

The following chart shows the comparison of the ten optional cellular technologies that were evaluated for the City. Each of the options utilizes one or more of the cellular solutions.

	Options									
Criteria	**(1) 200-foot pole**	**(3) 100-foot poles**	**(2) 140-foot poles plus (5) 70-foot poles, or (10) 70-foot poles**	**Distributed Antenna System (100+) 35-45 foot poles**	**100+ Small Cells 35-45 foot poles**	**Poles on the perimeter of City**	**Increase heights of existing poles**	**Put poles on top of buildings outside of City**	**Satellite**	**Wifi Mesh over 1,000 nodes**
Carriers would support	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗
Establishes a baseline service that benefits the entire City	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗
Econimically feasible w/o a tax increase to residents	✓	✓	✗	✗	✗	✓	✓	✓	✓	✓
Can be accomplished by City (does not require lease or purchase of private property)	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗
Utilizes the minimum number of Towers	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗
Comments	Meets criteria Carriers have budgets for this type of deployment	Meets criteria Carriers have budgets for this type of deployment	Cost prohibitive. Carriers will not support. Some poles would need to be placed on private property to get complete coverage.	Cost prohibitive Carriers will not support. Not 5G. Would require poles to be placed on private properties. Typically used in malls and venues	Cost prohibitive Carriers will not support. Would require digging up all roadways to provide fiber. Typically used in downtown Manhattan type areas and NFL stadiums	There are already 12 macro sites surrounding the village They are not able to provide service for inner village areas.	Requires 100' minimum towers to enable carriers to transmit above the tree clutter	There are already macro sites on surrounding buildings. Does not provide sufficient coverage to entire village.	Only line of site, as a compliment to 5G, only planned to be used in remote areas with very few users, current services text message only	Mesh Networks are used for Internet access, not cellular access.

Cellular Solution Recommendations

5G wireless towers (macrocell or large towers) are better suited for covering large areas with fewer installations, while 5G small cells are ideal for increasing capacity in densely populated areas, but not a viable choice for large areas with dense foliage. 4G DAS is not future proof and not suited to the large area of Cherry Hills Village and the foliage density. Internet MESH Radios are not used for cellular networks, they are like Wi-Fi internet access technology. D2D Satellite is great for remote open areas with minimal population density. Satellite companies and Carriers plan to provide US coverage in such areas in 2026 and beyond.

Based on the chart showing the comparison of cellular technologies, **it is recommended that the City consider either one centrally located 200-foot tower or three 100-foot towers located throughout the City**. These two proposed cellular solutions provide the City with ample coverage and high capacity 5G services providing a cost-effective solution supported by the four major carriers' technical requirements and budgets.

Detailed information regarding the evaluation of the cellular solutions can be found in **Section 5** of this report.

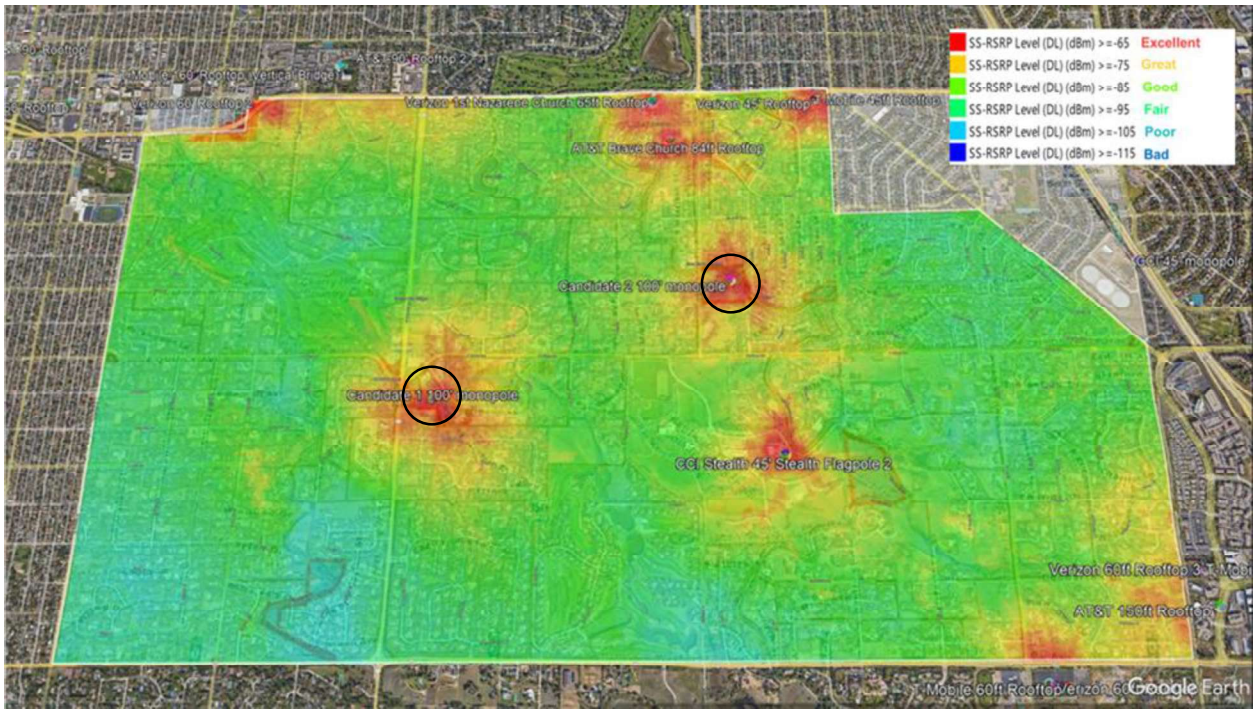
Conceptual Cellular Designs and Cost Estimates

The recommended one 200-foot tower option was not explored further because it would require the City to modify its Code to substantially increase the maximum height of a cellular tower from 70 feet to 200 feet. While the recommended three 100-foot towers option would also require the City to increase the maximum height of a cellular tower from 70 feet to 100 feet, it is much less of an increase. Therefore, below are three proposed HLDs for the recommended 100-foot towers option, which includes a 70-foot towers design that would not require a Code change, and the estimated costs for each design.

Option 1 - Two (2) 100' Monopole Towers

The following tower network design and RF coverage map shows two 100-foot monopoles on public property or public rights-of-way. Both tower locations have been circled. This map also includes several existing tower locations. Again, the City will need to modify its Code to permit 100-foot poles.

It is worth noting that while the two 100-foot towers in combination with the existing towers will improve cellular coverage throughout the City, they will not provide the same level of coverage as the three 100-foot towers in combination with the existing towers shown in Option 2, or the six 70-foot towers shown in Option 3. Option 2 and 3 are shown below.



Option 1 Cost Estimate

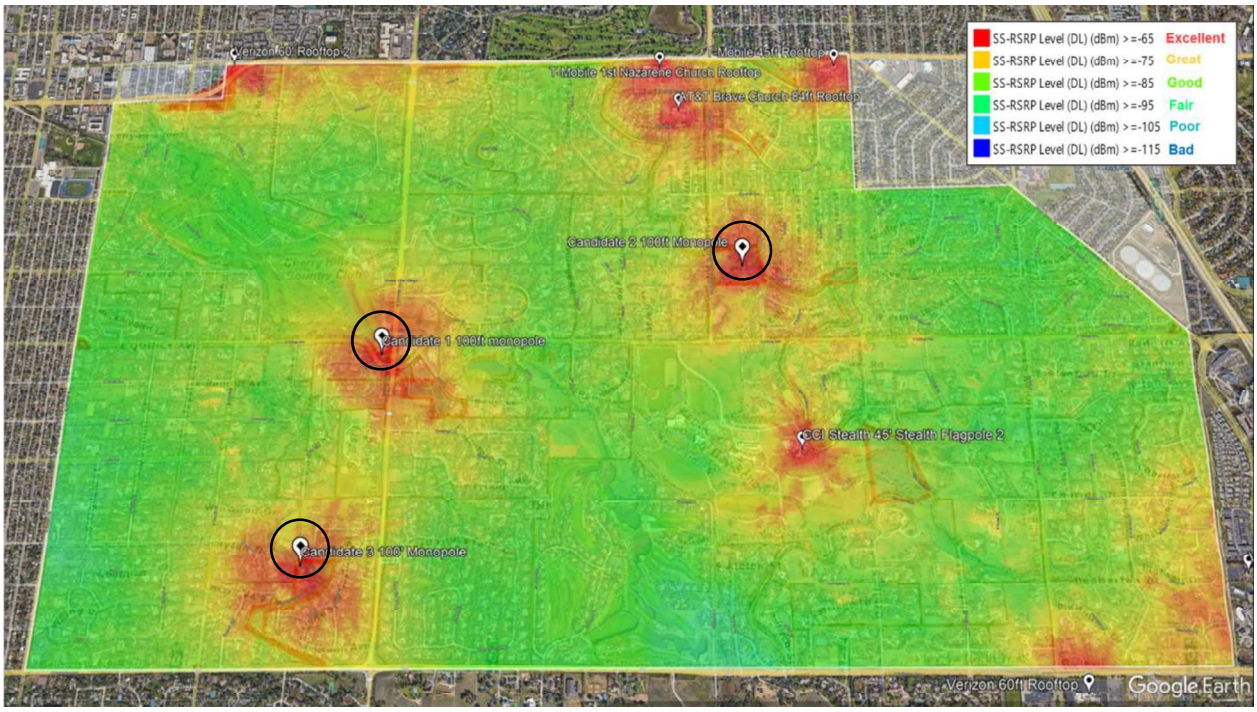
Site	Longitude	Latitude	Cost Per Tower*	# of Towers Per Site	Total Tower Costs Per Site
Candidate 1 100' monopole (Village Center)	-104.957477	39.636394	$300,000	1	$300,000
Candidate 2 100' monopole (Three Pond Park)	-104.938974	39.642295	$300,000	1	$300,000
Option 1 Total Tower Costs					**$600,000**

* Cost per tower includes construction costs only. It does not include the costs of cellular radios, antennas, etc. (these costs are covered by carriers)

Option 2 - Three (3) 100' Monopole Towers (Recommended Solution)

The following tower network design and RF coverage map shows three 100-foot monopoles on public park property. All three tower locations have been circled. This map also includes several existing tower locations. As previously stated, the City will need to modify its Code to permit 100-foot poles.

It is worth noting that the three 100-foot towers in combination with the existing towers will provide the most comprehensive cellular coverage throughout the entire City. This is the recommended solution based on the alignment between this design and the selection criteria based on the Vision Statement and Goals that were developed from the input provided by Council during the Visioning Session.



Option 2 Cost Estimate

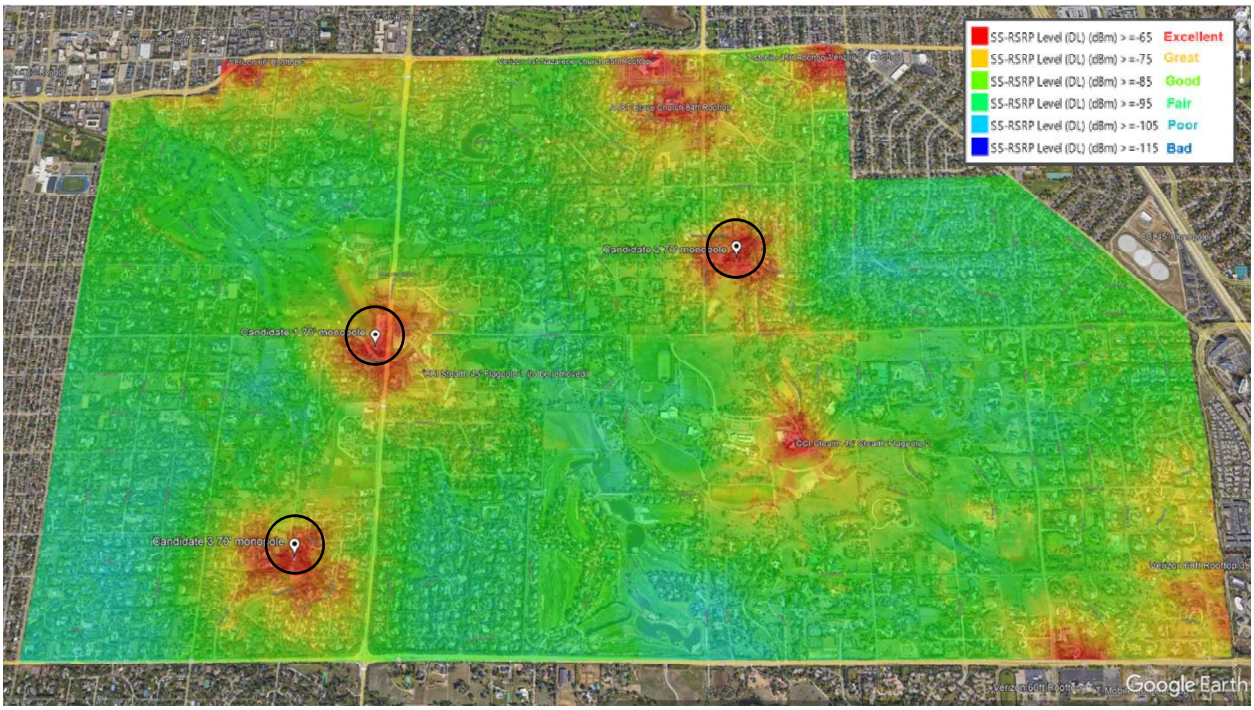
Site	Longitude	Latitude	Cost Per Tower*	# of Towers Per Site	Total Tower Costs Per Site
Candidate 1 100' monopole (City Park)	-104.957477	39.636394	$300,000	1	$300,000
Candidate 2 100' monopole (Three Pond Park)	-104.938974	39.642295	$300,000	1	$300,000
Candidate 3 100' monopole (Woodie Hollow Park)	-104.96412	39.628524	$300,000	1	$300,000
Option 2 Total Tower Costs					**$900,000**

* Cost per tower includes construction costs only. It does not include the costs of cellular radios, antennas, etc. (these costs are covered by carriers)

Option 3 - Six (6) 70' Monopole Towers

The following tower network design and RF Coverage map shows six 70-foot monopoles in three locations on public park property. To ensure that there is enough space for up to four carriers at each of the three candidate tower locations, there will be two 70-foot towers at each of the locations and the two 70-foot towers at each location will need to be separated by at least 80 feet. All three tower locations have been circled. This map also includes several existing tower locations. It is important to note that the City Code currently allows 70-foot poles on public property or public rights-of-way.

It is worth noting that while the six 70-foot towers in combination with the existing towers will significantly improve cellular coverage throughout the City, they will not provide the same level of coverage as the three 100-foot towers in combination with the existing towers.



Option 3 Cost Estimate

Site	Longitude	Latitude	Costs Per Tower*	# of Towers Per Site	Total Tower Costs Per Site
Candidate 1 70' monopole (City Park)	-104.957477	39.636394	$250,000	2	$500,000
Candidate 2 70' monopole (Three Pond Park)	-104.938974	39.642295	$250,000	2	$500,000
Candidate 3 70' monopole (Woodie Hollow Park)	-104.96412	39.628524	$250,000	2	$500,000
Option 2 Total Tower Costs					**$1,500,000**

* Cost per tower includes construction costs only. It does not include the costs of cellular radios, antennas, etc. (these costs are covered by carriers)

Conduct Cellular Financial Analysis

The development of potential technical solutions focused on the creation of a cost-effective, shared infrastructure model to deliver a carrier-grade platform. A preliminary design was created and subsequently perfected, at which time financial cost estimating was completed for the wireless equipment. Concurrently, the completion of the business model and site determinations led to an estimate of capital expense for the towers.

The Cherry Hills Village model provides not only the ability to create communication upgrades at one-time, at a fixed cost, but analysis has shown the ability to generate a solid return on invested dollars.

A study of the financial feasibility of the project was conducted to determine if a system could be built and operated to meet the City's goals for connectivity in improving cellular service for homes and residents. The financial analysis focused on two models and assumed that the City would build an asset for cellular providers to use that would then become the basis of a public-private partnership to improve last-mile cellular connectivity.

- **Model 1: Three 100' Towers** (Option 2 from above)**.** This model plans on three 100' towers, each with four providers, which would require a change to the City Code for increased tower height and require a vote of the residents to allow a lease on park property for more than five years.
- **Model 2: Six 70' Towers** (Option 3 from above)**.** This model avoids the need to increase the maximum height of the towers, instead siting two towers, each with two providers at the chosen locations to extend cellular service to residents. This would still require a vote of the residents to allow a lease on park property for more than five years.

Several assumptions played a role in guiding the development of the financial analysis models. Utilizing current industry material and construction costs, the models reflect the total capital cost of the towers, but not improvements such as fiber backhaul, that will be required to connect the towers. It was determined that this cost, as well as operating expenses, will be borne by the carrier(s) that locate on the towers. Operating attributes including staffing, maintenance, vehicles, supplies, and other considerations were categorically excluded. While the analysis is reflective of a one-year buildout of the entire project footprint, a phased approach may be used to customize the planned schedule of the project.

It is worth noting that tower design Option 1 from above was not included in the financial analysis because while the two 100-foot towers will improve cellular coverage throughout the City, it will not provide the same level of coverage as the three 100-foot towers in Option 2 from above, or the six 70-foot towers shown in Option 3 from above.

Financial Analysis Findings

Based on the assumptions, the proposed project is financially feasible based on the following conclusions that can be reached based on the financial analysis of the Three 100' Towers model:

- Total Capital Expenses of $900,000-$1,500,000 to fund the network.
- Positive Net Income in Year 4-5 following construction.

Explore Public Private Cellular Partnerships

The approach to engaging with potential cellular partners started by building a list of potential partners and other interested parties. Building this list involved developing a Request for Expressions of Interest (RFEI). The RFEI can be found in Appendix C of this report. This approach created a cycle in which partners were identified and brought to the table more quickly and led to a higher likelihood of successful progress.

Prior to the RFEI closing, the City received four responses:

- Aero Wireless Group
- NeuComm
- Telogistix
- Zayo

Key Findings

To help the City better understand the four responses and to possibly narrow down the list of potential partners, all four RFEI responders were interviewed.

Zayo, who owns fiber in and around Cherry Hills Village, identified that they would be interested in providing fiber (with financial assistance from the City) but were somewhat reluctant to partner with a tower builder.

The other three firms could construct both the towers and fiber network. All three firms stated they would not need financial assistance from the City if they privately owned and maintained the facilities and were able to collect rent directly from the carriers. As an alternative, they also acknowledged they would be willing to have the City own and pay for the installation of fiber, towers, and ongoing maintenance. This alternative would then allow the City to collect rent directly from the carriers.

The City felt that owning the fiber portion of the facilities was not in the City's best interest as the ability to respond to service breaks and other maintenance issues would become problematic. However, owning and contracting out the maintenance of the towers and receiving the potential rent revenue might be something the City could consider.

Carrier Outreach

When the City decided to move forward with potential 5G/Cellular improvements, it also created the need to explore partnerships with each of the four major cellular carriers. An outreach program was developed to meet with the carriers, that included a fully conceived network improvement proposal, complete with spectrum assignments and financial partnership requirements. The exploration of partnerships included an outreach effort to all four major carriers (AT&T, Dish Network, T-Mobile, and Verizon) to determine their potential interest in participating in the proposed project.

Dish Network indicated strong interest and AT&T also expressed interest but indicated they would need more time to fully evaluate their options and other projects. At the time this report was written, the outreach effort is ongoing regarding discussions with T-Mobile and Verizon.

Recommendations

The following recommended next steps are based on the key outcomes from discussions with Council and staff, as well as the findings shared throughout this Study. It is important to note that recommendations 5, 6, 7, and 8 are only applicable if the City decides to own the network. While the recommendations are listed in sequential order this does not necessarily mean they need to be implemented in this order.

Recommendation #1

It is recommended that the City move forward with the three 100-foot tower design. It is worth noting that the three 100-foot towers in combination with the existing towers will provide the most equitable cellular coverage throughout the entire City.

Recommendation #2

It is important to note that City Code currently only allows 70-foot poles on public property or public rights-of-way, so it is recommended that the City modify its Code to permit 100-foot poles.

Recommendation #3

To secure carriers for the poles, a lease must be signed that allows for their telecommunication equipment to be placed in City parks. Carrier leases last at least 20 years or potentially longer. Section 3.9 of the City's Home Rule Charter currently limits leases on public property to no more than 5 years, including extensions. To comply with the City Charter, it is recommended that the City seek approval from voters to allow a lease for cell towers in City owned parks for a time frame consistent with the industry standard.

Recommendation #4

It is recommended that the City initiate contract negotiations with one or more of the RFEI responders to construct, operate, manage, and maintain, as well as to potentially own, the proposed tower network.

Recommendation #5

If the City decides to own the towers, then it is recommended that the City initiate lease negotiations with the carriers to place their equipment on the towers.

Recommendation #6

If the City decides to own the towers, then it is recommended that the City initiate the process to secure funding to construct the towers.

Recommendation #7

If the City decides to own the towers, then it is recommended that the City initiate the process of developing the Low-Level Design of the planned tower network which is necessary to create associated construction and permitting plan sets.

Recommendation #8

If the City decides to own the towers, then once one or more partner contracts are finalized, carrier leases are negotiated, funding is secured, and the Low-Level Design is completed, then it is recommended that the City begin the deployment of the cellular tower infrastructure.

Section 2: Evaluation of Existing Cellular Conditions

Background

The initial step of the evaluation of existing cellular conditions was to identify local cellular providers to help identify deployed cellular assets. Based upon the identified existing cellular providers, GIS tools were used to show existing infrastructure, and provide real-time, GIS-based information. These tools helped the City better understand what it is seeing; giving the City the ability to explore various models; and retain the information for future phases of the Study.

Additionally, the review included an analysis that determined the location of all cellular infrastructure, and its potential availability to be utilized for improving cellular coverage as well as future cellular expansion in Cherry Hills Village.

The evaluation included the use of state-of-the-art Radio Frequency (RF) design tools utilized by the carriers to create a highly robust model of current cellular coverage in the community, based on its access to current carrier locations and services. This model included an assessment of signal strength and capacity based on terrain and tree cover, as well as an evaluation of the current use of 5G low-, mid-, and high-band spectrum in the community.

The evaluation also included a general review of Cellular Broadband technology as it relates to Cherry Hills Village, including technology trends and the future of cellular communication. An overview of Cellular technology can be found in **Appendix B** of this report.

Radio Frequency Coverage Evaluation and Key Findings

State-of-the-art Radio Frequency (RF) design tools were used to create robust models of current cellular coverage in the community, based on the access to current carrier locations and services. These models included an assessment of signal strength and capacity based on terrain and tree cover, as well as an evaluation of the current use of 5G low-, mid-, and high-band spectrum in the community.

Shown below are the RF coverage maps for each of the providers.

Dish

- Currently Roaming with T-Mobile and AT&T

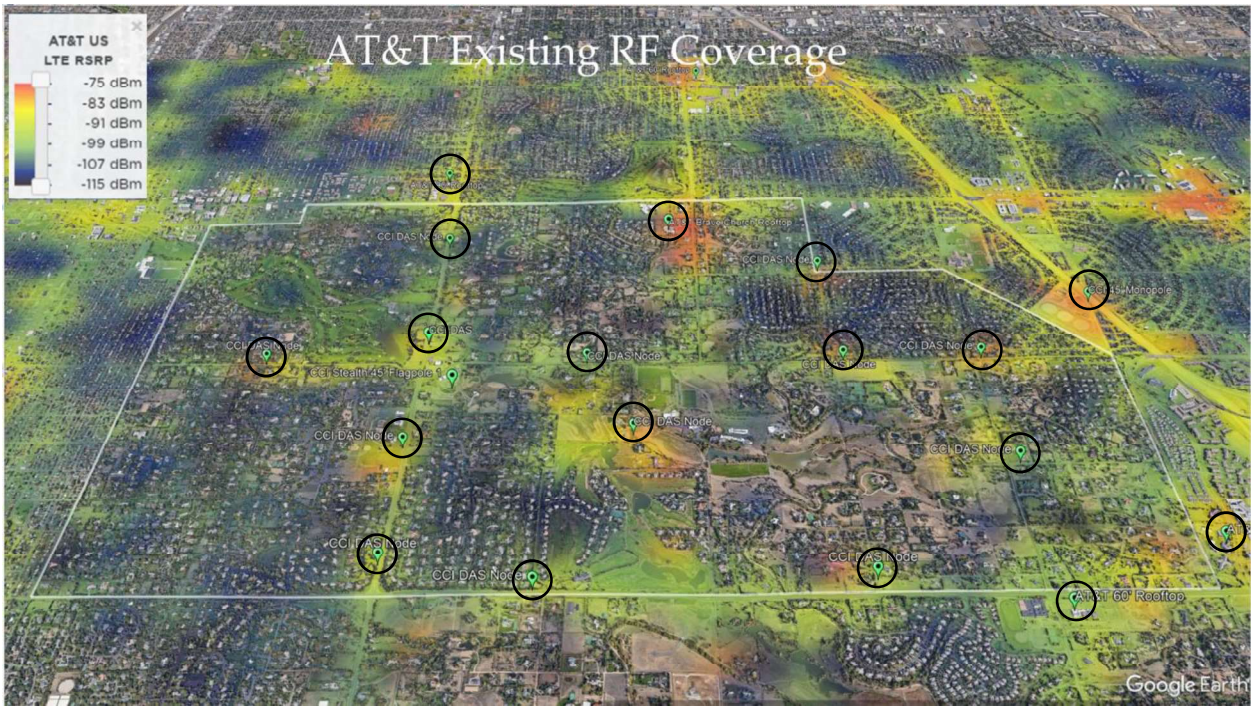
A specific RF coverage map for Dish is not available because as indicated, Dish utilizes the same facilities as the other providers to provide services.

AT&T

AT&T currently uses the following facilities within the City.

- Current tenant on 12 Outdoor Nodes from Crown Castle
- Other RF coverage from rooftop cell sites surrounding Cherry Hills Village

Below is the RF coverage map for AT&T. Towers are shown as green thumb tacks and are circled. Red areas indicate excellent coverage, and dark blue areas indicate poor coverage. The area outlined in white indicates the Cherry Hills Village city limits.

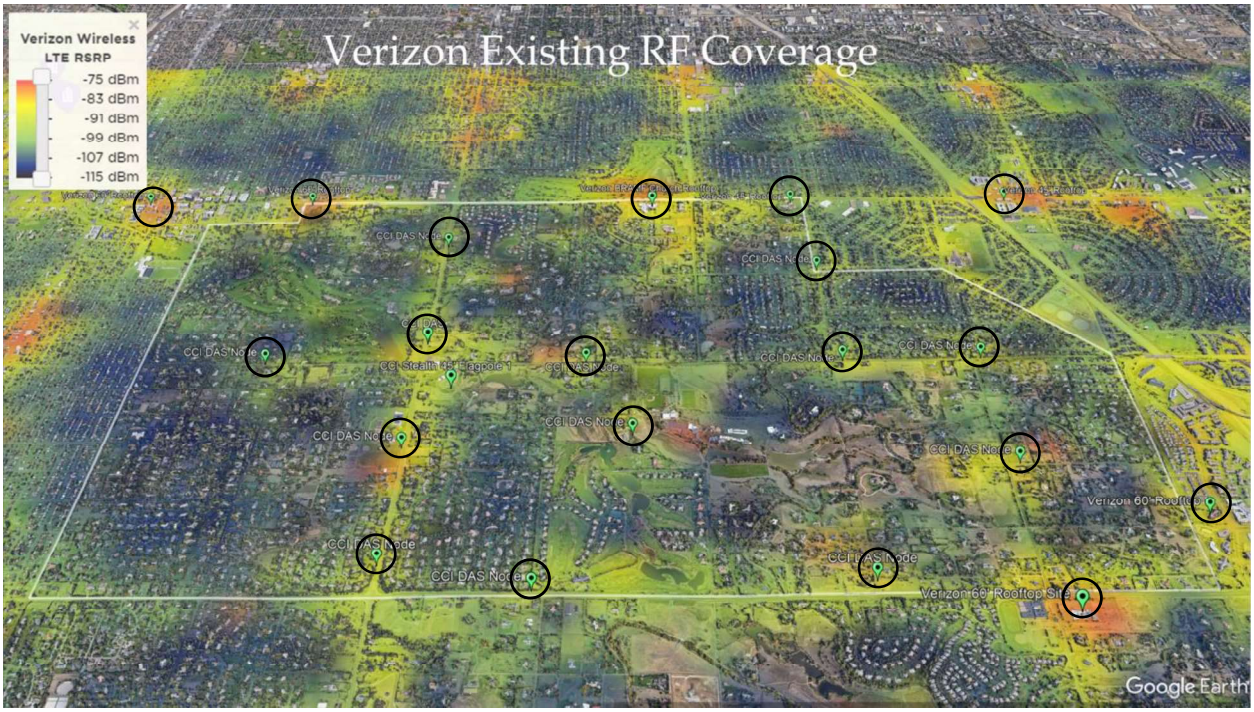


Verizon

Verizon currently uses the following facilities within the City.

- Current tenant on 12 Outdoor Nodes from Crown Castle
- Other RF coverage from rooftop cell sites surrounding Cherry Hills Village

Below is the RF coverage map for Verizon. Towers are shown as green thumb tacks and are circled. Red areas indicate excellent coverage, and dark blue areas indicate poor coverage. The area outlined in white indicates the Cherry Hills Village city limits.

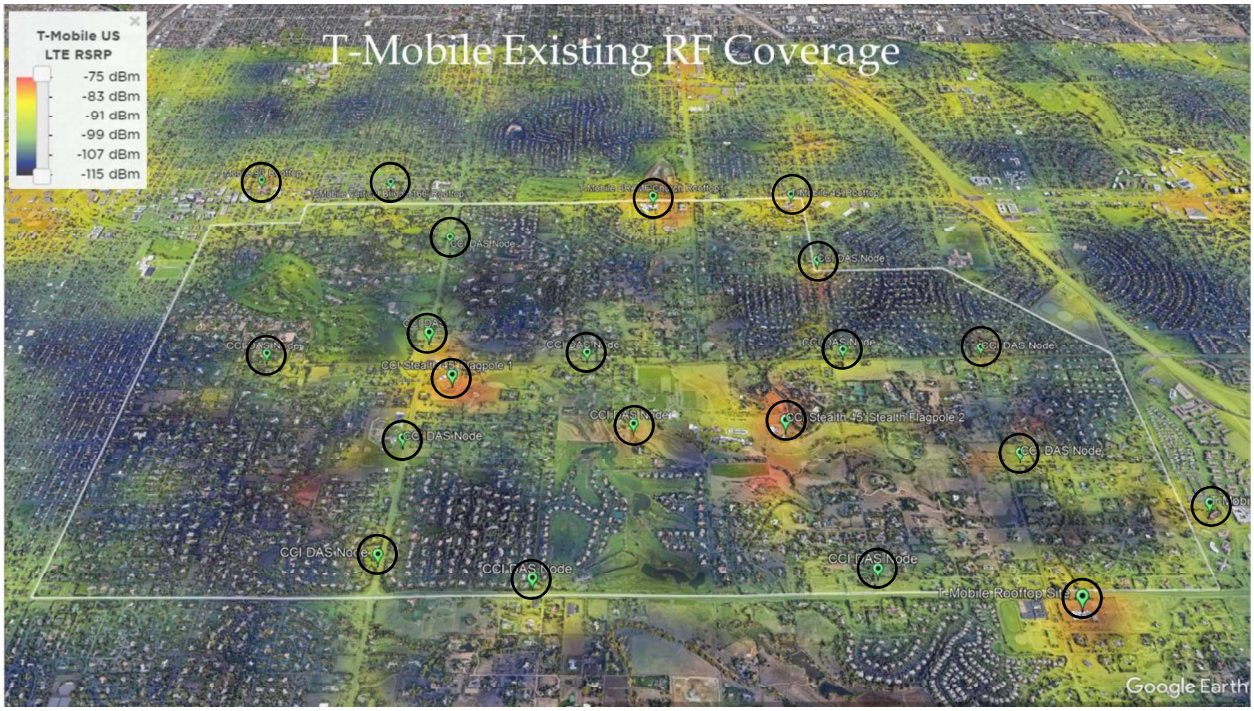


T-Mobile

T-Mobile currently uses the following facilities within the City.

- Current tenant on 12 Outdoor Nodes from Crown Castle
- Current tenant on two (2) 45' Stealth Flagpoles from Crown Castle
- Other RF coverage from rooftop cell sites surrounding Cherry Hills Village

Below is the RF coverage map for T-Mobile. Towers are shown as green thumb tacks and are circled. Red areas indicate excellent coverage, and dark blue areas indicate poor coverage. The area outlined in white indicates the Cherry Hills Village city limits.



Key Findings

- The amount of dark blue areas (poor coverage) shown on all three RF coverage maps in most areas of the City, seems to substantiate the feedback the City receives from its citizens regarding poor cellular coverage.
- T-Mobile
  - Decent 5G coverage in low-band, but the assessment indicated poor 5G coverage in mid-band, which does not perform well in stealth antenna enclosures, such as the enclosures used on the two stealth flagpoles.
- Verizon
  - Decent 4G LTE coverage, but the assessment indicated poor 5G coverage in mid-band.
  - Can be addressed with a few well-placed macrocell towers within Cherry Hills Village.
- AT&T
  - Decent 4G LTE coverage, but the assessment indicated poor 5G coverage in mid-band.
  - Can be addressed with a few well-placed macrocell towers within Cherry Hills Village.
- Dish
  - Currently Roaming with T-Mobile and AT&T.

Section 3: Citizen Cellular Surveys

Background

Cherry Hills Village City Council prioritized feedback and input from its citizens regarding the current state of cellular and broadband service. This information is crucial for helping the City identify areas of the greatest need, partner cellular and Internet Service Providers (ISPs) to work with for a given area, and funding opportunities to support any future initiatives. The City welcomed citizen participation as it looked at how the presence of cellular and broadband (internet) services impact the community, and how facilitating cellular and broadband access can meet the City's duty of promoting safety, health, and welfare of all members of the community.

Citizen surveys were used to help City decision makers better understand community needs. They helped to determine the community's desire for cellular and broadband services; current market conditions and deficiencies, predicted take rate and optimum monthly cost that users would be willing to pay for the service; stakeholder needs and what role the government should have, if any, in providing cellular and broadband services. Two surveys were developed, one focused on cellular services, and one focused on broadband services.

Both surveys included a detailed list of questions to capture the data needed. They included questions about the composition of their household, whether they have children, whether they work at home, solely or occasionally, and the age of the respondent. Survey questions also included cellular, and broadband provided upload/download speed, general location of the responding party, for both cellular and broadband services, and their opinion on what role municipal government should have in providing these services.

Both surveys were accessible via a link on the City's website. It is important to note that the surveys included a link to a speed test website. Once on the speed test website, testing was conducted to determine actual upload/download speeds in a manner that can be verified and documented. To obtain the best possible speed test results, the person completing the survey was asked to complete it from their residence.

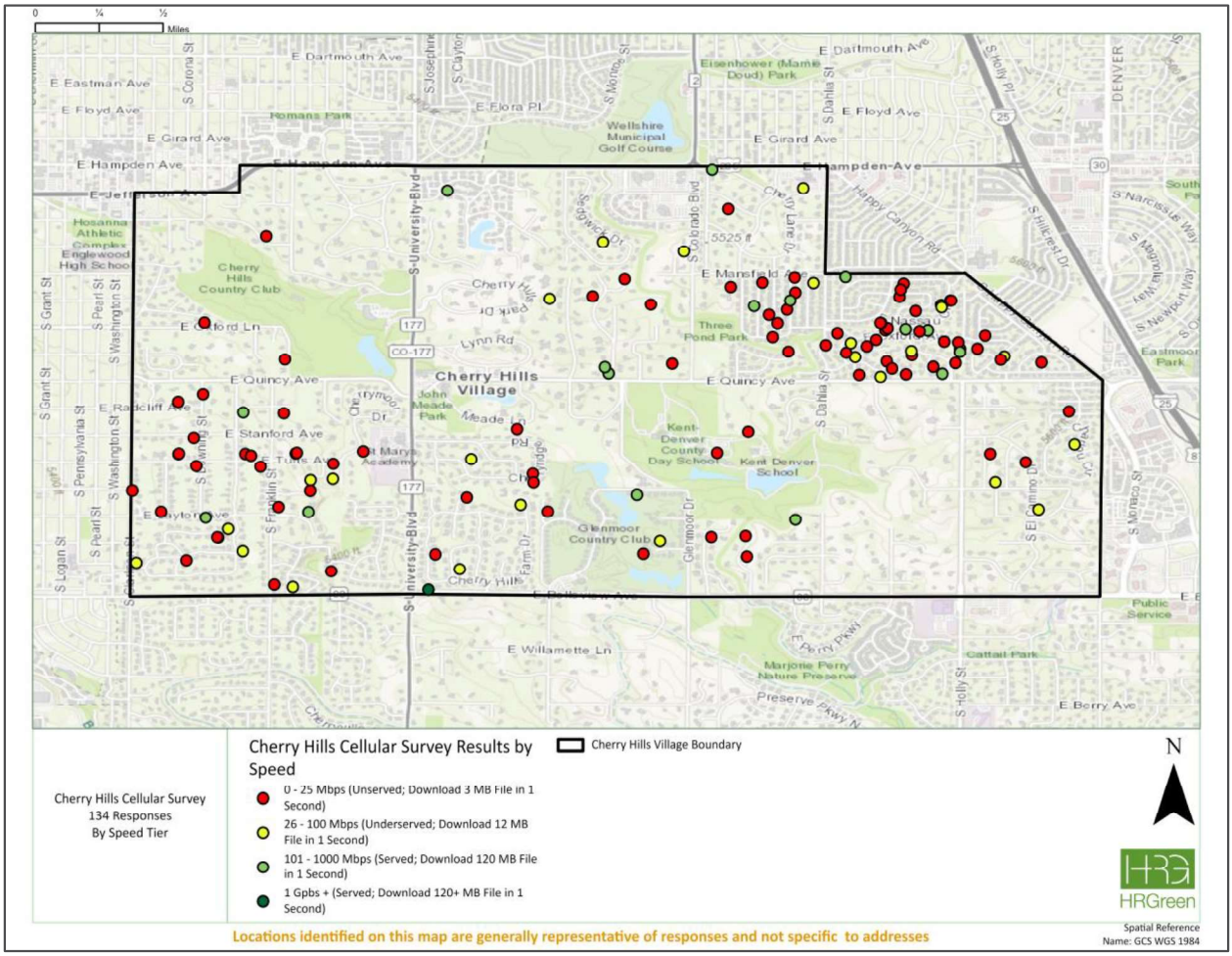
The surveys took only a few minutes to complete. All responses were anonymous and confidential. Participation was limited to one person per household. As these were surveys to assess both cellular and wired internet service, participants were encouraged to use a device that could be connected to a cellular connection (4G/LTE/5G) and/or a wired internet connection (through Wi-Fi or Ethernet), to take the surveys.

Both surveys were available from June 5, 2023, to August 4, 2023. The City received 134 responses to the Cellular Survey and 85 responses to the Broadband Survey.

Survey data was collected via GIS-enabled tools to enable a deep understanding of conditions neighborhood by neighborhood.

Cellular Survey Responses and Key Findings

Below is a map showing the results of the **Speed Tests** from the Cellular Survey.



Below is a table that summarizes responses to some of the key questions from the citizen's Cellular Survey:

Question	Response
Cellular **Uses**	Phone calls, Email, News, Shopping, Banking, Web surfing, Streaming music, Smart home, Online Apps, Social media
Cellular **Reliability**	**70% = Somewhat to Very Dissatisfied** 13% = Neutral 17% = Somewhat to Very Satisfied
Cellular **Speed**	**70% = Somewhat to Very Dissatisfied** 18% = Neutral 12% = Somewhat to Very Satisfied

Question	Response
Cellular **Price**	**39% = Somewhat to Very Dissatisfied** 36% = Neutral 25% = Somewhat to Very Satisfied
Use cellular service to **work from home or run a business**?	**63% = Yes** 37% = No
How often do you **experience outages**?	3% = Never 13% = 1 hour or less per month 12% = 1 hour or less per week 30% = 1 hour or less per day **42% = More frequently than 1 hour per day**
Do cellular providers **meet the needs** of the community?	**81% = Bare Minimum to Not at All** 12% = Neutral/It's Ok 7% = Mostly to Very Well
City needs to help facilitate better cellular services?	**87% = Agree or Strongly Agree** 12% = Neutral 1% = Disagree or Strongly Disagree
If City should help facilitate better cellular service, would you be **willing to pay higher taxes**?	**37% = Yes** 24% = No 7% = Not Sure 32% = Need More Information to Decide

Key Findings

- There was a strong correlation with the RF coverage maps regarding poor coverage.
- Consistently poor speed test results across most cellular carriers.
- Significant dissatisfaction with cellular reliability, speed, and price.
- 86% of respondents support City involvement to fix the cellular issue.
- A minority indicated a willingness to pay higher taxes for the City to facilitate better cellular service. Specifically, 37% responded yes, they are willing and 32% responded they need more information to decide.

Section 4: Vision & Goal Setting Workshops

Background

Two vision and goal setting workshops (August 23, 2023, and September 5, 2023) were held to help inform City decision makers regarding the potential future planned cellular and fiber deployment throughout the City. The first workshop was an open house that involved the City Council and residents. The second workshop was with City Council and it explored setting goals and developing the vision of the City as they related to cellular communications and fiber.

The vision and goal setting workshops investigated and provided various scenarios including all feasible public or private ownership options for cellular/fiber construction and implementation, as well as the possibility of leasing conduit and fiber. During the workshops the best practices in other communities that have had experience with leading a broadband effort in their communities were shared.

Prior to the City Council Visioning Session, which took place on Tuesday, September 5, 2023, a multi-part Council Vision Exercise Survey and supporting materials were developed.

The first part of the Council Vision Exercise Survey, the Vision Survey, included questions about the level of importance the Council would rate certain statements regarding cellular and broadband services in the City.

The last part of the Vision Exercise Survey included a weblink to information that presented an overview of the different municipal broadband models. Although these models primarily focus on broadband, they can also be applied to cellular services. Additional information about the broadband models can be found in **Appendix D**.

Open House

The goal of the workshop was to provide information to the public about the current state of the cellular and fiber situation in the City drawn from the data collected thus far as part of the Study. The open house was an opportunity for the public to share their experiences with cellular and broadband within the City. It was also an opportunity for the public to ask questions about the Study and the potential next steps that the City was looking at as the Study progressed.

The open house took place on Wednesday, August 23, 2023, at the Cherry Hills Village City Hall. Members of City Council and City staff attended. Eighty (80) people from the community signed the registry and some of them provided written comments prior to leaving the open house. While the open house was scheduled to start at 6:00 pm and conclude at 7:30 pm, a few people arrived as early as 5:30 pm. The format of the open house was very informal, so people could come and go as they pleased.

Seven storyboards were developed for and displayed at the open house. These storyboards shared the information gathered during the first phase of the Study, as well as some information about a potential solution, and options around public and private ownership of cellular facilities, conduit, and fiber. These storyboards included a Study Storyboard, a Cellular Coverage Storyboard, a Broadband Models Storyboard, a Cellular 101 Storyboard, a Cellular Survey Storyboard, a Broadband 101 Storyboard, and a Broadband Survey Storyboard.

During the open house, the City Manager shared a few comments about the Study and the intent of holding the open house. Throughout the open house City staff and Council members floated around the room speaking with attendees to answer questions and share information.

The following are some of the comments received during the open house. These comments were incorporated into the City Council Visioning Session.

Comments

- "Having trouble connecting with doctors to share important information that needs to be communicated both ways".
- "It becomes a safety situation when parents cannot communicate with kids".
- "Elderly parents live out of state – becomes a problem when their calls cannot be received".
- "In the new hybrid work from home world, unreliable cell service prohibits effective work".
- "Whether a CEO or a new hire, it is uncomfortable, embarrassing, frustrating, and unacceptable to be unable to complete a call".
- Cell coverage is perfect in some homes.
- "City should develop two optional solutions and Council should vote on which one City staff should perfect".
- Citizens would like to volunteer to allow a cell tower to be installed in their yard by one or more carriers.

Key Findings

- Generally, attendees shared negative experiences with cellular services within the City
- Public safety was mentioned as a major concern due to poor cellular coverage
- Ability to effectively work from home is negatively impacted by unreliable cell service
- Some attendees shared that they believe the City has a cellular problem, not a broadband problem
- Individuals from some private sector organizations were in attendance and shared some potential solutions
- Some attendees volunteered to allow a cell tower to be installed on their property
- Suggestions were made by some attendees that potential solutions could be shared during the Visioning Session with Council, so Council could decide which solution might work for the City.

Vision Survey

Prior to the City Council Visioning Session, which took place on Tuesday, September 5, 2023, a multi-part Council Vision Exercise Survey and supporting materials were developed.

The first part of the Council Vision Exercise Survey, the Vision Survey, included questions about the level of importance the Council would rate certain statements regarding cellular and broadband services in the City.

The following are the responses received from the Council members to the Vision Survey questions.

Question	Response
Current cellular services are **adequate** in **residential** areas?	0% = Agree to Strongly Agree 20% = Neutral **80% = Disagree to Strongly Disagree** 0% = No Opinion
Current cellular services are **adequate** in the **public** and private **park** and **recreation** areas?	0% = Agree to Strongly Agree 20% = Neutral **60% = Disagree to Strongly Disagree** 20% = No Opinion
Current cellular services are **adequate** when **driving in** and **through** the Village?	0% = Agree to Strongly Agree 20% = Neutral **60% = Disagree to Strongly Disagree** 20% = No Opinion
How **important** is it for **residents** and **guests** to have **access** to **broadband** services?	**80% = Very Important to Absolutely Essential** 20% = Important 0% = Slightly Important to Not at All Important 0% = No Opinion
How important is it that broadband services are accessible and affordable to all?	**60% = Very Important to Absolutely Essential** 20% = Important 20% = Slightly Important to Not at All Important 0% = No Opinion
Broadband services are adequate in the residential areas?	**40% = Agree to Strongly Agree** 20% = Neutral 20% = Disagree to Strongly Disagree 20% = No Opinion
The City should encourage and/or enable the deployment of cellular and broadband services?	**80% = Agree to Strongly Agree** 20% = Neutral 0% = Disagree to Strongly Disagree 0% = No Opinion

Do you have any comments regarding any of the previous questions?

City Council Responses
We already encourage and enable providers to provide services
Cellular is the bigger issue that needs to be addressed
Most in the City can get access to high-speed internet (100Mbps download, 25Mbps upload)
There are several areas in the City that have limited cell phone service, and this needs to be improved

If the City were to consider the possibility of enhancing cellular and broadband services, what do you see as the biggest benefits?

City Council Responses
911 calls would be acceptable
Enhancing cellular would be that calls could be made from locations within the City, whether at home, home office, or while on the road and be done reliably.
Better cell phone coverage for residents who rely solely on cell service
Accessibility
Enhanced cellular service is safety and citizen satisfaction.

If the City were to consider the possibility of enhancing cellular and broadband services, what are your biggest concerns? Why?

City Council Responses
Cost
Doing anything that would put the City "in the business of" providing these services
Building the infrastructure and not getting tenants (carriers)
Who will pay for it
It will require an enormous investment with no guarantee that cellular services will be improved

Which one of the following statements best describes your vision for the City's involvement in enhancing cellular and broadband services throughout the community?

City Council Responses
The City should create, review, and revise ordinances and practices to support private sector fiber and cellular asset development throughout the community (Private Developer, Open Access Broadband model)
Do not have an opinion yet, looking to the results of the initiatives we have implemented to help form one
Somewhere between the Publicly Owned, Privately-Serviced Broadband model and the Hybrid Ownership Broadband model. Would need to learn more about them and the associated cost of them to finalize recommendation
All the options seem to focus on broadband with cellular secondary. Only concerned with cellular coverage. If we must enter the broadband arena to increase cell coverage, then would consider it. But otherwise, have no interest in broadband.

The following are the responses received from Council members regarding some of the remaining questions.

Question	Response
Broadband/Cellular coverage is the critical infrastructure in the 21st century, and as such needs to be a public sector priority	**60% = Agree** 20% = Disagree 20% = No Opinion
Cherry Hills Village will endeavor to provide reliable broadband infrastructure to all its residents	**60% = Agree** 40% = Disagree 0% = No Opinion
The City should provide some type of funding from existing reserves to improve cell coverage throughout the City without asking the residents to raise taxes	**60% = Agree** 0% = Disagree 40% = No Opinion
Cherry Hills Village aims to be a trusted partner with fiber and cellphone providers to improve services to our residents	**80% = Agree** 0% = Disagree 20% = No Opinion
Providing consistent, quality, and reliable cell phone coverage is necessary to ensure the safety and welfare of the residents of Cherry Hills Village.	**80% = Agree** 0% = Disagree 20% = No Opinion
Like electricity a century ago, fiber/cellular communication is a foundation for a better way of life	**60% = Agree** 0% = Disagree 40% = No Opinion
Our mission is to improve lives by providing innovative solutions that expand the access, adoption, and use of high-speed internet/cellular service and its related technologies to all residents.	**60% = Agree** 20% = Disagree 20% = No Opinion
The City should create, review, and revise ordinances and practices to support private sector fiber and cellular asset development throughout the community.	**80% = Agree** 0% = Disagree 20% = No Opinion

Question	Response
The current level of cellular and broadband services is adequate within the City, so the City should not be involved in enhancing cellular and broadband services throughout the community.	0% = Agree **80% = Disagree** 20% = No Opinion
Broadband/Cellular access is a public good	**80% = Agree** 0% = Disagree 20% = No Opinion

The last part of the Vision Exercise Survey included a weblink to a white paper that presented an overview of the different municipal broadband models. There are several models for fully private and fully public broadband networks, plus a growing range of municipally enabled broadband strategies that rely on a combination of public and private investment. Despite the many ways that municipalities have gone about implementing their broadband programs, there are five main ways to do it, each requiring a different level of investment and engagement from the municipality. Additional information about the broadband models can be found in **Appendix D**.

Key Findings

- Results mirrored the public perception of the need for improved cellular service.
- Results indicated dissatisfaction with cellular quality in residential areas, public areas, and while driving through the City.
- Results aligned with public perception that there seems to be sufficient broadband services in the City.
- Results indicated that broadband is viewed as a necessary asset for quality of life.
- 80% of Council felt the City should “encourage or enable” improvements in broadband and cellular.

Visioning Session

The City Council Visioning Session took place on Tuesday, September 5, 2023, at the Cherry Hills Village City Hall.

The goal of the Session was to:

- Provide the City Council the data that had been collected and the feedback from the public.
- Take the feedback and input from the City Council to draft a Vision for the City regarding Cellular Coverage.

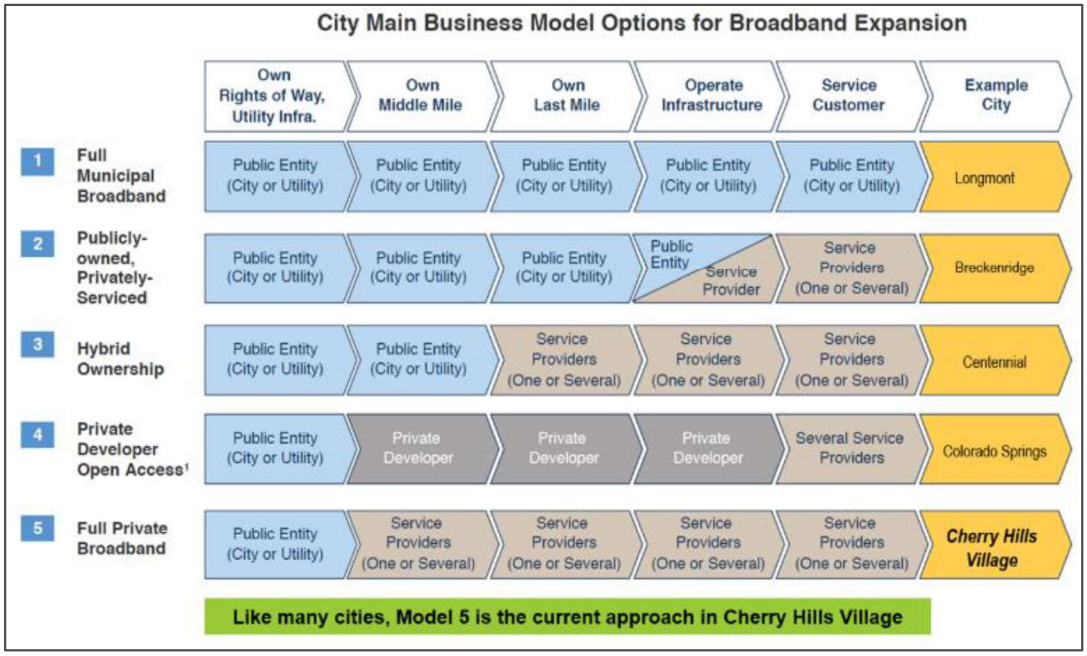
The Agenda for the Visioning Session included the following:

- Technology Overview
- Study Background
- Cellular Findings
- Broadband Findings
- Creating a Council Vision
- Discussion & Next Steps.

Creating a Vision

After sharing the Technology Overview, Study Background, Cellular and Broadband Findings with the Council, the discussion shifted to Creating a Council Vision. Initially, this part of the discussion focused on potential partnership alternatives. The alternatives range from *Municipally Owned and Operated* to *Allowing the Private Sector to Drive Deployment*. Establishing partnerships is part of the next phase of the Study, so this discussion will be applicable during that process. The following graphic was used as a means of sharing information during this discussion.

The discussion then focused on an overview of the different municipal broadband models. There are five main models, each requiring a different level of investment and engagement from the municipality. Although these models primarily focus on broadband, they can also be applied to the provisioning of cellular services. The following diagram was shared.



The Cellular results of the Council's Vision Survey were the next topic discussed. The results seem to mirror the public perception of the need for improved cellular service. Most Council members indicated dissatisfaction with cellular quality in residential areas, public areas, and while driving through the community.

Next, the discussion covered the Broadband results of the Council's Vision Survey. The results also aligned with public perception that there seems to be sufficient broadband services in the community. The results indicated that broadband is viewed as a necessary asset for quality of life. Additionally, 80% of the Council members felt the City should "encourage or enable" improvements in broadband and cellular.

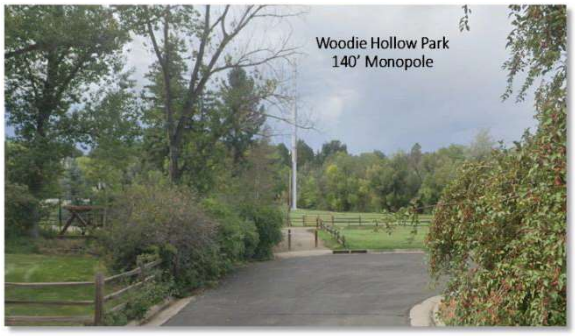
At this point, the discussion centered on *Possible Solutions*. Initially, three approaches to solutions were explored. The three approaches are *City Owned Towers and Fiber*; *City Owned Towers*; and *Policy Only*. The following graphic, which was shared with Council during the Visioning Session, describes each of these approaches.

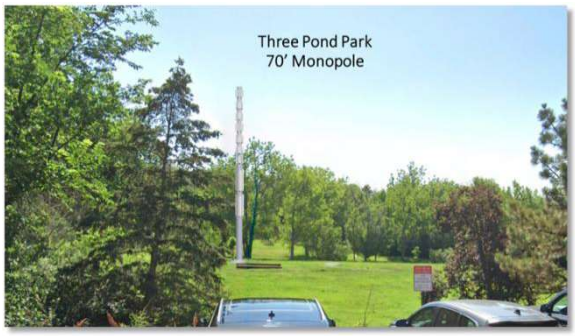
The *Possible Solutions* discussion then looked at a couple of *Possible 5G Solutions*. These *Solutions* included:

A. Two (2) 140' macro towers and five (5) 70' stealth macros

B. Seven (7) 70' stealth macros

Here are a couple of photo simulations, one showing a 140' Tower and one showing a 70' Tower.

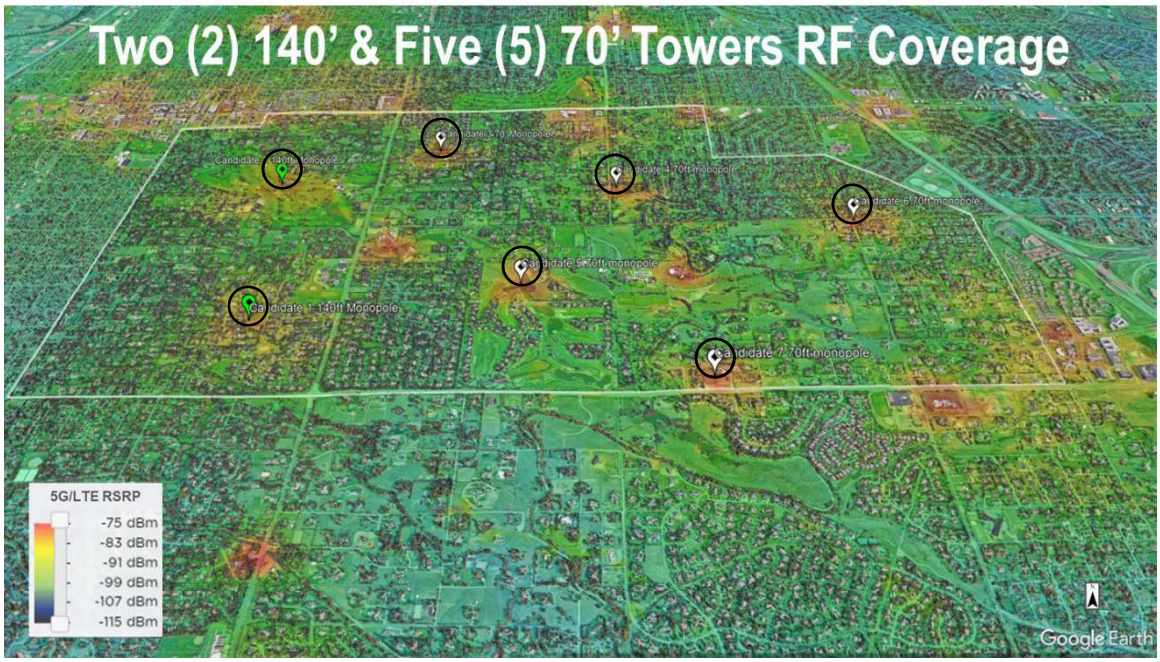




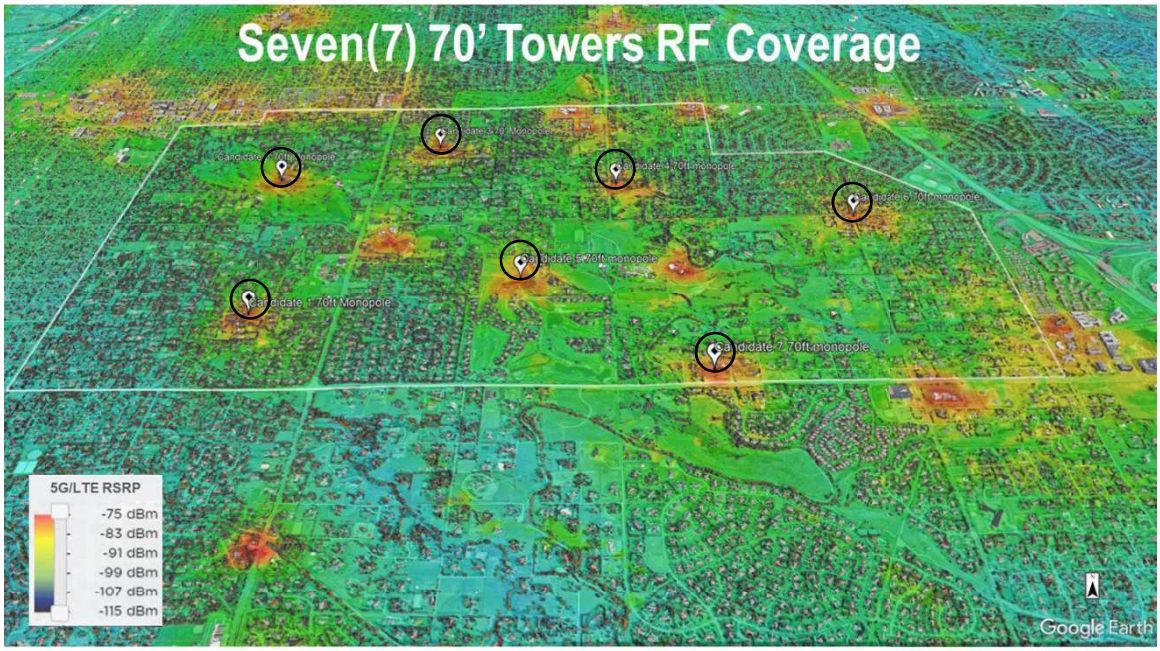
The following important things to note regarding the *Possible 5G Solutions* were discussed.

- Existing macro sites are included as part of the possible solutions
- Possible solutions are focused on COVERAGE and CAPACITY
- Best solutions involve macro sites
- Approximately $200k for a 70' monopole (tower)
- Approximately $300k for a 140' monopole (tower)

The following graphic of *Possible 5G Solution A* was discussed during the Visioning Session. The two 140' towers are represented by green thumb tacks and the five 70' towers are represented by white thumb tacks. The white line represents the city limits. All seven towers are circled.



The following graphic of *Possible 5G Solution B* was also discussed during the Visioning Session. The seven 70' towers are represented by white thumb tacks and are circled. The white line represents the city limits.



After the presentation, the Mayor opened the floor for Council discussion. At the conclusion of the discussion, Council provided the following direction:

- Draft an overall vision for the City related only to cellular coverage. It was decided that fiber and broadband to the home were not to be contemplated except as they relate to cellular service and the infrastructure needed to improve total cellular coverage in the City.
- Continue to investigate larger tower configurations and locations as a possible solution.
- Begin the process of finding possible partners to implement the Vision. Before any final configuration or placement is decided, these partners should be consulted to ensure the towers and their placement are satisfactory to their needs.
- Bring partners forward to the City Council to negotiate formal agreements for cost sharing, infrastructure installation and permitting, provider use agreements, etc.

Based on the data that was collected and the feedback from the public, as well as City Council's discussion and direction, the following Vision Statement and Goals were developed. It is important to note that a Vision and Goals needed to be established prior to the network being designed, which is the next phase of this Study.

Vision Statement and Goals

Vision Statement

Through partnerships and collaboration, the City endeavors to improve cellular coverage throughout its entire jurisdiction. Like water, sewer, and electricity, cellular service has become a necessity. By partnering with infrastructure and service providers the Council strives to improve the health, safety, and welfare of its residents, by providing comprehensive cellular coverage throughout the entire City.

Goals

1. Implement a telecommunications solution that provides reliable citywide cell phone coverage, and that providers will utilize.
2. Locate towers on City owned property or rights-of-way, when possible
3. Ensure that towers do not exceed the maximize height permitted in the City Code. And if needed, provide City Council with the necessary language to modify the code.
4. Engage with potential partners to ensure the designed solution meets all their needs and requirements.
5. Explore all partnership opportunities.
6. Utilize a Request for Expressions of Interest (RFEI) or a Request for Proposal (RFP) process to establish one or more public private partnerships.
7. Explore funding opportunities.

Visioning Session Next Steps

The following next steps were discussed as the Visioning Session concluded. It is important to note that after the Visioning Session, the City authorized Phase III of the Study to be executed in parallel to Phase II of the Study, so the following list of next steps includes tasks from both Phase II and Phase III of the Study.

- Preliminary Cellular Design & Cost Estimate (Phase II, Task 1)
- Preliminary Fiber Design & Cost Estimate (Phase II, Task 1; see **Appendix D**)
- Conduct Cellular Financial Analysis (Phase II, Task 2)
- Evaluate Broadband Funding Alternatives (Phase II, Task 3; see **Appendix D**)
- Explore Public Private Cellular Partnerships (Phase III, Task 1)
- Complete Cellular Communication/Fiber Study (Phase II, Task 5)

Section 5: Develop Preliminary Cellular Designs

Background

Based upon the outcomes and recommendations from the Vision Session with the Council, including the Vision Statement and Goals, the next step in the Study was to complete an evaluation of optional cellular solutions and technologies to determine the best solution(s) for the City. Once that evaluation was completed, then high-level designs (HLDs) of the recommended optional solution(s) were developed that could be used for cost estimating (and possible future detailed design). The HLDs used GIS-based tools.

Drawing on field and desk surveys, and GIS maps, system level designs and cost estimates were prepared for developing next generation cellular networks. In developing this approach, the focus was on creating a robust, reliable, and cost-effective approach to meeting the City's needs.

Based on an analysis of existing infrastructure, conceptual designs, high-level maps, and routing, candidate specifications and system-level overviews of the potential infrastructure were provided. This analysis in turn became a roadmap for financial analysis and business modeling, and for future decisions (potentially including detailed engineering, construction, and operations).

Again, leveraging the results of Phase I and the partial results of Phase II, several cellular designs were explored. However, based on the Vision Statement and Goals, three proposed cellular designs were created. These designs were built upon the existing and suggested RF coverage maps by identifying any necessary expansion locations to complete coverage of the community with not only equitable coverage but high-capacity data designs. The three designs created were based on the spectrum owned by each carrier and the type of state-of-the-art telecommunications technology deployed by the carriers. The designs included the creation of RF frequency templates to ensure that future locations will be attractive to potential private partners, who each utilize their own spectrum. Additionally, the network designs included the creation of potential pole designs for consideration by City leadership.

Upon completion of the preliminary designs, cost estimates were prepared for developing the cellular networks.

Optional Cellular Solutions

There are multiple ways to provide 5G cellular service for a specific area. Mobile operators (Carriers) build networks using a multitude of solutions:

- Macro Radios on Towers or Buildings
- Small Cells
- Distributed Antenna Systems (DAS)
- Internet Mesh Radios on Poles or Buildings
- Direct to Device (D2D) Satellites

Each comes with pros and cons from a technical and business (cost) perspective.

The following were evaluated for each of the cellular solutions:

- What they are
- How they are used
- Pros and Cons
- Viability for the City of Cherry Hills Village
- Examples
- Numbers and facts

Overview of Pros, Cons, and Viability of Each Cellular Solution

Each solution has its own set of advantages and disadvantages, and they complement each other to provide comprehensive coverage. The choice of which solution to use often depends on the specific needs and characteristics of the area being served.

5G Wireless Towers (Macrocell Towers)

The general characteristics of 5G Wireless towers are:

- A macrocell tower, also known as a macrocell site, is a large cellular base station that uses radios and antennas attached to towers to send and receive radio signals. Macrocell towers are part of a radio access network (RAN) and are designed to provide high-power radio coverage utilizing many different licensed frequency bands to large areas for mobile network access and capacity. They can be 50 to 600 feet tall and provide coverage for up to 10 square miles. Macrocell towers are often found in rural areas or along highways, and can support multiple cellular wireless carriers, public safety, and other communication systems
- Macro radios on cell towers and taller buildings have been the central component of wireless networks for many years and will remain the backbone of all 4G / 5G / 6G networks for the foreseeable 30+ year future. The main reasons for this are the physics of radio frequency and the economics of deployment. Cell towers are the preferred technology able to provide enough coverage and capacity over large areas and are by far the most efficient and lowest cost of ownership to build and manage mobile networks for the operators.
- Cell towers combined with new technology such as **Massive MIMO** and **Beamforming** create an unmatched combination for cost effective deployment of full coverage, high capacity, and low latency mobile networks.
    - **Massive MIMO**, or massive multiple-input multiple-output, is a wireless communications technology that uses a large number of antennas on base stations to improve communication performance.
    - **Beamforming** or *spatial filtering* is a signal processing technique used in sensor arrays for directional signal transmission or reception.
- Once a tower is built, it is rarely removed from the network. Other deployment strategies such as small cells and satellites are all complementary to the tower network, and do not change the need for towers to remain as the backbone part of the network to provide the necessary RF coverage and capacity.
- The carriers are still signing up for 25+ year extended leases on all existing and new towers, because it is the most cost effective and fastest way for them to provide service.
- **Infrastructure:** Uses tall towers to install high-capacity radios and antennas.
- **Coverage:** Macrocell towers provide excellent coverage in all types of areas, especially suburban and rural areas.
- **Speed:** Can offer high speeds, often above 100 Mbps.
- **Latency:** Generally low, making it suitable for real-time applications like gaming and video calls.
- **Installation:** Requires fiber and power connections to each tower.

<u>Pros of 5G Wireless Towers (Macrocell Towers)</u>

- **Larger Coverage Area**: 5G Macrocell towers have a broader coverage range, making them more economical and efficient to cover larger numbers of subscribers over a large area with the minimum number of radios.

- **High Capacity**: These towers can handle a large number of users simultaneously.
- **Reliability**: 5G macrocell towers or macro sites are generally more robust and can withstand harsh weather conditions better than other options.
- **High speed**: The amount of spectrum that can be brought to bear is unmatched by any other architecture. Typically, each carrier will deploy over 400MHz of spectrum per macro site on a tower, which is necessary for reliable and high-speed mobile services.
- **Low latency:** The low latency that can be achieved by 5G Wireless Towers can only be matched by direct fiber optic connections.

Cons of 5G Wireless Towers (Macrocell Towers)

- **Visual Impact**: They are large structures that may not blend well with the surrounding environment, potentially causing aesthetic concerns.
- **Permitting Issues**: Getting permits for new towers can be a lengthy and bureaucratic process.

Viability for Cherry Hills Village:

Cell towers are the most viable option with the lowest cost for greatest performance.

5G Small Cells (Microcell Towers)

The general characteristics of 5G Small Cells are:

- **Small cell towers**, also known as small cell wireless facilities, are a type of wireless broadband infrastructure that is smaller than traditional cell towers, or "macrocells". They are short-range cellular towers that are typically installed every few blocks, rather than miles apart, and can be placed on existing structures like streetlights, poles, or the sides of buildings. Small cell towers are often used to supplement and increase the coverage of macrocell towers, especially in areas with high demand or dense populations.
- **Infrastructure:** Small, low-power nodes placed on structures like streetlights and buildings.
- **Coverage:** Best for dense urban areas and indoor environments.
- **Speed:** Extremely high speeds, especially with high-band (mmWave) technology.
- **Latency:** Very low, ideal for real-time applications.
- **Installation:** Very disruptive installation as all streets will need to be dug up to provide dedicated fiber strands and power to each small cell. Rather than a few tall towers, small cells will require many units for comprehensive coverage. The estimated need for the City would be 100+ small cell sites.

Pros of 5G Small Cells:

- **Increased Capacity in Dense Areas**: Small cells are ideal for high-density urban areas such as downtown Denver, and event venues such as NFL stadiums where demand for network capacity is high.
- **Visual Impact**: Smaller radios on 30-foot-tall poles at 100+ sites will not impact the skyline as much as tall towers.

Cons of 5G Small Cells:

- **Extremely High Cost:** The cost to provide direct fiber strands and dedicated power to 100+ poles are extremely high. The budget to deploy 2-3 radios times 100+ sites is extremely high, and it is not in the budget for carriers to cover an area such as the City.

- **Limited Coverage**: Small cells have a smaller coverage area, which means more of them are needed to cover the same area as a single tower.
- **Infrastructure Requirements**: They need access to power and fiber optic backhaul connections, which require large scale infrastructure investments.
- **Permitting and Zoning**: While easier to obtain than towers for a single site, multiple small cells require a large number of permits and must adhere to local zoning regulations.
- **Visual Impact**: Smaller radios on 30-foot-tall poles at 100+ sites will not impact the skyline but may have an impact in neighborhoods especially in front of residential homes.

Viability for Cherry Hills Village:

Not a viable option due to the small number of existing poles and required number of new small cells poles. The solution would exceed 100 poles and associated massive work to provide fiber strands and power to each pole.

4G (not 5G) Distributed Antenna Systems (DAS) on Poles

The general characteristics of 4G DAS are:

- **Infrastructure:** Small, low-power nodes placed on structures like streetlights and buildings.
- **Coverage:** Best for indoor environments. Historically used in some outdoor environments such as the City, but today DAS is typically no longer used.
- **Speed:** Very low speeds due to radio capacity and power limitations. Not 5G.
- **Latency:** Moderate, not fast enough for state-of-the-art 5G applications
- **Installation**: Requires a 3rd party company to manage and run a separate radio network that the carriers plug their radios into. Complicated and hard to modify.

Pros of 4G DAS:

- **Visual Impact**: Smaller radios on 30-foot-tall poles at 100+ sites will not impact the skyline as much as tall towers.

Cons of 4G DAS:

- **Limited Capacity and Coverage**: DAS poles have a smaller coverage area than even small cells, which means more of them are needed to cover the same area as a single tower. Estimated 100+ for the City. Only 4G, not true 5G, not something carriers deploy anymore.
- **Infrastructure Requirements**: They need access to power and fiber optic backhaul connections, which require large scale infrastructure investments.
- **Permitting and Zoning**: Like small cells, requiring permits and must adhere to local zoning regulations.
- **Economics:** Very expensive to build to cover wide areas due to fiber deployment costs and number of DAS nodes needed. Not in any of the four national carriers' budgets for an area such as the City.
- **Visual Impact**: Smaller radios on 30-foot-tall poles at 100+ sites will not impact the skyline but may have an impact in neighborhoods especially in front of residential homes.

Viability for Cherry Hills Village:

Not a viable option due to the small number of existing poles and number of new 4G DAS poles required. This would exceed 100 poles and be too cost prohibitive to overcome dense tree clutter to provide acceptable performance.

Internet MESH Radios on Poles and Buildings

The general characteristics of Internet MESH Radios are:

- Not an option for the City but covered here for comprehensive reasons when looking at all potential options.
- MESH installations are not 4G/5G "cellular" networks. They are used in a similar manner to Wi-Fi to provide internet access without having fiber to each home.
- **Infrastructure:** Small, low-power nodes placed on structures like rooftops, poles, streetlights, and buildings.
- **Coverage:** Very small RF coverage at 28-foot rooftops and poles. Also easily blocked by other buildings and tree clutter
- **Speed:** Very low speeds due to radio capacity and power limitations
- **Latency:** Moderate, but not fast enough for 5G applications
- **Installation**: Requires far more units (over 1000) compared to other solutions for comprehensive coverage.

Pros of MESH Radios:

- **Easy to deploy:** Can be attached to house rooftop with a pipe.

Cons of MESH Radios:

- **Limited Coverage**: Mesh Radios have a smaller coverage area than even small cells or DAS, which means many more of them are needed to cover the same area as a single tower.
- **Infrastructure Requirements**: They need access to power and fiber optic backhaul connections, which may not always be readily available.
- **Permitting and Zoning**: While easier than towers, Mesh radios must adhere to local zoning regulations.
- **Economics:** Can be very expensive to maintain over wide areas due to service truck roll out costs and the number of MESH Radios needed.

Viability for Cherry Hills Village:

Not a viable option since it is not a cellular network and not deployed by any of the four national carriers in an area such as the City. The only Mesh networks deployed by US carriers are for Wi-Fi and typically only deployed indoors.

Direct-to-Device (D2D) Satellite 5G

The general characteristics of D2D Satellite 5G are:

- Not an option for the City but covered here for comprehensive reasons when looking at all potential options.

- Low Earth Orbit (LEO) Satellites: Companies like SpaceX (Starlink), Amazon (Project Kuiper), and OneWeb are deploying LEO satellite constellations to provide global internet coverage. Most LEO satellites are NOT equipped for cellular service, just internet coverage, which are two separate services.
- To be clear, the vast majority (over 95%) of all LOE satellites deployed to date are only providing internet access, not cellular service. Only SOS type text messages are widely available today.
- **Infrastructure:** Relies on satellites in orbit to beam internet directly to devices on the ground.
- **Coverage:** Can provide almost exclusively outdoor (not indoor, not inside car, not under trees) internet access in remote and rural areas where traditional infrastructure is lacking.
- **Speed:** Typically, slower than 5G towers, but improving with advancements in satellite technology. Note satellites provide internet access, not cellular access.
- **Latency:** Higher latency due to the distance signals must travel to and from space.
- **Installation:** Requires a clear view of the sky and a satellite dish, but no extensive ground infrastructure.

Pros of D2D Satellite 5G:

- **Wide coverage area:** Satellites provide coverage to devices in underserved rural areas with an economically viable model.
- **Service Levels:** Satellites allow carriers to reach their mandated coverage obligations and achieve previously unattainable service level goals.
- **Spectrum Monetization: S**atellites enable carriers to monetize their spectrum assets across a broader service area. The carriers are planning to provide cellular spectrum for satellite services. This means that in the future the carriers may have ~92% of their spectrum on towers and ~8% on satellites. Primarily to provide coverage in extremely sparsely populated, remote areas.
- **Internet of Things/Redcap Sensor Networks:** Satellites enable the deployment of low capacity/low-cost sensors in the millions (over much wider areas than previously possible).
- **Network Resilience**: Satellites provide network resilience and emergency response during natural disasters and terrestrial disruptions.
- **Ground Infrastructure:** Less needed.

Cons of D2D Satellite 5G:

- **Traffic capacity:** Satellites can only support a small number of users across a wider service area but lack the spectral bandwidth to support any significant number of users. The practical and economic limits on the number of satellites makes the capacity per unit area from each satellite limited.
- **Spectrum Sharing:** Spectrum, being a scarce resource, will have to be partially shared between the carriers and satellite providers to enable reasonable access and service. Less than 10% of the cellular spectrum is currently being planned to be put on satellites in the future.
- **Signal Blockage:** Does not work indoors or with high density clutter (such as under a tree) can limit D2D service, needing terrestrial towers to augment or even provide service. Note: Starlink requires a laptop sized antenna aimed outside towards the sky to work. The third generation Starlink dish size is 20-inches x 15-inches.
- **LEO Latency:** Typically, ~80ms meaning that use cases requiring very low latency will always need a terrestrial tower counterpart to maintain the lowest latency, especially for mission critical applications.

Viability for Cherry Hills Village:

Not a viable option due to limitation on capacity.

Comparison of Evaluated Technologies

The following chart shows the comparison of the ten optional cellular technologies that were evaluated for the City. Each of the options utilizes one or more of the cellular solutions.

Options										
Criteria	**(1) 200-foot pole**	**(3) 100-foot poles**	**(2) 140-foot poles plus (5) 70-foot poles, or (10) 70-foot poles**	**Distributed Antenna System (100+) 35-45 foot poles**	**100+ Small Cells 35-45 foot poles**	**Poles on the perimeter of City**	**Increase heights of existing poles**	**Put poles on top of buildings outside of City**	**Satellite**	**Wifi Mesh over 1,000 nodes**
Carriers would support	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗
Establishes a baseline service that benefits the entire City	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗
Econimically feasible w/o a tax increase to residents	✓	✓	✗	✗	✗	✓	✓	✓	✓	✓
Can be accomplished by City (does not require lease or purchase of private property)	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗
Utilizes the minimum number of Towers	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗
Comments	Meets criteria Carriers have budgets for this type of deployment	Meets criteria Carriers have budgets for this type of deployment	Cost prohibitive. Carriers will not support. Some poles would need to be placed on private property to get complete coverage.	Cost prohibitive Carriers will not support. Not 5G. Would require poles to be placed on private properties. Typically used in malls and venues	Cost prohibitive Carriers will not support. Would require digging up all roadways to provide fiber. Typically used in downtown Manhattan type areas and NFL stadiums	There are already 12 macro sites surrounding the village They are not able to provide service for inner village areas.	Requires 100' minimum towers to enable carriers to transmit above the tree clutter	There are already macro sites on surrounding buildings. Does not provide sufficient coverage to entire village.	Only line of site, as a compliment to 5G, only planned to be used in remote areas with very few users, current services text message only	Mesh Networks are used for Internet access, not cellular access.

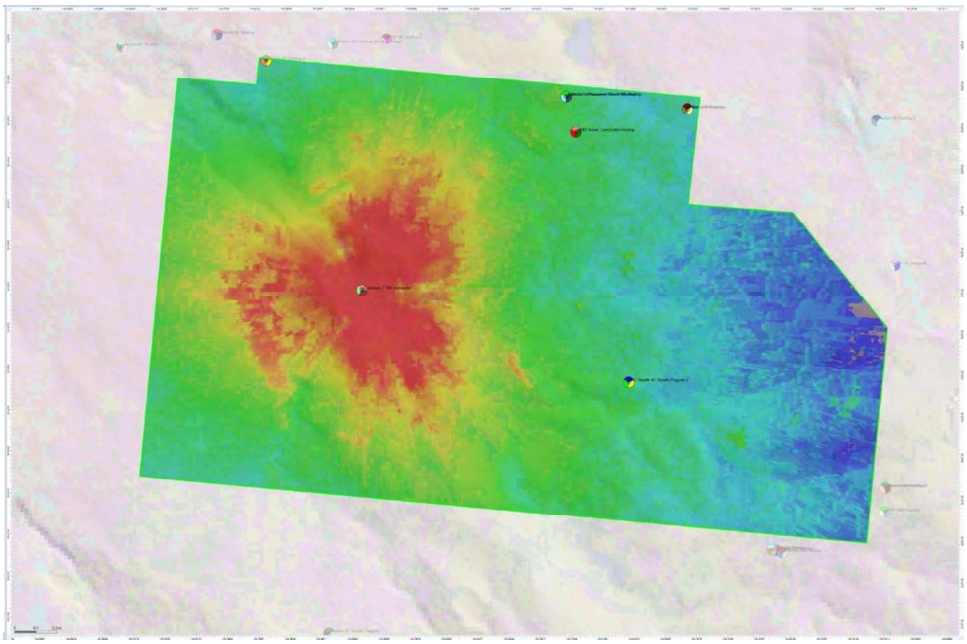
Cellular Solution Recommendations

5G wireless towers (macrocell or large towers) are better suited for covering large areas with fewer installations, while 5G small cells are ideal for increasing capacity in densely populated areas, but not a viable choice for large areas with dense foliage. 4G DAS is not future proof and not suited to the large area of Cherry Hills Village and the foliage density. Internet MESH Radios are not used for cellular networks, they are like Wi-Fi internet access technology. D2D Satellite is great for remote open areas with minimal population density. Satellite companies and Carriers plan to provide US coverage in such areas in 2026 and beyond.

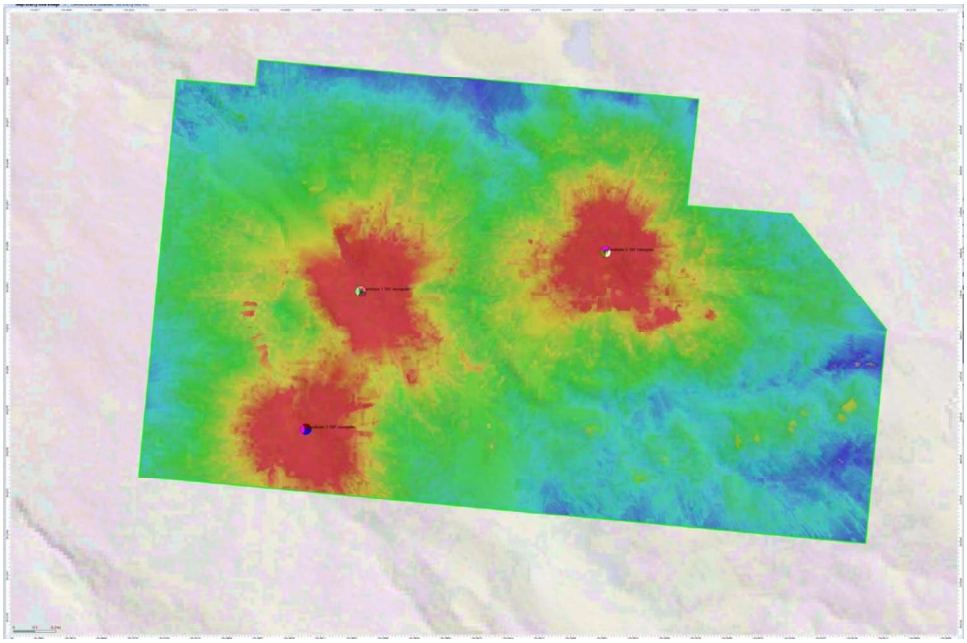
Based on the chart showing the comparison of cellular technologies, **it is recommended that the City consider either one centrally located 200-foot tower or three 100-foot towers located throughout the City**. These two proposed cellular solutions provide the City with ample coverage and high capacity 5G services providing a cost-effective solution supported by the four major carriers' technical requirements and budgets.

Below are high-level examples of the coverage and capacity capability of the two proposed 5G macro tower solutions within City limits.

Single 200-foot Tower - Provides significant RF Coverage over a wider area due to 200-foot height with greatest cost/coverage benefit and minimal overall skyline visual impact.



Three (3) 100ft Towers – Provides adequate RF Coverage over similar area with reasonable cost/coverage benefit and more overall skyline visual impact.



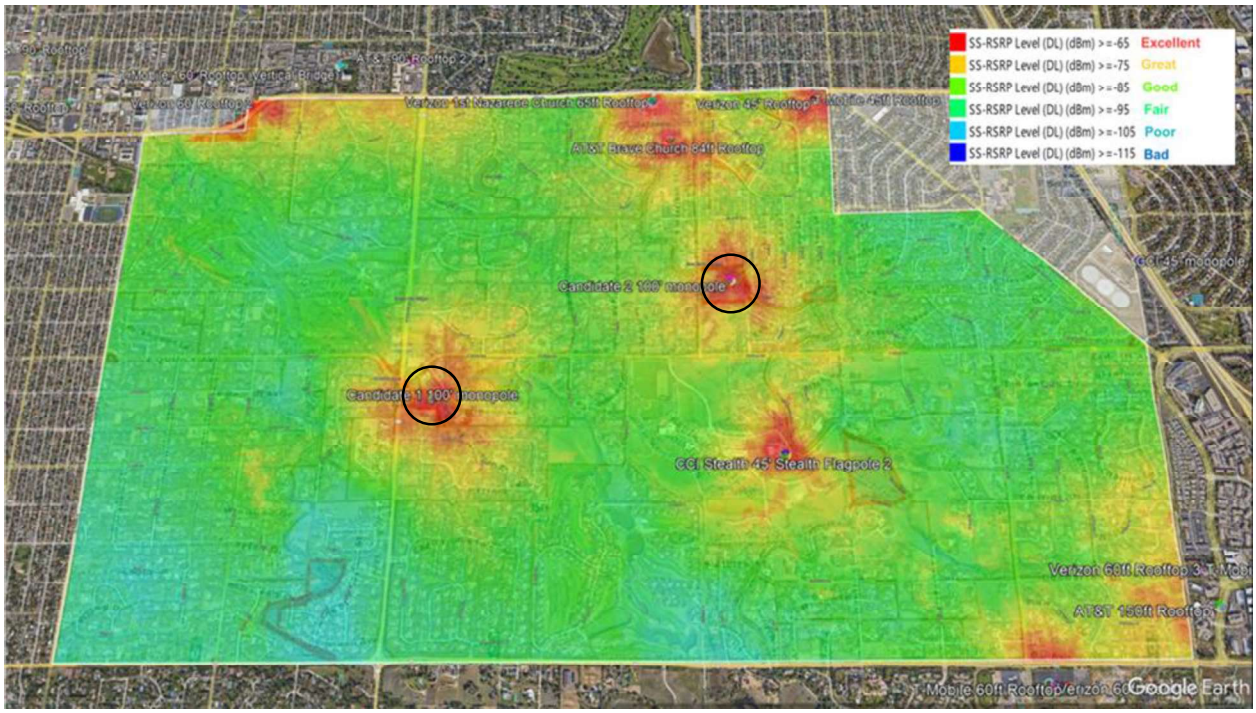
Conceptual Cellular Designs and Cost Estimates

The recommended one 200-foot tower option was not explored further because it would require the City to modify its Code to substantially increase the maximum height of a cellular tower from 70 feet to 200 feet. While the recommended three 100-foot towers option would also require the City to increase the maximum height of a cellular tower from 70 feet to 100 feet, it is much less of an increase. Therefore, below are three proposed HLDs for the recommended 100-foot towers option, which includes a 70-foot towers design that would not require a Code change, and the estimated costs for each design.

Option 1 - Two (2) 100' Monopole Towers

The following tower network design and RF coverage map shows two 100-foot monopoles on public property or public rights-of-way. Both tower locations have been circled. This map also includes several existing tower locations. Again, the City will need to modify its Code to permit 100-foot poles.

It is worth noting that while the two 100-foot towers in combination with the existing towers will improve cellular coverage throughout the City, they will not provide the same level of coverage as the three 100-foot towers in combination with the existing towers shown in Option 2, or the six 70-foot towers shown in Option 3. Option 2 and 3 are shown below.



Option 1 Cost Estimate

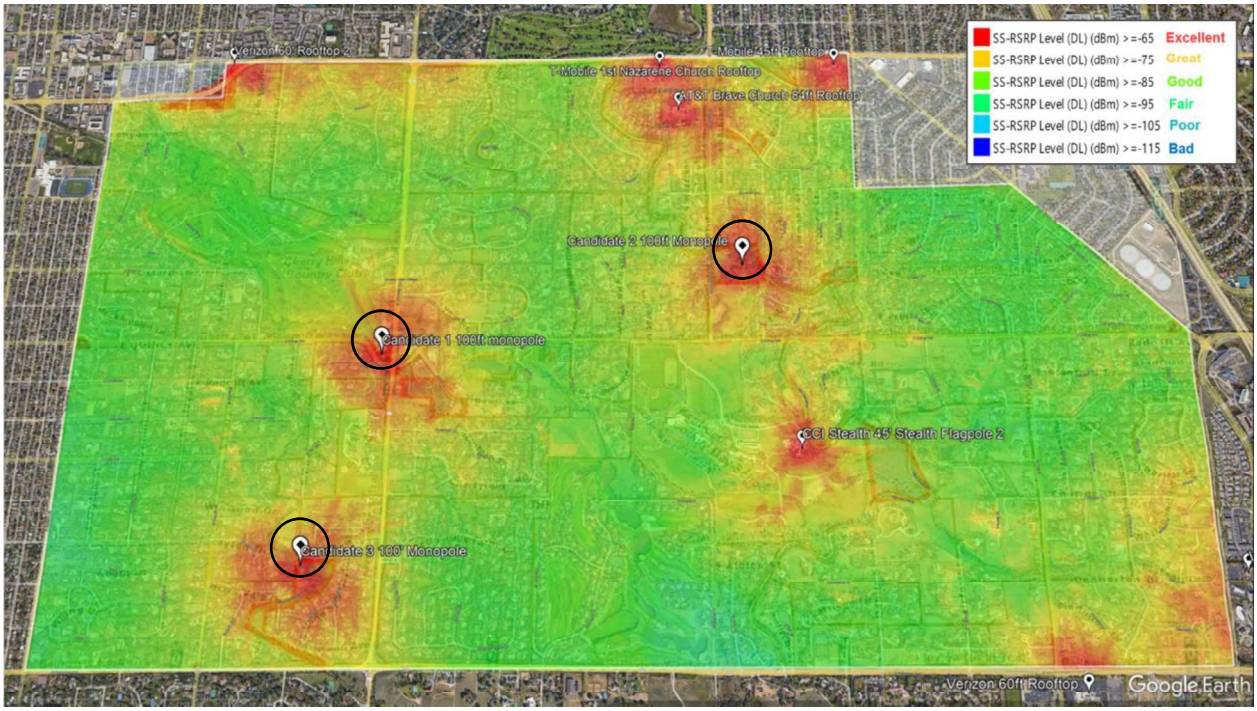
Site	Longitude	Latitude	Cost Per Tower*	# of Towers Per Site	Total Tower Costs Per Site
Candidate 1 100' monopole (Village Center)	-104.957477	39.636394	$300,000	1	$300,000
Candidate 2 100' monopole (Three Pond Park)	-104.938974	39.642295	$300,000	1	$300,000
Option 1 Total Tower Costs					**$600,000**

* Cost per tower includes construction costs only. It does not include the costs of cellular radios, antennas, etc. (these costs are covered by carriers)

Option 2 - Three (3) 100' Monopole Towers (Recommended Solution)

The following tower network design and RF coverage map shows three 100-foot monopoles on public park property. All three tower locations have been circled. This map also includes several existing tower locations. As previously stated, the City will need to modify its Code to permit 100-foot poles.

It is worth noting that the three 100-foot towers in combination with the existing towers will provide the most comprehensive cellular coverage throughout the entire City. This is the recommended solution based on the alignment between this design and the selection criteria based on the Vision Statement and Goals that were developed from the input provided by Council during the Visioning Session.



Option 2 Cost Estimate

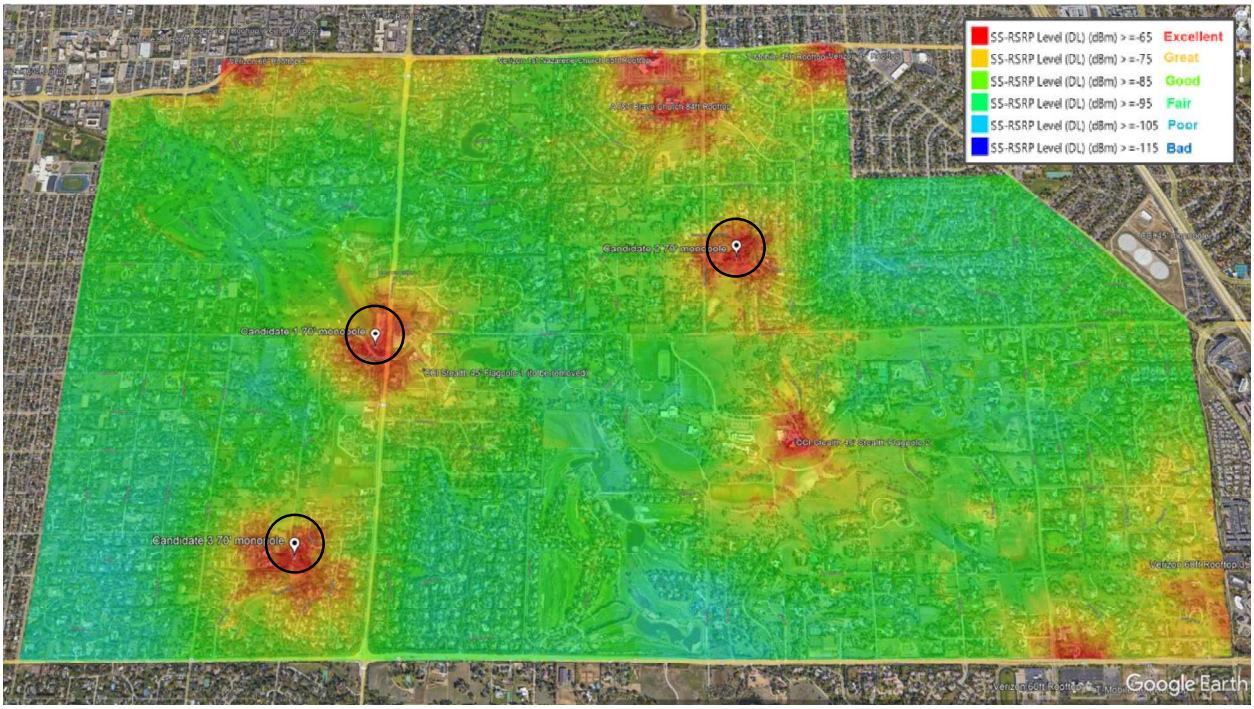
Site	Longitude	Latitude	Cost Per Tower*	# of Towers Per Site	Total Tower Costs Per Site
Candidate 1 100' monopole (City Park)	-104.957477	39.636394	$300,000	1	$300,000
Candidate 2 100' monopole (Three Pond Park)	-104.938974	39.642295	$300,000	1	$300,000
Candidate 3 100' monopole (Woodie Hollow Park)	-104.96412	39.628524	$300,000	1	$300,000
Option 2 Total Tower Costs					**$900,000**

* Cost per tower includes construction costs only. It does not include the costs of cellular radios, antennas, etc. (these costs are covered by carriers)

Option 3 - Six (6) 70' Monopole Towers

The following tower network design and RF coverage map shows six 70-foot monopoles on public park property. To ensure that there is enough space for up to four carriers at each of the three candidate tower locations, there will be two 70-foot towers at each of the locations and the two 70-foot towers at each location will need to be separated by at least 80-feet. All three tower locations have been circled. This map also includes several existing tower locations. It is important to note that the City Code currently allows 70-foot poles on public property or public rights-of-way.

It is worth noting that while the six 70-foot towers in combination with the existing towers will significantly improves cellular coverage throughout the City, they will not provide the same level of coverage as the three 100-foot towers in combination with the existing towers.



Option 3 Cost Estimate

Site	Longitude	Latitude	Costs Per Tower*	# of Towers Per Site	Total Tower Costs Per Site
Candidate 1 70' monopole (City Park)	-104.957477	39.636394	$250,000	2	$500,000
Candidate 2 70' monopole (Three Pond Park)	-104.938974	39.642295	$250,000	2	$500,000
Candidate 3 70' monopole (Woodie Hollow Park)	-104.96412	39.628524	$250,000	2	$500,000
Option 3 Total Tower Costs					**$1,500,000**

* Cost per tower includes construction costs only. It does not include the costs of cellular radios, antennas, etc. (these costs are covered by carriers)

Section 6: Conduct Cellular Financial Analysis

Background

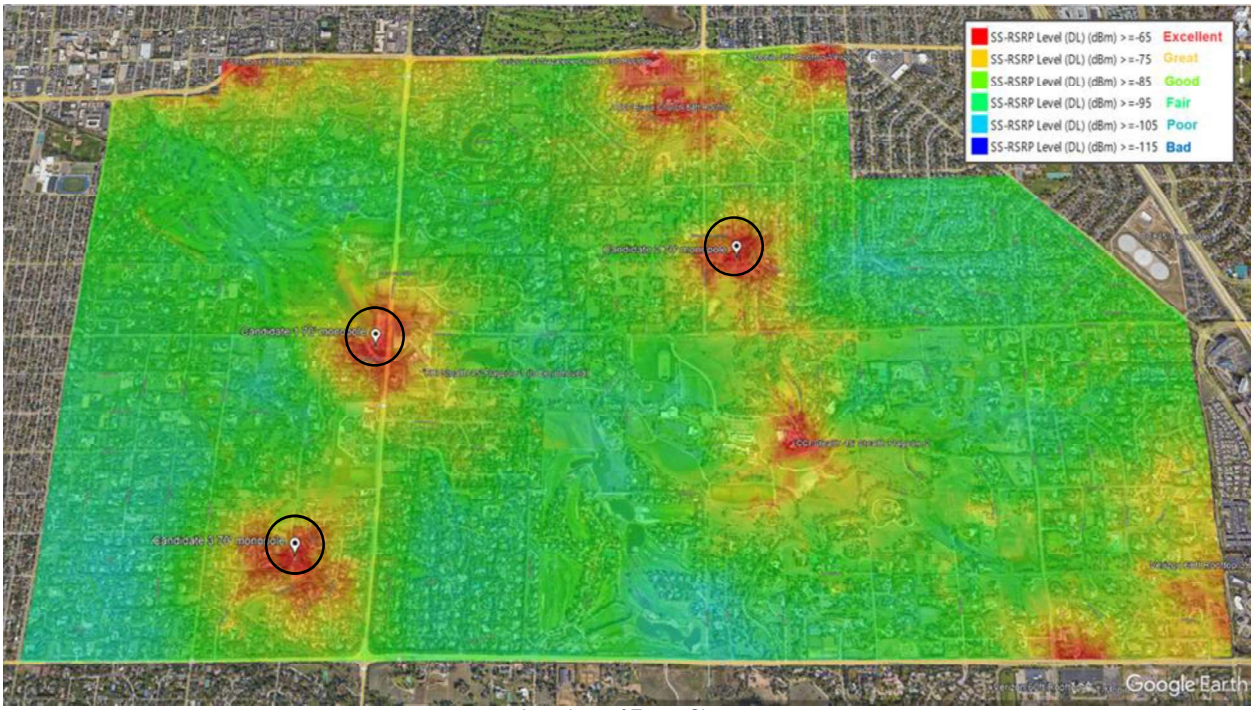
The development of potential technical solutions focused on the creation of a cost-effective, shared infrastructure model to deliver a carrier-grade platform. A preliminary design was created and subsequently perfected, at which time financial cost estimating was completed for the wireless equipment. Concurrently, the completion of the business model and site determinations led to an estimate of capital expense for the towers.

The Cherry Hills Village model provides not only the ability to create communication upgrades at one-time, at a fixed cost, but analysis has shown the ability to generate a solid return on invested dollars.

Financial Analysis

A study of the financial feasibility of the project was conducted to determine if a system could be built and operated to meet the City's goals for connectivity in improving cellular service for homes and residents. The financial analysis focused on two models and assumed that the City would build an asset for cellular providers to use that would then become the basis of a public-private partnership to improve last-mile cellular connectivity.

- **Model 1: Three 100' Towers** (Option 2 from above)**.** This model plans on three 100' towers, each with four providers, which would require a change to the City Code for increased tower height and a vote of the residents to allow a lease on park property for more than five years.
- **Model 2: Six 70' Towers** (Option 3 from above)**.** This model avoids the need to increase the maximum height of the towers, instead siting two towers, each with two providers at the chosen locations to extend cellular service to residents. This would still require a vote of the residents to allow a lease on park property for more than five years. Tower locations are circled in the map below.



Locations of Tower Sites

Several assumptions played a role in guiding the development of the financial analysis models. Utilizing current industry material and construction costs, the models reflect the total capital cost of the towers, but no improvements – such as fiber backhaul – that will be required to connect the towers. It was determined that this cost, as well as operating expenses, will be borne by the carrier(s) that are located on the towers. Operating attributes including staffing, maintenance, vehicles, supplies, and other considerations were categorically excluded. While the analysis is reflective of a one-year buildout of the entire project footprint, a phased approach may be used to customize the planned schedule of the project.

The costs of towers were calculated to be $300,000 per 100' tower and $250,000 per 70' tower. As such the capital costs for the two models ranged from a total of $900,000 in Model 1 and $1,500,000 in Model 2.

It is worth noting that tower design Option 1 from Section 5 was not included in the financial analysis because while the two 100-foot towers would improve cellular coverage throughout the City, it would not provide the same level of coverage as the three 100-foot towers in Option 2 from Section 5, or the six 70-foot towers shown in Option 3 from Section 5.

All assumptions and price sensitivities were identified and justified. The financial models provide the City with order-of-magnitude estimates of the overall project cost and support the implementation roadmap by providing inputs for potential business models, financing options, and partnering opportunities. The financial model takes the following into account.

Sensitivities of Key Assumptions:

- Customer segmentation
- Market penetration
- Pricing
- Tiered revenue structures
- Operating costs
- System construction
- Staffing levels
- Base, best and worst-case analysis

Pro Forma

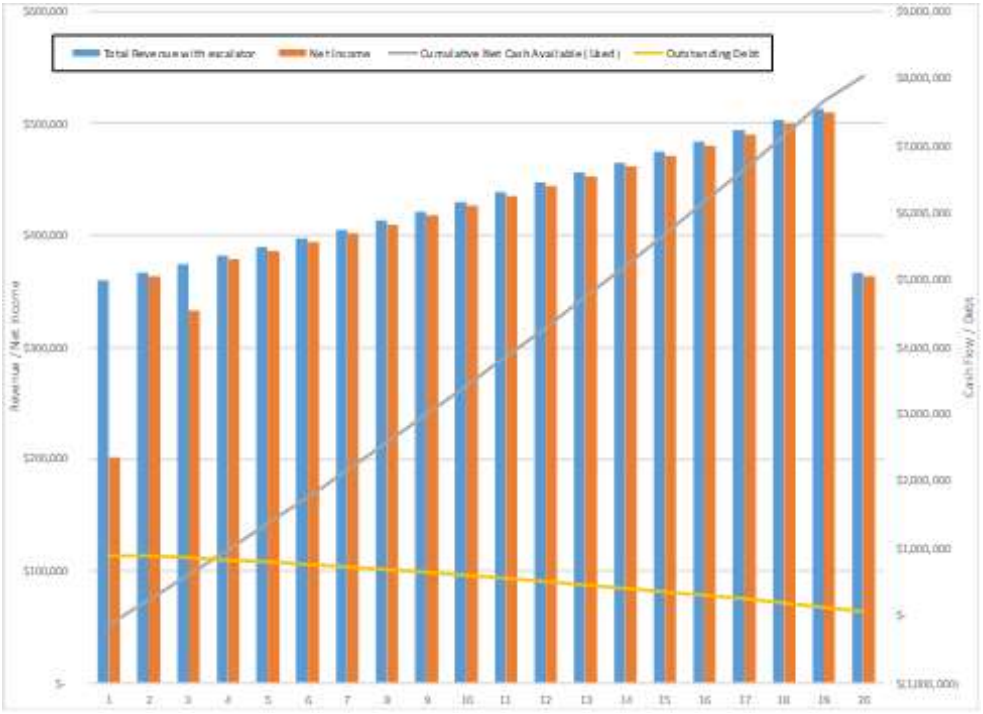
- Operating income and cash flow
- Net present value analysis
- Subscriber revenue by service
- Subscriber revenue by customer/customer class
- Reserve fund requirements
- Uses and sources of funds
- Operating expenses
- Operational savings
- Depreciation summary
- Projected construction costs for network, hardware, buildings and other equipment
- Return on investment (ROI)

Model 1: Three 100' Towers

In Model 1, Cherry Hills Village would design and deploy three 100' towers for lease by the four cellular providers to provide expanded coverage and capacity to the City's residents. Each monopole would cost $300,000, with four providers paying $2,500 a month in leasing revenue to the City, along with an annual escalator of 1.99%. This model would require no additional staffing and create limited management complexity for the City.

Site	Cost Per Tower	# of Towers Per Site	Total Tower Costs Per Site
Candidate 1 100' monopole (City Park)	$300,000	1	**$300,000**
Candidate 2 100' monopole (Three Pond Park)	$300,000	1	**$300,000**
Candidate 3 100' monopole (Woodie Hollow Park)	$300,000	1	**$300,000**
Total Tower Costs			**$900,000**

The City would expect to receive approximately $360,000 a year in revenue, which allows it to reach a break-even point by year 4.



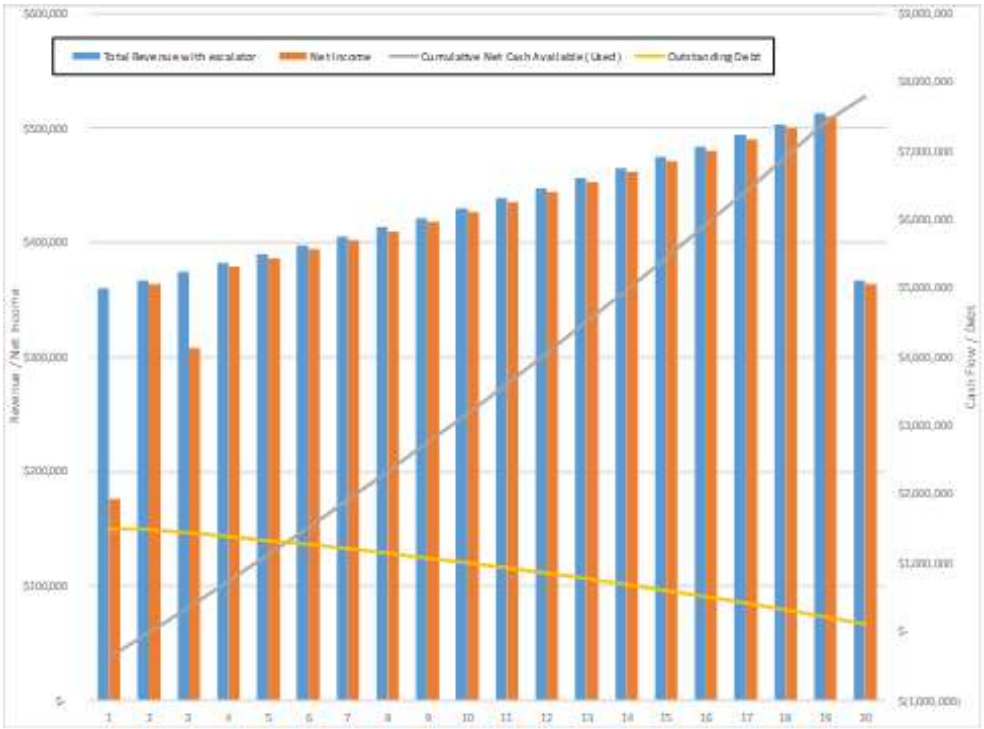
Model 1

Model 2: Six 70' Towers

In Model 2, Cherry Hills Village would design six 70' towers to avoid height restrictions imposed by the current City Code. Each site would host two providers' cellular equipment, each paying $2,500 a month in leasing revenue with a 1.99% annual escalator. The City would expect to receive slightly more than $360,000 in annual lease revenue, which would enable it to break-even in year 5.

Site	Costs Per Tower	# of Towers Per Site	Total Tower Costs Per Site
Candidate 1 70' monopole (City Park)	$250,000	2	**$500,000**
Candidate 2 70' monopole (Three Pond Park)	$250,000	2	**$500,000**
Candidate 3 70' monopole (Woodie Hollow Park)	$250,000	2	**$500,000**
Total Tower Costs			**$1,500,000**

This revenue could then be reinvested into other broadband infrastructure improvements such as fiber connecting the tower facilities or other anchor institutions. Any revenues from service provided to these entities may significantly reduce the payback period on this investment. This model would, again, require minimal staffing and create limited additional management complexity for the City.



Model 2

Financial Analysis Findings

Based on these assumptions, the proposed project is financially feasible based on the following conclusions that can be reached based on the financial analysis of the model:

- Total Capital Expenses of $900,000-$1,500,000 to fund the network.
- Positive Net Income in Year 4-5 following construction

Section 7: Explore Public Private Cellular Partnerships

Background

The approach to engaging with potential partners started by building a list of potential partners and other interested parties. Building this list involved developing a Request for Expressions of Interest (RFEI), posting the RFEI on the City's bid system, sending the RFEI to the list of potential partners, processing responses to the RFEI, interviewing the responders, and selecting potential partners based on the level of interest. This approach created a faster-moving cycle in which partners were identified and brought to the table more quickly and led to a higher likelihood of successful progress.

While the RFEI process is useful to determine interested parties, generally, it might not provide the City with enough details to fully determine a proposed partner nor the form of the partnership. It is recommended that the City conduct a formal Request for Proposal (RFP) to identify and select its partner(s) for the potential buildout.

When Cherry Hills Village made a decision to move forward with potential 5G/Cellular improvements, it also created the need for the City to explore partnerships with each of the four major cellular carriers. An outreach program was developed to meet the carriers where they work, by bringing a fully conceived network improvement proposal, complete with spectrum assignments and complete financial partnership requirements. The exploration of partnerships included an outreach effort to all four major carriers (AT&T, Dish Network, T-Mobile, and Verizon) to determine their potential interest in participating in the proposed project.

Request for Expressions of Interest

The RFEI was developed and posted on the City's bid system on October 17, 2023. Potential responders had until November 15, 2023, to submit questions about the RFEI, and their RFEI responses were due on December 1, 2023. The RFEI can be found in **Appendix C** of this report.

RFEI Responses

Prior to the RFEI closing at 5:00 pm on December 1, 2023, the City received four response to the RFEI.

Below are the four respondents to the RFEI:

- Aero Wireless Group
- NeuComm
- Telogistix
- Zayo

Key Findings

To help the City better understand the four responses and to possibly narrow down the list of potential partners, all four RFEI responders were interviewed.

Zayo, who owns fiber in and around Cherry Hills Village, identified that they would be interested in providing fiber (with financial assistance from the City) but were somewhat reluctant to partner with a tower builder.

The other three firms could construct both the towers and fiber network. All three firms stated they would not need financial assistance from the City if they privately owned and maintained the facilities and were able to collect rent directly from the carriers. As an alternative, they also acknowledged they would be willing to have the City own and pay for the installation of fiber, towers, and ongoing maintenance. This alternative would then allow the City to collect rent directly from the carriers.

City staff felt that owning the fiber portion of the facilities was not in the City's best interest as the ability to respond to service breaks and other maintenance issues would become problematic. However, owning and contracting out the maintenance of the towers and receiving the potential rent revenue might be something the City could consider.

Carrier Outreach

For this proposed project to be successful, City staff decided that the City should have at least two major carriers committed to the project. So, the exploration of partnerships included an outreach effort to all four major carriers (AT&T, Dish Network, T-Mobile, and Verizon) to determine their potential interest in participating in the proposed project.

Dish Network indicated strong interest and AT&T also expressed interest but indicated that they would need more time to fully evaluate their options and other projects. At the time this report was written, the outreach effort is ongoing regarding discussions with T-Mobile and Verizon.

Section 8: Recommendations

The following recommended next steps are based on the key outcomes from discussions with Council and staff, as well as the findings shared throughout this Study. It is important to note that recommendations 5, 6, 7, and 8 are only applicable if the City decides to own the network. While the recommendations are listed in sequential order this does not necessarily mean they need to be implemented in this order.

Recommendation #1

It is recommended that the City move forward with the three 100-foot tower design. It is worth noting that the three 100-foot towers in combination with the existing towers will provide the most equitable cellular coverage throughout the entire City.

Recommendation #2

It is important to note that City Code currently only allows 70-foot poles on public property or public rights-of-way, so it is recommended that the City modify its Code to permit 100-foot poles.

Recommendation #3

To secure carriers for the poles, a lease must be signed that allows for their telecommunication equipment to be placed in City parks. Carrier leases last at least 20 years or potentially longer. Section 3.9 of the City's Home Rule Charter currently limits leases on public property to no more than 5 years, including extensions. To comply with the City Charter, it is recommended that the City seek approval from voters to allow a lease for cell towers in City owned parks for a time frame consistent with the industry standard.

Recommendation #4

It is recommended that the City initiate contract negotiations with one or more of the RFEI responders to construct, operate, manage, and maintain, as well as to potentially own, the proposed tower network.

Recommendation #5

If the City decides to own the towers, then it is recommended that the City initiate lease negotiations with the carriers to place their equipment on the towers.

Recommendation #6

If the City decides to own the towers, then it is recommended that the City initiate the process to secure funding to construct the towers.

Recommendation #7

If the City decides to own the towers, then it is recommended that the City initiate the process of developing the Low-Level Design of the planned tower network which is necessary to create associated construction and permitting plan sets.

Recommendation #8

If the City decides to own the towers, then once one or more partner contracts are finalized, carrier leases are negotiated, funding is secured, and the Low-Level Design is completed, then it is recommended that the City begin the deployment of the cellular tower infrastructure.

Appendix A: Cellular Regulatory Review

Background

A review of the cellular and broadband communications regulatory environment is important because the City will need to consider these regulations as part of its decision-making process. This review included research of the various federal and state regulations. A review of Federal Communications Commission (FCC) requirements was also performed.

The following provides a non-legal review of cellular and broadband communications regulations and laws, and how they define wireless facilities, how applications for local land use permits are to be processed, where small cell facilities may be placed on existing structures owned by a utility or local government in public rights-of-way, and development guidelines on private land. Agencies and individuals seeking specific legal advice should consult an attorney.

Additionally, at the City's request, a review of telecommunication franchise requirements was conducted. This review included Federal, state, and local telecommunication franchise requirements.

Federal Regulations

Section 704 (47 USC §332(c)(7)

The 1996 Telecommunications Act includes Section 704 (47 USC §332(c)(7)), commonly referenced as 47 USC §332(c)(7) or Section 704, that grants local governments the ability to regulate wireless infrastructure. Section 704 says in relevant part:

- Land use development standards may not unreasonably discriminate among the wireless providers, and may not prohibit or have the effect of prohibiting the deployment of wireless infrastructure
- Local governments must act on applications for new wireless infrastructure within a "reasonable" amount of time (reasonable is not defined).
- Land use policies may be adopted to promote the location and siting of telecommunications facilities in certain designated areas.
- Encourages the use of third-party professional review of site applications.
- Section 332(c)(7)(B)(iv) states that "…*no State or local government or instrumentality thereof may regulate the placement, construction, and modification of personal wireless service facilities on the basis of the environmental effects of radio frequency emissions to the extent that such facilities comply with FCC regulations concerning the environmental effects* [federal courts have ruled that this includes health effects] *of such emissions*."

  In general, this paragraph prohibits local governments from denying an application for a new wireless facility or the expansion of an existing facility on the grounds that radio frequency emissions are harmful to human health provided the wireless service provider met federal standards.

"Shot Clock" Declaratory Ruling

Following the enactment of Section 704 in 1996, wireless infrastructure deployment began across the United States, subject to various local and state regulations enacted in the wake of Section 704. The infrastructure industry eventually appealed to the FCC for assistance in expediting local government review of infrastructure applications, and as a result, the FCC issued what is known as the "Shot Clock" ruling in 2009 which requires infrastructure collocation decisions to be made within 90 days and new tower decisions to be made within 150 days, or the applicant could take the local government to court and request a judicial grant of their application. The US Supreme Court later affirmed that the FCC could impose these timelines on local governments.

(47 USC §1455) Section 6409(a) in the Middle Class Tax Relief and Job Creation Act

While the infrastructure industry benefited from the Shot Clock ruling, they still sought additional federal relief from local regulations. In 2012, Congress enacted legislation known as Section 6409(a) (commonly referred to as the **Spectrum Act**) to promote wireless broadband for public safety and commercial purposes.

Section 6409(a) says, in relevant part:

> *"…a State or local government may not deny, and shall approve, any eligible facilities request for a modification of an existing wireless tower or base station that does not substantially change the physical dimensions of such tower or base station."*

Because of a lack of explanation or definitions in Section 6409(a), the FCC was called upon to provide clarification, definitions and guidance to what Congress intended. In a Report and Order released October 21, 2014, in W.T. Docket 13-238, commonly called the "2014 Report and Order" the FCC provided clarifying definitions to the terms used in Section 6409(a).

2014 Report and Order

The introduction of the 2014 Report and Order states:

> *"Demand for wireless capacity is booming: more consumers are accessing mobile broadband every year, driving more innovation and expanding access to public safety. But our ability to meet this demand depends on the infrastructure that supports the services. We therefore take concrete steps to facilitate the deployment of the infrastructure necessary to support surging demand, expand broadband access, support innovation and wireless opportunity, and enhance public safety - all to the benefit of consumers and the communities in which they live."* (Paragraph 2)

> *"…Accordingly, our actions are intended to encourage deployments on existing towers and structures - rather than entirely new towers in recognition that collocations almost always result in less impact or no impact at all."* (Paragraph 3)

The effect on local government planning:

> *"…notwithstanding section 704 of the Telecommunications Act of 1996 or any other provision of law, a State or local government* ***may not deny, and shall approve****, any eligible facilities request for a modification of an existing wireless tower or base station that does not substantially change the physical dimensions of such tower or base station. An eligible facilities request is one that requests modification of an existing wireless tower or base station that involves (a) collocation of new transmission equipment; (b) removal of transmission equipment; or (c) replacement of transmission equipment."*

The 2014 Report and Order reaffirms that broadcasting infrastructure is also considered a wireless tower or base station for purposes of Section 6409(a) and that transmission equipment includes antennas, cables, and auxiliary power equipment, such as generators. It also defined "existing" as:

> *"…the term "existing" requires that wireless towers or base stations have been reviewed and approved under the applicable local zoning or siting process or that the deployment of existing transmission equipment on the structure received another form of affirmative State or local regulatory approval (e.g., authorization from a State public utility commission). Thus, if a tower or base station was constructed or deployed without proper review, was not required to undergo siting review, or does not support transmission equipment that received another form of affirmative State or local regulatory approval, the governing authority is not obligated to grant a collocation application under Section6409(a)."*

A wireless tower that does not have a permit because it was not in a zoned area when it was built, but was lawfully constructed is considered an "existing" tower. In other words, a collocation application that "shall be approved" under Section 6409(a) has to be for a location that has been previously reviewed and approved through the local regulatory approval process and is not a "substantial change" to the original approval.

Under the new FCC definition, a "**substantial change**" to an eligible tower or base station is as follows:

(1) (a) for towers outside of public rights-of-way, it increases the height of the tower by more than 10%, or by the height of one additional antenna array with separation from the nearest existing antenna not to exceed twenty feet, whichever is greater; (b) for those towers in the rights-of-way and for all base stations, it increases the height of the tower or base station by more than 10% or 10 feet, whichever is greater; or

(2) (a) for towers outside of public rights-of-way, it protrudes from the edge of the tower more than twenty feet, or more than the width of the tower structure at the level of the appurtenance, whichever is greater; (b) for those towers in the rights-of-way and for all base stations, it protrudes from the edge of the structure more than six feet; or

(3) it involves installation of more than the standard number of new equipment cabinets for the technology involved, but not to exceed four cabinets; or

(4) it entails any excavation or deployment outside the current site of the tower or base station;

(5) it would defeat the existing concealment elements of the tower or base station; or

(6) it does not comply with conditions associated with the prior approval of construction or modification of the tower or base station unless the non-compliance is due to an increase in height, increase in width, addition of cabinets, or new excavation that does not exceed the corresponding "substantial change" thresholds identified above. We further provide that the changes in height resulting from a modification should be measured from the original support structure in cases where the deployments are or will be separated horizontally, such as on buildings' rooftops; in other circumstances, changes in height should be measured from the dimensions of the tower or base station inclusive of originally approved appurtenances and any modifications that were approved prior to the passage of Section 6409(a).

The 2014 Report and Order affirms that these standards apply equally to legally nonconforming structures in the jurisdiction. They too will be eligible for Section 6409(a) modifications.

Wireless facility modifications under Section 6409(a) should remain subject to building codes and other non-discretionary structural and safety codes. In particular, the FCC clarified that Section 6409(a) does not *"preclude States and localities from continuing to require compliance with generally applicable health and safety requirements on the placement and operation of backup power sources, including noise control ordinances if any."*

As for timelines, the local government has sixty (60) days to review a new collocation application for an eligible facility under Section 6409(a). The timeline starts when the application is submitted. The local government can then *"stop"* or *"toll"* the clock within the initial thirty (30) days if the application is incomplete. The local government's request for additional information "must specify the code provision, ordinance, application instruction, or otherwise publicly stated procedures that require the information to be submitted."

The time clock restarts when the applicant resubmits with the missing information. If the application is still incomplete the local government can then *"stop"* or *"toll"* the process again by again identifying, in writing, missing information. The clock will restart again upon the second resubmission. After that the local government cannot stop the clock because of incompleteness.

If the local government does not complete the application review within sixty (60) days (subject to the tolling provisions above), the 2014 Report and Order adopts a *"deemed granted"* remedy.

If, after reviewing a proposed Section 6409(a) application, the local government determines that the application request is not eligible for Section 6409(a) processing because it constitutes a *"substantial change"*, then the ninety (90) day timeline from the 2009 Shot Clock ruling applies, starting from the day the local government decides the application is not Section 6409(a) eligible. The 2014 Report and Order does suggest that the *"deemed granted"* isn't necessarily the last word on the subject. Acknowledging that judicial determination may be necessary, the 2014 Report and Order states:

> *"…. a State or local authority may challenge an applicant's written assertion of a deemed grant in any court of competent jurisdiction when it believes the underlying application did not meet the criteria in [Section 6409(a)] for mandatory approval, would not comply with applicable building codes or other non-discretionary structural and safety codes, or for other reasons is not appropriately "deemed granted".*

The 2014 Report and Order emphasizes that Section 6409(a) applications must be tailored to request permissible information and then must be acted upon quickly in order to avoid a *"deemed granted"* remedy.

The 2014 Report and Order points out that Section 6409(a) applies only to the local government in its regulatory capacity and NOT as a landlord. Should the local government choose, in the capacity as landlord, to limit the number and type of infrastructure applicants on the local government property, Section 6409(a) will not apply. Furthermore, specific to the use of publicly owned property for the use of wireless communications equipment, the FCC states in the 2014 Report and Order:

> *"We find insufficient evidence in the record to make a determination that municipal property preferences are per se unreasonably discriminatory or otherwise unlawful under Section 332(c)(7). To the contrary, most industry and municipal commenters support the conclusion that many such preferences are valid."*

Thus, local governments can continue the practice of promoting a preference for sitting wireless infrastructure on public property in local regulations.

2018 Report and Order

The FCC's Declaratory Ruling and Third Report and Order adopted September 26, 2018 became effective nationwide on January 14, 2019.

> *"In this document, the FCC issues guidance and adopts rules to streamline the wireless infrastructure siting review process to facilitate the deployment of next-generation wireless facilities. Specifically, the FCC identifies specific fee levels for the deployment of Small Wireless Facilities, and it addresses state and local consideration of aesthetic concerns that affect the deployment of small wireless facilities. The FCC also addresses the "shot clocks" governing the review of wireless infrastructure deployments and established two new shot clocks for small wireless facilities."*

The following are the timelines for action by local government established by the FCC's Third Report and Order:

- 60 days to collocate a small wireless facility on an existing structure
- 90 days to collocate a facility other than a small wireless facility on an existing structure
- 90 days to deploy a small wireless facility using a new structure
- 150 days to deploy a facility other than a small wireless facility using a new structure

After the submission of a small wireless facility application, the local government has ten (10) days from the date of filing to determine if the application is complete or incomplete and notify the applicant. If the application is incomplete, then the shot clock stops and then restarts again from zero when the supplemental information is provided to the local government. As stated in paragraph 143 of the Third Report and Order,

> *"…once the applicant submits the supplemental information in response to a siting authority's timely request, the shot clock resets, effectively giving the siting authority an additional 60 days to act on the small wireless facilities collocation application."*

After the initial notice and response period, the standard tolling process then starts, meaning if the application remains incomplete, the local government must notify the applicant in detail as to the remaining insufficient items and the shot clock stops on that date and restarts from when the applicant resubmits until the application is finalized.

The shot clock and tolling system for facilities other than small wireless sites starts when an application is submitted to the local government. The local government has thirty (30) days to review the application to determine if the materials are complete or incomplete. If the application is not complete, the locality must provide in writing to the applicant a detailed summary of deficiencies. At that point, the shot clock stops and then restarts from the point where it stopped when the applicant submits revised materials, and so forth until the application process is finalized.

The FCC also addressed zoning related practices that could be interpreted as an effective prohibition of small wireless deployments and cautioned local governments to avoid land use regulatory practices that could appear to create a barrier to entry or efficient deployment of this type of infrastructure. Two specific areas, fees and aesthetics, were discussed in the document.

The FCC Order includes a section regarding underground requirements. The Order states that some jurisdictions have requirements that all infrastructure, including small cell equipment, must be deployed underground. The FCC Order goes on to say that a blanket requirement that all wireless facilities be deployed underground "*would amount to an effective prohibition given the propagation characteristics of wireless signals."* The FCC Order, therefore, concludes that aesthetics criteria also apply to undergrounding requirements.

While the FCC Order does not specify a specific spacing requirement, it does state that minimum spacing requirements, such as preventing a provider from replacing preexisting facilities or collocating equipment on an existing structure, would likely be unreasonable. The Order states that local governments have traditionally imposed minimum spacing between small cell wireless facilities that effectively limits the use of available utility poles.

The FCC determined that aesthetics requirements are not preempted if they are (1) reasonable, (2) no more burdensome than those applied to other types of infrastructure deployments, and (3) objective and published in advance (paragraph 86). A local government's aesthetics requirements must be objective, clearly defined, and ascertainable (paragraph 88) and cannot be so costly that the design standards could be a deterrent (effective prohibition) to the cost of the small wireless facility deployment.

While the FCC did not mandate a certain fee for small wireless facility application permits or third-party reviews, the FCC did provide parameters for what it deemed to be "reasonable" safe harbor fees for the following matters:

- $500 (non-recurring) for a single application that includes up to five (5) small wireless facilities and an additional $100 for each additional small wireless facility beyond the initial five (5) sites.
- $1,000 (non-recurring) for a new pole (not a collocation) for a small wireless facility.
- $270 (recurring) per small wireless facility per year for each collocation, new pole, and subsequent collocations on said facilities.

Any possible ROW (right-of-way) access fee or fee for attachment to municipally owned structures in the ROW; provided they are (1) a reasonable approximation of costs, (2) those costs themselves are reasonable, and (3) are non-discriminatory (paragraphs 79-80).

The FCC did allow that while the above fee parameters were their interpretation of "reasonable" under applicable federal laws, there was room for some variance from same, stating:

> *"…there should be only very limited circumstances in which localities can charge higher fees consistent with the requirements of Section 253. In those limited circumstances, a locality could prevail in charging fees that are above this level by showing that such fees nonetheless comply with the limits imposed by Section 253—that is, that they are (1) a reasonable approximation of costs, (2) those costs themselves are reasonable, and (3) are nondiscriminatory. Allowing localities to charge fees above these levels upon this showing recognizes local variances in costs."*

Federal Legal Challenges

Shortly after the FCC's Declaratory Ruling and Third Report and Order (known as the Small Cell Order) was released in September 2018 it was challenged by a coalition of local government entities and wireless carriers, including AT&T, Verizon, and Sprint (now T-Mobile). These organizations filed appeal petitions requesting federal courts to review the FCC Order.

Local government entities filed suit against the FCC claiming that the Order is a federal overreach. For instance, the CEO and Executive Director of the U.S. Conference of Mayors stated that the Order "misapplies federal law to federalize local public property" and "needlessly introduce[s] increased risk of right-of-way and other public safety hazards." On the other hand, several wireless carriers filed suit against the FCC claiming that the FCC did not go far enough, arguing that the Order should have included a *"deemed granted"* provision automatically approving applications after the shot clocks expire.

The United States Judicial Panel on Multidistrict Litigation designated the U.S. Court of Appeals for the Tenth Circuit as the court in which to consolidate the various petitions for review.

The Tenth Circuit on January 10, 2019, turned down a motion to stay the FCC's revised rules related to the rollout of small cell / 5G technologies. The Court concluded that the cities' motion to stay the ruling did not adequately demonstrate that they would suffer irreparable harm without putting the ruling on hold. Also, on January 10, 2019, the Tenth Circuit granted a motion to transfer the various petitions for review to the United States Court of Appeals for the Ninth Circuit.

On August 12, 2020, a panel of three judges from the 9th Circuit granted in part, and denied in part, petitions for review of three orders of the FCC concerning the newest generation of wireless broadband technology known as "5G" that requires the installation of thousands of "small cell" wireless facilities.

The orders, issued in 2018, are known as the Small Cell Order, the Moratoria Order, and the One Touch Make-Ready Order. The first two orders spelled out the limits on local governments' authority to regulate telecommunications providers. The third order was intended to prevent owners and operators of utility poles from discriminatorily denying or delaying 5G and broadband service providers access to the poles.

The panel held that, given the deference owed to the agency (FCC) in interpreting and enforcing the Act, the Small Cell and Moratoria Orders were, with the exception of one provision, in accord with the congressional directive in the Act, and not otherwise arbitrary, capricious, or contrary to law. The exception was the Small Cell Order provision dealing with the authority of local governments in the area of aesthetic regulations. The panel held that to the extent that provision required small cell facilities to be treated in the same manner as other types of communications services, the regulation was contrary to the congressional directive that allowed different regulatory treatment among types of providers, so long as such treatment did not "unreasonably discriminate among providers of functionally equivalent services." [47 U.S.C. § 332(c)(7)(B)(i)(I)] The panel also held that the FCC's requirement that all aesthetic criteria must be "objective" lacked a reasoned explanation.

FCC Maximum Permissible Exposure Regulations

The FCC is required by the National Environmental Policy Act of 1969, among other things, to evaluate the effect of emissions from FCC-regulated transmitters on the quality of the human environment. Several organizations, such as the American National Standards Institute (ANSI), the Institute of Electrical and Electronics Engineers, Inc. (IEEE), and the National Council on Radiation Protection and Measurements (NCRP) have issued recommendations for human exposure to RF electromagnetic fields. The potential hazards associated with RF electromagnetic fields are discussed in OET Bulletin No. 56, *"Questions and Answers About the Biological Effects and Potential Hazards of Radio frequency Electromagnetic Fields."*

On August 1, 1996, with the adoption and release of Report and Order, FCC 96-623, the FCC adopted the NCRP's recommended Maximum Permissible Exposure limits for field strength and power density for the transmitters operating at frequencies of 300 kHz to 100 GHz. In addition, the FCC adopted the specific absorption rate (SAR) limits for devices operating within close proximity to the body as specified within the ANSI/IEEE C95.1-1992 guidelines. The FCC's requirements are detailed in Parts 1 and 2 of the FCC's Rules and Regulations [47 C.F.R. 1.1307(b), 1.1310, 2.1091, 2.1093].

According to *47 CFR 1.1310*, the criteria listed in Table 1, shown below, shall be used to evaluate the environmental impact of human exposure to radiofrequency (RF) radiation.

Table 1. Limits for Maximum Permissible Exposure (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposure				
0.3–3.0	614	1.63	*100	6
3.0–30	1842/f	4.89/f	*900/f^2	6
30–300	61.4	0.163	1.0	6
300–1,500	.....	.....	f/300	6
1,500–100,000	.....	.....	5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3–1.34	614	1.63	*100	30
1.34–30	824/f	2.19/f	*180/f^2	30
30–300	27.5	0.073	0.2	30
300–1,500	.....	.....	f/1500	30
1,500–100,000	.....	.....	1.0	30

f = frequency in MHz * = Plane-wave equivalent power density

Occupational/controlled exposure limits apply in situations in which persons are exposed because of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when a person is transient through a location where occupational/ controlled limits apply provided he or she is made aware of the potential for exposure. The phrase fully aware in the context of applying these exposure limits means that an exposed person has received written and/or verbal information fully explaining the potential for RF exposure resulting from his or her employment. Except for transient persons, this phrase also means that an exposed person has received appropriate training regarding work practices relating to controlling or mitigating his or her exposure. Such training is not required for transient persons, but they must receive written and/or verbal information and notification (for example, using signs) concerning their exposure potential and appropriate means available to mitigate their exposure. The phrase exercise control means that an exposed person is allowed to and knows how to reduce or avoid exposure by administrative or engineering controls and work practices, such as use of personal protective equipment or time averaging of exposure.

General population/uncontrolled exposure limits apply in situations in which the general public may be exposed, or in which persons who are exposed as a consequence of their employment may not be fully aware of the potential for exposure or cannot exercise control over their exposure.

The FCC states that certain applicants are required to routinely perform an environmental evaluation with respect to determining compliance with the FCC's exposure limits. In the event that an applicant determines the site is not within compliance, the submission of an Environmental Analysis is required. The SAR limits for portable and mobile devices became effective August 7, 1996. The FCC's limits for field strength and power density became effective October 15, 1997 for all services except the Amateur Radio Service. The new limits became effective for the Amateur Radio Service on January 1, 1998. As of September 1, 2000, all FCC licensees were required to be in compliance with the FCC's RF exposure limits (See 47 C.F.R. 1.1307(b)(5)).

State Small Cell Regulations

Introduction

Colorado's Small Cell Facilities law, also known as House Bill 17-1193 (CRS § 29-27-401) went into effect July 1, 2017. The law impacts two types of permits issued by local governments for small cell facilities – rights-of-way permits and land use/zoning permits.

The law stipulates that local governments must allow access to public rights-of-way for small cell facilities, network operators, and other broadband providers. The law also establishes permit approval deadlines or shot clocks for governments regarding the processing of permit applications for small cell facilities, networks, and for collocations.

Definition

Colorado's Small Cell Facilities law states that the size of a small cell facility is defined as having a primary equipment enclosure no larger than seventeen (17) cubic feet in volume. The law goes on say that each antenna must be located inside an enclosure of no more than three cubic feet in volume or, in the case of an antenna that has exposed elements, the antenna and all of its exposed elements could fit within an imaginary enclosure of no more than three cubic feet. It also states that the following associated equipment may be located outside of the primary equipment enclosure and, if so located, is not included in the calculation of equipment volume: electric meter, concealment, telecommunications demarcation box, ground-based enclosures, back-up power systems, grounding equipment, power transfer switch, and cut-off switch.

This law applies to any *"political subdivision"* or *"local government entity" which means a county; city and county; city; town; service authority; school district; local improvement district; law enforcement authority; water, sanitation, fire protection, metropolitan, irrigation, drainage, or other special district; or any other kind of municipal, quasi-municipal, or public corporation organized pursuant to law.*

The law defines a *"public highway"* or *"highway" as all roads, streets, and alleys and all other dedicated rights-of-way and utility easements of the state or any of its political subdivisions, whether located within the boundaries of a political subdivision or otherwise.*

Locations

According to the law, qualifying small cell facilities and networks are considered permitted uses in all zoning districts. It goes on to state that any domestic or foreign telecommunications provider or broadband provider authorized to do business under the laws of Colorado has the right to construct, maintain, and operate conduit, cable, switches, and related appurtenances and facilities, and communications and broadband facilities, including small cell facilities and small cell networks, along, across, upon, above, and under any public highway in this state.

Shot Clocks

The law states that a local government has **ninety (90) days** to process a complete application that involves a collocation of a tower, building, structure, or replacement structure. It also states that a local government has **one hundred fifty (150) days** to process a complete application that involves a new structure or a new wireless service facility. An applicant and a local government may mutually agree that an application may be processed in a longer period according to the law.

It is important to note that the shot clock regulations from Colorado's Small Cell Facilities law, as shown above, do not align with the FCC's Small Cell Order shot clock regulations, as previously described. To address this potential conflict, it is recommended that the City align its small cell shot clock policy to the shot clock regulations in the FCC's Small Cell Order. Agencies and individuals seeking specific legal advice regarding this recommendation should consult an attorney.

The law stipulates that for small cell networks involving multiple individual small cell facilities within the jurisdiction of a single local government entity, the local government entity shall allow the applicant, at the applicant's discretion, to file a consolidated application and receive a single permit for the small cell network instead of filing separate applications for each individual small cell facility. And that a denial of any individual small cell facility in a consolidated application won't impact the other facilities proposed in the application.

Fees

Although the law does not mention specific fees, the law states (CRS § 38-5.5-108), *"neither a local government entity nor a municipally owned utility shall request or receive from a telecommunications provider, broadband provider, or a cable television provider, in exchange for permission to attach small cell facilities, broadband devices, or telecommunications devices to poles or structures in a right-of-way, any payment in excess of the amount that would be authorized by the local government entity or municipally owned utility."* This means that a local government entity may not require a provider to pay any compensation other than the compensation authorized by the State for the right to attach small cell facilities, broadband devices, or telecommunications devices to poles or other structures in the public right-of-way (47 U.S. Code § 224. Pole attachments).

It goes on to say that a municipality shall not request or receive from a telecommunications provider or a broadband provider, in exchange for or as a condition upon a grant of permission to attach telecommunications or broadband devices to poles, any in-kind payment.

Local Rights

Local jurisdictions may still deny or limit placement of communications or broadband facilities to protect public health, safety, and welfare so long as it does not advantage or disadvantage a telecommunications or broadband provider or have the effect of prohibiting a provider from providing service within the service area.

Franchise Regulations

Research into telecommunication franchise regulations shows that unlike some states, Colorado does not have any specific franchise regulations in its state statutes. Therefore, establishment of franchise regulations is left up to each municipal jurisdiction.

The Colorado Public Utilities Commission (CPUC) regulates telecommunications services and providers of telecommunications services in code *4 CCD 723-2*. This section of CPUC code references federal regulations regarding telecommunications services and service providers.

Colorado municipalities that have developed codes regarding telecommunications franchise agreements reference both CPUC and federal telecommunications regulations. The primary federal source for telecommunications franchise regulations is the *Cable Television Consumer Protection and Competition Act of 1992*.

Federal Franchise Requirements

Current federal franchise requirements are described in *47 USC 541: General franchise requirements*.

The following code is from *Title 47-Telecommunications*, *Chapter 5-Wire or Radio Communication*, *Subchapter V-A-Cable Communications*, *Part III-Franchising and Regulation*.

(a) Authority to award franchises; public rights-of-way and easements; equal access to service; time for provision of service; assurances

(1) A franchising authority may award, in accordance with the provisions of this subchapter, 1 or more franchises within its jurisdiction; except that a franchising authority may not grant an exclusive franchise and may not unreasonably refuse to award an additional competitive franchise. Any applicant whose application for a second franchise has been denied by a final decision of the franchising authority may appeal such final decision pursuant to the provisions of *section 555* of this title for failure to comply with this subsection.

(2) Any franchise shall be construed to authorize the construction of a cable system over public rights-of-way, and through easements, which is within the area to be served by the cable system and which have been dedicated for compatible uses, except that in using such easements the cable operator shall ensure-

(A) that the safety, functioning, and appearance of the property and the convenience and safety of other persons not be adversely affected by the installation or construction of facilities necessary for a cable system;

(B) that the cost of the installation, construction, operation, or removal of such facilities be borne by the cable operator or subscriber, or a combination of both; and

(C) that the owner of the property be justly compensated by the cable operator for any damages caused by the installation, construction, operation, or removal of such facilities by the cable operator.

(3) In awarding a franchise or franchises, a franchising authority shall assure that access to cable service is not denied to any group of potential residential cable subscribers because of the income of the residents of the local area in which such group resides.

(4) In awarding a franchise, the franchising authority-

(A) shall allow the applicant's cable system a reasonable period of time to become capable of providing cable service to all households in the franchise area;

(B) may require adequate assurance that the cable operator will provide adequate public, educational, and governmental access channel capacity, facilities, or financial support; and

(C) may require adequate assurance that the cable operator has the financial, technical, or legal qualifications to provide cable service.

(b) No cable service without franchise; exception under prior law

(1) Except to the extent provided in paragraph (2) and subsection (f), a cable operator may not provide cable service without a franchise.

(2) Paragraph (1) shall not require any person lawfully providing cable service without a franchise on July 1, 1984, to obtain a franchise unless the franchising authority so requires.

(3) (A) If a cable operator or affiliate thereof is engaged in the provision of telecommunications services-

(i) such cable operator or affiliate shall not be required to obtain a franchise under this subchapter for the provision of telecommunications services; and

(ii) the provisions of this subchapter shall not apply to such cable operator or affiliate for the provision of telecommunications services.

(B) A franchising authority may not impose any requirement under this subchapter that has the purpose or effect of prohibiting, limiting, restricting, or conditioning the provision of a telecommunications service by a cable operator or an affiliate thereof.

(C) A franchising authority may not order a cable operator or affiliate thereof-

(i) to discontinue the provision of a telecommunications service, or

(ii) to discontinue the operation of a cable system, to the extent such cable system is used for the provision of a telecommunications service, by reason of the failure of such cable operator or affiliate thereof to obtain a franchise or franchise renewal under this subchapter with respect to the provision of such telecommunications service.

(D) Except as otherwise permitted by *sections 531* and *532* of this title, a franchising authority may not require a cable operator to provide any telecommunications service or facilities, other than institutional networks, as a condition of the initial grant of a franchise, a franchise renewal, or a transfer of a franchise.

(c) Status of cable system as common carrier or utility

Any cable system shall not be subject to regulation as a common carrier or utility by reason of providing any cable service.

(d) Informational tariffs; regulation by States; "State" defined

(1) A State or the Commission may require the filing of informational tariffs for any intrastate communications service provided by a cable system, other than cable service, that would be subject to regulation by the Commission or any State if offered by a common carrier subject, in whole or in part, to subchapter II of this chapter. Such informational tariffs shall specify the rates, terms, and conditions for the provision of such service, including whether it is made available to all subscribers generally, and shall take effect on the date specified therein.

(2) Nothing in this subchapter shall be construed to affect the authority of any State to regulate any cable operator to the extent that such operator provides any communication service other than cable service, whether offered on a common carrier or private contract basis.

(3) For purposes of this subsection, the term "State" has the meaning given it in *section 153* of this title.

(e) State regulation of facilities serving subscribers in multiple dwelling units

Nothing in this subchapter shall be construed to affect the authority of any State to license or otherwise regulate any facility or combination of facilities which serves only subscribers in one or more multiple unit dwellings under common ownership, control, or management and which does not use any public right-of-way.

(f) Local or municipal authority as multichannel video programming distributor

No provision of this chapter shall be construed to-

(1) prohibit a local or municipal authority that is also, or is affiliated with, a franchising authority from operating as a multichannel video programming distributor in the franchise area, notwithstanding the granting of one or more franchises by such franchising authority; or

(2) require such local or municipal authority to secure a franchise to operate as a multichannel video programming distributor.

Chapter 5 - Franchises and Communication Systems

Chapter 5 of the City of Cherry Hills Village Municipal Code specifically addresses franchise agreements for *Cable Television*, *Gas and Electric*, and *Telephone Occupation Tax*. The following is from *Section 5-1-10: Approval of agreement*.

> *"The Cable Franchise Agreement by and between Comcast of Colorado IX, LLC and the City of Cherry Hills Village, Colorado, which is incorporated herein as if set forth in full, is approved by the City Council. The Cable Franchise Agreement shall be available for public inspection during normal business hours from the City Clerk at the offices of the City of Cherry Hills Village."*

This section of the City's Municipal Code seems to be narrowly focused on a franchise agreement with Comcast. While it is not included in this Study, the City may want to revise this section of their Municipal Code, so that it is more general and therefore can be applied to other potential franchisees. Examples of more general telecommunication franchise agreement codes can be found by reviewing the Municipal Code of other Colorado communities. *Chapter 30 - Cable Communication* of the City of Aurora's Municipal Code is one example of a more generalized telecommunication franchise agreement code.

Appendix B: Cellular Technology Overview

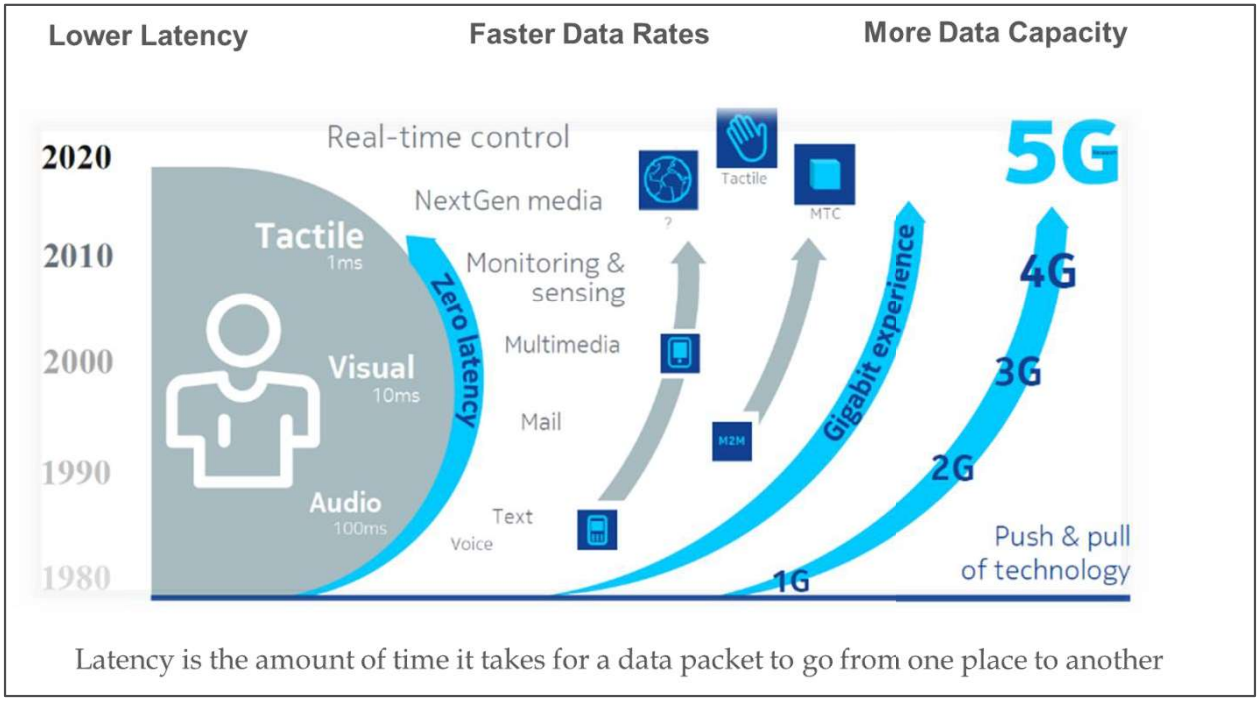
Demand for the Internet continues to skyrocket. Gartner, Inc., which is an international IT research and consulting firm, forecasts that 20.4 billion connected devices will be in use worldwide in the next few years, as most Americans have or will have more than a dozen devices connected to the internet. Gartner goes on to state that it is no wonder that mobility and ubiquitous connectivity are expectations that people have today and by many estimates, demand will continue to grow at an amazing 43% annual rate well into the future. So, it probably goes without saying that people and devices need reliable, anytime, anywhere connectivity. This expectation for faster, more dependable communication capabilities is accelerating the rollout of fiber optic-based 5G networks to keep pace not only with today's network demands but those of the future as well. It is important to point out that fiber optic-based networks are crucial to transport all voice and data including broadband and cellular traffic.

With the increasing use of devices in virtually all industry sectors, as well as an increasing dependence on smartphones and always connected computers, the constraints of 4G LTE technologies are being exposed. In contrast, 5G, which is the next generation of wireless network, offers new levels of speed (throughput, often measured in bits per second). Arguably, even more importantly, low latency (delay), low cost per bit, quality of experience and reliability will drive innovations across a broad spectrum of areas including virtual reality, augmented reality, smart energy grids, autonomous vehicles, telehealth, e-commerce, teleworking, education, and interconnected transport systems.

Since 1982 when the first mobile phone network was introduced, succeeding standards have been implemented approximately every nine years. The 4G LTE standard was implemented in 2010, so, right on schedule, technology companies are transitioning to 5G.

5G refers to the fifth generation of mobile phone networks. 5G enables significantly greater mobile speeds to enable real-time connectivity for mission-critical devices and applications. Soon, 5G networks will connect billions of devices that will require a wide variety of speed and large volumes of data.

The industry continues looking to the future as the uses and demands for mobile data keep expanding. 5G, which was rolled out in 2019 and will continue to grow for years to come, provides higher speeds, while offering improved capacity, scale, latency, and reliability.



Latency is the amount of time it takes for a data packet to go from one place to another

As was the case with earlier steps along the way to faster mobile data, 5G requires new hardware at the network and device level that's compatible with the 5G standards. There are numerous commercially available handheld mobile 5G devices in the US today, with new 5G devices continuously being developed and released.

Latency

Latency is the lag or delay between when data is sent and when it is received. Low latency becomes essential for critical control in certain situations such as autonomous vehicles and remotely controlled surgical procedures.

Spectrum

An analogy that could be used to best describe spectrum is to think about it as a highway. The amount of spectrum determines how many lanes a highway has. With more data (cars on the highway), the more lanes (spectrum) the better.

The bandwidth (number of lanes) that is available within a spectrum determines how much network performance is available to network users. In the low-band spectrum (fewer lanes), bandwidth is typically limited, so data rates tend to be low. In mid-band (more lanes) and high-band (large number of lanes) spectrum, the available bandwidth can be many times greater than what's available in low-band, which results in higher data rates.

In some 5G solutions, high-band spectrum offers higher capacity and speed. However, the high-band spectrum has an extremely short range of just a few hundred meters. Due to its short range, this spectrum requires massive network densification.

Although mid-band and high-band spectrum have reduced range, the higher frequencies involved mean that antennas can be smaller in size.

5G has initially been deployed in the mid band. This band has the best balance of distance and capacity for supporting 5G applications.

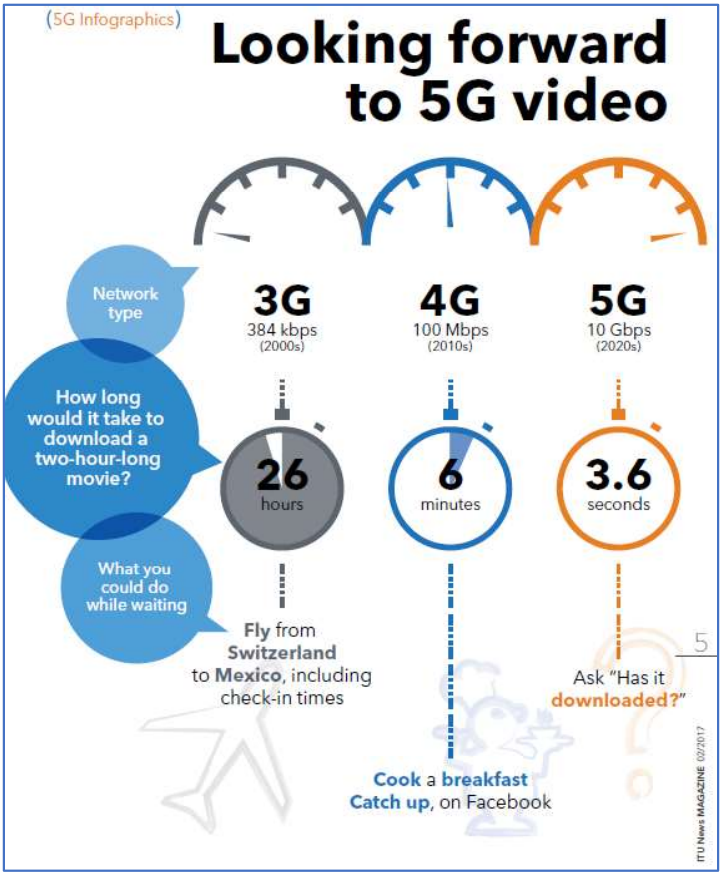
Capacity

One of the best ways to describe capacity is to examine one of the more popular uses of wireless networks, streaming a movie. When trying to stream a 4K movie over a 4G/LTE wireless network, people probably encounter an on-screen spinning disk or other message indicating that the movie is buffering. That is because 4G/LTE wireless networks often do not have enough capacity to handle demands such as streaming 4K movies due to lack of spectrum. In part, this lack of capacity stems from the relatively low frequencies used by existing networks.

On the other hand, 5G uses higher frequencies and a variety of technologies to allow, for example, users to watch 4K high-definition movies without being bothered by that annoying little spinning disk in the center of their screen.

Speed

Because 5G uses higher frequencies, it provides much higher data speeds. 5G incorporates several technologies that enable users to do things like download an entire HD movie in a couple of minutes.



Coverage

In addition to capacity and speed, coverage is another very important factor in determining how usable any wireless network may be. If a user cannot get a signal, the potential capacity and speed are meaningless.

5G wireless networks use a much broader range of frequencies than were utilized in earlier networks. While higher frequencies can deliver much higher bandwidth and data rates, higher frequency radio waves can only be effective over much shorter distances, so small cells only supply a few hundred feet of coverage.

Densification

Densification is adding more cell sites to an area. Network densification is being implemented due to the growing number of devices and increasing demand for data. When more cell sites exist in an area, users will most likely be closer to one of those sites, which means that coverage and capacity become less of a problem.

Deploying many low powered small cells is a solution for network densification. A network of small cells can be deployed anywhere needed as a complement to the existing network of macro cells to increase capacity and data rates.

Network densification needs to be complemented by both wireless and wired backhaul such as fiber optic cables.

Standards

Standards play an important role in ensuring that products and services from different companies are compatible. Telecommunications equipment manufacturers have agreed to make equipment that is compatible with established standards.

Uses

There are many uses for this level of capacity, speed, and low latency. These possibilities impact many of the central components of life: healthcare, education, the environment, safety, etc. Additionally, businesses are planning for the benefits for workplace safety, logistics, maintenance, supply chain communication, energy efficiency, telecommuting, job training, Internet of Things, etc.

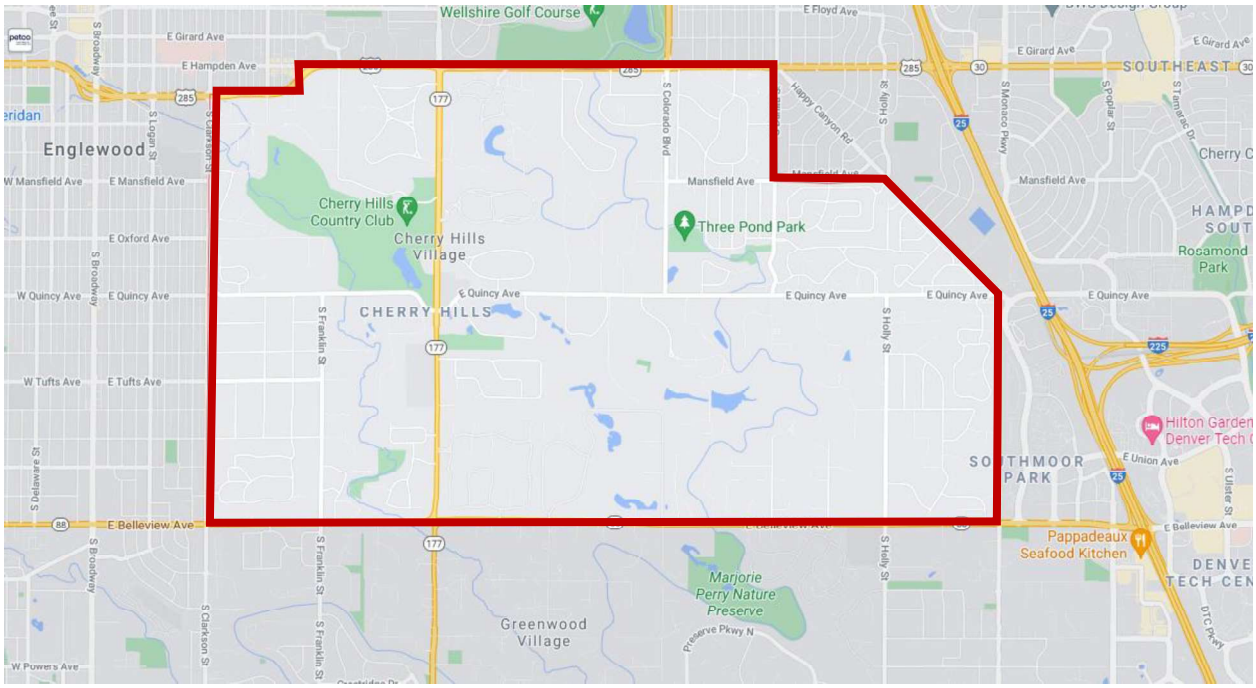
This level of connectivity will also provide local governments with tools for public safety, innovation, efficiency, convenience for citizens, and economic development. 5G technologies can also be used to improve the quality of service for situations in which many devices make use of the mobile network in densely populated areas. These benefits can be realized easily in situations with variable traffic and in areas where large numbers of employees work during the week. Densely populated city centers can also benefit from the ability of 5G networks to provide service to more devices in physically smaller spaces.

Appendix C: Request for Expressions of Interest

Request for Expressions of Interest
City of Cherry Hills Village Cellular Partnership
Release Date: *October 17, 2023*
Responses Due: *December 1, 2023*

Community Profile

The City of Cherry Hills Village shares its northern and eastern border with Denver, its western border with Englewood, and its southern border with Greenwood Village.



Cherry Hills Village is approximately six and one-half square miles comprised mostly of single-family detached homes, country clubs, schools, and places of assembly. The City's population is about 6,400. The City has an elected Mayor and a six-member City Council. The City Council appoints the City Manager.

The City provides services in the following areas: public safety, public works, community development, municipal court, general government, parks and recreation, and water and sewer. The total annual budget for the City is approximately $12.5 million.

Cherry Hills Village is requesting Expressions of Interest from potential private sector partners to improve cellular service throughout the entire City. This partnership envisions the City leveraging funding to construct a cellular tower network that can be utilized by multiple carriers and could include both 4G (LTE) and 5G technology. The City is looking to identify a partner or partners willing to assist in creating ubiquitous cellular coverage throughout Cherry Hills Village. It is envisioned, the partner(s) would be responsible for completing the cellular tower network and securing carriers to attach to the new system. The City is open to exploring different models, partnerships, and funding options.

Please refer to Appendix A to review three proposed optional cellular tower network designs and RF coverage maps, as well as a map of the proposed cellular tower fiber network.

This Request for Expressions of Interest (EOI) has been initiated to enable the City to identify one or more partners who would be interested in providing infrastructure and or expanded cellular services within the city limits. The City seeks input from interested potential partners regarding the terms and conditions under which partners would construct, own, operate and/or manage this cellular infrastructure and services. The City is also interested in hearing from carriers about the design and their interest in participating in the project.

Cherry Hills Village is particularly interested in working with one or more partners who will install, own, and operate the infrastructure allowing multiple carriers to operate on the system. The City would consider providing funding for the initial construction.

The ultimate goal of the City is to improve cellular coverage throughout the entire City, including on streets, trails, and open spaces. A network that covers the entire City and includes all major carriers will be needed to meet this goal.

Requested Information

The City is requesting Expressions of Interest from potential partners based upon the following Vision Statement and Goals that were established under the direction of City Council.

Vision Statement

Through partnerships and collaboration, the City endeavors to improve cellular coverage throughout its entire jurisdiction. Like water, sewer, and electricity, cellular service has become a necessity, by partnering with infrastructure providers and carriers the Council strives to improve the health, safety, and welfare of its residents, by providing comprehensive cellular coverage throughout the entire City.

Goals

1. Implement a telecommunications solution that provides reliable citywide cell phone coverage.
2. Locate towers on City owned property or ROW's, when possible.

3. Ensure that towers do not exceed the maximize height permitted in City Code. Towers may exceed 70 feet if an amendment is passed by City Council.
4. Engage with infrastructure providers and carriers to ensure the designed solution meets all their needs and requirements.
5. Explore all partnership opportunities.
6. Explore funding opportunities.

Response Requirements

1. Interested parties shall respond to the EOI in accordance with the schedule below and shall provide the following:
2. Affirm that you are interested in this partnership by providing a letter of interest from an owner, partner, CEO etc.
3. Provide a statement of experience discussing past performance, capabilities, and qualifications. Identify other cellular networks your firm has designed, built, maintained, or operated. Discuss other partnerships with other carriers, government, or non-profit entities you have undertaken. Describe the nature of the projects and your firm's role. Explain how your firm is a suitable partner for this project.
4. Please refer to Appendix A to review three proposed optional cellular tower network designs and RF coverage maps, as well as a map of the proposed cellular tower fiber network. Do you prefer any one of the three proposed optional cellular tower network designs? If so, please explain why you prefer it. If not, please share your thoughts about how you would design the network.
5. At a very high level, summarize the technological and operational approach you would use for this project. How would you use technology to meet the City's goals? How would you perform cellular network management? At what sort of facility (or facilities) would you place cellular network electronics? Would you require direct, dedicated fiber connectivity to all cellular facilities?
6. Summarize the business approach you would use for the project. How would your business plan help meet the City's goals? What are the key assumptions? What are your main areas of risk, and how can the City help reduce the risks?
7. Describe your previous experience/successes with projects funded from sources such as local, state, and federal government sources.
8. What is your proposed schedule for implementing service? Offer a timeline with key milestones. Would you be able to begin service before the entire City was constructed? Are there areas of the City you would recommend be constructed first?
9. What are your requirements for the City to meet in order for you to partner with the City on this project? What, if any, are the financial requirements you have of the City to enter a partnership? If you do not address this question as to financial requirements, it will be assumed that you are interested in the partnership but have no financial requirements whatsoever of the City.

10. What service options would you plan to offer over this network?
11. Provide three (3) references, including contact information, from previous contracts or partnerships.

Timeline and Process for this EOI

1. Interested Parties to this EOI should send an email expressing their interest in the project to HR Green, Project Manager for this EOI process. This email should be titled: "City of Cherry Hills Village Cellular EOI" and should be emailed to HR Green. Please include a company contact and the contacts name and email address in the body of the expression of interest.
2. *November 15, 2023*: *5:00 pm* Mountain - Questions on the EOI are due to HR Green.
3. *November 22, 2023*: Answers to questions sent to all interested respondents.
4. *December 1, 2023*: EOI responses due by *5:00 pm* Mountain. Responses should be emailed to HR Green. Late submissions may not be opened, and an email will be sent to those who missed the deadline.
5. *TBD*: Complete meetings with interested vendors.
6. *TBD*: Preliminary non-binding award of contracts and negotiation with selected interested vendor(s).

Questions

Questions may be addressed to HR Green and can be submitted via email until *November 15, 2023,* at *5:00 pm* Mountain Time. Questions and responses will be emailed to all interested respondents.

Rights and Disclaimer

HR Green, as the authorized representative of the City of Cherry Hills Village, reserves the right to reject any and all proposals in part or in full from interested parties, to extend the deadline to submit EOI responses, to waive any informalities and/or irregularities in the proposals, to re-advertise, to negotiate with one or more parties for the identified services, to put identified or other services out to bid, or to otherwise proceed to provide any identified or other service in the best interest of the City of Cherry Hills Village in its sole discretion.

Any proposal received because of this EOI is prepared at the Proposer's expense and becomes the property of the City of Cherry Hills Village. Proposals and all ideas contained therein shall not be deemed proprietary with respect to the City of Cherry Hills Village (unless specifically otherwise stated) and may be used by the City of Cherry Hills Village in any manner deemed in its best interest.

The City of Cherry Hills Village may, at its sole discretion, modify or amend any and all provisions herein. The City of Cherry Hills Village will not pay for any information herein requested or provided in response hereto, nor is it liable for any costs incurred by any responses hereto. The City of Cherry Hills Village reserves the right to extend the Request for Expressions of Interest dates. All changes or clarifications will be emailed to the interested Respondents.

Cherry Hills Village uses the Rocky Mountain E-Purchasing System (RMEPS) to distribute official copies of the EOI Documents for use in preparing responses. Respondents will be required to register with the website to download the Bid proposal documents and Addenda. If you experience problems with the RMEPS website, please call them for assistance. There is no charge by RMEPS for this service. Respondents are required to acknowledge all Addenda with their Proposal and are encouraged to view the Addenda posted on RMEPS prior to submitting.

BASIS FOR EVALUATION OF PROPOSALS

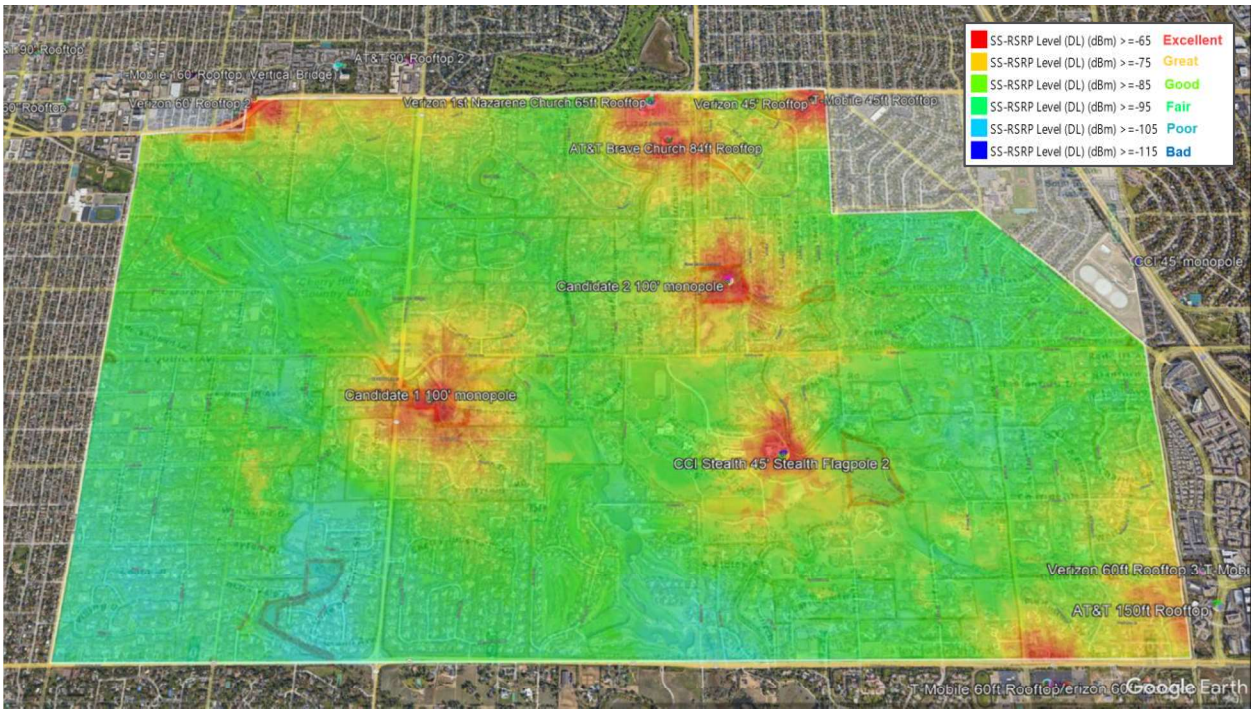
The City wants to identify and partner with one or more firms who would be interested in providing infrastructure and or expanded cellular services within the city limits. The following criteria will be considered in the evaluation of responses:

1. The terms and conditions under which Respondent's would construct, own, operate and/or manage this cellular infrastructure and services;
2. The quality of the Respondent's performance of previous like projects with the City and/or with other local governmental entities within the State of Colorado;
3. The Respondent's skill, ability, and capacity to perform the services and to furnish the materials, equipment or supplies required;
4. The Bidder's character, integrity, reputation, judgment, experience and efficiency;
5. The Bidder's ability to provide future maintenance or service;
6. The City and HR Green reserves the right to reject all responses when it determines that such action is in the public interest.

APPENDIX A

Option 1 Tower Network Design and RF Coverage Map (Subject to Change)

The following tower network design and RF Coverage map shows two 100-foot monopoles for two candidate tower locations on public property or public rights-of-way. This map also includes several existing tower locations. It is important to note that City Code currently only allows 70-foot poles on public property or public rights-of-way, so the City may consider modifying its Code to permit 100-foot poles.

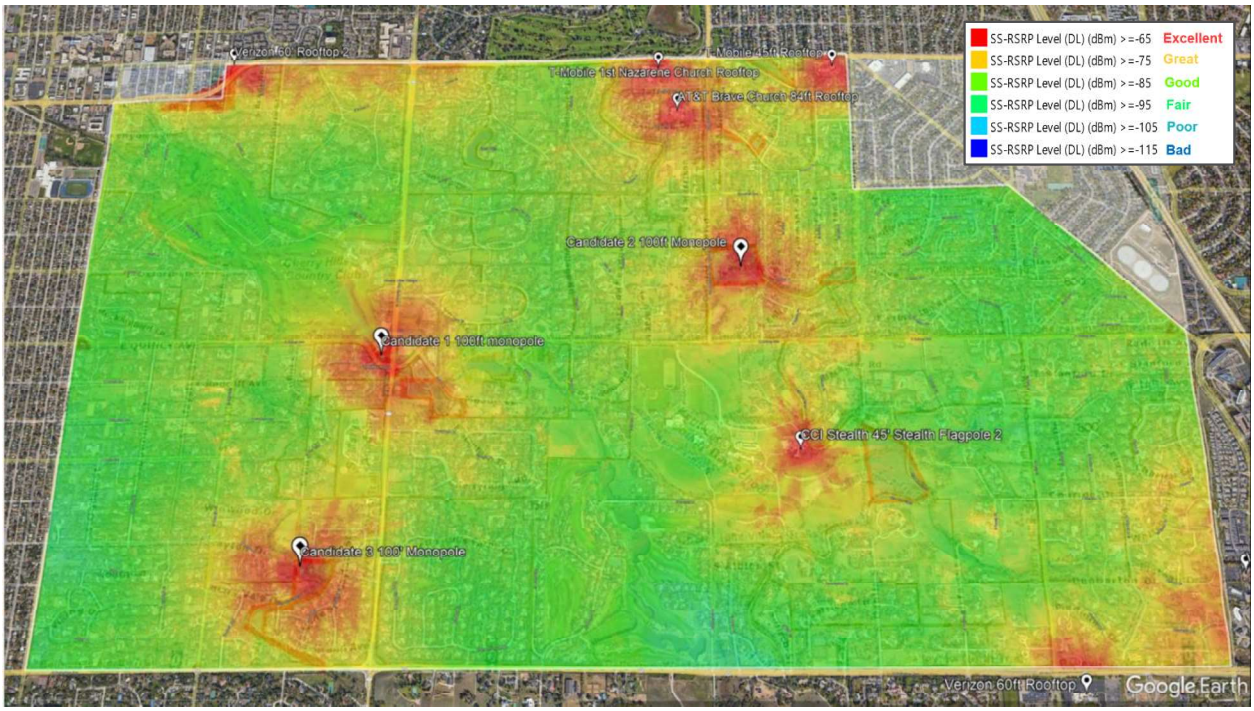


Option 1 Site Locations

Site	Longitude	Latitude	Altitude (ft)	# of Poles	Support Height (ft)
Candidate 1 100' monopole	-104.957477	39.636394	[5,387.14]	1	100
Candidate 2 100' monopole	-104.938974	39.642295	[5,472.44]	1	100

Option 2 Tower Network Design and RF Coverage Map (Subject to Change)

The following tower network design and RF Coverage map shows three 100-foot monopoles for three candidate tower locations on public property or public rights-of-way. This map also includes several existing tower locations. It is important to note that City Code currently only allows 70-foot poles on public property or public rights-of-way, so the City may consider modifying its Code to permit 100-foot poles.

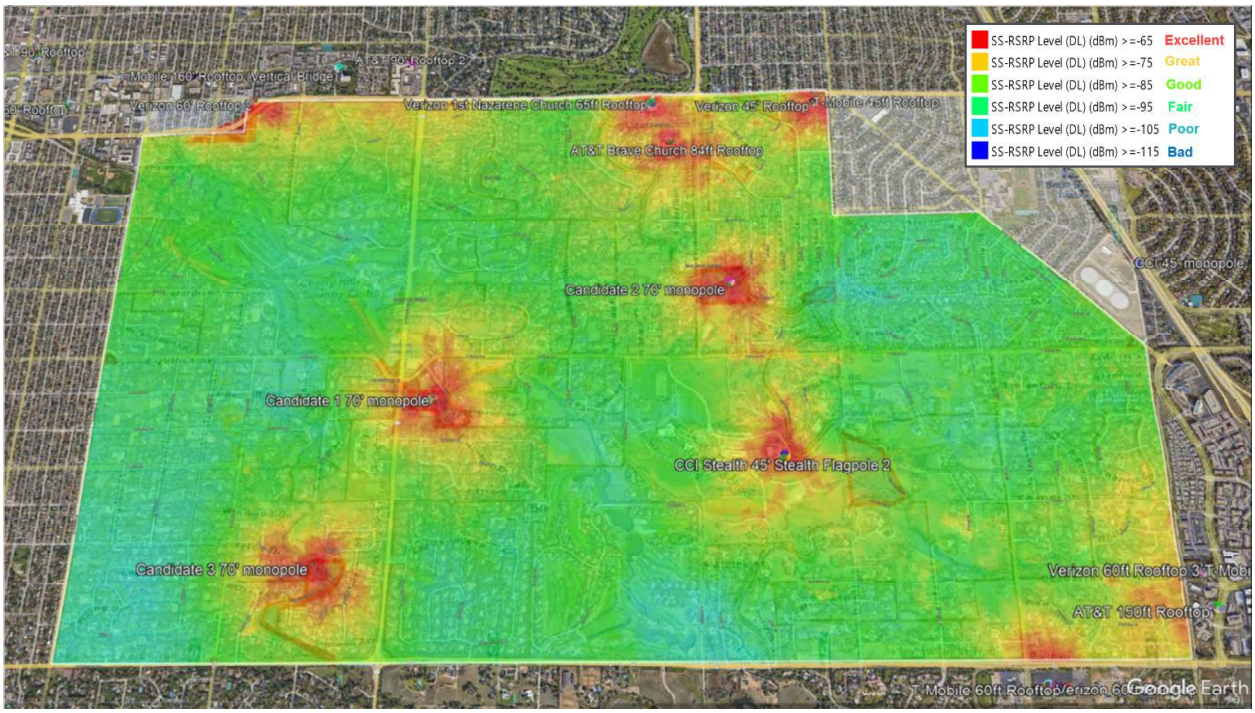


Option 2 Site Locations

Site	Longitude	Latitude	Altitude (ft)	# of Poles	Support Height (ft)
Candidate 1 100' monopole	-104.957477	39.636394	[5,387.14]	1	100
Candidate 2 100' monopole	-104.938974	39.642295	[5,472.44]	1	100
Candidate 3 100' monopole	-104.96412	39.628524	[5,393.7]	1	100

Option 3 Tower Network Design and RF Coverage Map (Subject to Change)

The following tower network design and RF Coverage map shows six 70-foot monopoles for three candidate tower locations on public property or public rights-of-way. To ensure that there is enough space for up to four carriers at each of the three candidate tower locations, there will be two 70-foot towers at each of the locations and the two 70-foot towers at each location will need to be separated by at least 80-feet. This map also includes several existing tower locations. It is important to note that City Code currently allows 70-foot poles on public property or public rights-of-way.

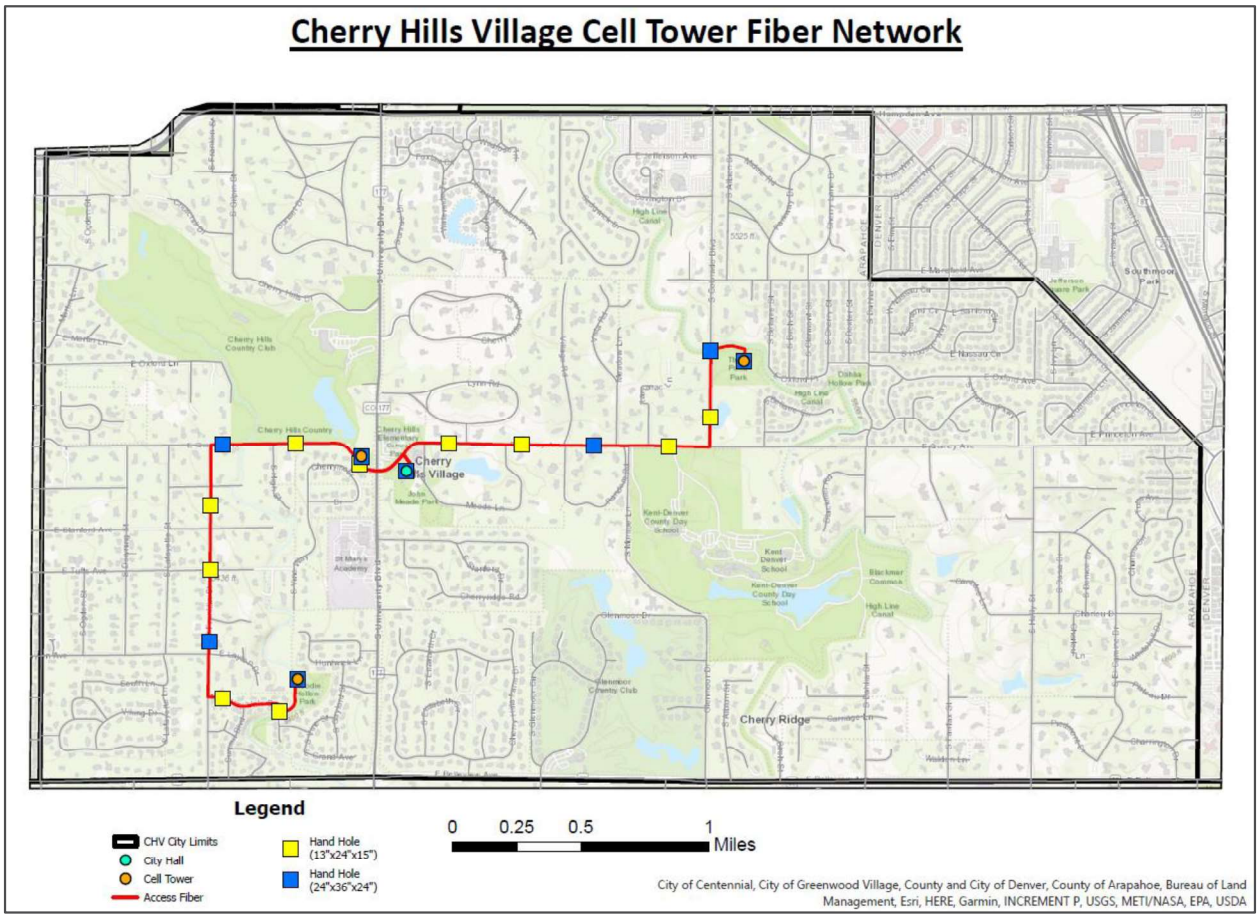


Option 3 Site Locations

Site	Longitude	Latitude	Altitude (ft)	# of Poles	Support Height (ft)
Candidate 1 70' monopole	-104.957477	39.636394	[5,387.14]	2	70
Candidate 2 70' monopole	-104.938974	39.642295	[5,472.44]	2	70
Candidate 3 70' monopole	-104.96412	39.628524	[5,393.7]	2	70

Proposed Cellular Tower Fiber Network Map (Subject to Change)

The following map shows the fiber infrastructure required to support three candidate cell tower locations on public property or public rights-of-way, and a central location (City Hall) to house cellular equipment. It is important to note that for the *Option 1 Tower Network Design*, the fiber to the Candidate 3 tower location, which is located in the Southwest corner of the City (Longitude: -104.96412 | Latitude: 39.628524), would not need to be installed.



Appendix D: Fiber Study

Section 1: Executive Summary

The Cherry Hills Village Study

The City of Cherry Hills Village is investigating the costs and benefits of various levels of involvement in the management and ownership of future cellular and fiber (broadband) communications within the City, and the infrastructure needs related to these services. Cherry Hills Village is interested in understanding the feasibility of providing improved widespread cellular service throughout the community.

The City desired to create a long-term Vision to address the community's goals for advanced and improved cellular communication. With this Vision defined, the City wanted a plan to provide a strategy for future cellular and broadband improvements including costs. The City understood that it was critical to involve the stakeholders in the visioning process to identify the community's wants and needs.

In April of 2023, City leaders selected HR Green to complete this Citywide Cellular Communications and Fiber Study to address how to best serve the cellular needs of Cherry Hills Village residents and how public and private entities could work together towards a common goal of improving cellular service and fiber (broadband) capability in Cherry Hills Village.

The primary objective of the Study was to make a recommendation as to how to improve cellular service with fiber (broadband) improvements being ancillary. Since the primary focus of this Study was on citywide cellular improvements, **Section 1** through **Appendix C** of this Report documents the cellular part of the Study. **Appendix D** of this Report documents the fiber (broadband) part of the Study.

Approach

The following multi-phase approach was used to complete this Study.

Phase I – Vision

- Assessment of Private Cellular Resources (See **Section 2**)
- Assessment of Private Broadband Resources (See **Appendix D**)
- Cellular Regulatory Review (See **Appendix A**)
- Evaluation of Existing Cellular Conditions (See **Section 2**)
- Evaluation of Existing Fiber Conditions (See **Appendix D**)
- Citizen Cellular Survey (See **Section 3**)
- Citizen Broadband Survey (See **Appendix D**)
- Broadband Market Assessment (See **Appendix D**)
- Vision and Goal Setting Workshops (See **Section 4**)

Phase II - Planning

- Preliminary Cellular Designs and Cost Estimates (See **Section 5**)
- Preliminary Broadband Design and Cost Estimate (See **Appendix D**)
- Conduct Cellular Financial Analysis (See **Section 6**)
- Evaluate Broadband Funding Alternatives (See **Appendix D**)
- Complete Citywide Cellular Communication and Fiber Study (See **Section 8**)

Phase III - Create Public Private Partnerships (P3) Solutions (Executed in parallel with Phase II)

- Explore Public Private Cellular Partnerships (See **Section 7**)

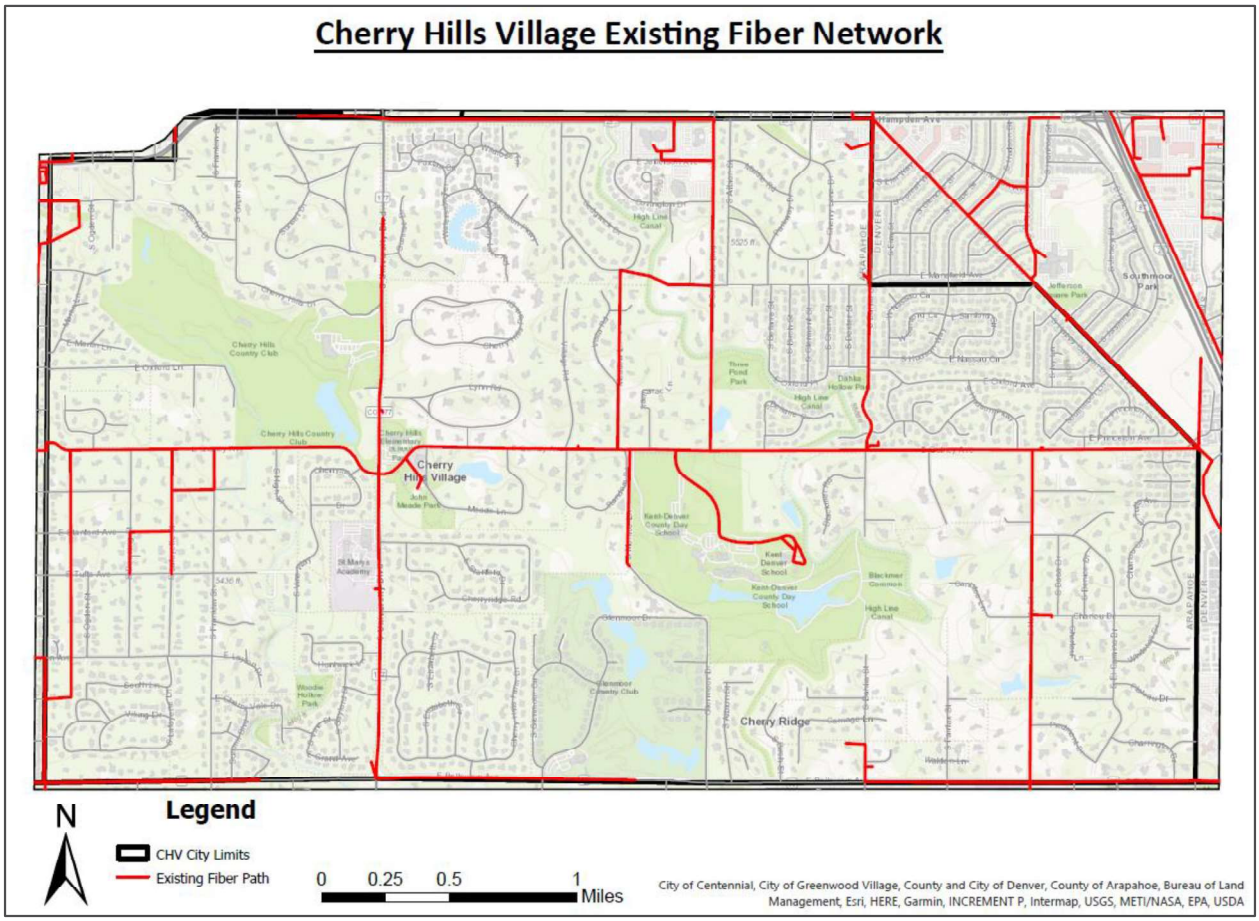
Key Broadband Findings

The following are some of the Key Fiber (broadband) Findings from the Vision phase of the Study.

Existing Fiber Evaluation

Network densification may need to be implemented in the City due to the growing number of devices and increasing demand for data. When more cell sites exist in an area, users will most likely be closer to one of those sites, which means that coverage and capacity become less of a problem. Network densification needs to be complemented by both wireless and wired backhaul such as fiber optic cables. The backhaul requirement drove the need to evaluate the existing fiber infrastructure within the City as a means of successfully meeting its goal of improving cellular services.

Below is that map showing the inventory of the existing fiber within the City.



It is important to note that not all of the current owners of fiber within the City shared their data, so this map only shows the data that was provided.

Key Fiber / Broadband Findings

- Fiber is present on primary corridors
- Assets may be available for cellular service

Citizen Surveys

Cherry Hills Village City Council prioritized feedback and input from its citizens regarding the current state of cellular and broadband service. This information is crucial for helping the City identify areas of the greatest need, partner cellular and Internet Service Providers (ISPs) to work with for a given area, and funding opportunities to support any future initiatives. The City welcomed citizen participation as it looked at how the presence of cellular and broadband (internet) services impact the community, and how facilitating cellular and broadband access can meet the City's function of promoting safety, health, and welfare of all members of the community.

Citizen surveys were used to help City decision makers better understand community needs. They helped to determine the community's desire for cellular and broadband services; current market conditions and deficiencies; predicted number of subscribers and optimum monthly cost that subscribers would be willing to pay for the service; stakeholder needs; and what role the government should have, if any, in providing cellular and broadband services. Two surveys were developed, one focused on cellular services, and one focused on broadband services.

Both surveys included a detailed list of questions to capture the data needed. Questions included the composition of the respondent's household, whether they have children, whether they work at home, solely or occasionally, and the age of the respondent. Survey questions also included cellular and broadband upload/download speed, general location of the responding party, and their opinion on what role municipal government should have in providing these services.

The surveys were accessible via a link on the City's website. It is important to note that the surveys included a link to a speed test website. Once on the speed test website, testing was conducted to determine actual upload/download speeds in a manner that could be verified and documented. To obtain the best possible speed test results, the respondent was asked to complete it from their residence.

Both surveys were available from June 5, 2023, to August 4, 2023. The City received 134 responses to the Cellular Survey and 85 responses to the Broadband Survey. The Citizen Broadband Survey results are summarized below. Full Broadband Survey details are available later on in this Appendix. The summary of the Citizen Cellular Survey results can be found in **Section 1.** Full Cellular Survey details are available in **Section 3**.

Citizen Broadband Survey Findings

- Residents generally have access to "Served" Broadband speeds (at least 100 Mbps download speed and 20 Mbps upload speed)
- Lumen (CenturyLink) and Comcast are primary broadband options
- Significant satisfaction with broadband Service and Speeds
- Broadband price is a slight concern
- 61% of respondents are against City involvement to fix the broadband issue
- Not willing to pay higher taxes for the City to facilitate better broadband service

Broadband Market Assessment

The significance of broadband coverage has evolved from a mere convenience to an indispensable necessity in contemporary society. A multitude of critical aspects, such as education, remote work, economic growth, talent retention, telemedicine, and more, now rely heavily on robust connectivity. Analyzing the competitive landscape of broadband coverage, however, poses considerable challenges due to the ever-changing nature of market dynamics, pricing structures, product offerings, and disparities across different sectors.

The initial step in comprehending the broadband landscape within a community involves delving into industry-reported data. This journey begins with a comprehensive Market Assessment, which entails an in-depth analysis of data provided by broadband service providers regarding their coverage areas. As part of their licensing obligations, these providers are mandated to furnish specific data related to their customer base. This data is typically accessible through the Federal Communications Commission (FCC) and other supplementary sources that offer further insights into the broadband ecosystem.

The analysis commences with a comprehensive examination, cataloging, and detailed documentation of the service offerings from each primary provider in Cherry Hills Village. Subsequently, a critical second step involves obtaining focused feedback. To obtain this feedback, the Market Assessment is complemented by a community-wide survey, which was completed and previously discussed. Such feedback illuminates not only the actual practices of providers but also pricing structures, customer satisfaction levels, and identifies unmet demands or underserved segments of the market.

Broadband Market Assessment Key Findings

- Many Internet Service Provider options are available in Cherry Hills Village.
- Service offerings widely vary by type and coverage location.
- Densest urban centers have a variety of choices between some of the leading service plans offered in the market, but the availability of these plans is limited.
- Companies are transitioning to higher tier speed technologies as they move their fiber-hybrid solutions closer to the customer premises.
- While most residents have some kind of service available to them, it may not be the best offering available in other places, as well as potentially being prohibitively expensive in areas with lower levels of competition.
- Cherry Hills Village may significantly benefit from further investment in broadband market competition and infrastructure deployment.

Vision & Goals Setting Workshops

Two vision and goal setting workshops (August 23, 2023, and September 5, 2023) were held to help inform City decision makers regarding the potential future planned cellular and fiber deployment throughout the City. The first workshop was an open house that involved the City Council and residents. The second workshop was with City Council and it explored setting goals and developing the vision of the City as they related to cellular communications and fiber.

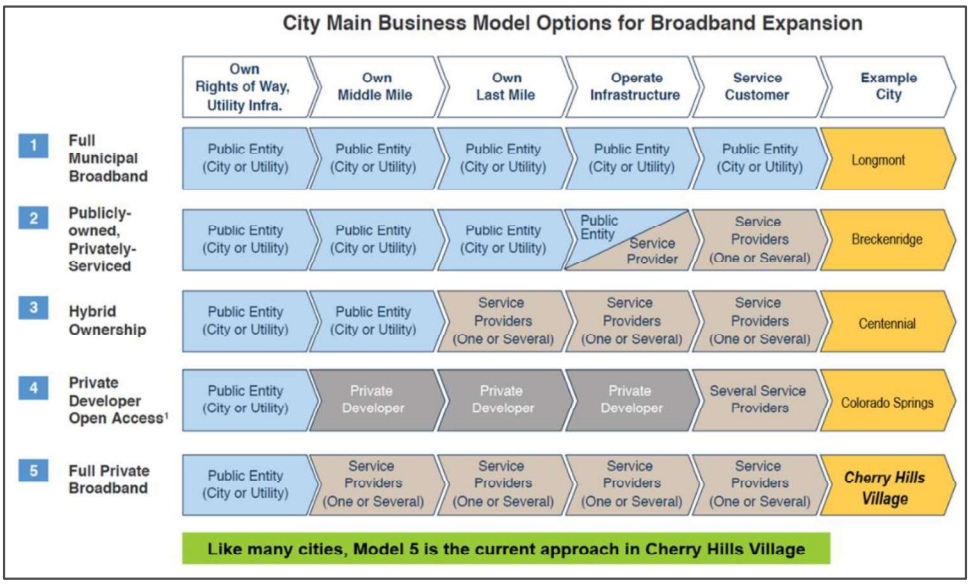
The vision and goal setting workshops investigated and provided various scenarios including all feasible public or private ownership options for cellular/fiber construction and implementation, as well as the possibility of leasing conduit and fiber. During the workshops the best practices in other communities that have had experience with leading a broadband effort in their communities were shared.

Prior to the City Council Visioning Session, which took place on Tuesday, September 5, 2023, a multi-part Council Vision Exercise Survey and supporting materials were developed.

The first part of the Council Vision Exercise Survey, the Vision Survey, included questions about the level of importance the Council would rate certain statements regarding cellular and broadband services in the City.

The last part of the Vision Exercise Survey included a weblink to information that presented an overview of the different municipal broadband models. Although these models primarily focus on broadband, they can also be applied to cellular services. Additional information about the broadband models can be found in **Appendix D**.

The following diagram shows the five main municipal broadband business models.



Based on the data that was collected and the feedback from the public, the Vision and Goals for the City regarding cellular coverage were developed. It is important to note that a Vision and Goals needed to be established prior to the network being designed, which is the next phase of this Study.

Some Comments provided at the Open House related to Broadband

- Internet sometimes drops for between 10 minutes and an hour or so, which happens once a week or so

Key Open House Findings related to Broadband Services

- Generally, attendees shared positive experiences with broadband services within the City.
- Some attendees shared that they believe the City has a cellular problem, not a broadband problem

Council Vision Exercise Survey Key Findings related to Broadband Services

- Results aligned with public perception that there seems to be sufficient broadband services in the City
- Results indicated that broadband is viewed as a necessary asset for quality of life.
- 80% of Council felt the City should “encourage or enable” improvements in broadband and cellular

Visioning Session

The goal of the Session was to:

- Provide the City Council the data that has been collected and the feedback from the public.
- Take the feedback and input from the City Council to draft a Vision for the City regarding Cellular Coverage.

The Agenda for the Visioning Session included the following:

- Technology Overview
- Study Background

- Cellular Findings
- Broadband Findings
- Creating a Council Vision (Included sharing of some possible 5G solutions)
- Discussion & Next Steps.

Vision Session Key Findings

After the presentation, the Mayor opened the floor for Council discussion. At the conclusion of the discussion, Council provided the following direction:

- Draft an overall vision for the City related only to cellular coverage. It was decided that fiber and broadband to the home were not to be contemplated except as they relate to cellular service and the infrastructure needed to improve total cellular coverage in the City.
- Continue to investigate larger tower configurations and locations as a possible solution.
- Begin the process of finding possible partners to implement the Vision. Before any final configuration or placement is decided, these partners should be consulted to ensure the towers, and their placement are satisfactory to their needs.
- Bring partners forward to the City Council to negotiate formal agreements for cost sharing, infrastructure installation and permitting, provider use agreements, etc.

Based on the data that was collected and the feedback from the public, as well as City Council's discussion and direction, the following Vision Statement and Goals were developed. It is important to note that a Vision and Goals needed to be established prior to the network being designed, which is the next phase of this Study.

Vision Statement and Goals

Vision Statement

Through partnerships and collaboration, the City endeavors to improve cellular coverage throughout its entire jurisdiction. Like water, sewer, and electricity, cellular service has become a necessity. By partnering with infrastructure and service providers the Council strives to improve the health, safety, and welfare of its residents, by providing comprehensive cellular coverage throughout the entire City.

Goals

1. Implement a telecommunications solution that provides reliable citywide cell phone coverage, and that providers will utilize.
2. Locate towers on City owned property or rights-of-way, when possible.
3. Ensure that towers do not exceed the maximize height permitted in the City Code. And if needed, provide City Council with the necessary language to modify the code.
4. Engage with potential partners to ensure the designed solution meets all their needs and requirements.
5. Explore all partnership opportunities.
6. Utilize a Request for Expressions of Interest (RFEI) or a Request for Proposal (RFP) process to establish one or more public private partnerships.
7. Explore funding opportunities.

Visioning Session Next Steps

The following next steps were discussed as the Visioning Session concluded. It is important to note that after the Visioning Session, the City authorized Phase III of the Study to be executed in parallel to Phase II of the Study, so the following list of next steps includes fiber (broadband) tasks from both Phase II and Phase III of the Study.

- Preliminary Fiber Design & Cost Estimate (Phase II, Task 1)
- Evaluate Broadband Funding Alternatives (Phase II, Task 3)
- Complete Cellular Communication and Fiber Study (Phase II, Task 5)

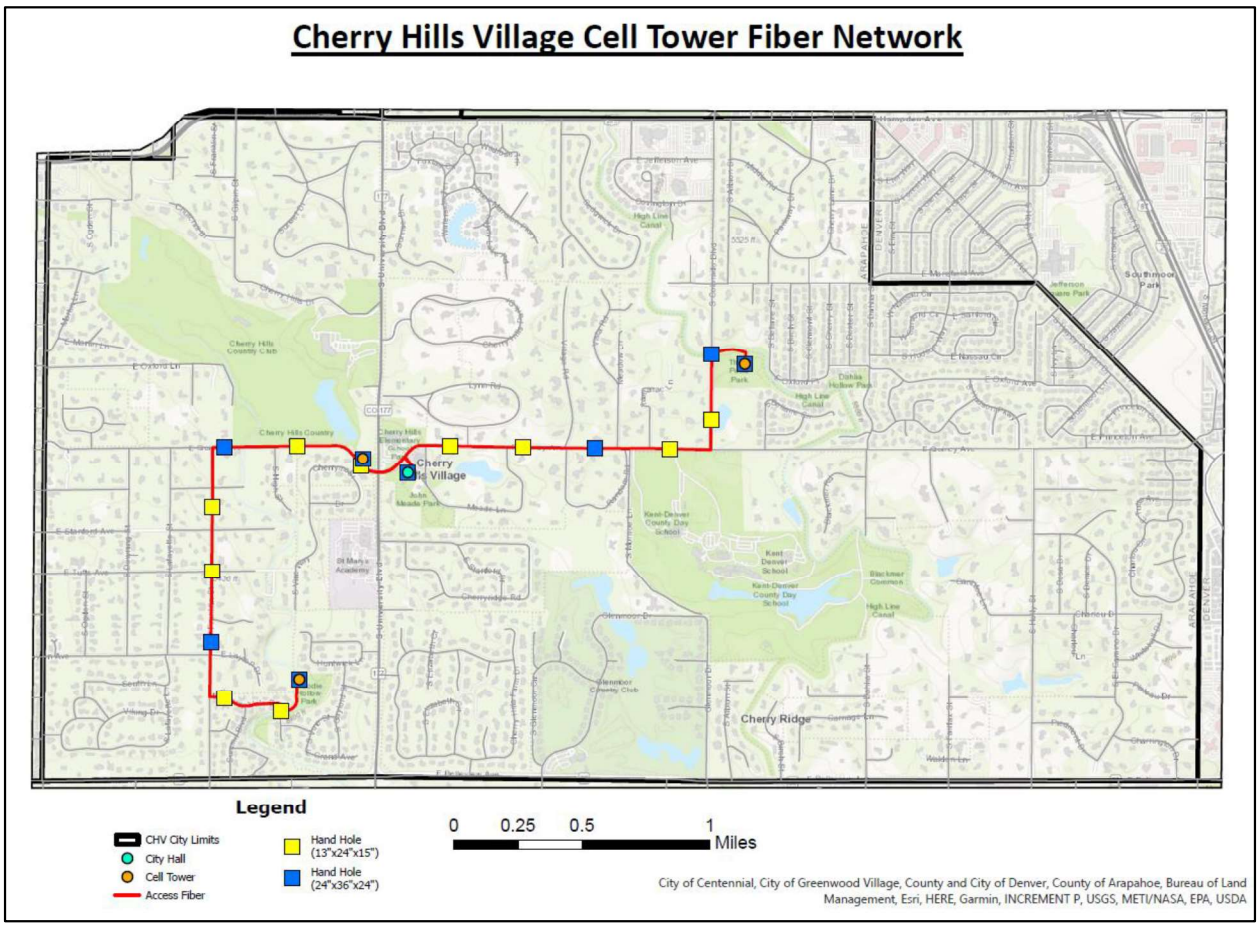
Development of the Preliminary Fiber Design

Based upon the outcomes and recommendations from the Vision Session with Council, including the Vision Statement and Goals, the next step in the Study was to complete a high-level design (HLD) of an optional fiber network that could be used for cost estimating (and possible future detailed design) The HLD used GIS-based tools.

Leveraging the results of Phase I and the partial results of Phase II, several cellular designs were explored. However, based on the Vision Statement and Goals, three proposed cellular designs were created. These designs were built upon the existing and suggested RF coverage maps by identifying any necessary expansion locations to complete coverage of the community with not only equitable coverage but high-capacity data designs. Once the three optional proposed cellular designs were created a fiber infrastructure design was created to support the candidate cell tower locations as well as a cost estimate to construct the fiber network.

Conceptual Fiber Design and Cost Estimate

The following map shows the fiber infrastructure required to support the three candidate cell tower locations on public park property, and a central location (City Hall) to house cellular equipment.



Cellular Tower Fiber Network Cost Estimate

Segment Number	Segment Description	Estimated 288ct Material Costs	Estimated Backbone Installation Cost (no splicing)	Estimated Design Engineering and PMO Labor Cost	Estimated 288ct Total Backbone Segment w/Splicing Cost
1	Candidate 1 Location (City Park)	$7,261	$32,366	$6,479	$63,652
2	Candidate 2 Location (Three Pond Park)	$42,098	$174,610	$20,172	$284,591
3	Candidate 3 Location (Woodie Hollow Park)	$53,994	$222,580	$25,872	$356,715
	Cherry Hills Village Overview	$103,352	$429,556	$52,523	**$704,958**

Evaluate Broadband Funding Alternatives

The ability to leverage federal, state, and regional grants and programs can substantially facilitate the cost of a network buildout. In recognizing the need for broadband support, federal and state governments provide funding in areas recognized as unserved or underserved based on public data on broadband availability and speeds in different regions across the country. Historically, this data has been criticized as poorly prepared, marginally reliable, and overly generalized. As a result, a community like that in Cherry Hills Village may be considered as adequately covered and served by broadband providers, whereas residents may actively experience a lack of sufficient or affordable service.

Fortunately, we are on the cusp of a generational investment in broadband infrastructure. The federal government and state legislatures across the country have recognized the need for broadband funding support. Numerous federal and state programs are currently either being rolled out or are in various stages of legislative consideration.

In addition, alternative funding sources could help offset infrastructure and operational costs. It is also important to maintain awareness of other funding sources. It is not uncommon for an agency (regional, State or Federal) to have targeted programs that can provide funding for broadband projects. These can range from utility related topics to community betterment to citizen specific needs to business attraction or retention, block grants, etc.

Recommendations and Next Steps

Cherry Hills Village is unlikely to be granted any of the broadband grants, such as the BEAD program, because the FCC broadband maps consider it completely served. To become eligible, it may be advisable to conduct a more comprehensive broadband survey to serve as a data-evidenced basis for challenging the existing maps.

Section 2: Evaluation of Existing Fiber Conditions

Background

The initial step of the evaluation of existing fiber conditions was to identify local broadband providers to help identify deployed fiber assets. Based upon the identified existing fiber, GIS tools were used to show existing infrastructure, and provide real-time, GIS-based information. These tools helped the City better understand what it was seeing; giving the City the ability to explore various models; and retain the information for future phases of the Study.

Additionally, the review included existing fiber network patterns for the entire City, as well as an exploration of future needs. The analysis determined the location of all fiber networks and their potential availability to be utilized for improving cellular coverage as well as future broadband expansion in Cherry Hills Village.

The evaluation also included a general review of Broadband technology as it relates to Cherry Hills Village. An overview of Broadband technology can be found in **Appendix E** of this report.

Existing Fiber Evaluation and Key Findings

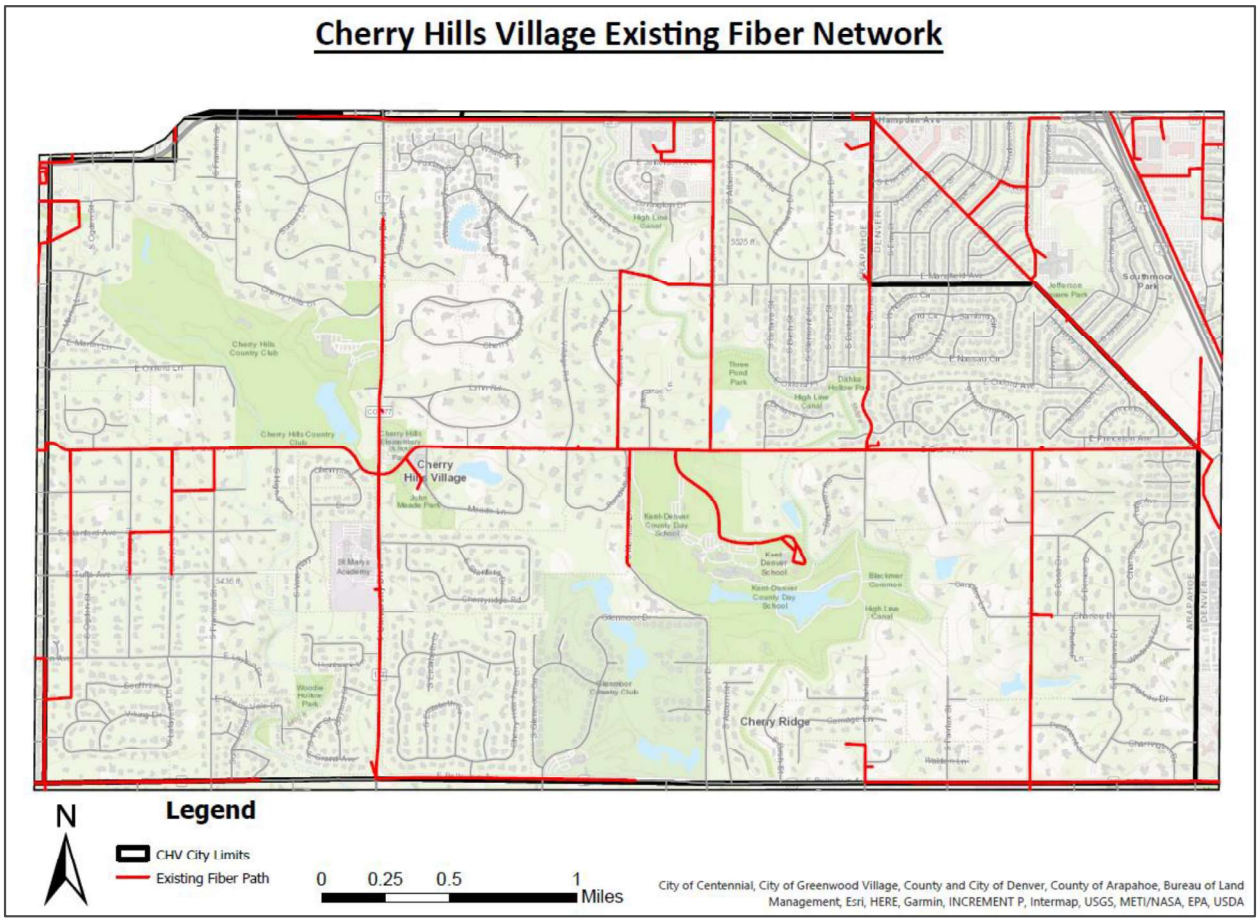
Network densification may need to be implemented in the City due to the growing number of devices and increasing demand for data. When more cell sites exist in an area, users will most likely be closer to one of those sites, which means that coverage and capacity become less of a problem. Network densification needs to be complemented by both wireless and wired backhaul such as fiber optic cables. The backhaul requirement drove the need to evaluate the existing fiber infrastructure within the City as a means of successfully meeting its goal of improving cellular services.

The first step to performing the evaluation of the existing fiber infrastructure within the City was to obtain data about the existing inventory of fiber assets. There seem to be several telecommunications companies that have installed fiber-optic infrastructure within the City. These organizations include Comcast, Lumen (CenturyLink), Crown Castle, Zayo, and others.

To initialize this data gathering, the City reached out to each of these organizations to ask for the data. This outreach also provided the City with the opportunity to initiate a conversation with the providers regarding their interest in potentially partnering with the City as it explores what its role might be in improving cellular services.

Most of the organizations were willing to share the maps of where they have installed fiber infrastructure. It is worth noting that some of these organizations have franchise agreements in place with the City and in some of these agreements the franchisee is required to provide data to the City regarding their fiber infrastructure.

Below is that map showing the inventory of the existing fiber within the City.



It is important to note that not all of the current owners of fiber within the City shared their data, so this map only shows the data that was provided.

Key Findings

- Fiber is present on primary corridors
- Assets may be available for cellular service

Section 3: Citizen Broadband Surveys

Background

Cherry Hills Village City Council prioritized feedback and input from its citizens regarding the current state of cellular and broadband service. This information is crucial for helping the City identify areas of the greatest need, partner cellular and Internet Service Providers (ISPs) to work with for a given area, and funding opportunities to support any future initiatives. The City welcomed citizen participation as it looked at how the presence of cellular and broadband (internet) services impact the community, and how facilitating cellular and broadband access can meet the City's duty of promoting safety, health, and welfare of all members of the community.

Citizen surveys were used to help City decision makers better understand community needs. They helped to determine the community's desire for cellular and broadband services; current market conditions and deficiencies, predicted take rate and optimum monthly cost that users would be willing to pay for the service; stakeholder needs and what role the government should have, if any, in providing cellular and broadband services. Two surveys were developed, one focused on cellular services, and one focused on broadband services.

Both surveys included a detailed list of questions to capture the data needed. They included questions about the composition of their household, whether they have children, whether they work at home, solely or occasionally, and the age of the respondent. Survey questions also included cellular, and broadband provided upload/download speed, general location of the responding party, for both cellular and broadband services, and their opinion on what role municipal government should have in providing these services.

Both surveys were accessible via a link on the City's website. It is important to note that the surveys included a link to a speed test website. Once on the speed test website, testing was conducted to determine actual upload/download speeds in a manner that can be verified and documented. To obtain the best possible speed test results, the person completing the survey was asked to complete it from their residence.

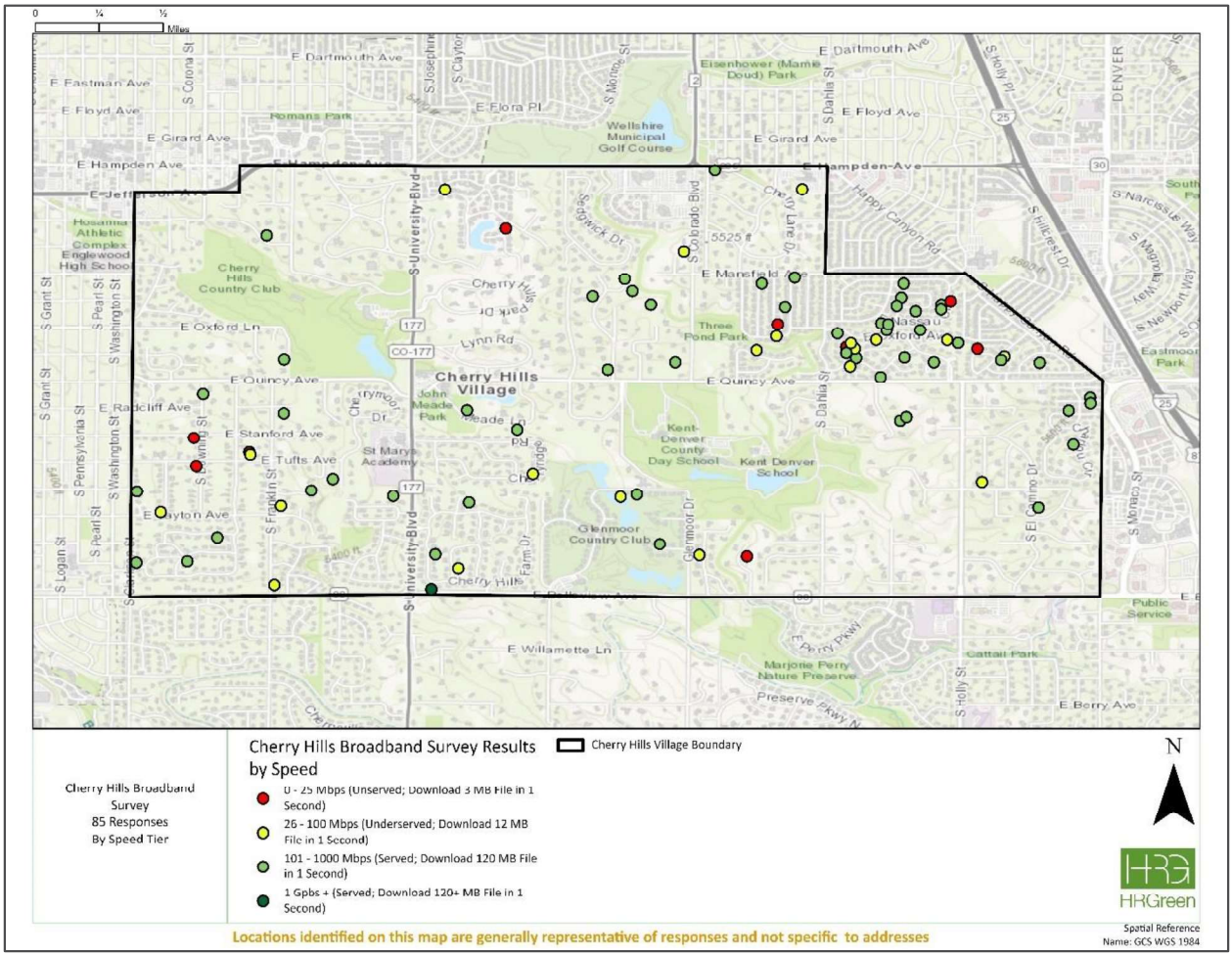
The surveys took only a few minutes to complete. All responses were anonymous and confidential. Participation was limited to one person per household. As these were surveys to assess both cellular and wired internet service, participants were encouraged to use a device that could be connected to a cellular connection (4G/LTE/5G) and/or a wired internet connection (through Wi-Fi or Ethernet), to take the surveys.

Both surveys were available from June 5, 2023, to August 4, 2023. The City received 134 responses to the Cellular Survey and 85 responses to the Broadband Survey.

Survey data was collected via GIS-enabled tools to enable a deep understanding of conditions neighborhood by neighborhood.

Broadband Survey Responses and Key Findings

Below is a map showing the results of the **Speed Tests** from the Broadband Survey.



Below is a table that summarizes the responses to some of the key questions from the citizen's Broadband Survey:

Question	Response
Broadband **Uses**	Email, News, Shopping, Banking, Web surfing, Streaming video, Online Apps, Video conf., Smart home, Social media
Broadband **Reliability**	29% = Somewhat to Very Dissatisfied 23% = Neutral **48% = Somewhat to Very Satisfied**
Broadband **Speed**	24% = Somewhat to Very Dissatisfied 20% = Neutral **56% = Somewhat to Very Satisfied**

Question	Response
Broadband **Price**	**42% = Somewhat to Very Dissatisfied** 32% = Neutral 26% = Somewhat to Very Satisfied
Use broadband service to **work from home or run a business**?	**67% = Yes** 33% = No
How often do you **experience outages**?	5% = Never **39% = 1 hour or less per month** 30% = 1 hour or less per week 21% = 1 hour or less per day 5% = More frequently than 1 hour per day
Do broadband providers **meet the needs** of the community?	30% = Bare Minimum to Not at All 22% = Neutral/It's Ok **48% = Mostly to Very Well**
City needs to help facilitate better broadband services?	18% = Agree or Strongly Agree 21% = Neutral **61% = Disagree or Strongly Disagree**
If City should help facilitate better broadband service, would you be **willing to pay higher taxes**?	25% = Yes **37% = No** 7% = Not Sure 31% = Need More Information to Decide

Key Findings

- Residents generally have access to "Served" Broadband speeds (at least 100 Mbps download speed and 20 Mbps upload speed)
- Lumen (CenturyLink) and Comcast are primary options
- Significant satisfaction with Service and Speeds
- Price is a slight concern
- 61% of respondents are against City involvement to fix the issue
- Not willing to pay higher taxes for the City to facilitate better broadband service

Section 4: Broadband Market Assessment

Background

The significance of broadband coverage has evolved from a mere convenience to a necessity. Many employment opportunities and lifestyle elements, such as education, remote work, economic growth, telemedicine, and more, now rely heavily on robust internet connectivity. Analyzing the competitive landscape of broadband coverage, however, poses considerable challenges due to the ever-changing nature of market dynamics, pricing structures, product offerings, and disparities across different sectors.

The initial step in comprehending the broadband landscape within a community involves delving into industry-reported data. This journey begins with a comprehensive Market Assessment, which entails an in-depth analysis of data provided by broadband service providers regarding their coverage areas. The analysis commences with a comprehensive examination, cataloging, and detailed documentation of the service offerings from each primary provider in the City of Cherry Hills Village.

As part of their licensing obligations, providers are mandated to report specific data related to their customer base. This data is typically accessible through the Federal Communications Commission (FCC) and other supplementary sources that offer further insights into the broadband ecosystem.

It is important to acknowledge the inherent flaws within this data. These shortcomings include data exclusivity for reporting requirements. The public has access to the data within the Broadband Data Collection (BDC) reports, but only providers and some types of outside entities have full access to the back-end data necessary for an in-depth market analysis. In addition, reporting and display cycles can render the submitted information outdated before it becomes available for analysis. There are also limited consequences for inaccurate reporting and data entry errors and some providers may have secondary motives to exaggerate their coverage, as it could affect their eligibility for grants. In addition, data is recorded at the census block level, potentially masking variations within that area when data is pulled to represent an entire block.

However, this data serves as the foundational dataset from which to initiate further analysis. It is also pivotal in securing federal and state grants. If inaccuracies persist, correcting them becomes imperative to ensure fair distribution of resources.

Given these data challenges, a high-level market assessment cannot be solely relied upon. Instead, it serves as a starting point for understanding coverage and identifying areas that necessitate validation against actual survey data. A word of caution is essential: conducting a market analysis without obtaining real-world feedback may lead to substantial inaccuracies. To cross-reference the Market Assessment results, a community-wide broadband survey was conducted, which was completed and previously discussed in this Appendix. Such feedback illuminates not only the actual practices of providers, but also pricing structures, customer satisfaction levels, and identifies unmet demands or underserved segments of the market.

Cherry Hills Village residents have a variety of Internet service options at their disposal, including DSL (over copper), cable, fiber, fixed wireless, and satellite, offered by multiple Internet Service Providers (ISPs). This section is dedicated to describing the consumer Internet offerings available in Cherry Hills Village from established ISPs, with the aim of providing a comprehensive snapshot of the local Internet market. It includes information on providers serving their customers through different transport mediums, such as copper (DSL), cable, fiber, fixed-wireless, and satellite. It is important to note that the definitions of the different broadband technologies can be found in **Appendix E** of this report.

Since data is provided by zip code, all the following findings are provided for the Cherry Hills Village area of zip codes:

- 80111
- 80113
- 80121

The following ISPs are available for residents and businesses in Cherry Hills Village:

- Always ON
- CenturyLink (Lumen)
- HughesNet
- LiveWireNet
- Quantum Fiber
- Starlink
- Ting
- T-Mobile
- VERIZON
- Viasat
- Webpass
- Xfinity

Residential Broadband Service Providers

80111

	Xfinity	Century Link	Always ON	Webpass	Verizon	T-Mobile 5G Home Internet	Ting	LiveWire	Starlink	Viasat	Hughes Net
Technology Type	Cable	DSL, Fiber	Fixed Wireless	Fixed Wireless	5G Internet	5G Internet	Fiber	Fixed Wireless	Satellite	Satellite	Satellite
Download (Mbps)	2 Gbps	940 Mbps	25 - 150 Mbps	1 Gbps	1 Gbps	33 - 245 Mbps	1 Gbps	250 Mbps	50 - 220 Mbps	150 Mbps	25 Mbps
Coverage	99.50%	82.40%	46.80%	20%	10.90%	46.80%	19.60%	11.60%	100%	100%	100%

80113

	Xfinity	Quantum Fiber	T-Mobile 5G Home Internet	Always ON	Verizon	Century Link	LiveWire	Starlink	Viasat	Hughes Net
Technology Type	Cable	Fiber	5G Internet	Fixed Wireless	5G Internet	DSL, Fiber	Fixed Wireless	Satellite	Satellite	Satellite
Download (Mbps)	1.2 Gbps	940 Mbps	33 - 245 Mbps	25 - 150 Mbps	1 Gbps	940 Mbps	250 Mbps	50 - 220 Mbps	150 Mbps	25 Mbps
Coverage	99.90%	49.10%	48.60%	48.60%	27.30%	70.10%	36.10%	100%	100%	100%

80121

	Xfinity	Century Link	T-Mobile 5G Home Internet	Always ON	Quantum Fiber	Ting	Starlink	Viasat	Hughes Net
Technology Type	Cable	DSL, Fiber	5G Internet	Fixed Wireless	Fiber	Fiber	Satellite	Satellite	Satellite
Download (Mbps)	2 Gbps	940 Mbps	33 - 245 Mbps	25 - 150 Mbps	940 Mbps	1 Gbps	50 - 220 Mbps	150 Mbps	25 Mbps
Coverage	99.80%	48.20%	44.60%	44.60%	8.90%	37.90%	100%	100%	100%

Business Broadband Service Providers

80111

	Comcast Business	CenturyLink Business	T-Mobile 5G Home Internet	Ting	LiveWire	Viasat	HughesNet
Technology	Cable	DSL, Fiber	5G Internet	Fiber	Fixed Wireless	Satellite	Satellite
Download (Mbps)	2 Gbps	940 Mbps	33 - 245 Mbps	1 Gbps	250 Mbps	150 Mbps	25 Mbps
Coverage	99.60%	82.40%	48.30%	19.60%	11.60%	100%	100%

80113

	Comcast Business	CenturyLink Business	T-Mobile 5G Home Internet	Quantum Fiber	LiveWire	Verizon	Viasat	HughesNet
Technology	Cable	DSL, Fiber	5G Internet	Fiber	Fixed Wireless	5G Internet	Satellite	Satellite
Download (Mbps)	2 Gbps	940 Mbps	33 - 245 Mbps	940 Mbps	250 Mbps	400 Mbps	150 Mbps	25 Mbps

Coverage	100%	70.10%	52.10%	2.20%	36.10%	2.20%	100%	100%

80121

	Comcast Business	CenturyLink Business	T-Mobile 5G Home Internet	Quantum Fiber	Verizon	Ting	Viasat	HughesNet
Technology	Cable	DSL, Fiber	5G Internet	Fiber	5G Internet	Fiber	Satellite	Satellite
Download (Mbps)	2 Gbps	940 Mbps	33 - 245 Mbps	940 Mbps	400 Mbps	1 Gbps	150 Mbps	25 Mbps
Coverage	99.80%	48.20%	47.40%	6%	0.40%	37.90%	100%	100%

Internet Service Providers in Cherry Hills Village

This assessment focused on residential internet options in Cherry Hills Village. This section provides an overview of ISPs in the City sorted alphabetically by the name of the service provider. It shows the percentage of the City covered by the service provider, the type of service provided, maximum download speeds, and, if available, the maximum estimated monthly cost for each service provider.

CenturyLink (Lumen)

With its headquarters based out of Monroe, Louisiana, CenturyLink provides Internet and phone services to customers in 36 different states. CenturyLink is the 3rd largest telecommunications business in the United States, providing telecommunication services to the Government, businesses, and residents throughout the country. CenturyLink was founded in 1930. CenturyLink recently merged with Lumen Technologies (Lumen).

The table below shows the cost of CenturyLink's plans, according to AllConnect.com:

Download Speed – Up To (Mbps)	Cost/Month
40	$49
100	$49
940	$65

AllConnect also collects data on the percentage of customers who get advertised data. The following table shows the percentage of customers who reported having the speed on the left column:

SPEED RANGE	DOWNLOAD SPEED	UPLOAD SPEED
.1 to 5 Mbps	8.0%	31.2%
6 to 10 Mbps	13.1%	26.5%
11 to 20 Mbps	7.5%	0.0%
31 to 75 Mbps	2.7%	42.2%
76 to 100 Mbps	68.8%	0.0%

Comcast (Xfinity)

Comcast is the biggest cable television company and the second biggest internet provider in the United States. The company offers the following internet service plans. Multiple prices were available for the same plans, which likely depends on the specific region in which the service is offered:

Plan	Download Speed – Up To (Mbps)	Cost/Month
Performance Pro+	200	$49.99/$59.99
Performance Starter+	25	$19.99
Performance Select	100	$34.99/$55
Blast! Pro+	400	$64.99/$74.99
Extreme Pro+	600	$60/$84.99
Gigabit	1000	$70/$94.99

HughesNet

Hughes Network Systems, LLC (formerly Hughes Communications) was founded in 1971. It is a wholly owned subsidiary of EchoStar (DirecTV). Hughes Network Systems is headquartered in Germantown, Maryland and provides a high-speed satellite internet service, HughesNet.

The key aspect that differentiates it and other satellite operators from terrestrial purveyors is not speed but data caps - how much data is allowed per month in each plan. As a customer increases in service tiers, they pay more for more data.

Plan	Download Speed – Up To (Mbps)	Upload Speed – Up To (Mbps)	Cost/Month
Internet	25 (10GB cap)	3	$59.99
Internet	25 (20GB cap)	3	$69.99
Internet	25 (30GB cap)	3	$99.99
Internet	25 (50GB cap)	3	$149.99

The table below shows the cost of HughesNet's plans as of March 2020. Their plans have data caps in place.

Provider	Type of Service	Business / Residential	Download Speeds (Mbps)	Upload Speeds (Mbps)	Cost/Month
HughesNet	Satellite	Residential	25 (10GB cap)	3	$60
HughesNet	Satellite	Residential	25 (20GB cap)	3	$70
HughesNet	Satellite	Residential	25 (30GB cap)	3	$100

HughesNet	Satellite	Residential	25 (50GB cap)	3	$150

Starlink

Starlink is a proposed and partially implemented Low Earth Orbit (LEO) constellation of over 12,000 satellites intended to provide internet service in underserved areas. There are currently over 2,300 working satellites in a 340-mile-high orbit.[i] Some say their sunlight reflections can be now seen at dusk with the naked eye.

This project is expensive and highly technically complex. Estimated to cost $6.1 billion to launch with an additional $10 billion for the required base station, a LEO space vehicle has a predicted operating life of five years. For access to this service, a Starlink customer is asked to pay $500 for equipment for their home and $99 per month for internet service.[ii] It will take 2.7 million customers paying $99/month for five years to recoup that initial investment of LEO and ground station infrastructure.

Colorado is 104,185 square miles or about 0.05% of the covered satellite area. That means about six of the satellites are over the state at one time. Since each satellite can transmit speeds up to 20 GB/s, Colorado should have access to 120 GB/s for the state. If only 1% of Colorado homes (2.5 M) were to sign up, each would have access to 4.8 Mb. That is substantially below any service offered through a fiber optic network. Thus, Starlink is only a solution for very rural areas.

The founder of the company, Elon Musk, confirms these expectations. Starlink will likely serve the "3 or 4 percent hardest-to-reach customers for telcos" and "people who simply have no connectivity right now, or the connectivity is really bad," Musk said.[iii] While satellites provide global coverage, each satellite covers a large area and bandwidth is split between all customers. In another interview Musk specifies "although those Starlink satellites, about 550 kilometers up, combine to deliver some 30 terabits per second and should offer worldwide coverage except for polar areas by August (2021), Musk warned that this doesn't necessarily leave much bandwidth for individual subscribers. Especially if they live too close together. It's really meant for sparsely populated regions".[iv]

For rural and remote areas, the system is promising in helping resolve the Digital Divide. As such, in 2020, the FCC awarded the company $885.5 million in federal funding to assist with deployment of the technology. This represented one of the largest awards in the FCC's Rural Digital Opportunity Fund (RDOF) subsidy program funding cycle.[v] In Colorado, the award was approximately $40 million to connect almost 20 thousand homes in rural areas.[vi]

T-Mobile 5G Home Internet

T-Mobile introduced its Home Internet Service in 2021. Since then, it has expanded to 6 states and is available to more than 30 million households nationwide.[vii]

The price is $50 a month for every customer. There is no plan or annual contract, or data caps. It runs on the same 4G/LTE or 5G network that is already available in the area, and only requires a gateway device that converts the signal to WiFi. Users typically see download speeds between 33 and 182 Mbps, which vary greatly depending on location, signal strength, weather conditions, and other factors that affect signal to noise ratio.

ViaSat (formerly Exede)

ViaSat Inc. (formerly Exede) was founded in May 1986. It is based in Carlsbad, California, with additional operations across the United States and worldwide. In 2017, Exede was rebranded ViaSat Internet. ViaSat is a provider of high-speed satellite broadband services and secure networking systems covering military and commercial markets.

The table below shows the cost of ViaSat's plans. Their plans have data caps in place.

Plan	Download Speed – Up To (Mbps)	Cost/Month

Bronze	12	$49.99
Silver	25	$69.99
Gold	50	$99.99

Verizon 5G Home Internet

Like T-Mobile 5G Home Internet, Verizon similarly offers home internet plans using the mid-band and high-band spectrum of their mobile network.

For a current subscriber of a Verizon mobile plan, the cost is $25 or $35 extra depending on the plan. Without an existing mobile plan, the cost is $50 or $70 a month. It is $10 more a month when not enrolled in autopay.

Key Findings

- Many Internet Service Provider options are available in Cherry Hills Village.
- Service offerings vary widely by type and coverage location.
- Densest urban centers have a variety of choices between some of the leading service plans offered in the market, but the availability of these plans is limited.
- Companies are transitioning to higher tier speed technologies as they move their fiber-hybrid solutions closer to the customer premises.
- While most residents have some kind of service available to them, it may not be the best offering available in other places, as well as potentially being prohibitively expensive in areas with lower levels of competition.
- Cherry Hills Village may significantly benefit from further investment in broadband market competition and infrastructure deployment.

Section 5: Develop Preliminary Fiber Design

Background

Based upon the outcomes and recommendations from the Vision Session with Council, including the Vision Statement and Goals, the next step in the Study was to complete a high-level design (HLD) of an optional fiber network that can be used for cost estimating (and possible future detailed design) The HLD used GIS-based tools.

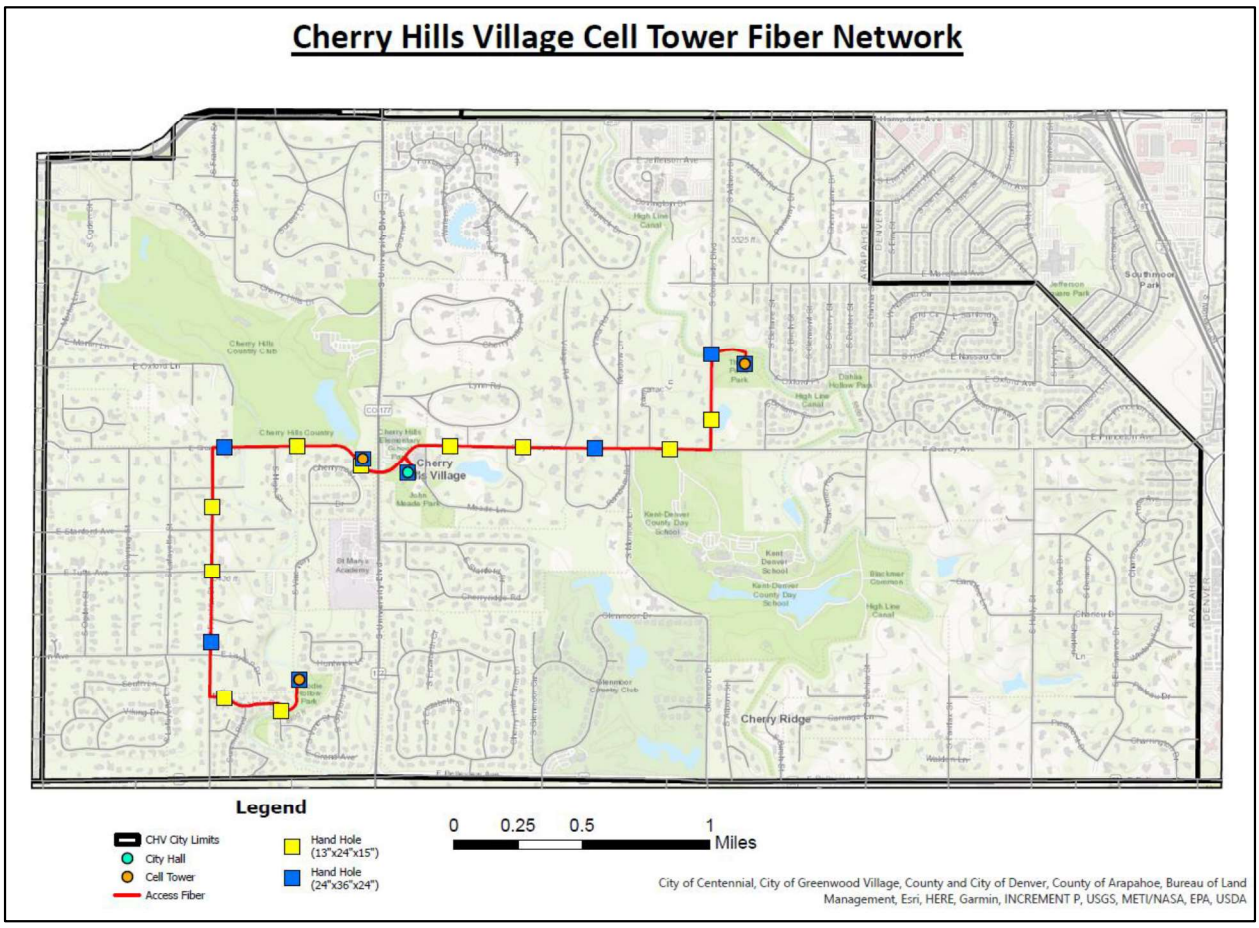
Drawing on field and desk surveys, and GIS maps, system level designs and cost estimates were prepared for developing next generation fiber networks. In developing this approach, the focus was on creating a robust, reliable, and cost-effective approach to meeting the City's needs.

Based on an analysis of existing infrastructure, conceptual designs, high-level maps, and routing, candidate specifications and system-level overviews of the potential infrastructure were provided. This analysis in turn became a roadmap for financial analysis and business modeling, and for future decisions (potentially including detailed engineering, construction, and operations).

Leveraging the results of Phase I and the partial results of Phase II, several cellular designs were explored. However, based on the Vision Statement and Goals, three proposed cellular designs were created. These designs were built upon the existing and suggested RF coverage maps by identifying any necessary expansion locations to complete coverage of the community with not only equitable coverage but high-capacity data designs. Once the three optional proposed cellular designs were created a fiber infrastructure design was created to support the candidate cell tower locations as well as a cost estimate to construct the fiber network.

Conceptual Fiber Network Design

The following map shows the fiber infrastructure required to support the three candidate cell tower locations on public park property, and a central location (City Hall) to house cellular equipment.



Estimated Fiber / Broadband Network Costs

Segment Number	Segment Description	Estimated 288ct Material Costs	Estimated Backbone Installation Cost (no splicing)	Estimated Design Engineering and PMO Labor Cost	Estimated 288ct Total Backbone Segment w/Splicing Cost
1	Candidate 1 Location (City Park)	$7,261	$32,366	$6,479	$63,652
2	Candidate 2 Location (Three Pond Park)	$42,098	$174,610	$20,172	$284,591
3	Candidate 3 Location (Woodie Hollow Park)	$53,994	$222,580	$25,872	$356,715
	Cherry Hills Village Overview	$103,352	$429,556	$52,523	**$704,958**

Section 6: Evaluate Broadband Funding Alternatives

Background

The ability to leverage federal, state, and regional grants and programs can substantially facilitate the cost of a network buildout. In recognizing the need for broadband support, federal and state governments provide funding in areas recognized as unserved or underserved based on public data on broadband availability and speeds in different regions across the country. Historically, this data has been criticized as poorly prepared, marginally reliable, and overly generalized. As a result, a community like Cherry Hills Village may be considered as adequately covered and served by broadband providers, whereas residents may actively experience a lack of sufficient or affordable service. Within the context of these considerations, this section provides an overview of sources of funding that could help offset infrastructure and operational costs.

Fortunately, we are on the cusp of a generational investment in broadband infrastructure. The federal government and state legislatures across the country have recognized the need for broadband funding support. Numerous federal and state programs are currently either being rolled out or are in various stages of legislative consideration. The availability of these sources to offset infrastructure and/or operational costs for a broadband project in Cherry Hills Village depends on several factors:

- The scope of the project matches intended grant recipient profile
- The timeline for funding application and disbursement matches the anticipated schedule for the project
- Ensuring the completion of all conditions and goals of the grant
- Attaining the matching investment capital required by some grants

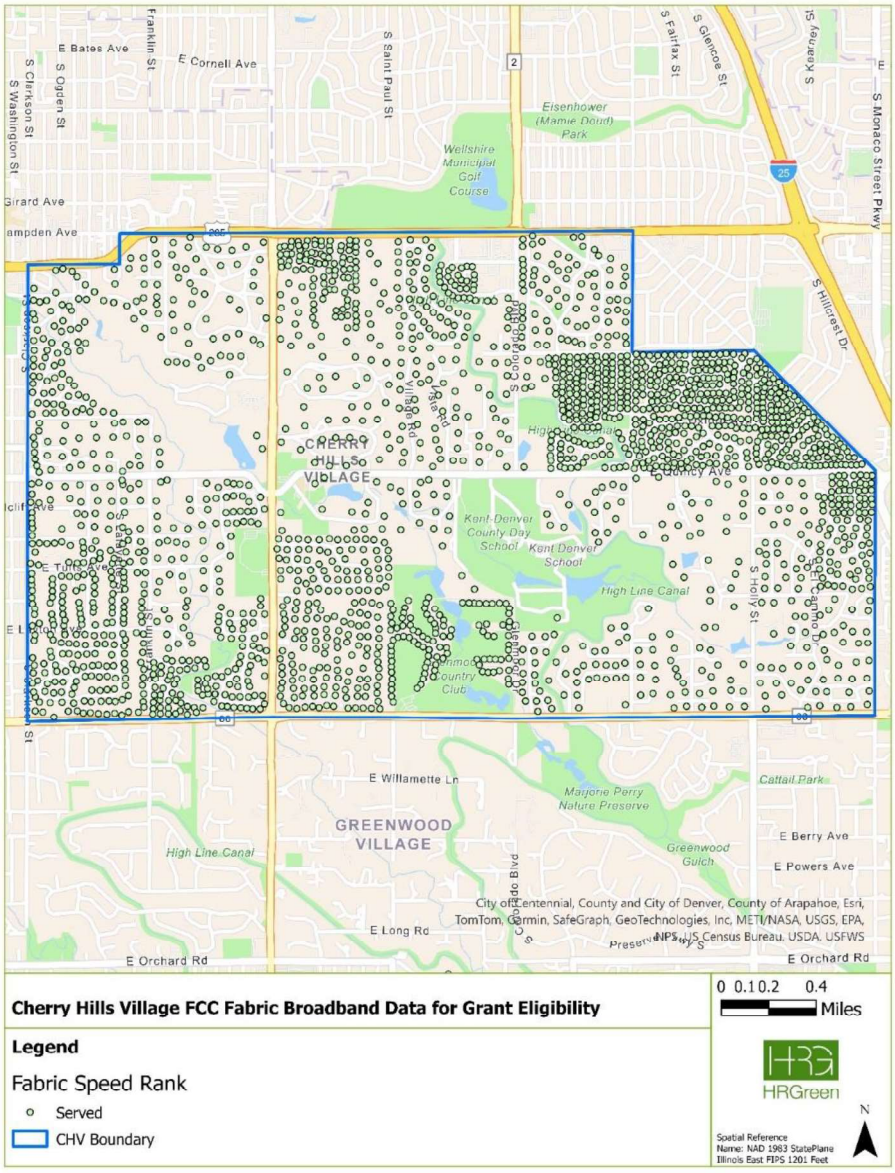
In addition, alternative funding sources could help offset infrastructure and operational costs. It is also important to maintain awareness of other funding sources. It is not uncommon for an agency (regional, State or Federal) to have targeted programs that can provide funding for broadband projects. These can range from utility related topics to community betterment to citizen specific needs to business attraction or retention, block grants, etc.

Cherry Hills Village may be potentially eligible to benefit from broadband project financing available from several sources, including federal and state broadband grant funding for eligible unserved and underserved areas, direct financing though bonds, debt financing though bank loans, and private investment and partnerships.

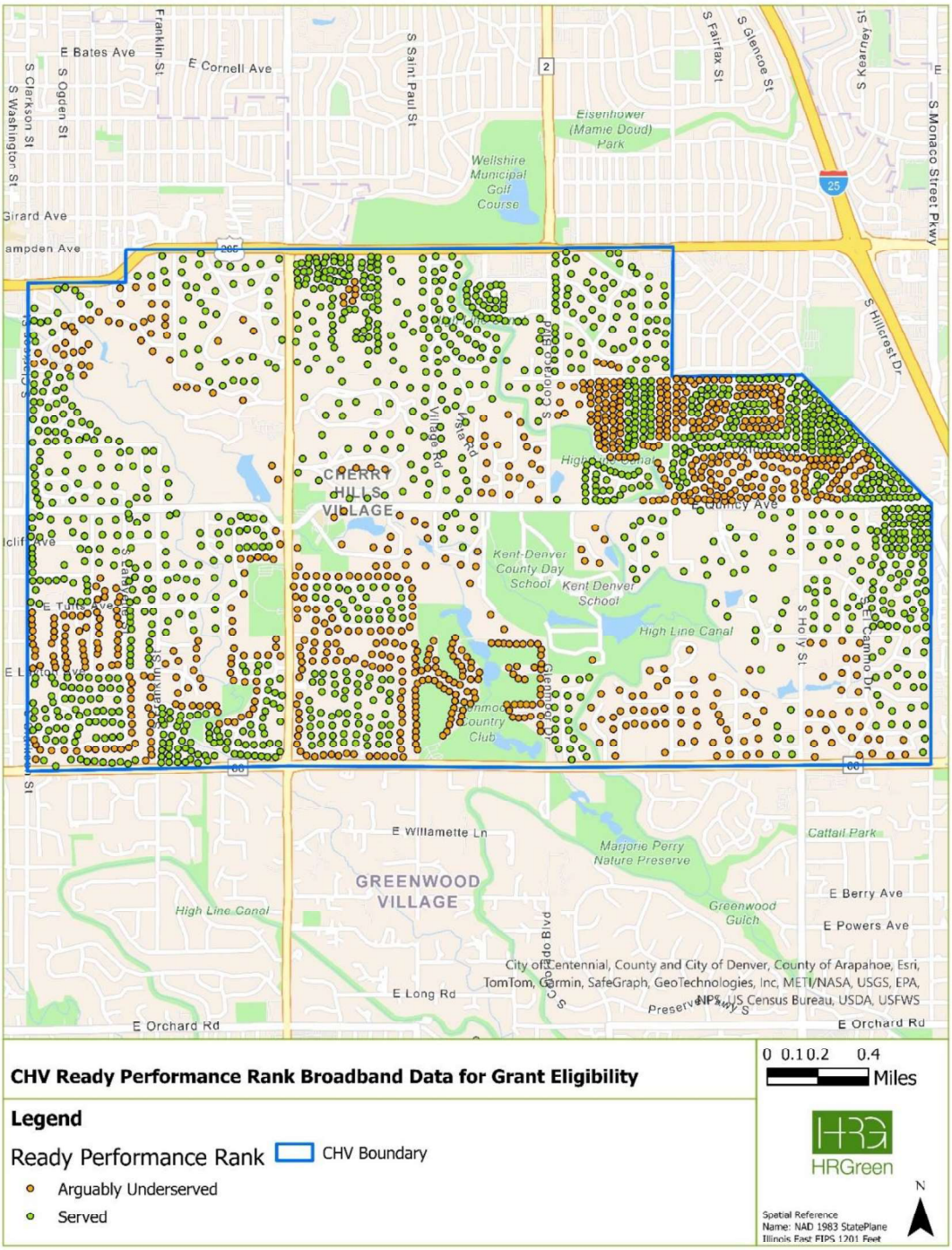
Colorado Grant Programs

In August 2023, the Colorado Broadband Office released the Five-Year Action Plan for BEAD. As required by the NTIA as part of the Broadband Equity, Access, and Deployment (BEAD) program, the Plan is a comprehensive plan to connect all Coloradans with high-speed broadband by 2028. The plan is based on the principles of universal access, equity, and sustainability. The Plan includes several specific initiatives to achieve these goals, such as expanding the state's middle-mile network, providing grants to local governments and nonprofits to build last-mile infrastructure, offering subsidies to help low-income Coloradans afford broadband service, and educating Coloradans about the importance of broadband access and adoption. The Plan also calls for the state to work with federal, local, and tribal governments to ensure that all Coloradans have access to high-speed broadband.

The BEAD program will fund $826.5M of broadband projects in Colorado. The BEAD application guidelines are expected to be released in April 2024, with the application opening in the summer. This program will provide funding to various entities, including local governments, nonprofit organizations, and Internet Service Providers (ISPs), to deploy broadband infrastructure and deliver internet services to areas with limited or no access.



The BEAD grant program aims to bridge the digital divide, ensure equitable access to education, healthcare, economic opportunities, and government services, and ultimately contribute to the overall socio-economic development of underserved and rural areas in Colorado. To be eligible for these grant programs, applicants must meet certain criteria, such as being in an unserved or underserved area, having a low-income population, or being a public entity. The amount of funding that each applicant receives will depend on the specific program and the needs of the community. The BEAD grant eligibility for providers within Cherry Hills Village is unlikely. The FCC Fabric map below shows that all residents in the City are 100% served with high-speed wireline broadband.



Nevertheless, the FCC Fabric maps may not fully reflect the reality of service in Cherry Hills Village. The Market Assessment included in **Section 4** of this Appendix highlights that the City is primarily served with cable coax technology, not the future-proof robust fiber, in most areas. Another source of information, which includes speed test data from the two largest aggregators Ookla and M-Lab, shows that the reality may be more nuanced. The above map shows the "Ready Score", which reveals that potentially some areas of Cherry Hills Village are underserved. For more information on how this data is compiled please visit: https://intercom.help/ready-6ebadf5aa1d5/en/articles/6809767-bsl-performance-rank-ready-performance-rank-explained.

Federal Grants and Loans

The federal government, through the FCC and the USDA, also provides funding for broadband programs around the country. The FCC, as mandated by the 1996 Telecom Act, implements universal service policies through the Universal Service Fund that is comprised of four programs: Connect America Fund, E-Rate, Rural Health Care, and Lifeline (supplying mobile devices to qualified low-income households – not included as relevant to this document). As an extension of the Connect America Fund Phase II Auction, the FCC also recently adopted the Rural Digital Opportunity Fund (RDOF) to serve rural homes and businesses and close the digital divide. The RDOF program is currently closed, but USDA Reconnect is launching a new application round based on FCC Fabric Maps.

United States Department of Agriculture (USDA) Programs

A. USDA ReConnect

Within the USDA, the Rural Utility Services (RUS) has been an important part of the development of utility infrastructure in the United States. They offer low interest loans for telecommunications based on the treasury rate. These rates change regularly, so it is important to check with RUS to get the most current rate. They also offer low interest loans for telecommunications used in electric utilities (of which the excess capacity can be used for other broadband services). RUS offers grants, loans and a combination of the two. RUS Programs include the ReConnect Program, the Telecommunications Infrastructure Loan Program, the Rural Broadband Access Loan, Community Connect Grants, and Distance Learning and Telemedicine Grants.

The last phase of ReConnect was in 2020, and it is opening again to allocate approximately $700M nationwide in grants and loans to support broadband in rural areas. The application is due by May 21, 2024. Considering the status of service within its boundaries, Cherry Hills Village is unlikely to qualify.

B. The Telecommunications Infrastructure Loan Program

This program provides financing for the construction, maintenance, improvement and expansion of telephone service and broadband in rural areas. Most entities that provide telecommunications in qualified rural areas including:

- State and local governmental entities
- Federally Recognized Tribes
- Non-profits, including Cooperatives, and limited dividend or mutual associations
- For-profit businesses (must be a corporation or limited liability company)

Areas that are eligible to apply include rural areas and cities with a population of 5,000 or less and areas without telecommunications facilities or areas where the applicant is the recognized telecommunications provider. The above information is available on the RUS website for this program: https://www.rd.usda.gov/programs-services/telecommunications-infrastructure-loans-loan-guarantees

C. Rural Broadband Access Loan

Stated purpose: The Rural Broadband Access Loan and Loan Guarantee Program (Broadband Program) furnishes loans and loan guarantees to provide funds for the costs of construction, improvement, or acquisition of facilities and equipment needed to provide service at the broadband lending speed in eligible rural areas. To be eligible for a broadband loan, an applicant may be either a non-profit or for-profit organization, and must take one of the following forms:

- Corporation;
- Limited liability company (LLC);
- Cooperative or mutual organization

- A state or local unit of government
- Indian tribe or tribal organization
- Individuals and Partnerships are not Eligible.

Areas that are eligible to apply:

- Proposed funded service areas must be completely contained within a rural area or composed of multiple rural areas, as defined in 7 CFR 1738
- At least 15 percent of the households in the proposed funded service area are unserved,
- No part of the proposed funded service area has three or more "incumbent service providers."
- No part of the proposed funded service area overlaps with the service area of current RUS borrowers or the service areas of grantees that were funded by RUS
- Communities where USDA Rural Utilities Service has previously provided funding for construction of broadband infrastructure may not be eligible.

The above information is available on the RUS website for this program: https://www.rd.usda.gov/programs-services/rural-broadband-access-loan-and-loan-guarantee

D. Community Connect Grants

The stated purpose of this program is to help fund broadband deployment into rural communities where it is not yet economically viable for private sector providers to deliver service. Grants are specifically targeted to local and tribal governments for very low-income rural communities (under 20,000 residents) with completely unserved and very low-income populations. Rural areas that lack any existing broadband speed of at least 10 Mbps downstream and 1 Mbps upstream are eligible. Within the area, 15% must be unserved and there cannot be three or more current providers. Because they are funding rural utilities, the municipal population must be less than 20,000 and not adjacent to a City of over 50,000.

The recipients must provide at least 4 Mbps Down/1 Mbps Up with free service to all households and community institutions for two years to a community center. One key with this grant is that the service area does not have to be uniform, but any areas that will be served must be contiguous.

With interest rates being as low as they are currently, if broadband construction is part of the adopted strategy, there should be an analysis of available loan providers and their interest rates. If RUS rates are not at least a point lower (and possibly more than that), then the filing and ongoing requirements might not be worth the difference in rate. Depending on the application requirements, RUS has typically taken 12 to 18 months to approve loans.

Depending on the strategy that the City pursues, if it includes building telecommunications infrastructure, RUS should be considered. The above information is available on the RUS website for this program: https://www.rd.usda.gov/programs-services/community-connect-grants

E. Distance Learning and Telemedicine Grants

The program helps rural communities become remotely connected to teachers and medical service providers. This program is particularly important during the time of the pandemic and has been provided an additional $25 million through the CARES Act. Relatedly, there are other funds made available by the CARES Act specifically for telehealth ($200m to FCC, $180m to HHS, and $2.15b to the VA). In addition, $13.5b was made available in Education Stabilization Funding to invest in technology supporting distance education, making school districts another eligible anchor tenant with potential support for expansion of the municipal broadband network.

For more information, please visit the program page at https://www.rd.usda.gov/programs-services/distance-learning-telemedicine-grants.

Federal Communications Commission (FCC) Programs

A. FCC Connect America Fund (CAF) and Rural Digital Opportunity Fund (RDOF)

The FCC conducted a Connect America Fund Phase II auction throughout 2018 and 2019 and the subsequent RDOF auction in 2020. Both programs are no longer accepting applications.

B. E-Rate

The Federal Communications Commission (FCC) established E-Rate to provide schools, libraries and universities with discounts of 20-90% off the costs of telecommunications, internet networks and ongoing expenses. E-Rate is administered through the Universal Service Administrative Company (USAC) with oversight provided by the FCC.

The specific dates that determine when schools and libraries can apply for funding can change slightly from year to year but follow a mid-winter to Spring pattern. Once the application process ends in the Spring, the funding year begins for those applications.

There is a specific ID a school or library must get, then specific forms to fill out to apply. And there are competitive bid requirements (there must be an RFP and it must be open for 28 days) to be eligible for the funding. And there are different options for how this will be paid to the institution and to the vendor. Also, there are documentation requirements that need to be understood and followed.

The level of E-rate funding for schools and public libraries is based on the number of students who participate in the free or reduced cost school lunch program at all the public K-12 schools in the City. Schools and libraries might be an important part of funding strategies for infrastructure. Excess capacity can be added to these networks at substantially less cost than an independent build.

Arapahoe County public libraries utilize the E-Rate program. Again, the level of funding for the libraries is based on the number of students who participate in the free or reduced cost school lunch program at all the public K-12 schools in the City.

Information about the E-Rate program can be found on the USAC website: https://www.usac.org/e-rate/

C. Healthcare Connect Fund

This fund was also created by the FCC and is administered by the Universal Service Administrative Company (USAC). It was created to give Health Care Providers (HCP) the ability to have broadband services that meet health care's capacity needs. It particularly encourages the formation of state and regional networks.

HCPs can apply individually or in a consortium. Funded applicants receive a 65% subsidy on all eligible broadband equipment and services. These dollars can be used for construction of networks. The intent of the funds is predominantly for rural healthcare providers. Urban facilities can be included if they are in a consortium that includes at least 51 percent rural providers. If there are health care providers who could be part of a holistic strategy, this fund could be an important component of connectivity. As with E-rate, excess capacity can be added to these projects at significant savings.

More information about the HCF can be found on USAC's website at: https://www.usac.org/rural-health-care/healthcare-connect-fund-program/

D. Affordable Connectivity Program (ACP)

In 2024, the Affordable Connectivity Program is ending due to funding running out. Originally, the Infrastructure Investment and Jobs Act (IIJA) of 2021 established the ACP as a $14B extension of the previous Emergency Broadband Benefit (EBB) Program initially passed as part of the December 2020 Covid-19 Relief package, after the appropriations are expended. The program contributed $30 dollars a month (lower than the $50 a month under the EBB) towards an internet service plan for qualifying households to help low-income families offset costs of broadband connectivity. The program also helped low-income individuals pay for personal devices. Individual Internet Service Providers will need to establish a replacement program where able, but no more Federal money is expected to continue funding the program.

Economic Development Administration

Within the United States Department of Commerce is the Economic Development Administration, which oversees Economic Development Assistance grants. Information about these grants can be found on the EDA website: https://www.eda.gov/funding/programs

Typically, these grants have been based on job creation. There are different categories of grants, but they all focus on how many jobs can be created. Broadband does appear to be fundable infrastructure, although there have not been a lot of broadband projects funded. Having said that, with broadband infrastructure being eligible and some projects having been funded, it should be considered.

The key questions seem to be: how many jobs can be created and how will this project directly impact job creation?

The EDA recommends contacting one of their regional Economic Development Representatives (EDR) to discuss projects and to have them review grant applications before they are submitted. Their typical timetable to submit applications is that they will receive applications at any time – although that is subject to available funds from year to year.

Housing and Urban Development (HUD)

HUD administers the Community Development Block Grant Program (CDBG). It was established to help communities address various community development needs. Based on a national formula relying primarily on census data, CDBG provides annual grants to more than 1,200 local and state governmental entities. Although CDBG grants have been utilized very little for broadband programs, HUD has confirmed that broadband programs can be eligible for CDBG dollars.

There are two main categories of grant eligibility: Entitlement and non-entitlement. Entitlement grants are awarded to larger cities and urban counties (greater than 50,000). Non-entitlement areas are for smaller cities and administered by states. Also, there are Section 108 loan funds which could be available. Grants can be used as security for Section 108 loans, leveraging the grant dollars for more impact. Non-entitlement areas can also use their grants in this way, but since they are administered by the State, the State would have to agree to leverage those funds.

Information about the CDBG program can be found on the HUD website:
https://www.hud.gov/program_offices/comm_planning/communitydevelopment

Bond and Loan Financing

Additional sources of potential funding include municipal bonds such as general obligation bonds, and revenue bonds, as well as bank loans or private investment financing.

The Cherry Hills Village has the option of issuing general obligation bonds or revenue bonds. General obligation bonds are guaranteed repayment by issuers by any means necessary, including increased taxes. Revenue bonds are repaid using the revenues from the bonds that the project facilitated in funding. Repayment is not guaranteed if the project potentially does not collect enough in revenue to pay back investors. These types of municipal bonds are not subject to income tax at the state or federal level if the investor is a resident of the state, although not all of Colorado's municipal bonds are tax free.

Often, the investor may be a local bank, mutual fund brokerage, or other type of financial institution. Cherry Hills Village can also pursue infrastructure project-based bank loans and private investment. The terms and conditions of these loans can vary based on continuous changes in state banking laws. It is recommended that these loans are combined with state grants and tax abatement programs to the maximum extent possible.

It is important to note that any bond or loan may trigger TABOR requirements per the Colorado Constitution and Colorado Revised Statutes.

Recommendations and Next Steps

Cherry Hills Village is unlikely to be granted any of the broadband grants, such as the BEAD program, because the FCC broadband maps consider it completely served. To become eligible, it may be advisable to conduct a more comprehensive broadband survey to serve as a data-evidenced basis for challenging the existing maps.

Appendix E: Broadband Technology Overview

Based on the current evolution of broadband funding at the state and national level, and the economic realities of broadband deployment costs, it is crucial to understand the relative advantages and costs of various broadband technologies.

Broadband network performance is frequently judged by throughput (or speeds). However, a more holistic evaluation of technologies will also consider more technical components, which make them supportive of emerging use cases like two-way video (videoconferencing), distance learning, telemedicine, and other uses.

For purposes of this review, technologies were evaluated on the following criteria:

- Area of Coverage: Fixed wireless and satellite broadband have the advantage of covering large geographic territories from a single point of presence such as a tower or orbiting station. Copper, coaxial and fiber require direct connection and physical network at each individual service point.
- Cost to Subscribers: For lower-income homes and small businesses, broadband service plans can represent a meaningful barrier to adoption. The cost of service, therefore, is a key consideration in evaluating possible technical solutions.
- Deployment Cost: Deployment of broadband technology nearly always involves the deployment of large amounts of capital with a business plan that typically seeks to cover the cost of that deployment plus interest, operating expenses, and profit over a long-service window (typically 4-20+ years). Costs vary significantly from high-capital deployments for fiber and coaxial cable to lower cost technologies such as fixed wireless or satellite.
- Throughput/Speed/Data Rate: The amount of data per unit of time successfully delivered through the network over a communication channel between two points.
- Service Reliability: The frequency of potential outages that compromise consistent access to the service. Wireless service is inherently less reliable due to propagation characteristics being heavily influenced by obstacles, clutter, and weather.
- Latency: The delay in the amount of time it takes for a unit of data to reach its destination across a network.
- Jitter: The variation in latency when transferring data. It is a defining metric in the network's ability to consistently transfer real-time data traffic such as Voice over IP (VoIP), video conferencing, and virtual desktop infrastructure.
- Packet Loss: The measure of unsuccessful attempts to transfer units of data to its destination.

The following table demonstrates each of the described technologies within given evaluation criteria on a scale of Good = **Green**, Average = **Yellow**, and Poor = **Red**.

	Fiber	Cable	DSL	Fixed Wireless	GEO Satellite	LEO Satellite	Cellular
Area of Coverage							
Cost to Subscribers							
Deployment Cost							
Throughput/Speed/Data Rate							
Service Reliability							
Latency							
Jitter							
Packet Loss							

Internet Technology Type by Performance Metrics

Each type of technology carries with it certain advantages and disadvantages in coverage, service capacity, and ease of installation and deployment. While fiber is typically the best technology in most metrics, it is also the most expensive to install. In contrast, satellite technology is ubiquitous, but does not meet many quality metrics necessary for maintaining robust and reliable customer service.

Fiber to the Premises (FTTP)

Fiber optic deployments rely on the construction of networks that convert electrical signals carrying data to light and send that information directly over small glass fibers about the diameter of a human hair. The key advantage of fiber optic cables is its capacity to carry massive amounts of information at nearly the speed of light, resulting in service that is symmetrical, low latency and capable of extremely high speeds. FTTP deployments are frequently viewed as the “gold standard” due to the technical advantages noted above. Providers of FTTP deployments frequently offer service plans of 100/100 Mbps or 1,000/1,000 Mbps (or Gigabit service).

Fiber deployments are either completed with buried or aerial construction methods. Buried fiber is the most secure method and avoids many of the risks of aerial deployment because they are immune to the effects of wind and ice damage. On the other hand, many providers prefer to deploy aerial cables on public rights of way and existing utility pole infrastructure. Aerial deployments create more risk of service disruption but the initial capital deployment for aerial fiber can be as much as 40 to 50 percent less than the cost of a buried deployment.

Fiber optic service does have many technical advantages, but the cost of deploying the physical infrastructure and supporting electronics necessary to operate the network can make fiber optic too expense for many rural and remote areas. This can be especially true in areas where geology includes rock and other difficult-to-dig areas.

Coaxial Cable (DOCSIS 3.0/3.1)

Most of the homes and businesses served by the incumbent cable providers are receiving their video and broadband on a technology known as Data Over Cable Service Interface Specification, DOCSIS 3.1. DOCSIS was launched by the cable industry to convert its original video distribution plant to a system capable of carrying not only video, but two-way transmission of data to and from customer premises. DOCSIS relies on a hybrid of coaxial cable and fiber optic cable to deliver services.

Like fiber optic networks, DOCSIS service technology relies on either buried or aerial distribution of cables to carry data and video to customer premises. The implementation of DOCSIS 3.1 allowed the cable industry to compete with new fiber-to-the-home providers by significantly increasing download speeds for customers. The technology is capable of up to 10Mbps (10 Gigabit) speeds, but most cable service plans currently available in the market feature 100Mpbs or 250Mbps offerings.

One of the limitations of a coaxial cable plant is the significant expansion of available upload speeds. Many cable providers, in fact, still offer uploads speeds between 3 and 35 Mbps. This capacity has been sufficient for many of the historic uses of broadband, but many emergent uses (telemedicine, video conferencing, remote learning) rely on both up and download capacity and there have been reports of dissatisfaction with DOCSIS in this more symmetrical environment.

The cable industry is also investing in direct fiber-to-the-premises for business and enterprise customers, while initiating the deployment of the next DOCSIS evolution to increase both download and upload speeds.

Digital Subscriber Link (DSL)

DSL service was implemented by the incumbent telephone companies as a replacement for dial up internet. The technology has seen several upgrades and can support asymmetrical speeds of up to 25/3 Mbps. DSL is one of the most prevalent technology deployments available in the City's service area, as local and incumbent providers have continued to update older 10/1 Mbps DSL service to newer technologies capable of meeting the federal broadband standard of 25/3 Mbps and, with some upgraded equipment speeds of up to 100/10 Mbps.

One concern with DSL is the use of "up to" speeds when compared to actual speeds realized by customers. Because DSL is reliant on existing copper pair telephone lines, physical proximity to transmitting equipment is a key factor in determining actual speeds. While customers who are close to DSL gear receive speeds near the advertised speeds, there is a significant degradation of DSL speeds as customers move further away from the point of presence.

On the other hand, DSL continues to provide some of the lowest cost of services in the industry. The typical DSL internet bill is in the $50-$60 range, which compares favorably with the pricing of satellite service providers.

Fixed Wireless

Fixed wireless internet uses radio waves transmitted from a cell tower to foster an internet connection. This connection can be transmitted over either the federally licensed spectrum or via unlicensed spectrum. Unlike the wired services outlined above, fixed wireless simply relies on an exterior antenna to provide homes and businesses with broadband level services.

Fixed wireless is also different from satellite broadband in that signals are usually connected at the tower to a backhaul fiber network to carry the signal onward to the internet. While speeds, latency, and path loss due to clutter (obstacles like trees) or weather events are generally inferior to fiber and coaxial technologies, those metrics are generally superior to satellite service.

Fixed wireless internet broadband is frequently a positive alternative to traditional DSL service, offering higher connectivity speeds than those available from DSL providers. Because it is not dependent on physical connections, it is well suited to rural and remote settings. Many wireless providers offer low latency and higher data allowances that are available from satellite providers that are a traditional alternative to DSL in rural and remote geographies.

Satellite Broadband

Geostationary Orbit

Most known satellite internet service has been traditionally provided from geostationary earth orbit (GEO) satellites that orbit at exactly 22,236 miles above the earth, but recent technology is enabling service from other orbits as well, most notably Low Earth Orbit (LEO) - less than 1,200 miles in altitude. In between, Medium Earth Orbit (MEO) satellites, such as GPS, are at approximately 12,550 miles in altitude.

GEO satellites have been used as internet service technology by providers such as ViaSat and Hughes Network Systems for decades. HughesNet controls roughly 60% of the satellite internet market in the United States. Many GEO satellite internet companies are located in Colorado.

GEO satellite service represents an improvement over early dial up and copper-based technologies, which only offered speeds up to 10/1 Mbps. Because of this, adoption of GEO satellite service has been primarily in geographies described above as remote, and in some rural and remote areas it represents the only available alternative that meets the 25/3 Mbps FCC standard for broadband.

With GEO satellite internet, a consumer can receive .5 Mbps download and 80 Kbps (less than 1 Mbps) upload speeds.[viii] These data rates are typically lower than any other internet service technology, except dial-up which is now an exceedingly rare service.

A report by the Congressional Research Service in August 2021 notes a number of key challenges with GEO satellites as a technology that supports future-forward broadband needs.[ix] The distance that data must travel to a satellite in orbit and back results in lower data rate, higher latency, and a lack of reliability in using many real-time applications such as video conferencing. Latency of GEO providers averages nearly 636 milliseconds (ms) for the two large commercial providers. For comparison, reliable online gaming requires latency less than 20 ms. Technology experts have noted many challenges with the use of this technology during the recent pandemic.

The report also notes that GEO service carries a higher average price to consumers and businesses. The average price of a GEO satellite plan is $123 per month, compared to an average of $52-$59 per month of traditional wired services.

For decades, satellite constellations have been lauded as terrestrial alternatives and there has been a boom-and-bust economy for satellite constellations hoping to replace commercial wireline and wireless networks. Due to high start-up costs, launch costs, and a slowness to respond to communications technology upgrades, notable satellite internet companies such as Teledesic, Iridium, and Globalstar filed for bankruptcy protection throughout the 1990s and 2000s. More recently, Intelsat, OneWeb, Speedcast, and Global Eagle continue to experience bankruptcy issues.[x]

Low Earth Orbit

While GEO satellite broadband has been available for dozens of years, a number of companies announced (or are already deploying) constellations of low-earth orbit (LEO) satellites to improve on the traditional challenges with existing satellite provider services. Due to the constellation's closer distance to the earth, LEO satellite service promises to significantly improve on speed of service issues, with a particular focus on latency and upload speed improvements.

Speculation on LEO internet service focuses on its promise to provide broadband service similar in quality achieved with wireline or terrestrial wireless technology. The technology holds the potential to resolve the digital divide in areas with challenging topography where it is difficult to deploy terrestrial infrastructure and to provide service to mobile users (in cars, airplanes, at sea).

LEO satellites operate at much lower altitudes comparing to MEO and GEO satellites but require a network of thousands of satellites that orbit at a height of 300+ miles above earth. The vastly larger number of satellites allow the allocation of more network resources, but also require frequent handovers between satellites when communicating with ground receivers.

This relatively low orbit proximity to earth's surface reduces latency when compared to higher satellite orbits but is still a much longer distance than cellular (LTE/5G) networks. Weather and the consumer's line of sight to the satellite can also greatly vary service quality and reliability.

Cellular Broadband

The evolution of cellular connectivity through 4G, LTE, and now 5G service have created opportunities for some customers to eliminate traditional wired or wireless broadband services and to rely entirely on their cell phone or cellular hot spots to provide home connectivity. Cellular broadband is designed for mobility, particularly in higher traffic areas. It varies widely in service quality depending on service area, signal strength, technology hardware, software protocols, modulation coding and schema, number of active users, applications, and many other factors which can significantly compromise its consistent use and reliability. It can be an option in rural and remote areas where alternatives are not available, but wireline internet service access is likely to be more reliable.

Appendix F: Definitions

The definitions below have been compiled from Cherry Hills Village Municipal Code, and a variety of other sources, including the online version of the Merriam-Webster Dictionary and Wikipedia.

Antenna

An apparatus designed for the purpose of emitting radiofrequency ("RF") signals, to be operated or operating from a fixed location pursuant to Federal Communications Commission ("FCC") authorization, for the provision of personal wireless service (such as cellular service) and any commingled information services. For purposes of this definition, the term "antenna" does not include an unintentional radiator, mobile station, or device authorized under 47 C.F.R. part 15.

Broadband

A high-speed communications network that is divided into multiple independent channels for simultaneous transmission of signals (such as voice, data, or video). The network medium can be coaxial cable, optical fiber, wireless (cellular), twisted pair (telephone wire), or satellite.

Cellular

A radiotelephone system in which a geographical area (such as a city) is divided into small sections each served by a transmitter of limited range.

Last Mile

The final leg of the telecommunications networks that deliver telecommunication services to retail end-users (customers). More specifically, the *last mile* describes the portion of the telecommunications network chain that physically reaches the end-user's premises.

Macrocell Facility

A cell site in a cell phone network that provides radio coverage served by a high-power antenna. Generally, macrocells provide coverage larger than *Small Cell Facilities*. The antennas for macrocells are mounted on ground-based masts, rooftops, and other existing structures, at a height that provides a clear view over the surrounding buildings and terrain. These facilities are around 50 to 200 feet tall.

Middle-Mile

In a local government environment, the segment of a local government telecommunications network that links a local government's facilities and potentially community anchor institutions (Public Safety Organizations, Educational Institutions, Libraries, Medical Facilities, Recreational Facilities, etc.) together and may also link to one or more internet service providers (ISP). The term *middle mile* arose to distinguish this part of the network from the *Last Mile*.

Radio Frequency (RF)

Any of the electromagnetic wave frequencies that lie in the range extending from below 3 kilohertz to about 300 gigahertz and that include the frequencies used for communications signals (as for radio and television broadcasting and cellphone and satellite transmissions) or radar signals.

Served

The FCC defines this as at least 100 Mbps download speed and 20 Mbps upload speed.

Small Cell (Small Wireless) Facilities

Facilities that meet each of the following conditions:

(1) The facilities—

a. Are mounted on structures fifty (50) feet or less in height including their antennas, or

b. Are mounted on structures no more than ten (10) percent taller than other adjacent structures, or

c. Do not extend existing structures on which they are located to a height of more than fifty (50) feet or by more than ten (10) percent, whichever is greater;

(2) Each antenna associated with the deployment, excluding associated antenna equipment is no more than three (3) cubic feet in volume;

(3) All other wireless equipment associated with the structure, including the wireless equipment associated with the antenna and any pre-existing associated equipment on the structure, is no more than twenty-eight (28) cubic feet in volume;

(4) The facilities do not require antenna structure registration under 47 C.F.R. part 17; and

(5) The facilities do not result in human exposure to radiofrequency radiation in excess of the applicable safety standards specified in 47 C.F.R. § 1.1307(b).

Telecommunications

The transmission, between or among points specified by the user, of information of the user's choosing, without change in the form or content of the information as sent and received.

Underserved

The FCC defines this as being speeds less than 100 Mbps download speed, but greater than 25 Mbps download speed, and less than 20 Mbps upload speed, but greater than 3 Mbps upload speed.

Unserved

The FCC defines this as being speeds of up to 25 Mbps download speed and 3 Mbps upload speed.

Wireless Communication Facilities

Facilities that transmit and/or receive electromagnetic wireless communication signals. It includes antennas, microwave dishes, horns, and other types of equipment for the transmission or receipt of such signals, communication towers or similar structures supporting said equipment, equipment buildings, parking area and other accessory development. A wireless communication facility does not include a facility entirely enclosed within a permitted building where the installation does not require a modification of the exterior of the building; nor does it include a device attached to a building, used for serving that building only and otherwise permitted under other provisions of this Chapter.

Appendix G: End Notes

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[viii] https://transition.fcc.gov/indians/opportunity.pdf

[ix] https://crsreports.congress.gov/product/pdf/R/R46896

[x] SpaceNews. "Op-Ed | Satellite Bankruptcies circa 2000 vs. 2020: We've Come a Long Way!," April 15, 2021. https://spacenews.com/op-ed-satellite-bankruptcies-circa-2000-vs-2020-weve-come-a-long-way/