City of South San Francisco
Broadband Strategic Plan

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Final Report

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An ENTRUST Solutions Group Company

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1. Executive Summary

The City of South San Francisco's Broadband Strategic Plan is a culmination of efforts to enhance City communications and facility connectivity, public infrastructure development, economic growth, and community access and affordability. Key findings and conclusions from each section are distilled below:

Asset Inventory

There is significant infrastructure within South San Francisco that can be leveraged for broadband – whether as locations in the public sphere or right-of-way to host equipment, conduit, and fiber pathways to connect facilities and neighborhoods, opportunities to deploy smart city devices and applications, or integration of public and private networks in innovative partnerships.

The City operates an internal dark fiber network that interconnects key facilities, with bandwidth of 1-10 Gbps, depending on location, provided by a private Internet Service Provider (ISP). However, the City network does not connect all City locations, does not have a fully redundant “ring” architecture or diverse routing, and does not yet extend up Sign Hill.

As shown in Figure 1, the City’s conduit and fiber network includes 19.2 miles of existing conduit, and 4.9 miles of existing fiber optic cable. The City has an additional 12 City sites and 6 community facilities that require connectivity. There are also 98 traffic signals across the City, but only 13 of these are currently connected (or in process) on the network. There is a CIP project underway to incrementally connect traffic signals with fiber optic cable where prioritized or when aligned with City communications networks.

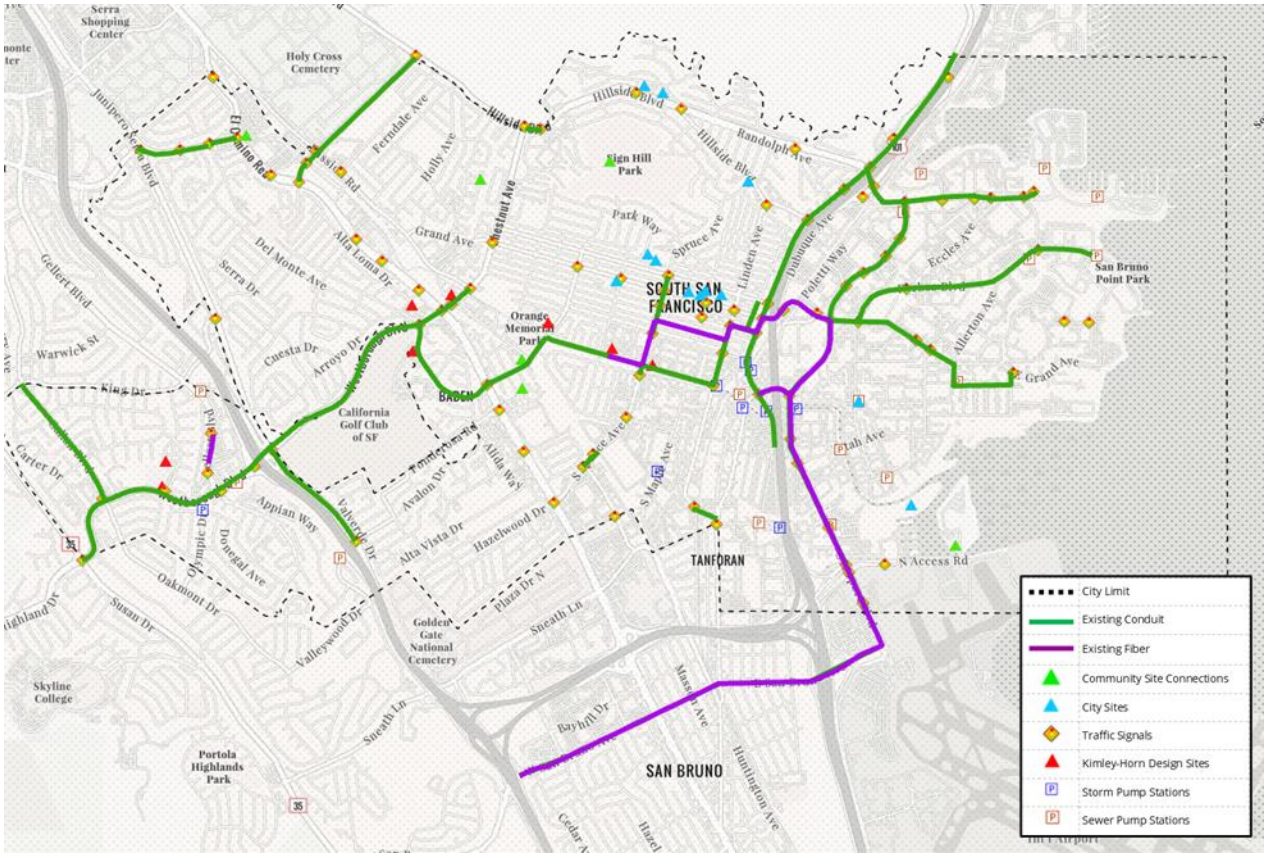

Figure 1. City Assets & Public Facilities

The City network is being leveraged by a project that will connect nine critical City sites and 13 traffic signal cabinets, as well as extending backbone fiber into two underserved neighborhoods to expand community access. The estimated construction costs for this Critical City Site project are estimated at $1.9 million and includes 1.5 miles of conduit and 7.7 miles of fiber cable.

The City is also coordinating with the City/County Association of Governments in San Mateo County on the design of a Smart Corridor project, which will develop a traffic management system along key arterial corridors that parallel U.S. Highway 101 and Interstate 280. This project will install additional conduit and fiber cable, providing the City the opportunity to further expand its fiber network. This project is synergistic with the City project to extend a City-wide traffic signal interconnect network using fiber optic cable.

Needs Assessment

Although the City is generally considered "well-served" at a high level (under FCC standards)[1], there are significant areas and neighborhoods that are challenged by a lack of high-speed broadband – whether due to a lack of private infrastructure from AT&T and Comcast, or because of income, language, or socio-economic challenges related to the Digital Divide.

There are many census blocks within the City where more than 10% of households lack an internet connection – exceeding the national average. Moreover, there are more than 6,700 households within the City that qualify for the federal Affordable Connectivity Program (ACP) subsidy, which provides up to $30/month to help households pay for internet access; only about 18% of these households are actually participating in the program, falling well short of participation levels statewide or nationwide.

The California Public Utilities Commission (CPUC) has identified many households and businesses across the City that qualify as "unserved," defined by the State as without broadband service meeting the minimum standard of 100 Mbps download and 25 Mbps upload capabilities. This unserved status not only identifies areas where the Digital Divide is impacting households and opportunities for employment, remote learning, telehealth, and other services that utilize the internet, but these locations also are eligible for several State broadband grants.

In order to better understand the realities for South San Francisco residents and the City departments tasked with providing services to these stakeholders, Magellan and the IT Department conducted 17 meetings and interview sessions with over forty individuals from throughout City departments, the City Manager's office and elected officials, and with multiple community-based organizations.

Interview participants emphasized the Digital Divide made the response to the COVID-19 pandemic much more difficult, particularly among underserved groups struggling to access community and government services. Each of these community organizations stressed the crucial importance of affordable internet. Internet access remains out of reach for a significant portion of the population since many residents and clients have fixed and limited incomes.

[1] The current FCC standard for "broadband service" is a minimum of 25 Mbps download speed and 3 Mbps upload speed. Many consider this definition to be inadequate and outdated. The Infrastructure Investment and Jobs Act sets a higher definition for minimum speeds to be considered "broadband" at 100 Mbps download and 20 Mbps upload.

Additionally, poor wireless coverage affects the public, community service organizations, public safety, and field staff of City departments among others. Wireless gaps hinder public safety, event and visitor connectivity, and wireless broadband availability to businesses and residents. Construction and completion of the Community Wi-Fi network is hindered by a lack of response from PG&E to project permit application to install Wi-Fi equipment on 74 PG&E poles. The project permit applications have been pending in various administrative forms since November 2022. There is urgency to define an agreed path forward to complete the installation of the Community Wi-Fi network access points so it is important to continue work to identify the decision maker at PG&E and/or the CPUC that can make this happen.

Broadband Policies and Initiatives

Broadband-friendly policies and initiatives will form the backbone of the City's efforts to expand communications infrastructure, enhance connectivity, enable digital inclusion, and create a future-ready environment. These strategies are instrumental in propelling the city toward bridging the digital divide and fostering a technologically empowered community.

The City's Open Trench Notification policy and road moratorium policies *work together* to support efficient and effective placement of broadband infrastructure, discouraging utility providers from uncoordinated actions that excavate newly paved roads, while incentivizing cooperation for facility placement.

Other long-range capital improvement projects may involve significant excavation and improvements that provide the opportunity to jointly deploy broadband assets at incremental cost, typically through adding communications conduit to open trenches/excavation, or by planning for wireless/Wi-Fi capabilities and smart city applications on poles, public buildings, or other public areas. Magellan reviewed and identified 23 projects in the City's CIP that could expand broadband infrastructure using a joint trench approach.

The City Council has approved the Lindenville Specific Plan including a condition of approval that requires placement of conduit for the purpose of future fiber installation. The City could list further standard installation requirements similar to other cities' requirement, and these standard conditions of approval should be considered for all development work citywide, so that future development of broadband and fiber optic deployments can be expanded at marginal cost, thus ensuring future broadband competition and internet access.

The City seeks to deploy more Smart City applications, such as cameras, irrigation sensors, street lighting with controlled dimming, automated cross walks, real time bus

signage, parking management and navigation, license plate readers, and more. The City should consider the formation of a Smart City Steering Committee to provide focus and maintain momentum for Smart City projects. This Committee should be cross-departmental, including senior leadership from all relevant departments, and may even consider inter-agency communication for expanded impact.

Ultimately, these opportunities for joint trench, dig once, and smart city deployment will require future influx of City funding to secure materials and equipment. The City should create a Technology Enterprise Fund that can be used for future broadband infrastructure, with an initial seed funding allocation, and sustainably maintained by dedicating future revenues from telecommunications leases, licenses, and other revenue-generating activities enabled by the City's broadband infrastructure. The unscheduled nature of joint trench/Open Trench Notification opportunities means cities need a dedicated funding source outside of the normal budgeting process to take advantage of new or unforeseen opportunities for broadband expansion, which might be missed under conventional budgeting practices.

Conceptual Network Design

The conceptual network design for the City identifies fiber routes and other infrastructure requirements to meet identified City needs. The Conceptual Network Design[2], as shown in Figure 2, includes approximately 4.4 miles of new backbone conduit and fiber, 1.4 miles of new service drops/laterals, 5.1 miles of new fiber pulled into existing City conduit, and interconnecting 2.5 miles of the existing City fiber network with splice points, handholes, cabinets and supporting infrastructure. The conceptual design also includes interconnectivity with the California Middle-Mile Backbone Initiative (MMBI), the planned state-wide middle-mile project, to ensure regional interconnectivity and route redundancy.

2 The Conceptual Network Design assumes that the Critical City Sites design recently completed by Kimley-Horn has been constructed and is operational – i.e., that this phase of the project is a part of the "existing City assets." Thus, the anticipated lengths, breakdown, and construction costs for this particular phase are not included in the cost estimates.

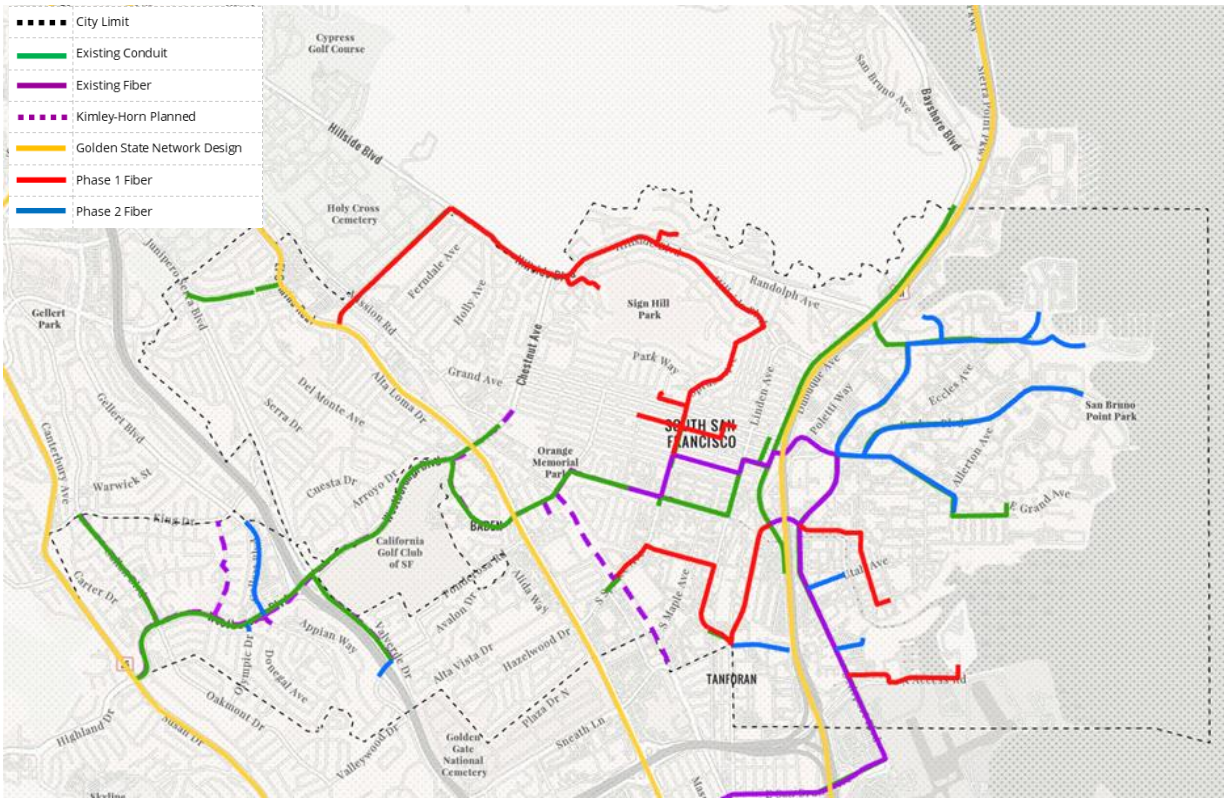

Figure 2. Conceptual Network Design

The Conceptual Network Design can be constructed in a 2-phased approach in order to prioritize the loop architecture necessary for greater community and business access, ensure critical site connectivity, provide flexibility relative to grant availability, budgets, and resource constraints, and to maximize the network reach into new markets to attract a private partner. The phases can be further broken down into sub-phases or built incrementally and opportunistically through effective CIP and private project coordination.

Phase 1 ensures a citywide redundant loop architecture that minimizes service interruptions, connects 14 remaining City and community facilities currently not on the network, and 20 traffic signals. Further loop redundancy of fiber connections, particularly to the west, can be achieved in the future opportunistically using joint trench opportunities and projects such as the Mission Road Rule 20A project for utility undergrounding which would provide a segment of conduit.

Phase 2 adds fiber network connectivity to 14 sewage pump station sites. Two things should be noted about Phase 2. First, two-thirds of the Phase 2 additional fiber would be deployed through existing City conduit, which is considerably cheaper than new underground construction (estimated to be $25 per foot versus $125 per foot). Second there are at least 23 traffic signals along these routes so there would be

synergies among programs (wastewater and traffic control, as well as other uses) for this extension of the City's network. Thus, the case could be made to move this deployment up the prioritization list to be funded opportunistically via joint trench opportunities and Technology Enterprise Fund.

Similarly, the Water Quality Treatment Plant could be moved up the priority list. Within the planning horizon the City has the opportunity to prioritize network construction flexibly such that the Phase 1 and Phase 2 identification in this Plan can be modified going forward. These modifications can include other storm water pump stations as they are upgraded, such as the Airport underpass, South Maple, and South Airport.

Ultimately, milestones and timelines will be established in execution of this Plan for buildout of Phases 1 and 2, including city implementation under CIP, Development adding segment pieces, opportunistic joint trenching, and the Technology Enterprise Fund. Funding will be the important constraint.

The estimated construction cost for the entire Conceptual Network Design (both phases) is approximately $4.2 million. This estimate accounts for design, engineering, permitting, upgrades to existing infrastructure, and the deployment of new underground conduits and fiber cables. The design engineering and field surveying process would verify and record all existing assets and could uncover additional fiber that would eliminate the need for some of the new construction, thereby lowering the total overall construction costs.

Public/Private Partnership Considerations

Alternative business models a city may select range along a risk/reward continuum, from "passive" models (policy and infrastructure only) to "active" models (full retail operation). The choice of business model needs to align with the vision of the community and its leadership and be one that fits organizationally into the City's municipal operation. The Public Private Partnership ("P3") model appears to align best with the City of South San Francisco's vision, operations, and risk/reward tolerances.

A P3 would allow the City to leverage its existing and planned fiber optic network assets to expand broadband availability in the community by making the network available for use by private Internet Service Provider (ISP) providers.

To begin creation of a P3, the City should publicly solicit potential partners via a Request for Proposal (RFP) and select through negotiation one or more private or public ISPs to provide and sell retail internet services over a network incorporating desired segments of City-owned fiber in exchange for lease payments, revenue share, new City network construction, or a combination thereof. Soliciting and selecting a

private partner is not a typical procurement process but is a negotiated arrangement that will take time to define and finalize.

Key Recommendations

1) *Expand the City's Fiber Backbone to Improve City Facility Connectivity, Expand Community Broadband Access, and future-proof the network.*

The City can complete a carrier-grade backbone loop that connects 18 City facilities, 25 pump stations, and 98 traffic signals at an estimated cost of $4.2 million. The phased approach allows for incremental builds as resources and funding allow, while laying out a roadmap for coordination and alignment with other major projects to minimize costs. A carrier-grade fiber loop will also enable the City to identify a qualified private ISP that can operate, manage, and maintain the network while expanding broadband access in the community at competitive rates.

Extending the City's fiber network under the conceptual design will also future-proof the network and support emerging applications such as Emergency Vehicle Preemption (which is planned) and connected vehicle needs via next generation 5G and 6G wireless services which must be connected with fiber backhaul.

2) *Initiate Design & Engineering for Phases 1 & 2 at an estimated cost of $130,400.*

The first two phases of the Conceptual Design – Citywide Redundant Loop and City Facilities – create a high impact and maximize the value of the City's network (and thus attract private investment). By undertaking design engineering, the City would be demonstrating a commitment to moving forward – being "shovel ready" – and thus enhancing its grant competitiveness for state and federal broadband grants.

Design engineering would include field surveying and verification, identifying additional usable assets that may not be recorded in City maps, value engineering to reduce the overall cost, confirming the final routing and design, and compiling a Bill of Materials.

3) *Solicit & Negotiate a Public-Private Partnership to Operationalize the City's Broadband Network.*

The City's existing network, its role within the Smart Corridor project, and the Conceptual Network Design proposed in this Strategic Plan - as well as the planned expansion through the Critical City Site Design project recently completed by Kimley-Horn – have positioned the City to be able to expand the benefits beyond just City

administration and services and into the community at large. However, operationalizing, monetizing, and managing a retail data network requires resources, staffing, and start-up capital that likely exceed the City's existing capacity. The City should transparently solicit a public-private partnership through an RFP to find a qualified ISP that is willing to manage, maintain, market, and operate the City's network in exchange for a portion of the revenues generated through retail sales.

4) Pursue Competitive Grant Opportunities through State and Federal Broadband Grants.

The State of California, through the Advanced Services Fund (CASF), has $150 million in annual allocations (through 2032) for broadband grants for infrastructure, public housing, and adoption programs. The City is eligible for these funding sources and should pursue these grants to provide for construction of the Citywide Conceptual Network, for the marginal costs to connect CPUC-designated unserved households and other at-need neighborhoods, and to assist with digital literacy and navigation programs in the community.

5) Coordinate Joint Build and CIP Projects for Broadband Expansion.

Coordinating infrastructure expansion through joint utility work and CIP projects is the most cost-effective strategy to expand City broadband assets, particularly into under-served areas and new developments. Effective coordination on all projects that require excavation will ensure that all utilities—public and private—can economically expand their broadband footprint in the South San Francisco. The City can incrementally and opportunistically build its own fiber network, connect key City facilities, and enable Smart City applications. Effective joint build and utility coordination requires an effective and enforced "dig once" ordinance, a strong road moratorium, a curated master project list that aggregates all public and private excavation work in the public right-of-way, and organized, regular meetings between the various agencies and utilities.

6) Apply Development Conditions to Major Projects

Planning ahead for a broadband future is the most cost-effective way to both minimize costs and ensure new housing and commercial development thrives. The City should add broadband and fiber expansion to the existing public infrastructure requirements (water, sewer, sidewalks, etc.) that developers must finance and construct for new developments.

The City Council has approved the Lindenville Specific Plan including a condition of approval that requires placement of conduit for the purpose of future fiber installation. This condition requires the installation of "three-inch diameter PVC conduit along the project frontage, in the right-of-way, if any trenching is to take place, for the purpose of future fiber installation. Conduit shall have a pull rope or tape. A #8 stranded trace wire will be installed in the conduit or other trace wire system approved by the City." The City could list further standard installation requirements similar to other cities' requirement, such as depth requirements (laid to a depth of not less than 18 inches below grade in concrete sidewalk areas, and not less than 24 inches below finished grade in all other areas when feasible, or the maximum feasible depth otherwise), install minimum 3-foot radius sweeps and bends, furnish with an external "warning" ribbon tape a minimum of 3-inches above the conduit, and all conduit couplers and fittings shall be installed watertight, with sealed end caps upon installation.

These standard conditions of approval should be considered for all development work citywide, so that future development of broadband and fiber optic deployments can be expanded at marginal cost.

7) Establish a Technology Enterprise Fund

Many cities create dedicated funds for revenues generated from leases of City assets by private telecommunications companies. A dedicated fund with ongoing revenues—separate from the General Fund—prioritizes new City/public technology deployment for future build opportunities (funding for fiber network expansions through incremental builds/joint trench coordination or for locating new smart city devices concurrent with expansion of private wireless connectivity).

Creating an enterprise fund helps plan strategically for the years to come when use of public assets/ROW will increase and could create significant new City revenues. The unscheduled nature of joint trench/dig once opportunities means cities need a dedicated funding source outside of the normal budgeting process to take advantage of open trenches.

The City should consider holding revenues generated by the City through lease or other agreements for use of City broadband infrastructure – including cellular antennas on street light poles, placement of cabinets or vaults in the ROW, leasing land or towers for cell tower installation, dark fiber or conduit occupancy leases, or other telecom-related/ROW revenue generating activities – in a separate account to offset maintenance and expansion costs.

8) Use City Communications to Inform and Promote Use of the FCC Affordable Connectivity Program (ACP)

The ACP is a major cost-free tool for addressing digital equity issues. ACP enrollment in South San Francisco (18% of eligible households) is less than half the average level of both the state of California (38%) and the United States (39%). The City should support inclusion of Affordable Connectivity Program information in communications and outreach for communities, consumers and programs to raise awareness of the ACP benefit and further information on eligibility and enrollment. Examples include making sure schools, libraries, heath clinics and community centers know about ACP and have information needed to help eligible students, clients and patrons enroll. Put outreach materials in the hands of teachers, health care providers and community workers. These materials are available at ACP Consumer Outreach Toolkit | Federal Communications Commission (fcc.gov)

2. Asset Inventory

Inventory and assessment of the City and public infrastructure assets that can be leveraged for broadband use is an essential first step in developing a comprehensive broadband strategic plan. Magellan identified significant infrastructure within South San Francisco that can be leveraged for broadband – whether as locations in the public sphere or right-of-way to host equipment, conduit and fiber pathways to connect facilities and neighborhoods, opportunities to deploy smart city devices and applications, or integration of public and private networks in innovative partnerships.

2.1 CITY FACILITY CONNECTIVITY

The City's Information Technology (IT) Department manages its existing fiber optic "iNet" facilities to serve City needs and it plans to extend fiber connectivity through the City to connect all City buildings. Capacity is provided via an enterprise-wide area network (WAN) built with dark fiber from a private ISP, Wave (now Astound). This iNet interconnects key buildings at 10 Gbps, with other buildings connected at 1 Gbps. However, the iNet City fiber does not connect all City locations, does not provide full redundancy via diverse routing, and does not yet extend up Sign Hill. Expanding fiber connections up Sign Hill is important for EMS radio communications, expanding Wi-Fi to the public, fire monitoring and other smart city initiatives. Also, fiber connectivity is useful to support use of point-to-point technology where fiber is not available (for example, to Paradise Valley).

The City's network uses Dense Wavelength Division Multiplexing" (DWDM) to serve additional sites and support higher bandwidth in the future. DWDM is an optical technology used to increase available bandwidth on existing fiber optic facilities by combining multiple signals simultaneously at different wavelengths on the same fiber. This transmission technique uses multiple light wavelengths or colors to send data over the same fiber. The City is using this network both for its own needs and to provision extended reach for private partners, all while avoiding the cost and disruption of repeated additional construction in the public rights of way.

Figure 3 shows the Community Site connections including the Housing Authority, Boys and Girls Club, Safe Harbor Shelter, Sign Hill, and Treasure Island Mobile Home and RV Park; the City Sites are identified in Table 3, below, while the Critical City Sites design project are identified in Table 1, below. Figure 4 shows the City's current fiber networking, fiber routes recommended for connecting additional City and community sites, adaptive traffic signals in this Plan, all by Council District.

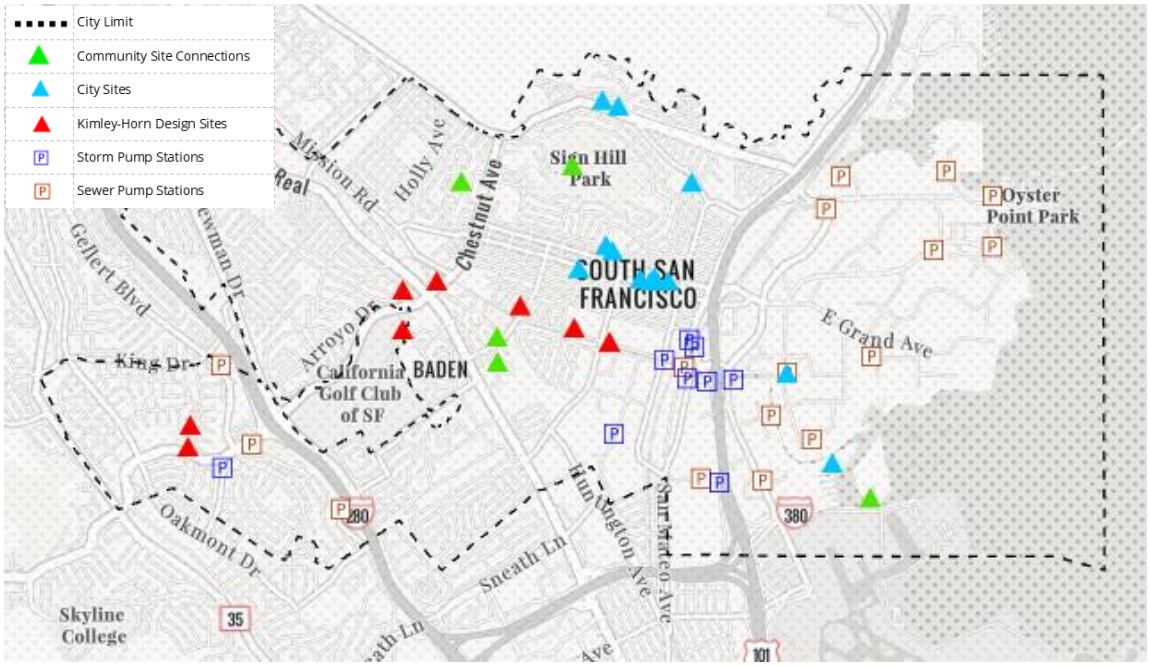

Figure 3. City & Community Sites & Facilities

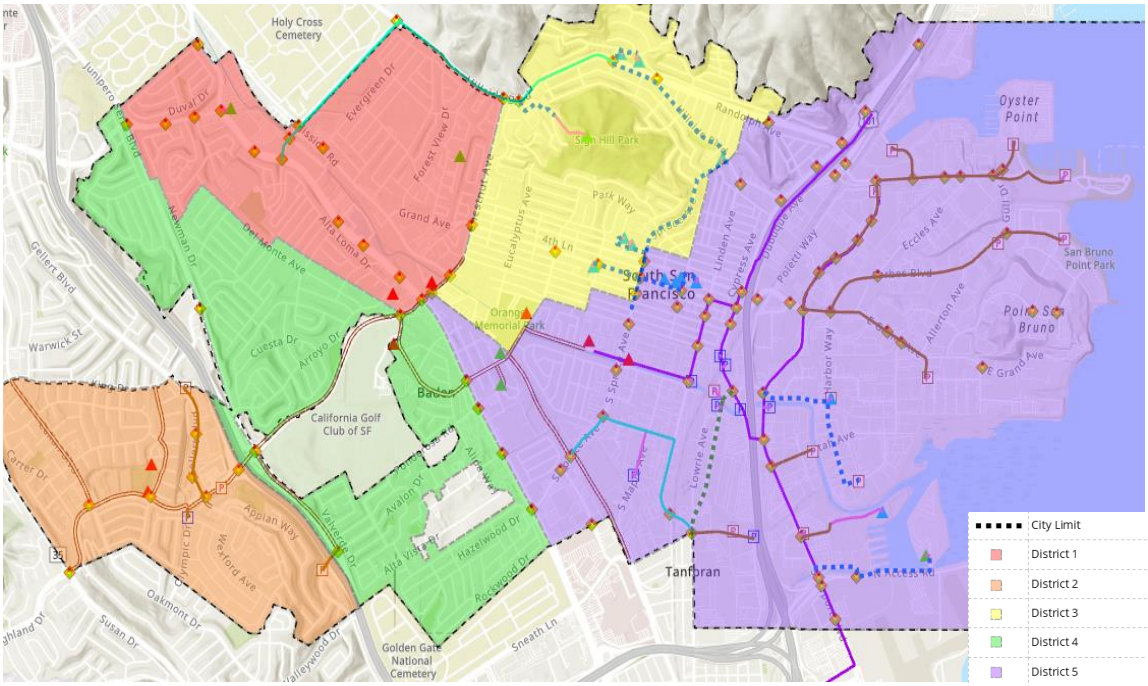

Figure 4. City & Community Sites & Facilities by Council District

2.2 PUBLIC BROADBAND INFRASTRUCTURE

The City of South San Francisco has deployed extensive fiber optic cable and conduit connecting some City locations (see Figure 5). However, the network has not yet been

completed into a fully redundant "ring" architecture, and many City sites and assets are not yet connected to the network. In a ring architecture, each location is connected to two other locations so that there is a circular ring path for data. In the event of a fiber cut or equipment failure, the data flow among network locations reverses and maintains communications between all network locations. One objective of the Broadband Strategic Plan is to add fiber optic facilities that will provide reliable redundant network connections for City facilities to maintain City services in the event of a fiber cut or other disruption. Redundancy is also an essential requirement for any private partner to use the network to serve its customer.

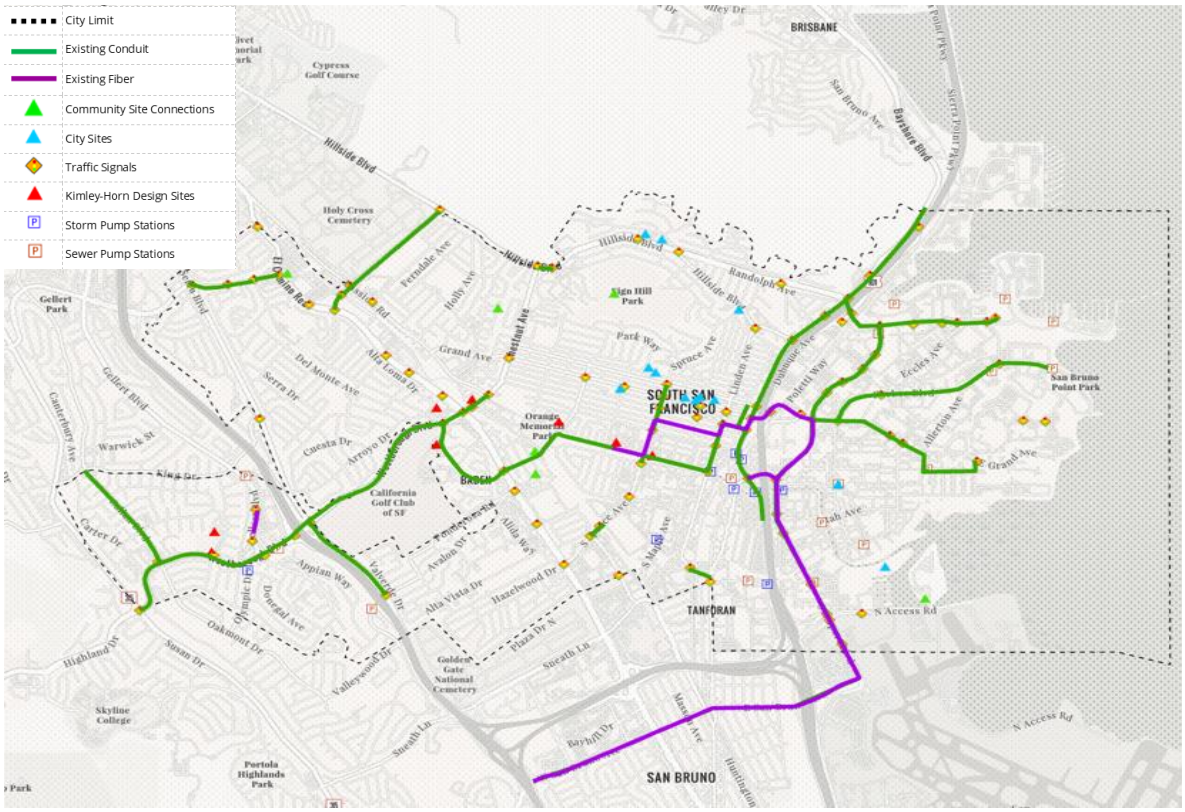

Figure 5. City-Owned Fiber Optic Cable and Conduit Assets

The City has a total of 19.2 miles of existing conduit, and 4.9 miles of existing fiber optic cable, as shown in Figure 5.The City has added significant conduit via its open trench notification/dig once practice, including routes with two (2) 2-inch conduits (alongside conduit and fiber owned by Intermountain and other providers), signal interconnect cable (SIC) with spare conduit and wireless devices, and a set of conduits along the 101 for the Smart Corridors project that uses CCTV cameras, ITS (Intelligent Transportation Systems) devices, signal controllers, and variable message signs for incident management. Use of existing conduit and fiber can reduce the cost of fiber deployment. Even if fiber cables are old or limited in use, they can be replaced in conduit (at incremental cost) with higher-strand cables to exponentially increase capacity. The City can use conduit for its own purposes, and/or may

lease it to network service providers to reduce barriers to entry and encourage competitive broadband services; however, conduit capacity is finite and can quickly be fully exhausted with just a couple of carriers pulling in their own cables. A preferred option is to lease fiber strands themselves to carriers (each of which can be 5-10 microns in diameter), and when combined with wave division multiplexing technology, high-strand cables (288) can provide virtually unlimited capacity.

In addition to identifying where conduit is located, each segment needs to be assessed in future design engineering work for size (diameter) and capacity (the number of cables already installed in a single conduit, and the number of fiber strands within each cable that are already in use), as well as condition (physical damage, bend radius, accessibility, etc.). Conduit does not always need be designated specifically for broadband/fiber networks; existing conduit structures, such as traffic signal control networks, street lighting, or even abandoned water/sewer lines can be rehabilitated and utilized to deploy fiber optic cable. The engineering and labor required to deploy new underground conduit can represent 35-65% of the total cost of deployment, so utilizing existing assets can create significant cost savings.

In tables and figures in this Plan, “existing City-owned conduit” refers to conduit structures that are already placed in the ground and owned by South San Francisco, which are believed to be available for fiber optic cable placement. Since any existing asset is subject to damage and decay and therefore may require maintenance or rehabilitation to be used, proofing of the conduit is a step that will have to be taken to verify there is continuity from end to end.

Similarly, the City’s existing spare fiber optic cable will need to be tested to ensure it remains suitable for use. Fiber optic cables have certain criteria that must be met for proper installation and placement of fiber – for example, no hard 90-degree elbows can be used and the handholes must be large enough to maintain at least a 24” diameter loop.

2.3 CITY TRAFFIC SIGNALS AND INTERCONNECT NETWORK

Traffic signal poles and associated structures are typically located along major transportation arterials, which similarly correspond with major commercial corridors, and are interconnected with electrical and/or signal control conduit networks. Many signal interconnect networks were originally conduit with twisted copper cables, but these underground conduit networks can be rehabilitated and used to pull in fiber optic cable at a fraction of the cost of deploying new underground infrastructure. The rehabilitation needs to remedy the original construction where copper cable can be

bent in hard 90-degree angles and wrapped very tightly inside of handholes resulting in small handholes and 90-degree elbows – fiber optic cable cannot be bent like this. Nonetheless, alignment with road arterials makes signal control networks potentially useful assets for cost-effectively deploying new fiber backbones to critical economic development areas.

There are 98 signals total as shown in the Adaptive Deployment Build-Out shown in Figure 6 below, including 35 where future controller and fiber connection is planned. The Critical City Sites design project will provide connections for 13 of these. Backup and redundancy for this network application is critical so the establishment of network redundancy in Phase 1 of this Strategic Plan provides means to enhance redundant communications for the adaptive traffic control system.

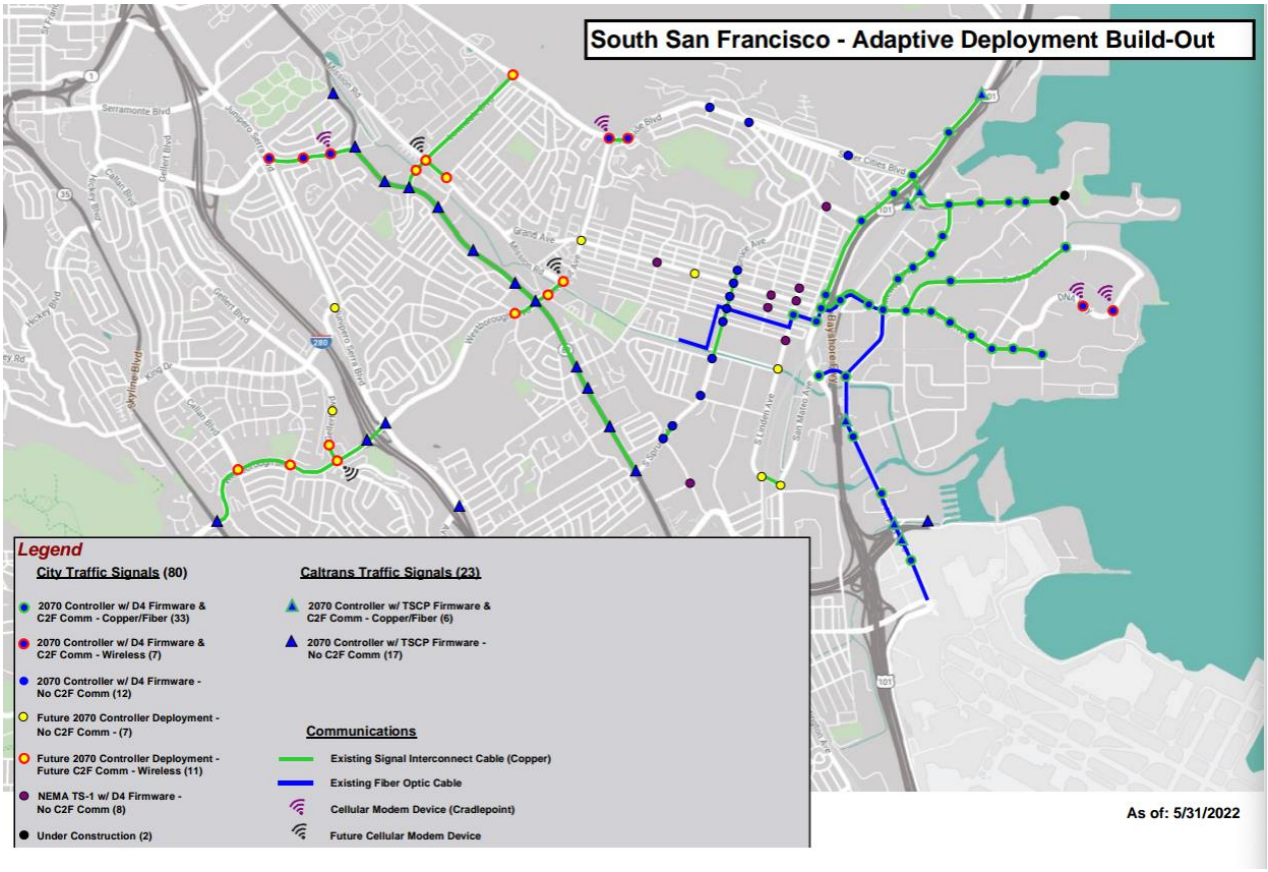

Figure 6. Adaptive Traffic Signal Deployment

The City Adaptive Traffic Control System project will allow the City to prioritize throughput on designated street corridors, select the optimal signal cycle length, provide smooth traffic flow along a coordinated street corridor, distribute signal phase times in an equitable fashion, manage the length of vehicular queues, and actively adapt to changing traffic conditions. This traffic signal network is being integrated into the City's overall communications network under this Broadband

Strategic Plan. Specifically, each phase of the Broadband Strategic Plan includes placement of fiber necessary to connect adaptive traffic control signals.

The fiber for adaptive traffic control will be connected to the Traffic Management Center at 550 North Canal. The adaptive traffic signal upgrade will upgrade and connect all traffic signals in the City with fiber optic networking and some coaxial cable.

2.4 CRITICAL CITY SITES NETWORK DESIGN PROJECT

The City is working concurrently with the planning and design firm Kimley-Horn to prepare high-level designs, plans, specifications, and estimates for additional fiber to extend the City fiber optic network and connect nine critical City facilities, as well as adaptive traffic signals. The project will use a combination of new fiber in existing City conduit, as well as new underground conduit and fiber to leverage and extend the City's current fiber optic network.

The design (see Figure 7) will include lateral connections to nine additional City locations, as well as laterals for the 13 traffic signal control cabinets that are located along the planned route. Under this design, the City seeks to pass the maximum number of commercial sites possible in addition to serving municipal, school, and city locations with sufficient fiber strands. The design also includes extending a fiber backbone to two (2) specific neighborhoods to support connecting CPUC-designated unserved locations through a potential California Advanced Services Fund (CASF) grant.

Table 1. City Facilities connected by Critical City Sites Network Design Project

Facility	Address	Department
Library, Parks and Recreation Center	901 Civic Campus Way	Library, Parks and Recreation
Police Department Admin & Dispatch	1 Chestnut Avenue	Police
Main Library (future early learning/preschool)	840 W. Orange Ave.	Library, Parks and Recreation
Corporation Yard	550 N. Canal St.	Public Works, and Parks and Recreation
Fire Admin & Station 61	480 N. Canal St.	Fire
Orange Memorial Park	781Tennis Drive	Parks and Recreation
Fire Station 64	2350 Galway Drive	Fire

Facility	Address	Department
Westborough Building	2380 Galway Drive	Parks and Recreation
Fire EOC - Main	480 N. Canal St.	Fire

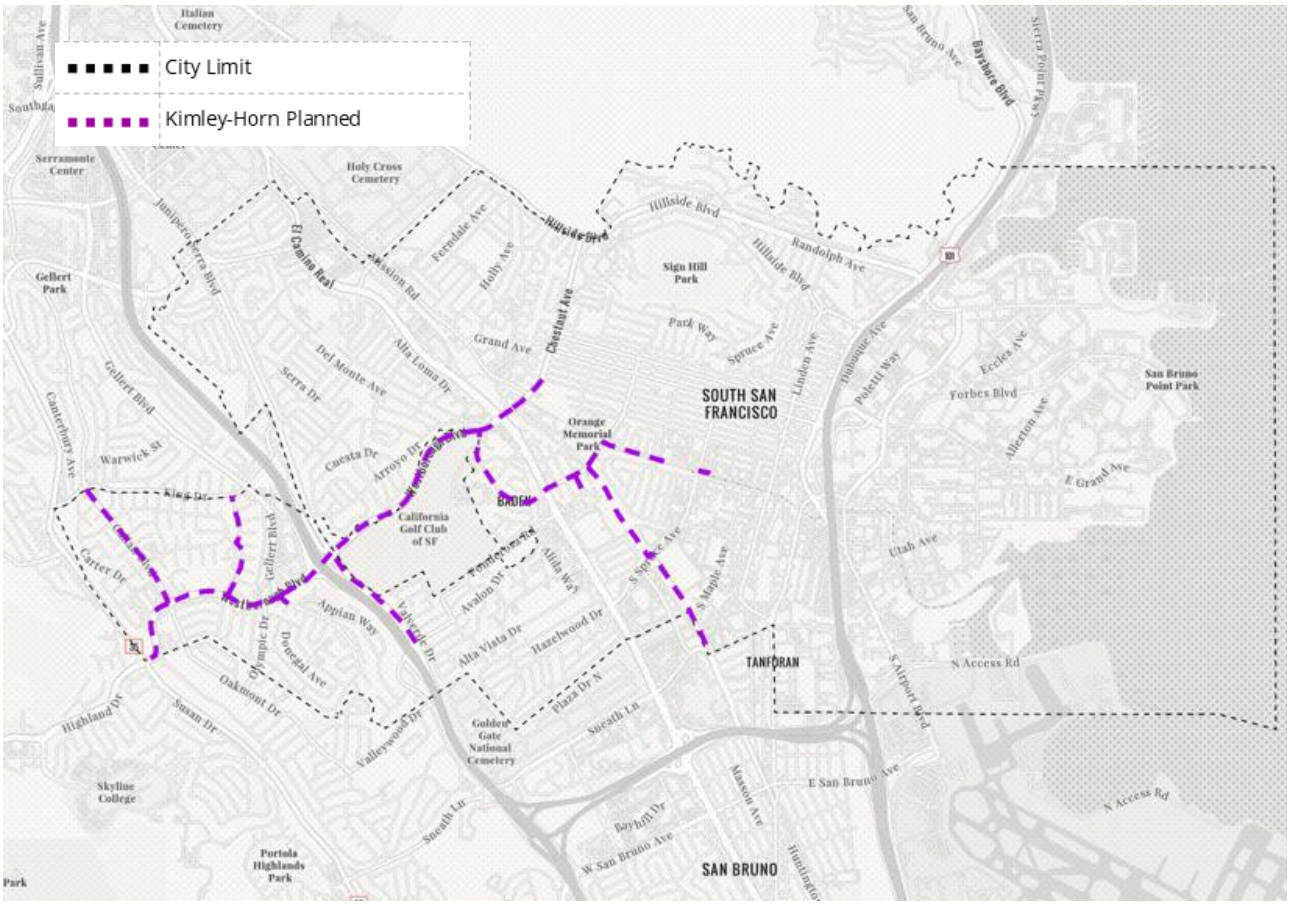

Figure 7. Critical City Site Design

Magellan has coordinated with and included the Critical City Site Design in the Strategic Plan. The Magellan conceptual network design includes the cables, handholes, and broadband infrastructure from the design, and Magellan was able to work with Kimley-Horn to ensure that fiber access boxes and vaults are placed and sized adequately to allow for future growth as envisioned in the Strategic Plan.

Estimated construction costs for the Critical City Site design are $1,942,600, which includes installation of approximately 1.5 miles of 3-inch conduit, 7.7 miles of fiber optic cable, and required pull boxes, vaults, splice closures, and termination panels.

2.5 SMART CORRIDOR

Public Works is managing the City's participation in the Smart Corridor Project as a member of the City/County Association of Governments of San Mateo County

("CCAG"). The South San Francisco portion of the Smart Corridor Project will develop a traffic management system along key arterial corridors that parallel US-101 and I-280. This will provide the ability to efficiently manage traffic congestion safely through local streets during normal operating conditions, major freeway incidents, and special events. The City is also located along the Bay Area's main transportation routes, including U.S. Route 101, Interstate 280, Caltrain, BART, San Francisco Bay Ferry, and the San Francisco International Airport.

Need for the Smart Corridor arises from significant traffic impacts on local streets during major traffic incidents on US-101 and I-280, due to the significant amount of traffic that exits the freeway in search of a route to bypass freeway congestion. The City currently lacks the tools to communicate with drivers on preferred alternative routes, which may result in increased congestion on the local network and unpredictable travel times.[3]

The Smart Corridor project is funded from a combination of sources, including the Transportation Fund for Clean Air fund from the Bay Area Air Quality Management District, Traffic Light Synchronization Program, Measure M ($10 Vehicle Registration License fee in San Mateo County), and State Transportation Improvement Program (STIP) grant.[4]

The project is being constructed in segments.[5] Segment A (Santa Clara County line to San Bruno) has been completed. Segment C ("North Cities") is planned, while Segments D (Future North Cities Stage) and E (Future Phase) are not yet funded. Segment B in South San Francisco has been designed, however construction has been delayed due to supply chain issues, permitting conflicts, and unexpected issues and obstructions in the field while testing.[6] Therefore, the term of the funding agreement with the City has been extended to June 30, 2024. This is the most current date anticipated for when the City could rely on the project's fiber facilities for its networking.

3 South San Francisco Smart Corridor Project Fact Sheet.

4 Smart Corridor | C/CAG

5 San Mateo County Smart Corridor Project Limit and Status, Smart-Corridor-Project-Limits-and-Status-Map.pdf (ca.gov)

6 C/CAG Agenda Report, June 8, 2023, from Sean Charpentier, Executive Director.

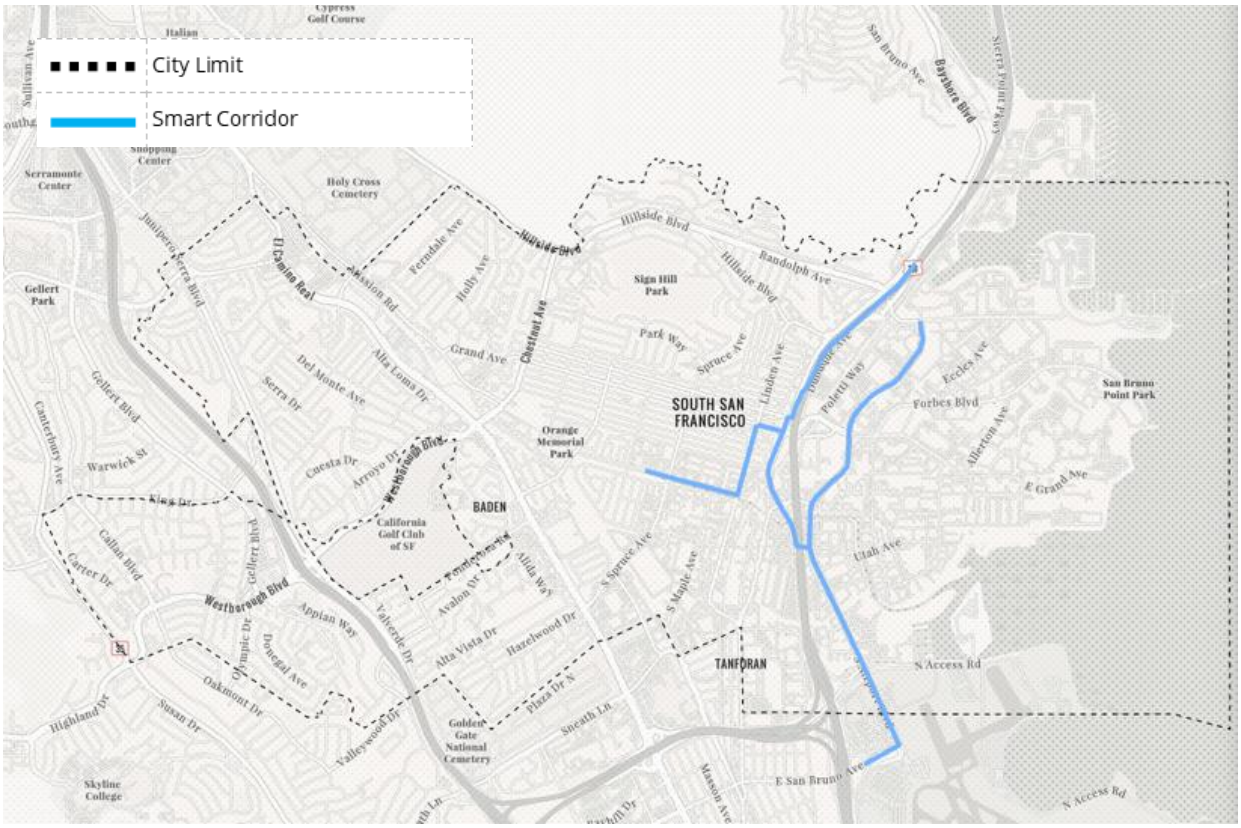

Figure 8. San Mateo County Smart Corridor Project

The Smart Corridor uses fiber optic communications (6 miles) to connect traffic monitoring cameras and dynamic message signs and upgrade traffic signal controllers on local streets adjacent to US-101 and I-280. The Smart Corridor project maximizes efficiency of the existing transportation network, smoothing traffic flow, which leads to improved safety and reduced travel times.[7]

As part of the project, the City will receive two 2-inch conduits for fiber optic cable from the Smart Corridor contractor. Further, the City and C/CAG will share the 288 fiber optic strands along the smart corridor, set aside the necessary strands for the project, and lease out the remaining available strands to interested third parties. Although an agreement has not yet been created, conceptually the City would market and advertise these available strands, and net revenues remaining after deduction of the City's administrative expenses would be divided equally between the City and CCAG. These net revenues to the City could be a funding source for the Technology Enterprise Fund (below). Use of the fiber, over and above the strands that are required for the Smart Corridor project, may include using or marketing the fiber for:

[7] South San Francisco Smart Corridor Project Fact Sheet.

- Smart City applications beyond traffic management such as public safety cameras, free public internet via wi-fi, Supervisory Control and Data Acquisition (SCADA) connections[8] for pumps and meters, smart streetlights, parking management, etc.
- Future-proofing the network to support emerging applications such as Emergency Vehicle Preemption (which is planned) and connected vehicle needs via next generation 5G and 6G wireless services which must be connected with fiber backhaul.
- Digital Inclusion and Literacy programs including programs and services for internet access for libraries, parks, community centers, low-income housing, etc.
- Public/private partnerships for connections for City assets.
- Connections for public/non-profit organizations.
- Connections for community anchor institutions which could generate revenue by connecting hospitals, private schools, and religious organizations.
- Connections for businesses which could generate revenue.
- Commercial leasing of assets to providers or through partnerships.

2.6 CALIFORNIA MIDDLE MILE BACKBONE INITIATIVE

The State of California has been very active in designing and implementing broadband policies to expand broadband availability and digital literacy in the state. Governor Newsom made significant findings in Executive Order N-73-20[2] issued on August 14, 2020, addressing the need for improved broadband services, closely followed by passage of Senate Bill 156, which addressed broadband through the 2021 budget package.

The state middle-mile network is well underway, with portions of the network being planned and designed within the City of South San Francisco along California State Routes 35 and 82 and U.S. Highway 101, although the planned alignment of the route along SR82 was shifted to the east in the August 2023 draft design. Further modifications to the planned MMBI routing are possible as the project moves into the final stages of design.

[8] Security considerations are addressed by using separate fiber strands within the 288-strand cable for this networking.

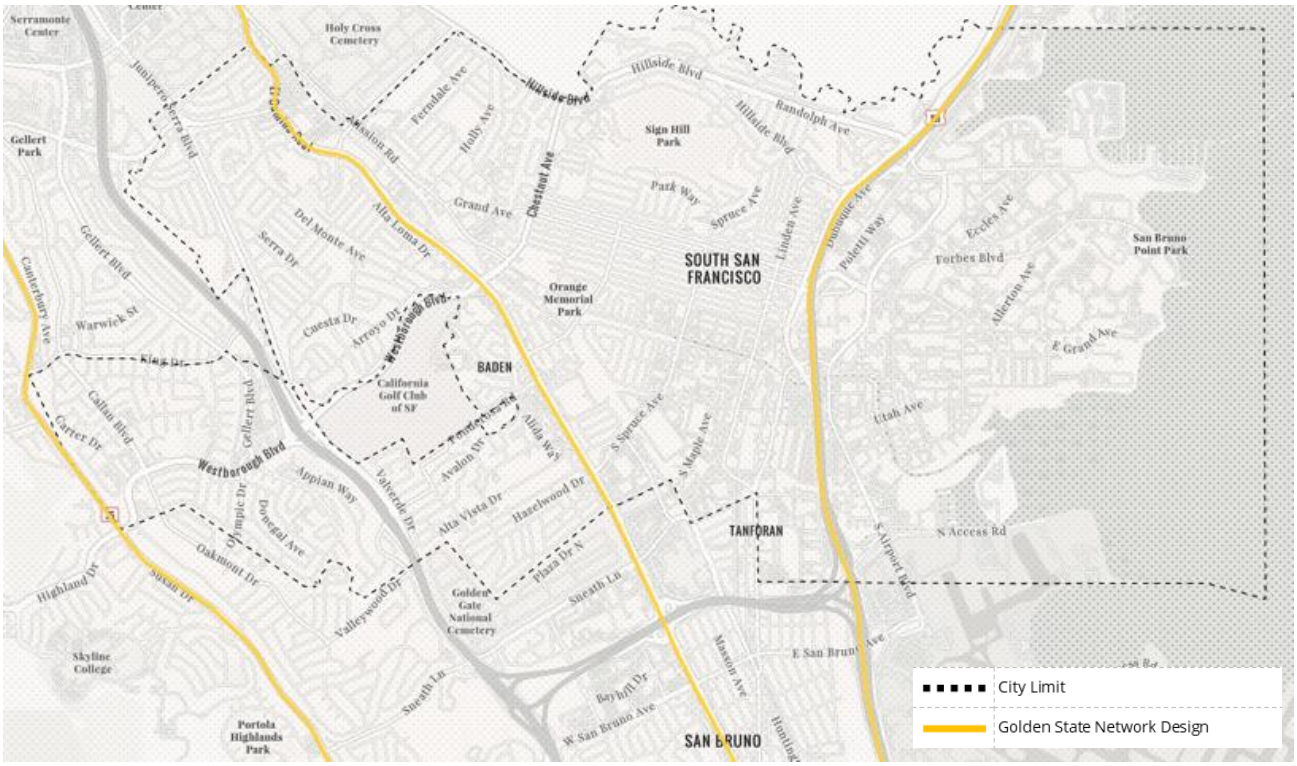

Figure 9. California Planned Middle Mile Backbone Initiative (MMBI)

The anticipated routing of the Middle Mile Backbone Initiative (MMBI) in South San Francisco will provide a public-access fiber infrastructure that can provide the City long-haul data transport access to data centers and internet exchanges in San Francisco, Los Angeles, San Jose, Palo Alto, and elsewhere. Traditionally, these long-haul transport routes would need to be leased from private organizations. Additionally, the MMBI can be utilized to complete local network loops in concert with this Strategic Broadband Plan and its phases to ensure City redundancy without having to construct and install new routes, creating significant cost savings. The construction of the MMBI will provide both cost savings and enhanced network reliability for the City's fiber optic backbone.

3. Needs Assessment

The needs assessment was built on a prior assessment of the City's wireless connectivity requirements conducted by Magellan in 2022. For this Broadband Strategic Plan, Magellan also conducted 17 meetings and interview sessions with over 40 individuals from throughout City departments, the City Manager's office and elected officials and multiple community-based organizations.

3.1 INDICATORS OF NEED

The Federal Communications Commission (FCC) identifies a location as "unserved" if it cannot secure fixed (wired) broadband services from any carrier and qualifies a location as "under-served" if it cannot access broadband download speeds above 25 Mbps. However, the State of California and the CPUC uses a higher standard: locations receiving less than 25 Mbps download and 3 Mbps upload, *or* if the only option for internet access is a legacy Digital Subscriber Line (DSL) copper connection, are essentially "unserved" – and anything less than 100 Mbps download and 25 Mbps upload are "under-served."

The City has many addresses that qualify under California's minimum standard for broadband service, which include locations with legacy DSL connections, as identified in Figure 10.[9] However, this CPUC map shows unserved addresses based solely on whether any ISP carrier is physically capable of providing service – it does not take into account individual household constraints or barriers if/when service is able to be provided. Many households lack an internet service or connection not due to any technical limitations of the ISP, but because of income or other socio-economic factors (language barriers, digital literacy, etc.) – commonly referred to as the "Digital Divide."

[9] Source: CPUC SB 156 Last Mile Federal Funding Account Public Map, August 21, 2023: Unserved locations lacking access to wireline 25 Mbps downstream and 3 Mbps upstream excluding legacy technology (e.g. Digital Subscriber Line and Cable DOCSIS 2.0 or older) https://federalfundingaccountmap.vetro.io/map#11.31/38.6185/-121.4896

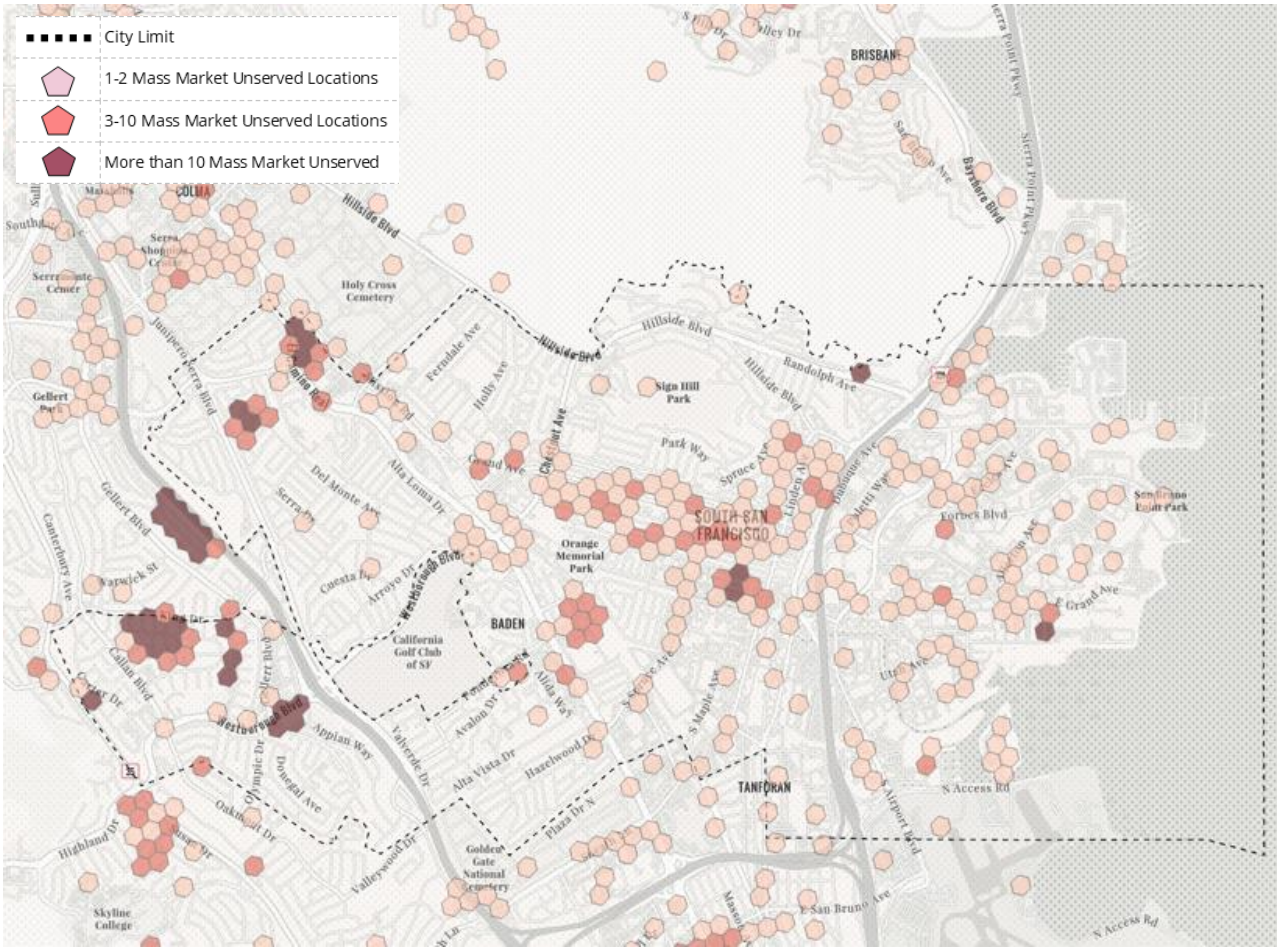

Figure 10. CPUC FFA Unserved Locations

Digital Divide and Digital Equity

The Digital Divide and improving Digital Equity were significant concerns of the City leadership and management. Digital Divide is the division between households, individuals, and businesses where there are disparities in the access to the internet. Digital Equity is the concept that every person should have equal access to digital technologies including affordable and reliable internet access, computers and devices, educators who are adept at using the technology and digital literacy. Most of South San Francisco is served by the local incumbents, yet there are geographic and socio-economic gaps within the City where broadband adoption rates lag behind state and national averages as shown in Figure 11.

Figure 11. Census Map/Digital Equity Act Population Viewer[10]

In late 2021, the Federal Communications Commission launched the Affordable Connectivity Program (ACP) that helps households secure affordable broadband by subsidizing up to $30 per month for an internet subscription. Households with incomes less than 200% of the federal poverty guidelines are eligible for the subsidy. However, participation in the program requires households apply through a government website, which is not often readily apparent or accessible from the carriers' sales websites, which can contribute to low participation rates.

Table 2. Affordable Connectivity Program (ACP) Participation[11]

	ELIGIBLE HOUSEHOLDS	PARTICIPATING HOUSEHOLDS	% PARTICIPATION
UNITED STATES	51.6 million	17.7 million	39%
CALIFORNIA	5.8 million	2.2 million	38%
SOUTH SAN FRANCISCO	6,790	1,232	18%

The City's rate lags behind the state and national average, and indicates there are still many eligible households within the City that could utilize the program to significantly reduce their monthly costs for internet services.

[10] Source: American Community Survey (ACS) Internet Connectivity Variables – Percent of Households with No Internet Access (2019)

[11] Source: https://www.educationsuperhighway.org/no-home-left-offline/acp-data/#dashboard

When a community has broadband coverage but low adoption rates/usage, the cause is usually one or more challenges related to the Digital Divide. The causes of the Digital Divide vary, and solutions should be tailored to not only a specific City, but even to individual communities. There are five common causes of the Digital Divide:

Affordable Internet Access

The cost of internet access varies by location and by the provider. Most cities have areas that are economically distressed and are comprised of households that do not earn enough income to support adequate broadband services. Not being able to afford internet access is an issue by itself; however, this can lead to several secondary impacts and a downward spiral for these households, as the internet is critical for finding gainful employment, participation in key educational activities, and accessing healthcare.

The pandemic highlighted and pushed forward the online nature of the world economy and forced many activities that were normally done in person to be done online, including banking, health care, distance learning, and shopping. When households are unable to participate in these activities because they don't have internet access, the digital divide actually widens. The FCC's Affordable Connectivity Program is one tool that can help lower the monthly recurring cost for broadband connectivity; however, even with a $30/month subsidy, a $70-80/month broadband bill can be unaffordable for many households. In the stakeholder focus groups, many stakeholders expressed substantial concerns about affordability of internet access.

No Access to Technology Devices

To access the internet, an individual must use a device, smart phone, tablet, computer, etc. These devices can be expensive, and unlike the monthly subscription cost of internet access, devices require a significant up-front investment of hundreds of dollars. Many households simply cannot afford these devices, especially when technology advancements make devices obsolete after a couple of years. Many local community-based organizations and non-profits refurbish donated electronic devices and distribute them to households without access. This suggestion was made in several of the stakeholder interviews.

Digital Literacy

Many households and individuals have internet access and devices to use but lack Digital Literacy (the knowledge and technical skills to access and use the internet). This issue is particularly pronounced among older and low-income households. Community-based organizations can often help build digital literacy through outreach, community forums and classes, or targeted programming. This concern was noted in the stakeholder interviews.

Geographic Limitations to Broadband

Incumbent providers prefer to build in areas of high density; areas where the houses, multi-dwelling units, or businesses are too far apart make it difficult for private companies to achieve a return on investment in the short periods of time they seek to repay capital. This results in areas with low density – particularly rural or semi-rural areas – having a lack of private infrastructure and, thus, insufficient internet services. Cities that have this issue must create an environment to entice providers to build in these areas, or the City must build it with public funds to support their constituents.

Language Barriers

Many households speak English as a second language, but many resources – particularly those centered around technology – are not accessible without strong English skills. Again, community-based organizations can be the bridge for this challenge with digital navigators, programming, classes, and targeted outreach for those households. This concern was noted in stakeholder interviews.

Stakeholder Input on Digital Literacy and Equity Concerns

- City and community leaders confirmed that digital equity is a significant issue across the City. The COVID-19 pandemic tested broadband capacity with changes to routine events, including virtual school, work-from-home, virtual worship meetings, and conducting more business online. This raised challenges related not only to connectivity, but also to access to computers and other devices. Stakeholders noted libraries have had a central role in digital literacy training. Patrons can make appointments and get assistance over the phone to use Zoom or other remote technology platforms. The libraries offer programs on how to use LinkedIn or databases to find customers for small businesses.
- Many library patrons can't afford broadband or don't have a device. Lower income households only have one device with multiple simultaneous uses and users. Facilities located in lower-income areas do community outreach and advertising and work with seniors. Stakeholders noted the libraries offer a low-literacy program version with English or Spanish literacy skills, funded by grants through the Community Learning Center.
- Stakeholders expressed the need for additional Wi-Fi capacity. Cost and affordability is a big challenge. The libraries have been looking at adding Wi-Fi to “Learning Wheels,” a pre-school on wheels with a childhood learning station that goes to WIC centers, events, and daycares, which sees a few thousand

families a month.[12] The library looked at lending hotspots and ways to give or loan devices but could not commit to the upfront cost of devices or regular charges for cellular Wi-Fi hot spots.

3.2 2022 WIRELESS STUDY FINDINGS

In the 2022 Wireless Feasibility Study, Magellan interviewed over two dozen City staff members regarding broadband connectivity. Department staff described requirements for additional broadband infrastructure including provision of wireless broadband service for Westborough, digital inclusion programs focused on working families and small businesses, and commute/transit for tech workforce. Anecdotal accounts are that "Westborough feels it keeps getting left behind" and internet services are "terrible."[13] Key findings from the Wireless Feasibility Study included:

- The City has key programs in Community Learning Centers, Parks and Recreation Centers, Economic Development, and Public Works that could benefit from greater connectivity but also could be leveraged to improve availability and benefits of broadband. Emergency services, first responders, and other public safety personnel have evolving needs related to changes in how they monitor and respond to incidents.
- All cell carriers have cell sites in South San Francisco where they have deployed some 5G with approximately 100 Mbps download speeds. But some areas of the City have poor coverage, including critical facilities like fire stations. Cellular boosters have been considered for fire stations to keep engines continuously connected when they move or are stationary. Police have problems with mobile data connections in much of Westborough, including Westborough Square.
- The key broadband needs seem to be related to wireless connectivity for municipal functions, including event and visitor connectivity at parks and other facilities. Field access for City personnel was inconsistent, as was Wi-Fi coverage. Cellular coverage in some areas is excellent—high-speed 5G—while other areas seem to have little or none. More broadly, the City needs to balance tech industry development with housing costs, retaining support industries, and traffic management.

The City acted on the Wireless Study's recommendations by contracting with SmartWave in November 2022 to build the Community Wi-Fi network, which involves

[12] FCC Chairwoman Rosenworcel announces "Learn Without Limits" initiative. DOC-394625A1.pdf (fcc.gov). This initiative would allow funding by the FCC's E-Rate program for Wi-Fi on school buses and Wi-Fi hotspots for schools and libraries to check out to patrons or students in need.

[13] 2022 Broadband and Wireless Feasibility Study, "Needs Assessment" beginning at page 36.

installation of 74 access points on city-owned luminaires mounted on PG&E poles. The City applied for a project permit with PG&E but multiple meetings and communications have been unsuccessful in gaining a clear path forward with PG&E including cancellation of the original project permit application by PG&E when the assigned PG&E representative was transferred. Council members have reiterated and explained on behalf of the community the priority that Community Wi-Fi must have. There is urgency to reach an agreed path forward to complete the installation of the Wi-Fi access points so it is important to continue work to identify the decision maker at PG&E and/or the CPUC that can make this happen.

3.3 STAKEHOLDER INPUT

For this Broadband Strategic Plan, Magellan conducted 17 meetings and interview sessions with over 40 individuals from City departments and multiple community-based organizations. With the help of the City's Information Technology department, Magellan organized stakeholder meetings to obtain input on broadband needs and goals. The stakeholder meeting participants are listed in Appendix A. The stakeholder meetings included discussion of current broadband connectivity and how well it meets current needs, pending changes or plans that impact connectivity needs, longer term goals and priorities that will require improved faster broadband connectivity, and any general issues or trends that are expected to impact broadband connectivity needs.

Magellan created a standard questionnaire for use in the meetings to ensure discussions were consistent and covered all key topics. The City's Information Technology Department took the lead in identifying critical stakeholder organizations and leaders and scheduling the meetings. The City and Magellan sought input from City departments, civic leaders, anchor institutions, leaders in health, education, social services, public safety, and other community leaders. Magellan greatly appreciates each of these organizations taking the time to make senior management available to discuss their perceptions of broadband availability and broadband needs in the City. The content in this section came directly from interviewees, not from Magellan personnel. The views expressed by stakeholders in the interviews as outlined here do not necessarily reflect the opinions or recommendations of Magellan.

City leadership desires the Broadband Strategic Plan to be a "living document," so that as goals are reached it can be updated to address "then what's next" questions. Businesses were not contacted for the stakeholder outreach since the City has not received complaints from businesses about broadband availability and it is believed that businesses generally have been able to meet their broadband needs in the marketplace. Magellan reached out separately to broadband providers to assess their

interest and willingness to participate in building fiber optic broadband capacity under a yet-to-be-defined partnership (or licensing) agreement. In this outreach Magellan leveraged the Service, Infrastructure and Market Analysis conducted in the previous Broadband and Wireless Feasibility Study.[14] These discussions have further relevance for the City, as described in Section 6 on Public/Private Partnership Considerations for the City.

City Agency and Department Needs

Individual city departments' communications with the IT department on broadband capacity needs have worked well to ensure connectivity needs are met. In some cases, these communications include annual needs assessment meetings conducted with service providers. City managers noted and agreed there could be better coordination between departments and that there is not presently a good venue for such collaboration. One coordination gap was exemplified by streets being dug up for a project after recently being repaved. These discussions precipitated sharing the schedule of projects between IT and Public Works which should have future benefit and provide a stronger implementation of the City's open trench notification ("dig once") policy.

Project coordination is especially ripe for implementation since the City is starting a Five-Year pavement rehabilitation program throughout the. It is important that projects – including broadband projects – do not cut streets that were recently (in the past five years) rehabilitated. Public Works believes a ***"road moratorium"*** (a master list, curated by the City, of recently paved roads that are prohibited for a period of time from new excavation) would benefit the City by protecting its assets – newly paved roads.

The City's departments noted that inconsistent wireless connectivity affects staff in the field as well as SCADA and metering applications. Any steps that can be taken by the City to bring wireless connectivity up to an adequate level across the community would be beneficial for department staff as well as residents and businesses. Many departments stated ***additional cameras*** are a priority, including Parks and Recreation for diverse uses such as preventing illegal dumping, security, nature cameras, etc. Broadband network expansion was envisioned to support future Centennial Trail improvements incorporating Wi-Fi/wireless use. The extended fiber optic network can also be designed to include Westborough Park access through community centers and meet broadband connection needs for additional fire station and library

[14] Broadband and Wireless Feasibility Study, beginning at page 27.

locations. These are features of the Critical City Sites Network Design currently being conducted by Kimley-Horn.

City departments and agencies also emphasized other specific needs, goals and objectives:

- Fire Stations 62, 64, 65, Paradise Valley Park, and Terra Bay Gymnasium are without fiber connectivity. The City will need to provide these fiber connections since the iNet does not provide fiber services to these locations.
- Better coordination between departments on broadband is needed; there is not currently a good venue or process for coordination.
- The cost for asset installation, inspections, and application must be considered if conditions are added for placement of broadband connections (including for City CIP projects).
- Departments are aware of and considering various potential Smart City applications where they benefit City operations, including smart sprinkler systems for fire control and public safety cameras. Potential applications include building management systems, irrigation controllers, IOT trash cans, smart lighting, smart parking meters, air quality sensors, security systems, fleet management systems and intelligent transportation applications. However, there is not a formal focus on this at present.
- Cameras and video are a priority application for many departments, which require fiber connectivity.
- Expansion of Wi-Fi coverage is a programmatic need for many departments.
- Mobile and wireless coverage requires improvement for public safety to eliminate dead spots and dropped calls. Fiber is needed on Sign Hill to provide backhaul capacity for wireless services and provide capacity for adjacent City parks and locations.
- A street moratorium is important since significant pavement rehabilitation has recently been completed.
- Current planned and ongoing projects will support fiber connectivity to upgrade traffic signals to provide management, Emergency Vehicle Preemption, and other traffic control capabilities.
- Latency and transmission issues are a problem with current wireless systems used by Water Quality Control Plant Division. A different solution is needed.

City Council Input

The Council members interviewed emphasized certain key goals and objectives.

The COVID 19 pandemic – a time when connectivity was imperative – showed where those residents without adequate broadband live and work in the community, and the

difficulty this underserved group of people had in connecting for community and government services. It is essential for the City to promote and ***provide affordable internet connectivity throughout the City;*** the City's fiber optic network can be deployed to support that goal. Fiber optic connectivity needs to be extended to many locations, including Oyster Point, the Westborough neighborhood, community organization locations, City parks, community Wi-Fi, and kiosk locations on major streets.

One key goal is for the City to be an "***age friendly city***". This has several implications for broadband infrastructure and digital literacy programs, specifically at tech centers, housing authority locations, senior homes, and community organizations including the Economic Advancement Center, potentially through partnerships with the life science employers in the City.

The City should be "***in charge of its own destiny***" for broadband facilities supporting government and community services. This will allow the City to connect new facilities when needed, provide affordable internet for community organizations, and expand affordable internet to underserved areas of the City, such as the Westborough neighborhood,

A City-wide fiber optic network is ***essential infrastructure*** to support City services including adaptive traffic management for efficient traffic flows, the County-wide "Smart Corridor" initiative, "Smart City" applications where City departments can achieve efficiencies and service improvements, support for the trend of expanding "Internet of Things" applications, City-wide wireless coverage for efficient and productive work by City employees and contractors in the field, increasing use of video for security and operational purposes, online registration and classes, permitting applications, Wi-Fi for recreation and events throughout the City including markets, food trucks, and point of sale applications, and economic development of a modern City.

The City has a ***longer-term financial framework for infrastructure*** used to provide services. and plan for broadband infrastructure. A sustainable strategy requires the fiber optic network prepare and budget for regular technology refreshes.

Community Organizations

Magellan and the IT Department interviewed several community organizations to gain insight into broadband issues that might exist in the social services sector. These community organizations[15] were:

- The Housing Authority
- Rotary Terrace
- Economic Advancement Center (EAC)
- Samaritan House and Safe Harbor
- Boys and Girls Club

A major theme shared by the community organizations revolved around affordability. The COVID-19 pandemic starkly highlighted the digital divide, particularly among underserved and low-income groups struggling to access community and government services. This issue underscores the overarching concern for affordable internet, a challenge faced by all organizations.

Each of these community organizations stressed the **crucial importance of affordable internet**. Internet access remains out of reach for a significant portion of the population since many residents and clients have fixed and limited incomes. The Federal Communications Commission's new Affordable Connectivity Program is designed to address this issue. Effective outreach by the City and its community service partners is necessary to ensure program utilization.

Access and affordability challenges persist, especially among clients on fixed incomes. Restricted building access limits options to incumbent providers, stifling customer choice and competition. Additionally, limited Wi-Fi availability and technical familiarity pose barriers. The scarcity of shared computers in lab settings compounds the problem.

Internet access helps meet crucial needs for residents and clients at these community organizations, including digital literacy and training, job training, work force development, youth training for software development and technical jobs, resume services, business plans, accommodating the change to greater use of e-commerce, STEM classes, schooling and homework, rehousing, online tenant portals, etc. Addressing the challenge of English as a second language is also critical in plans to ensure inclusivity.

[15] The City provides internet access connectivity for the Community Learning Center and the Economic Advancement Center.

While some organizations possess adequate basic broadband access, there are critical concerns and needs that require attention. These organizations' broadband access might not seamlessly extend to their clients and residents due to limitations in availability of internet access, devices and computer labs and Wi-Fi networking. For instance, a community organization in Sunshine Gardens had to resort to StarLink as a temporary solution due to limited wired or wireless provider access.

The City's allocation of COVID pandemic relief funding played a pivotal role in funding broadband connectivity programs. This was evident in the Economic Advancement Center's provision of free connections, laptops, job training, and housing assistance to hundreds of clients daily. The need for continuing such programs and expanding them to co-working spaces, e-commerce support, and incubator/accelerator spaces is clear. Additionally, addressing digital literacy issues in South San Francisco is essential to ensure equitable access and foster technical education and training.

Despite the Library's current efforts in digital inclusion, there remains a need for additional resources to enhance their impact and address the community's needs effectively. Collaborations between the City and various organizations have spawned digital inclusion programs, but stakeholders emphasize ongoing evaluation and augmentation to cater to South San Francisco's diverse population.

The vision of revitalized Senior Centers aligns with South San Francisco's commitment to becoming an "age-friendly" city. The demand for Wi-Fi in community centers and the popularity of senior technology programs underscore the need to cater to the technological requirements of an aging population.

The community service organizations noted that their needs typically are separated between office and administration versus resident/client needs.

Wireless Access

Several locations around the City are well known to suffer from poor wireless connectivity, and were documented in the 2022 Broadband and Wireless Feasibility Study:

1. Sunshine Gardens
2. Westborough area
3. Sister Cities Boulevard area
4. Hillside and Chestnut area
5. Oyster Point

Poor wireless coverage affects the public, community service organizations, public safety, and field staff of city departments among others. Two suggested solutions

were to expand public Wi-Fi and extend city fiber into these areas to stimulate and support wireless providers.

The interviews identified numerous locations where public Wi-Fi could be beneficially expanded, many reinforcing the information and conclusions in the 2022 Broadband and Wireless Feasibility Study:

- The City leveraging its existing assets to create a South San Francisco Broadband Utility that provides wireless connectivity throughout the City in partnership with a qualified wireless network operator to oversee the maintenance of the network. Digital inclusion programs should be integrated into the program's governance structure.
- Use existing City-owned fiber-optic cable, including the new fiber being placed from the downtown area to Highway 35, Skyline Boulevard, to support better broadband and cellular coverage in the Westborough neighborhood, including CBRS. Encourage and partner with the cellular providers to increase the coverage in the Westborough neighborhood. This is being accomplished with the Kimley-Horn design.
- Deploy a new underground fiber route at Sign Hill Communication building which is included in Phase I which is to connect additional City locations.
- Deploy three new wireless/radio access points, one in the Westborough area, one on Sign Hill, and one at City Hall.
- Provide for the expansion and deployment of wireless antennas in the low-to-moderate income areas of the City using the South San Francisco Broadband Utility. The network as designed in the Broadband and Wireless Feasibility Study served two zones south of Sign Hill which were identified as locations where residents struggle with affordability. Deploying free Wi-Fi in these zones will enhance the ability to access broadband.
- Support digital inclusion programs including ongoing digital inclusion efforts by the Library's Community Learning Center, and the Robert Cerri Teglia Recreation Center as well as exploring other digital literacy programs and groups such as National Digital Inclusion Alliance, the International Telecommunications Union, makers spaces, and other successful programs. These programs should be integrated into the governance of the Citywide Wi-Fi network, overseen by an advisory group, to ensure the most community impact.

3.4 CONCLUSIONS AND IMPLICATIONS

The key findings from our stakeholder outreach and needs assessment are:

- Despite having multiple ISPs serving the City, there are pockets of unserved locations and significant households with no internet connectivity, suggesting the City faces a Digital Divide where affordability or other socio-economic factors are preventing universal access.
- Affordable internet is an overarching concern, with limited-income residents unable to afford access.
- There is broad agreement on significant digital divide and digital equity concerns in the City. The Pandemic exposed these divides which limited access to essential services in the underserved communities at the worst possible time. There is community support for the City should take reasonable steps to address those concerns, including using the City's broadband infrastructure to aid in bridging the divide.
- The California Public Utilities Commission map of unserved locations, and the Census Bureau's Digital Equity mapping align to show concentrations of unserved locations in South San Francisco neighborhoods east[16], Downtown[17] and northwest[18] and southwest (Westborough). This confirms the views of City leadership and department managers as well as needs identified by stakeholders.
- The City has substantial fiber optic networking today that can be economically leveraged with additional broadband infrastructure to create a City-wide diverse and redundant network that can connect all City and community locations and addresses digital divide and affordability concerns.
- The City's need for additional fiber connectivity is evident in various contexts.
    - Cameras for CCTV and Wi-Fi require fiber connections spanning multiple City departments.
    - The absence of Wi-Fi on the Centennial Trail highlights the potential benefits of fiber connectivity for future trail enhancements.
    - Some key city locations such as fire and police stations, Main Library, parks and gymnasiums, community centers, wastewater and sewer plant need fiber connectivity.

[16] Bounded by California Avenue and Randolph Avenue, Airport Boulevard and North Spruce/Maple Avenues.

[17] Generally, between Chestnut Avenue and Airport Boulevard, Railroad Avenue and Miller Avenue.

[18] Bounded by Chestnut Avenue and Evergreen Drive, Hillside Boulevard and Grand/Miller Avenues.

    - Community service locations need better broadband connectivity.
    - The Smart Corridor and adaptive traffic signal programs are underway which are based on fiber optic connectivity.
- There are gaps in wireless broadband coverage across different City areas. These gaps hinder public safety, event and visitor connectivity, and wireless broadband availability to businesses and residents. City fiber connectivity for backhaul and support of Wi-Fi can help fill this gap particularly in the Sign Hill and Westborough areas.
- Construction and completion of the Community Wi-Fi network is hindered by a lack of response from PG&E to project permit application to install Wi-Fi equipment on 74 PG&E poles. The project permit applications have been pending in various administrative forms since November 2022. There is urgency to define an agreed path forward to complete the installation of the Community Wi-Fi network access points so it is important to continue work to identify the decision maker at PG&E and/or the CPUC that can make this happen.
- An emerging driver for increased bandwidth demand is the growing use of bandwidth-intensive applications, including security cameras utilizing cloud-based architecture. With computer applications moving to the cloud, broadband requirements intensify.
- The City's Open Trench Notification policy and road moratorium policies are working to support efficient and effective placement of broadband infrastructure, discouraging utility providers from uncoordinated actions that excavate newly paved roads, while incentivizing cooperation for facility placement.
- The City can play a role in addressing connectivity disparities by extending its fiber optic network. Community Service organizations struggle to afford adequate broadband capacity, hindering their ability to serve clients effectively. The City's involvement could encompass various initiatives, such as providing Wi-Fi coverage in community organization complexes, negotiating broadband contracts which these organizations are allowed to use, and donating used City computers and computer furniture for shared community labs. Efforts to enhance wireless connectivity in poorly connected areas, like Sunshine Gardens, Westborough, and the North-Central edge of the City, will be invaluable. Extending the City's fiber network supports wireless applications (Wi-Fi/CBRS), while also tackling issues of digital literacy and basic skills among residents.
- Broadband internet access addresses vital needs, including digital literacy, job training, education, e-commerce, and support services for residents and clients.

- Addressing English as a second language is crucial for fostering inclusivity and equitable access.
- Broadband funding, co-working spaces, and technical programs are essential for community empowerment, including seniors, as the City strives to be "age-friendly."

4. Broadband Policies & Initiatives

Broadband-friendly policies and initiatives play a pivotal role in facilitating the deployment of new infrastructure and capabilities while keeping costs minimal through efficient coordination between departments, public agencies, and utilities. South San Francisco (SSF) has embarked on a path to implement a range of these forward-looking policies, fostering an environment conducive to improved connectivity and digital inclusion. Building upon these initiatives, the city is poised to bridge the digital divide, empower its residents, and enhance community services.

4.1 DIG ONCE/OPEN TRENCH NOTIFICATION ORDINANCE

In 2019, the City adopted an ordinance[19] to create an "open trench notification" policy, which recognizes the importance of broadband to the City and the many benefits of project coordination and "digging once" to deploy broadband infrastructure. The ordinance is based on recognition that broadband is a necessity for residents and businesses, supports economic and educational development, equal access to opportunities and higher standard of living, and incentivizing collaborative projects to develop the City's broadband network while preserving public investment in streets and public infrastructure while reducing traffic congestion and disruption of public access.

The Open Trench Notification procedure under the ordinance is administered by the Public Works Department. The procedure is triggered when applications for excavation in the public right of way meet certain criteria: specifically, if the excavation project spans 900 feet, three city blocks, involves terrain that is difficult or expensive to traverse (such as a bridge), or is an element of a larger project that will install or upgrade utility infrastructure, the notification procedure will be triggered. Also, more generally the notification procedure will be triggered if the project involves construction that will result in an excavation that could reasonably include or prepare for the installation of broadband conduit.

19 City of South San Francisco Municipal Code, Chapter 13.40 Open Trench Notification and Telecommunication Infrastructure Improvements (qcode.us)

Public Works manages a list of telecommunications providers that it uses for open trench notifications which includes a blank Notice of Intent to Participate (NOIP) in collocating facilities in the project area. Any NOIP is reviewed by Public Works and sent to the project applicant for subsequent negotiation with the third party submitting the NOIP. If agreement is reached the encroachment permit will be amended and work will proceed.

This process is also used for improvements to be constructed as part of the City's Capital Improvement Projects. The City should take advantage of the Open Trench Notification policy wherever possible to reduce costs of placement of new fiber optic facilities to extend the City's network. The "Open Trench Notification Policy and Procedure" currently provides the joint trench opportunity along San Mateo Avenue. In this instance, joint trenching allows the City to complete a fiber ring which in turn provides network redundancy.

Note how the open trench notification and road moratorium policies *work together* to achieve the desired outcome of efficient placement and protection of City assets and investment. Open Trench/Joint trench provides an incentive and opportunity for service providers to install facilities at incremental cost to a planned project. A road moratorium implemented by Public Works will place costs on utility providers that excavate newly paved roads thus recovering at least part of the diminished value of City investment in roads due to pavement cuts. The road moratorium disincentivizes utility providers from "going it alone" without project coordination while the open trench notification policy provides the incentive and opportunity to cooperate and place facilities at incremental cost.

Beyond repaving projects, network infrastructure can be economically deployed in conjunction with other infrastructure projects. The "smart corridor" cooperation is a significant example. Similarly, the City is completing a City-wide adaptive traffic signal project based on extensive fiber deployment to connect all city traffic lights back to the Traffic Management Center.

4.2 CAPITAL IMPROVEMENT PLAN ANALYSIS

A Capital Improvement Program (CIP) outlines the planned and ongoing capital projects for a city that maintains or replaces existing infrastructure assets such as streets, sidewalks, lighting, parks, and wastewater/sewer lines, facilities, or construct new assets. Long-range projects may involve significant excavation and improvements that provide the opportunity to jointly deploy broadband assets at incremental cost, typically through adding communications conduit to open trenches/excavation, or by

planning for wireless/Wi-Fi capabilities and smart city applications on poles, public buildings, or other public areas.

As a key task in its scope of work, Magellan met with senior City managers to discuss capital projects as they might relate to economic and efficient broadband expansion. Several projects have already incorporated broadband connectivity planning, including:

- The new Community Civic Campus that includes a new library, parks & recreation facility, council chambers, and a police operations/9-1-1 dispatch center.
- Smart Corridor SSF Expansion, which implements Intelligent Transportation System (ITS) equipment such as an interconnected traffic signal system, close circuit television (CCTV) cameras, trailblazer/arterial dynamic message signs, and vehicle detection system for managing the system during non-recurring traffic congestion cause by diverted traffic due to major incidents on the freeway.
- Pre-School, W. Orange Avenue Library re-use
- Adaptive Traffic Control System, citywide deployment
- Mission Road Rule 20A Project

Magellan further evaluated each project in the current CIP for potential additional broadband opportunities: deploying new communications conduit in open trenches, connecting new or existing City assets, expanding community Wi-Fi or wireless distribution points, or to take advantage of critical bridge, creek, or freeway crossings.

Many projects appear to provide some opportunity – typically to jointly install communications conduit at the same time that a trench or other excavation takes place (also known as “dig once”). The engineering and labor of digging a trench (or, even more costly, directional boring) accounts for 35-65% of the total cost of deploying underground conduit; open excavation allows conduit to be placed simultaneously at a fraction of the normal cost. Even if the planned CIP excavation is minimal – for example, adding conduit to just a single block or section of road, or providing conduit for a key bridge, road, or waterway crossing – adding the broadband asset during other planned construction provides significant cost savings and can, over time, assist in incrementally building a robust public fiber optic network.

For example, if the updated Pedestrian and Bicycle Master Plan included construction of bicycle paths along Junipero Serra Boulevard between Hickey Boulevard and

Westborough Boulevard, addition of joint trench conduit/fiber to that project would save $600,000 or more (at a high level).[20]

Magellan identified 23 CIP projects with potential opportunities for broadband expansion, as noted Appendix B. These projects should be reviewed in greater detail by the appropriate City department to verify and confirm the process for incorporating broadband.[21]

4.3 LINDENVILLE SPECIFIC PLAN

Lindenville, located just south of downtown, is undergoing a transformative phase. The City's 2040 General Plan Update identified a Vision for the Lindenville sub-area as "a vibrant and inclusive neighborhood that maintains a base of job opportunities, promotes the creative economy, and creates a new residential neighborhood where all people can thrive." On September 27, 2023 the City Council adopted the Lindenville Specific Plan, which incorporates a range of land use alternatives that will guide future development.

The primary objective of the Lindenville Specific Plan is to actualize the General Plan's vision for the area by creating a vibrant mixed-use neighborhood, a thriving employment hub, and an arts and cultural center. The plan aims to introduce fresh possibilities for residents to both live and work in the vicinity while enhancing circulation, establishing new green spaces, and improving the streetscape.

The Specific Plan[22] establishes four distinct Character Areas:

- A "mixed use neighborhood" which balances a mixture of housing, retail and services, open spaces, civic uses, and legacy industrial uses, centered around a transformed Colma Creek.
- South Spruce Avenue Corridor is "an active, safe, and inviting corridor for living, shopping, and working." Included are mixed use housing types and a "node of

[20] New construction for fiber and conduit is estimated to cost $130 per foot, while construction of same using joint trench opportunity is estimated to cost $50 per foot. The distance between Hickey Blvd. and Westborough Blvd. is estimated to be 7711 feet, yielding a cost difference of $616,880 ($1,002,430 - $385,550).

21 Appendix C of the Broadband and Wireless Feasibility Study contain further details on state and federal broadband policies that can incentivize joint deployment of utility assets while discouraging "go it alone" projects.

[22] City Council Agenda Item #14; Report regarding adoption of documents related to the Lindenville Specific Plan, associated General Plan amendments, Zoning Code Amendments, and Addendum to the 2040 General Plan Environmental Impact Report; Agenda Date September 27, 2023.

publicly-accessible active ground floor uses such as retail, restaurants, and clinics".

- An "employment area" with a mixture of warehousing, manufacturing, processing, and storage and distribution uses" with incentives to modernize the industrial building stock.
- The South Linden Arts and Makers District with a variety of uses "to promote arts and cultural identity, including live-work housing, studios, makers spaces, and supportive uses such as restaurants and bars.

The Specific Plan Vision includes creation of new housing opportunities and community services; creation of a second generation industrial neighborhood that will support emerging industrial and creative uses; retention and creation of new creative uses in the Arts and Makers District; a blue-green infrastructure network to build climate resilience; enhancing open spaces; protecting residents and building occupants from air pollution and industrial pollutants; and connecting communities with a mobility network that is multimodal, safe, and connected.

The LIndenville Specific Plan addresses infrastructure as one component:

> As Lindenville evolves, it will be presented with a new set of challenges as the types of uses in the Plan Area change combined with *advances and innovations in technology*, changes in policy, and shifting patterns in climate conditions. A sustainable future vision for Lindenville calls for the development of infrastructure solutions to support the Specific Plan's vision for a new Mixed Use Neighborhood, an increase in residential population, and utilization of green infrastructure for stormwater management and public realm enhancement. … Existing infrastructure, built out before the 1990s for an almost exclusively industrial land use base, could adequately serve the Plan's build out scenarios by planning for changes to peak usage patterns, *strategic improvements and maintenance*, and new development and adaptive reuse standards.[23]

The Lindenville Vision will require high speed broadband infrastructure, which is now often considered in new development as the "4th Utility" (in addition to gas, water and electric). Decades ago, telephone utilities were installed in Lindenville for prior industrial uses, which is inadequate and outdated for two reasons – current broadband use in Lindenville is relatively light, given the present industrial character and the lack of modern fiber infrastructure. Key telecommunications stakeholders

[23] Lindenville Specific Plan, Chapter 7 – Infrastructure, at page 142, *emphasis added*.

acknowledge the challenges and costs associated with placing updated broadband facilities to serve areas previously in industrial use.

The redevelopment contemplated by the Specific Plan presents the opportunity to significantly improve and organize “dry” utility infrastructure by undergrounding existing electric and broadband lines. Undergrounding utilities will provide the opportunity to place conduit for fiber optic cable, reduce the likelihood of outages and disruptions while enhancing community aesthetics. Undergrounding dry utility lines can be accomplished on a “joint trench” basis concurrent with upgraded street corridors, which preserves City investment in streets, sidewalks and curbs.

Improvement of “Wet” utilities such as storm drains and sanitary sewer systems are also planned under the Specific Plan as well and present similar opportunities for placement of conduit for broadband. This should be considered in alignment with the fiber optic network planning in this plan for sewer and stormwater pumpstation connectivity.

Placement of modern fiber optic broadband infrastructure enables the City and the Lindenville neighborhood to adapt efficiently and cost-effectively to future land uses, needs and requirements. This modern broadband infrastructure and capacity will be integral to support new land use under the Lindenville Specific Plan. Smart City applications, connected and autonomous vehicles and transportation applications, street lighting, and residential and business use are clear needs which should be planned for under a “campus area” perspective.

The Planning Department does have a standard condition of approval requiring the installation of "three-inch diameter PVC conduit along the project frontage, in the right-of-way, if any trenching is to take place, for the purpose of future fiber installation. Conduit shall have a pull rope or tape. A #8 stranded trace wire will be installed in the conduit or other trace wire system approved by the City." This would apply to any entitled project throughout the city.

Further standard installation requirements can be listed similar to other cities’ requirement, such as depth requirements (laid to a depth of not less than 18 inches below grade in concrete sidewalk areas, and not less than 24 inches below finished grade in all other areas when feasible, or the maximum feasible depth otherwise), install minimum 3-foot radius sweeps and bends, furnish with an external “warning” ribbon tape a minimum of 3-inches above the conduit, and all conduit couplers and fittings shall be installed watertight, with sealed end caps upon installation.

This standard condition of approval should be considered for all development work citywide. Additionally, it is crucial to engage in discussions with wireless providers regarding the implementation of 5G technology, and plan for needed infrastructure

for wireless services. Lastly, the requirements for broadband infrastructure placement in Lindenville should balance and consider that these requirements would also apply to the City here and have some cost to administer as well that should be accounted for.

4.4 TECHNOLOGY ENTERPRISE FUND

The 2022 Wireless Feasibility Study recommended the City establish a Technology Enterprise Fund, or a dedicated enterprise fund for revenues generated from leases of City assets by private telecommunications companies. A technology fund with ongoing revenues—separate from the General Fund—prioritizes new City/public technology deployment for future build opportunities (funding broadband infrastructure, locating new Smart City devices concurrent with expansion of private wireless connectivity, or funding for fiber network expansions through incremental builds/joint trench coordination).

The City's need for a Technology Enterprise Fund is perhaps even more pronounced now than in the previous 2022 study. Creating an enterprise fund in the early stages helps plan strategically for the years to come when new development will come to fruition and use of public assets/ROW will increase. Additionally, the unscheduled nature of joint trench/Open Trench Notification opportunities means cities need a dedicated funding source outside of the normal budgeting process to take advantage of new or unforeseen opportunities for broadband expansion, which might be missed under conventional budgeting practices. This forward-looking approach facilitates the funding of essential projects such as broadband infrastructure, the concurrent expansion of Smart City devices alongside private wireless connectivity, and incremental fiber network expansions through joint trench coordination.

The City has a Broadband Expansion Project budget line item with similar intent, but it is funded with appropriations from the General Fund which can vary year to year. The City is considering use of a Broadband Impact Fee. A Technology Enterprise Fund with dedicated funding such as a Broadband Impact Fee would be better suited to support and contribute funding toward the goals and objectives of the Broadband Strategic Plan. This fund could be best initiated with approximately $250,000 in seed money, to be replenished annually as needed. Furthermore, net revenues from marketing the Smart Corridor fiber networking could be used for additional funding for the Technology Enterprise Fund.

4.5 SMART CITY APPLICATIONS

Growing communities require effective technology solutions and systems that monitor, collect, and analyze relevant data to drive intelligent and informed decisions by elected and appointed city leaders. The term "Smart City" is used to describe an array of applications, services, and technologies that support established City goals and priorities.[24] The City's expansion and augmentation of its fiber optic network will provide the crucial infrastructure platform for Smart City applications. The City's Guiding Principles in its General Plan rely on broadband connectivity for Smart City applications.

> *The City of South San Francisco provides high quality and accessible services, facilities, and amenities for residents at all stages of their lives. As a "smart city." South San Francisco leverages high-speed internet technology and connectivity to improve engagement, transportation, utilities, education, public health and safety, environmental quality, energy, and the quality and efficiency of City operations. The City ensures digital equality by promoting internet connectivity in all neighborhoods to bridge access to reliable and affordable information.*[9]

The goal is to lead innovative digital, data-driven change positively impacting community services, land use, facilities, public safety, and workforce. These technical solutions are supported with transparent governance to ensure security, fairness, and privacy. Many Smart City applications are associated with a major worldwide trend called the Internet of Things (IoT). Most Smart City applications begin with the deployment of a remote device, or the "Thing" in IoT, as shown in Figure 12.

[24] In this document the capitalized terms "Smart City" refer to the set of technologies.

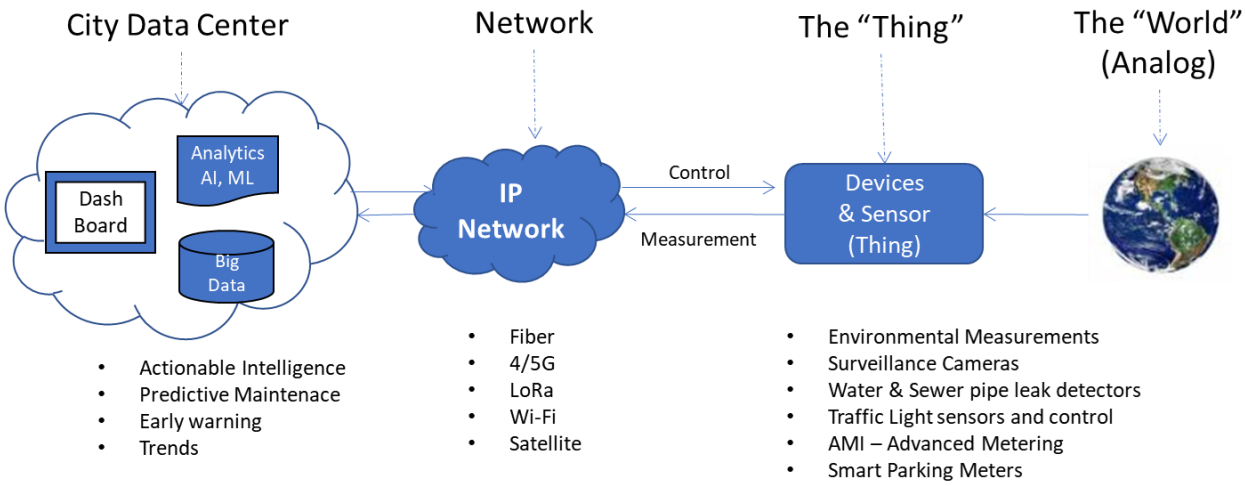

Figure 12. Smart City IoT Architecture

"Things" can be traffic cameras, air quality sensors, seismic monitors, water main leak detectors, smart streetlights, or a device that determines parking stall availability. These devices capture data that needs to be transmitted to the City's servers over a network—whether the servers are on-site, at a co-location data center, or in the cloud (often stored on all three).

Smart City digital infrastructure includes fixed (wired) infrastructure, such as fiber optic cables, mobile infrastructure (cell towers/antennas), and data centers with interconnect facilities. The transmitting network requirements are highly application- and location- dependent. For example, a sensor measuring air quality sends small amounts of data periodically and may be able to utilize wireless connectivity; however, a high-resolution surveillance camera sends large streams of data continuously and may require dedicated fiber optic cable. For these reasons, fiber forms the foundation for Smart City technologies and radio-based wireless connections provide the support structure for the devices and applications.

There is a vast array of Smart City applications that can be imagined which must be reduced to the applications which are most useful and beneficial for the City. Each of the departments interviewed was familiar with Smart City concepts and technologies and had some ideas of Smart City applications that might be beneficial for the department and the City.

Several City departments indicated that they were considering new Smart City applications, and some had already been implemented, including irrigation devices to schedule watering and detect leaks, etc.

City departments further identified a need for ***more cameras***, smart street lighting with controlled dimming in low traffic hours for energy saving, automated cross walks, real time bus arrival signage at bus stops, next bus real time information, smart

parking management and navigation, equipping busses with Wi-Fi and/or advertising, security and sensors, license plate readers, wayfinding, building management systems, irrigation controllers, and more.

Smart City Steering Committee

The press of day-to-day tasks, duties and priorities make it difficult for City departments to focus on future plans, such as Smart City applications. Magellan recommends that the City consider formalizing its Smart City considerations via the formation of a **Smart City Steering Committee**. Such a committee can provide focus and maintain momentum for Smart City projects, including through the CIP project review. The Steering Committee could institute a formalized process for project review of all city CIP initiatives to test viability of Smart City opportunities.

This Committee should be cross-departmental, including senior leadership from all relevant departments, and may even consider inter-agency communication for expanded impact. The committee should be led by the IT Department, which would provide a natural fit with the broadband project and allow the committee to hit the ground running. The Committee should first gather, review and investigate Smart City applications that have been under informal consideration by the various City departments (such as connecting smart sprinkler systems in case of fire, connecting controllers for streetlight dimming during low traffic hours) and review those applications for feasibility and broadband network alignment. Review and evaluation of each potential Smart City application should include:

- Determining the organization(s) or department(s) that would "own" the application and its implementation;
- Organizational adaptations that must be made within the City;
- Department ranking of importance of implementing the application versus other potential Smart City applications;
- City management and council ranking of the priority of the application versus other potential Smart City applications;
- Community views on the importance and utility of the Smart City application;
- Legal or policy requirements that must be addressed (if any);
- Costs of the application and its associated equipment;
- Network implications of supporting the application, including network proximity;
- Determining internet connection requirements for Smart City applications;
- Timeline for installation of the application, including activation of the application;
- Resources needed for installing and testing the application;

- Savings and benefits for the City generated by use of the application; and
- Funding and budget sources (including potential grant funding) and what budget actions are necessary.

5. Conceptual Network Design

Magellan developed the Conceptual Network Design based on priorities identified by the City, its stakeholders, and the community. The design serves to both connect critical City facilities and support City services, while expanding fiber infrastructure that could be concurrently used to improve community access to broadband.

The conceptual network design is truly that – conceptual. It is not a full engineering study and does not account for specifics such as building entry locations, which side of the street a particular fiber cable is located, or laterals/service drops onto private property, etc. The conceptual design is intended to provide a roadmap for the City, and specific projects undertaken should first complete a full engineering process that will conduct field surveys to verify existing data and assumptions to move the Conceptual Design to a High-Level Design (30% HLD), to a Low-Level Design (60% LLD), and ultimately to a Final Design.

5.1 CONCEPTUAL NETWORK ROUTES

The conceptual network design for the City of South San Francisco identifies fiber routes and other infrastructure requirements to meet identified City needs. The focus and size or scope of the design, along with construction methods and technical specifications, determine the estimated overall costs as well as possible phasing needed to complete the project. Thus, the conceptual design can inform decision-making about how, where, and whether to build.

For purposes of this Strategic Plan and Conceptual Design, Magellan worked from the assumption that the Critical City Sites design recently completed by Kimley-Horn has been constructed and is operational – i.e., that this phase of the project is a part of the "existing City assets." Thus, the anticipated lengths, breakdown, and construction costs for the Critical City Sites design are not included in the cost estimates below in Section 5.3.

The Conceptual Network Design would require construction of approximately 4.4 miles of new backbone conduit and fiber, 1.4 miles of new service drops/laterals, 5.1 miles of new fiber pulled into existing City conduit and interconnecting 2.5 miles of the existing City fiber network with splice points, handholes, cabinets and supporting infrastructure. The conceptual design also includes interconnectivity with the California Middle-Mile Backbone Initiative (MMBI), the planned state-wide middle-mile project, to ensure regional interconnectivity and route redundancy.

Proposed new backbone construction (depicted in red and blue) would be comprised of two 2" conduits deployed underground at 36 inches below the surface, filled with a 288-count fiber-optic cable, capable of meeting future demand. New laterals and service drops are assumed to be a single 2" conduit with a 24-count fiber cable.

The Conceptual Design creates a redundant fiber backbone loop around the City that minimizes service interruptions, connects 12 remaining City facilities to the network, as well as 6 community sites and facilities identified by the City, and extends to other areas to connect to pump stations and wastewater assets.

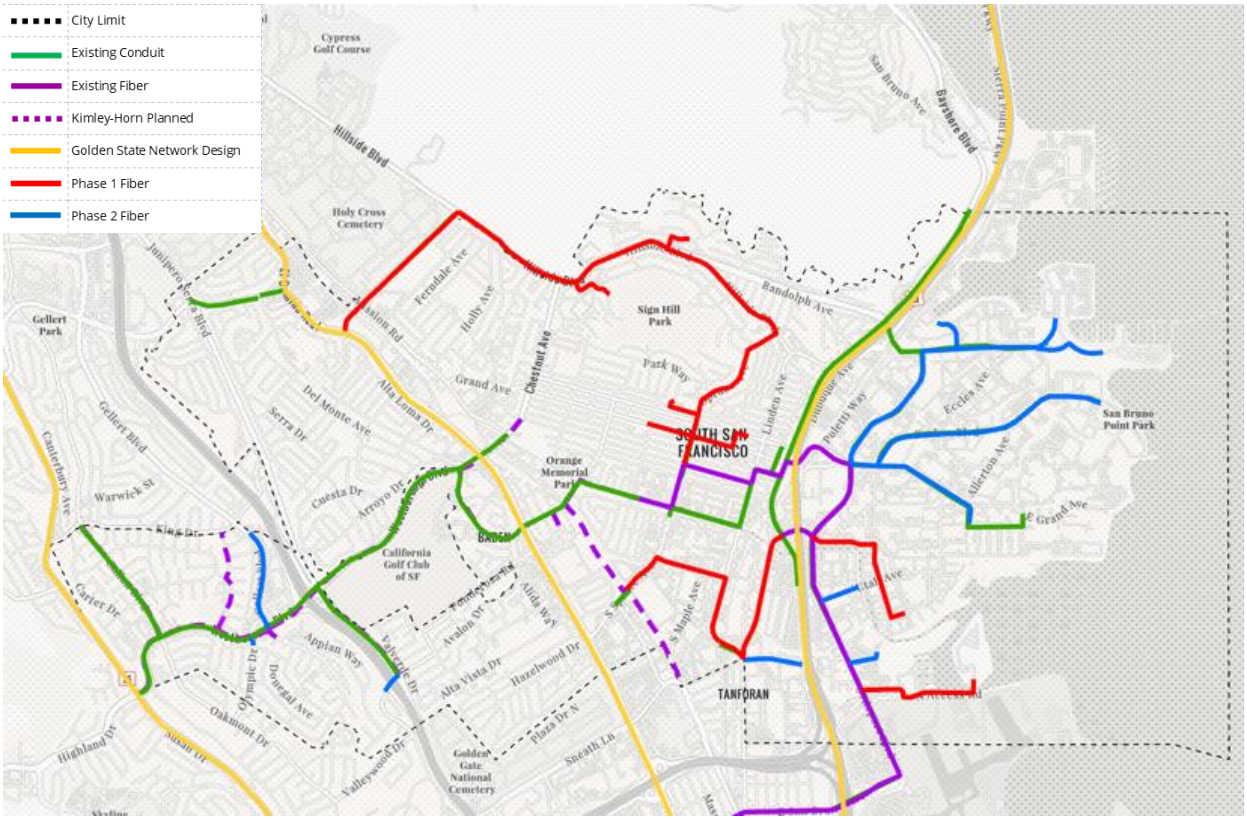

Figure 13. Conceptual Network Design

5.2 PHASED IMPLEMENTATION PLAN

The Conceptual Network Design can be implemented in a phased approach in order to prioritize the loop architecture necessary for greater community and business access, ensure critical site connectivity, provide flexibility relative to grant availability, budgets, and resource constraints, and to maximize the network reach into new markets to attract a private partner. The phases outlined below can be further broken down into sub-phases or built incrementally and opportunistically through effective CIP and private project coordination.

Magellan designed the routing and phased implementation for the City by evaluating and providing the best possible scenario for long-term success of the project. It is important to note that although the phased implementation is separated into three key phases, each phase should be evaluated and built in the order of need, spreading out the cost and speeding up deployment to certain locations where appropriate. Although the phases build off each other, they do not have to be built in the order presented, and in fact construction and routing may have to be adjusted to accommodate connections to the network.

Phase 1: Redundant Loop & City/Community Facilities

Phase 1 accomplishes two critical goals for the City: 1) ensures a citywide redundant loop architecture that minimizes service interruptions, and 2) connects 14 City and community facilities currently not on the network (as well as 20 traffic signals).

All robust networks regardless of technology; fiber, wireless, or HFC need route diversity and redundancy. Diversity is when a location has connections from two different directions reducing the impact of outages. Redundant fiber networking supports the City's planning for emergency preparedness and provides resiliency of data communications during emergencies. Phase 1 facilitates connection of the network into a ring so the locations on the City network built off of the ring, including the laterals, can be rerouted during outage emergencies and avoid service interruptions. Creating a backbone loop is critical for not only uninterrupted City services (including emergency services), but also if the City (or a private partner) were to utilize this backbone to provide competitive retail internet services to the community and businesses.

Phase 1 (Figure 14) would modify the City's fiber network into a redundant backbone loop through a combination of new construction, upgrading existing infrastructure, and interconnecting with the state-wide middle-mile network (MMBI).

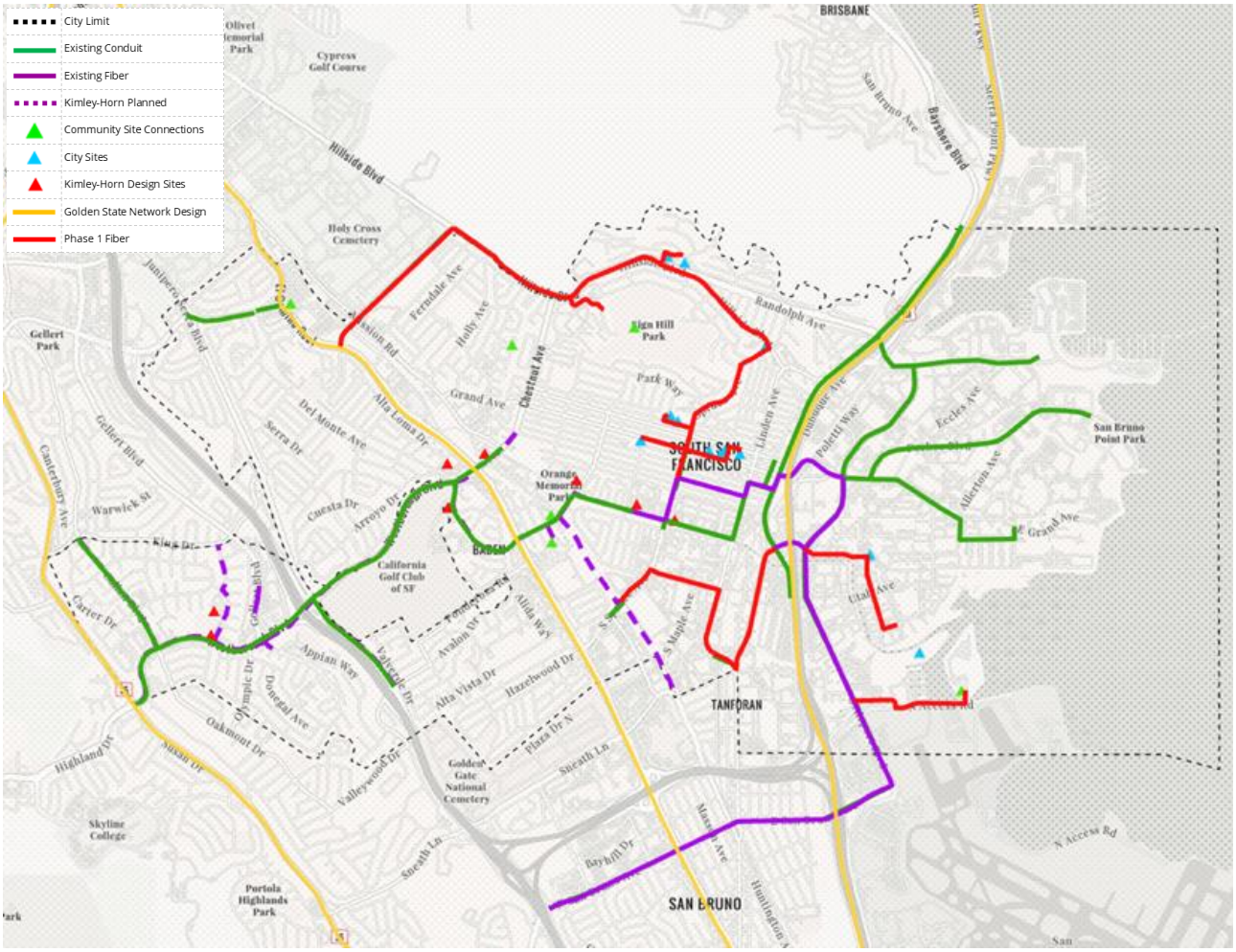

Figure 14. Phase 1: Addition of Redundant Ring & City/Community Facility Connections[25]

Phase 1 construction includes upgrades to 13,255 feet of existing City fiber, 6,374 feet of new fiber pulled through existing conduit, 16,926 feet of new underground backbone, and 3,929 feet of new service drops/laterals.

Fiber construction under Phase I not only supports diverse connections and redundancy for the City's network and connects 18 City and community facilities, but also passes traffic signals and other neighborhoods that can be connected to the network. In particular, Phase 1 enables connections to at least 14 traffic signals and extends a backbone into the Sign Hill and Lindenville neighborhoods.

[25] The Conceptual Design was completed in June 2023 and is based on the existing California Middle Mile Broadband Imitative (MMBI) design. On August 2, the State released an updated planned design for the MMBI, which adjusted some routes slightly and will require some minor adjustments to the Conceptual Design. These changes are not anticipated to be significant and can be addressed in detail during the design engineering phase of the project.

The 18 City facilities and 14 traffic signals designed to be connected through Phase 1 include:

Table 3. Additional City facilities to be connected in Phase 1

Facility	Address	Department
City Hall	400 Grand Ave.	City Council & Chambers, Elections, Attorney, Treasurer
Water Quality Control Plant	195 Belle Aire Road	Public Works
Police Department Substation and IT	329 Miller Ave.	Information Technology and Police
City Hall Annex	315 Maple Ave.	Building, Planning and Engineering
Grand Library	306 Walnut Ave.	Public Library
Roberta Cerri Teglia Center	601 Grand Ave.	Parks and Recreation
Community Learning Center	520 Tamarack Lane	Public Library and Parks and Recreation Preschool
Siebecker Preschool	510 Elm Court	Parks and Recreation
Fire Station 62	249 Harbor Way	Fire Department
Fire Station 65	1151 South San Francisco Dr.	Fire Department
Paradise Valley Park	291 Hillside Blvd.	Parks and Recreation
Terrabay Gymnasium	1121 South San Francisco Dr.	Parks and Recreation
Traffic Signals (14)	Various	Public Works
Sign Hill	So. Of Hillside Blvd.	Parks and Recreation

Phase 2: Wastewater Assets

During the information gathering phase for this report, it was noted that new buildings that have been, and potentially will be built, are interfering with the current wireless network the pump stations use for Supervisory Control and Data Acquisition (SCADA) connectivity. There are also latency issues that are causing stations to "time out," which means there is no communications from specific stations. Additionally, the backup options are limited in the event cell signals is lost or over-congested in the event of an emergency. Phase 2 adds fiber network connectivity to these pump station sites. This phase can be built incrementally and does not have to be built in its entirety; however, pump station sites with the greatest need should be prioritized.

Fiber backbone in Phase 2 would also connect 23 traffic control signals, as well as provide general broadband backbone infrastructure for the entire Oyster Point area and through the southern part of Lindenville.

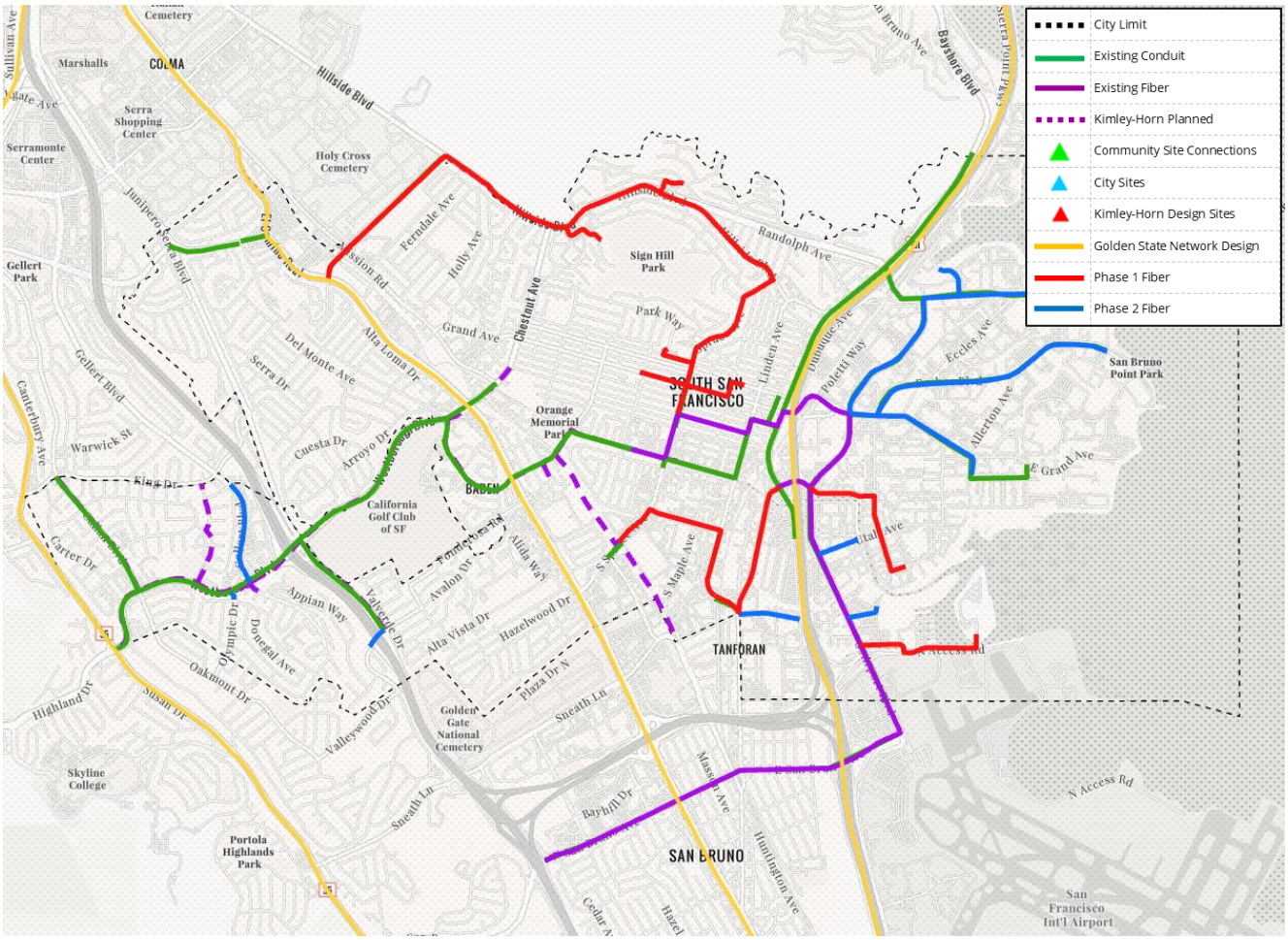

Figure 15. Phase 2: Fiber Connectivity for Pump Station & Wastewater Assets

Phase 2 construction includes 20,703 feet of new fiber pulled through existing conduit, 6,052 feet of new underground backbone, and 3,291 feet of new service drops/laterals.

Table 4. Sewer pump stations to be connected in Phase 2

FACILITY	ADDRESS
Pump Station No. 1	383 Oyster Point Blvd.
Pump Station No. 2	955 Gateway Blvd.
Pump Station No. 3	195 Kimball Way
Pump Station No. 4	249 Harbor Way
Pump Station No. 5	477 South Airport Blvd.
Pump Station No. 6	160 Utah Avenue
Pump Station No. 7	220 Littlefield Avenue
Pump Station No. 8	701 Forbes Blvd.
Pump Station NO. 9	1479 San Mateo Avenue
Pump Station No. 10	572 Forbes Blvd.
Pump Station No. 11	235 Shaw Road
Pump Station No. 14	1191 Veterans Blvd.
Lindenville Storm Water Station	27 South Linden Avenue
Shaw Road Storm Water Station	251 Shaw Road

In the event there are concerns over the cost of Phase 2 fiber/wireless hybrid designs could be considered. Those potential designs were not the subject of this study but could be defined, designed and costed. An incremental build approach to Phase 2 – taking advantage of joint trench/dig once opportunities, CIP alignment, development conditioning, and utility coordination – could build this phase out over time with cost effective strategies and significantly reduce the total estimated construction costs.

5.3 CONSTRUCTION COST ESTIMATES

The estimated capital construction cost of the Conceptual Network Design (all phases) is $4,193,088, which includes estimated design and engineering and permitting, required upgrades to 2.5 miles of existing City fiber, 5.1 miles of new fiber in existing conduit, 4.4 miles of new underground conduit and fiber for new backbone, and 1.4 miles of new service drops/laterals (see Table 5 for a breakdown by phase and construction type).[26]

[26] Construction costs are based on Magellan's analysis of comparable cities, recent construction bids, equipment and material costs, and a regional assessment of the labor and construction market. An inflation factor has been included to address future, short-term cost increases.

Table 5. Construction Cost Estimates

	FOOTAGE	$/LF	TOTAL
PHASE 1 - REDUNDANT LOOP & CITY FACILITIES			
EXISTING CONDUIT	6,374	$ 25	$ 159,350
EXISTING FIBER	13,255	$ 5	$ 66,274
NEW UNDERGROUND	16,926	$ 125	$ 2,115,753
DROPS	3,929	$ 80	$ 314,320
PHASE 1 TOTAL	**40,484**		**$ 2,655,697**
PHASE 2 - PUMP STATIONS & WATER ASSETS			
EXISTING CONDUIT	20,703	$ 25	$ 517,575
EXISTING FIBER	-	$ 5	$ -
NEW UNDERGROUND	6,052	$ 125	$ 756,536
DROPS	3,291	$ 80	$ 263,280
PHASE 2 TOTAL	***30,046***		***$ 1,537,391***
PROJECT TOTAL - ALL PHASES			
EXISTING CONDUIT	27,077	$ 25	$ 676,925
EXISTING FIBER	13,255	$ 5	$ 66,274
NEW UNDERGROUND	22,978	$ 125	$ 2,872,289
DROPS	7,220	$ 80	$ 577,600
TOTAL	**70,530**		**$ 4,193,088**

The design engineering and field surveying process would verify and record all existing assets and could uncover additional fiber that would eliminate the need for some of the new construction, thereby lowering the total overall construction costs. A completed design and engineering process will likely identify some areas where overhead poles exist and aerial cables can be used instead of undergrounding new conduit, which can cut deployment costs by as much as 35-45%.

Construction costs can be even further reduced through effective utility coordination, implementing a dig once/joint trench program, and aligning broadband expansion projects with other major CIP projects, particularly those with excavation in the City right-of-way. The labor required for excavation can account for 40-60% of total construction costs. When work is coordinated between utilities and public agencies, all parties can expand their fiber footprint at a fraction of the cost by taking advantage of synergies with other projects.

6. Public/Private Partnership Considerations

There are a range of business models a city may select (see Appendix C), which range along a risk/reward continuum. The choice of business model needs to align with the vision of the community and its leadership and be one that fits organizationally into the City's municipal operation. The selected business model will also align with the City's risk/reward tolerance to achieve its broadband goals.

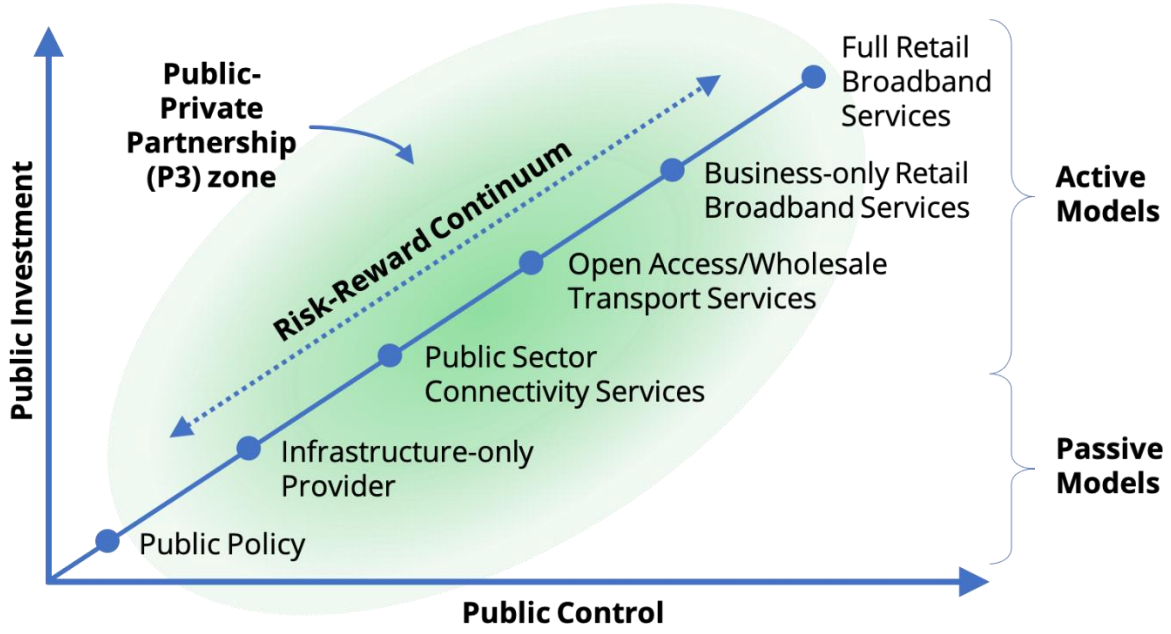

Figure 16. Business Model Risk/Reward Continuum

Discussions and information gathered during the project suggest a public-private partnership model would be appropriate to implement the Broadband Strategic Plan. For a variety of political and financial reasons, the City does not desire to establish a City broadband utility. However, the City does desire to leverage its existing and planned fiber optic network assets built to expand broadband availability for others throughout the City by making the network available for use by private Internet Service Provider (ISP) providers.

Public-private partnerships ("P3") are an emerging business model that provides an innovative solution to an ongoing municipal broadband issue: how does a local government extend broadband services in the community without operating a broadband network? Generally, P3s create a cooperative platform for a local

government and one or more private organizations to plan, fund, build, and maintain a broadband network within the city's jurisdiction.

The key factors that define a public-private partnership, as opposed to simply a customer-vendor relationship, is that: (a) all parties contribute, (b) each parties' benefits are shared based on their contributions, and (c) one partner does not pay another; there are few or limited transactions between partners.

To begin creation of a P3, the City would publicly solicit potential partners via Request for Information (RFI) and select through negotiation one or more private or public ISPs to provide and sell retail internet services over a network incorporating desired segments of City-owned fiber in exchange for lease payments, revenue share, new City network construction, or a combination thereof. This P3 approach is particularly suitable to the City given capital resource constraints, significant existing City conduit and fiber which sharing arrangements could multiply subscriber reach, and the potential new construction leveraging existing City facilities identified in the Conceptual Network Design.

It should be noted that soliciting and selecting a private partner is not a typical procurement process but is a negotiated arrangement that will take time to define and finalize. To make a P3 successful, each party should align on negotiated points, which can include:

- Who has rights to access the network – is it exclusive or non-exclusive?
- What are the public and private partners' goals and how are they incentivized?
- What roles and responsibilities does each partner have?
- What assets are financed through the public?
- What revenue model is used to recoup investment?
- What requirements must the private partner meet, in terms of service availability, speed, price, build locations, and performance schedules?
- How will the partners determine future buildouts and who pays for them?
- What happens if the private assets are sold or acquired?

The City is already taking the lead in managing and brokering fiber optic network assets created in the "Smart Corridor" project by CCAG – in which the City is a key partner. Under the Smart Corridor partnership, the City and CCAG will share the 288 fiber optic strands within South San Francisco, set aside the necessary strands for the traffic management network, and lease out the remaining available strands to interested third parties. The City would market and advertise these available strands, and net revenues remaining after deduction of the City's administrative expenses would be divided equally between the City and CCAG.

The P3 contemplated here would build on the Smart Corridor partnership and extend the reach of the City's entire network, including the Smart Corridor fiber, to potential partners who can operate, manage, maintain and market the City's network. This network reach has significant value and over time can generate revenues to help offset costs to the City. These revenues could also be a funding source for the Technology Enterprise Fund. Other benefits to the community could be realized by using the network as platform to extend broadband to unserved and underserved areas of the City, or to lower the barrier for cellular providers to reach neighborhoods with poor signals (such as Westborough) by proving cost-effective fiber backhaul.

7. Key Recommendations

1) Expand the City's Fiber Backbone to Improve City Facility Connectivity and Expand Community Broadband Access.

The City can complete a carrier-grade backbone loop, connecting 18 City facilities, 25 pump stations, and 98 traffic signals at an estimated cost of $4.2 million The phased approach allows for incremental builds as resources and funding allow, while laying out a roadmap for coordination and alignment with other major projects to minimize costs. A carrier-grade fiber loop will also enable the city to identify a qualified private ISP that can operate, manage, and maintain the network while expanding broadband access in the community at competitive rates.

Extending the City's fiber network under the conceptual design will also future-proof the network and support emerging applications such as Emergency Vehicle Preemption (which is planned) and connected vehicle needs via next generation 5G and 6G wireless services which must be connected with fiber backhaul.

2) Initiate Design & Engineering for Phases 1 & 2 at an estimated cost of $130,400.

The first two phases of the Conceptual Design – Citywide Redundant Loop and City Facilities – create a high impact and maximize the value of the City's network (and thus attract private investment). By undertaking design engineering, the City would be demonstrating a commitment to moving forward – being "shovel ready" – and thus enhancing its grant competitiveness for state and federal broadband grants.

Design engineering would include field surveying and verification, identifying additional usable assets that may not be recorded in City maps, value engineering to reduce the overall cost, confirming the final routing and design, and compiling a Bill of Materials.

3) Solicit & Negotiate a Public-Private Partnership to Operationalize the City's Broadband Network.

The City's existing network, its role within the Smart Corridor project, and the Conceptual Network Design proposed in this Strategic Plan - as well as the planned

expansion through the Critical City Site Design project recently completed by Kimley-Horn – have positioned the City to be able to expand the benefits beyond just City administration and services and into the community at large. However, operationalizing, monetizing, and managing a retail data network requires resources, staffing, and start-up capital that likely exceed the City's existing capacity. The City should transparently solicit a public-private partnership through an RFP to find a qualified ISP that is willing to manage, maintain, market and operate the City's network in exchange for a portion of the revenues generated through retail sales.

4) Pursue Competitive Grant Opportunities through State and Federal Broadband Grants.

The State of California, through the Advanced Services Fund (CASF), has $150 million in annual allocations (through 2032) for broadband grants for infrastructure, public housing, and adoption programs. The City is eligible for these funding sources and should pursue these grants to provide for construction of the Citywide Conceptual Network, for the marginal costs to connect CPUC-designated unserved households and other at-need neighborhoods, and to assist with digital literacy and navigation programs in the community.

5) Coordinate Joint Build and CIP Projects for Broadband Expansion.

Coordinating infrastructure expansion through joint utility work and CIP projects is the most cost-effective strategy to expand City broadband assets, particularly into under-served areas and new developments. Effective coordination on all projects that require excavation will ensure that all utilities—public and private—can economically expand their broadband footprint in the South San Francisco. The City can incrementally and opportunistically build its own fiber network, connect key City facilities, and enable Smart City applications. Effective joint build and utility coordination requires an effective and enforced "dig once" ordinance, a strong road moratorium, a curated master project list that aggregates all public and private excavation work in the public right-of-way, and organized, regular meetings between the various agencies and utilities.

6) Apply Development Conditions to Major Projects

Planning ahead for a broadband future is the most cost-effective way to both minimize costs and ensure new housing and commercial development thrives. The

City should add broadband and fiber expansion to the existing public infrastructure requirements (water, sewer, sidewalks, etc.) that developers must finance and construct for new developments.

The City Council has approved the Lindenville Specific Plan including a condition of approval that requires placement of conduit for the purpose of future fiber installation. This condition requires the installation of "three-inch diameter PVC conduit along the project frontage, in the right-of-way, if any trenching is to take place, for the purpose of future fiber installation. Conduit shall have a pull rope or tape. A #8 stranded trace wire will be installed in the conduit or other trace wire system approved by the City." The City could list further standard installation requirements similar to other cities' requirement, such as depth requirements (laid to a depth of not less than 18 inches below grade in concrete sidewalk areas, and not less than 24 inches below finished grade in all other areas when feasible, or the maximum feasible depth otherwise), install minimum 3-foot radius sweeps and bends, furnish with an external "warning" ribbon tape a minimum of 3-inches above the conduit, and all conduit couplers and fittings shall be installed watertight, with sealed end caps upon installation.

These standard conditions of approval should be considered for all development work citywide, so that future development of broadband and fiber optic deployments can be expanded at marginal cost.

7) Establish a Technology Enterprise Fund

Many cities create dedicated funds for revenues generated from leases of City assets by private telecommunications companies. A dedicated fund with ongoing revenues—separate from the General Fund—prioritizes new City/public technology deployment for future build opportunities (funding for fiber network expansions through incremental builds/joint trench coordination or for locating new smart city devices concurrent with expansion of private wireless connectivity). Revenues for this Fund can also be earned from the Broadband Impact Fee being considered by the City.

Creating an enterprise fund helps plan strategically for the years to come when use of public assets/ROW will increase and could create significant new City revenues. The unscheduled nature of joint trench/dig once opportunities means cities need a dedicated funding source outside of the normal budgeting process to take advantage of open trenches.

The City should consider holding revenues generated by the City through lease or other agreements for use of City broadband infrastructure – including cellular

antennas on street light poles, placement of cabinets or vaults in the ROW, leasing land or towers for cell tower installation, dark fiber or conduit occupancy leases, or other telecom-related/ROW revenue generating activities – in a separate account to offset maintenance and expansion costs.

8) Use City Communications to Inform and Promote Use of the FCC Affordable Connectivity Program

The ACP is a major cost-free tool for addressing digital equity issues. ACP enrollment in South San Francisco (18% of eligible households) is less than half the average level of both the state of California (38%) and the United States (39%). The City should support inclusion of Affordable Connectivity Program information in communications and outreach for communities, consumers and programs to raise awareness of the ACP benefit and further information on eligibility and enrollment. Examples include making sure schools, libraries, heath clinics and community centers know about ACP and have information needed to help eligible students, clients and patrons enroll. Put outreach materials in the hands of teachers, health care providers and community workers. These materials are available at ACP Consumer Outreach Toolkit | Federal Communications Commission (fcc.gov)

Appendix A: Stakeholder Interview Participants

Parks and Recreation (12/6/2022)

Greg Mediati – Parks and Recreation Director
Tony Barrera – IT Director
Angela Duldulao - Parks and Recreation Director
Brian Crume – Facility Program Manager
Joshua Richardson – Park Maintenance
Erin O'Brien – Parks and Recreation Business Manager
Mike Mulkerrins – Facilities Manager

Public Safety (12/6/2022)

Deputy Chief Matt Sampson – Fire Department
Tony Barrera – IT Director
Ken Anderson - Fire Emergency Services
Captain Keith Wall – Police Department
Daryl Jones – Police Department

Information Technology (12/6/2022)

Jeff Uchi – IT Systems Administrator
Tony Barrera – IT Director
Akbar Raufi – IT Systems Administrator
Manoe Lau – IT Systems Administrator

Economic & Community Development – Planning (12/9/2022)

Phillip Perry - Senior Permit Technician
Tony Barrera – IT Director
Erik Reitdorf – Assistant Building Official
Tony Rozzi - Deputy Director

Library & Community Learning Center (12/9/2022)

Angela Bernal-Silva – Management Analyst
Karla Molina Bourdon – Library Manager, Literacy Services
Tony Barrera – IT Director

Water Quality Control Plant Division (12/9/2022)

Brian Schumacker – Systems Librarian
Tony Barrera – IT Director
Eunejune Kim – Public Works Director/City Engineer
Nicholas Talbot – Assistant Plant Superintendent

Capital Projects (12/13/2022)

Sharon Ranals - City Manager
Tony Barrera – IT Director
Jacob Gilchrist – Director of Capital Projects

Public Works (12/13/2022)

Eunejune Kim – Public Works Director/City Engineer
Tony Barrera – IT Director
Dave Bockhaus – Deputy Director of Public Works
Angel Torres – Senior Civil Engineer
Randy Chen – Lead Electrical Technician (unsure)
Daniel Heffelfinger – Fleet Supervisor
Alex Henry - Craftsworker

Economic & Community Development – Housing (12/14/2022)

Heather Ruiz – Management Analyst II
Tony Barrera – IT Director
Neil Selander – Economic & Community Development Director
Ernesto Lucero - Economic Development Manager

City Councilmember Flores (1/3/2023)

Councilmember Eddie Flores
Tony Barrera – IT Director
Sharon Ranals – City Manager
Maria Patea - Administration, Parks & Recreation

Vice Mayor Mark Nagales (1/3/2023)

Mark Nagales – Vice Mayor
Tony Barrera – IT Director

Mayor Flor Nicolas (1/10/2023)

Flor Nicolas - Mayor
Tony Barrera – IT Director

Housing Authority (1/26/2023)

Leah Taylor - Executive Director, SSF Housing Authority
Tony Barrera – IT Director

Rotary Terrace (2/2/2023)

Tracy Angulo – Administrator, HumanGood
Tony Barrera – IT Director

Economic Advancement Center (2/8/2023)

Ernesto Lucero – Economic Development Manager
Tony Barrera – IT Director

Lindenville Planning (2/14/2023)

Tony Rozzi – Deputy Director
Billy Gross – Principal Planner
Tony Barrera - IT Director

Samaritan House- Safe Harbor (2/14/2023)

Jolie Bou – CFO, Samaritan House
Tony Barrera – IT Director

Boys and Girls Club (2/16/2023)

Monica Meija – Director of Operations, Friends for Youth
Tony Barrera – IT Director
Ruby Fong – Regional Site Director, Boys & Girls Club
Poncho Oseguera – Head of IT, Boys & Girls Club

Appendix B: Capital Improvement Program Review

Source: Proposed Capital Improvement Program, FY 2021-22

Table 6. Capital Improvement Program FY 2021-22

Project No.	Project Title	Project Description	Broadband Opportunities
		PARKS AND RECREATION	
	Centennial Way Trail Improvements	Construction of a new four-acre linear park along Centennial Way, between Huntington Avenue and Spruce Avenue	Connect City Assets; Install infrastructure for wireless/Wi-Fi connectivity; SMART City applications
PK2101	Transit Village Park Project	Development around the new BART station (Project may be stalled)	Connect City Assets; Install infrastructure for wireless/Wi-Fi connectivity; SMART City applications
		STORM DRAIN AND SANITARY SEWER	
SS2201	Country Club Park Sewer Master Plan	Sewer Expansion alternatives for unincorporated Country Club Park Neighborhood	Connect City Assets; Dig Once – Conduit Installation; SMART City Applications
SS2202	Oyster Point Pump Station (included in Phase 3)		
SD2101	Storm Drain Master Plan (Phase 3 includes connecting pump stations)	development of future capital improvement plan for storm drain system	Connect City Assets; Dig Once – Conduit Installation, crucial for "difficult" crossings; SMART City Applications
SS1801	Sewer Master Plan (Phase 3 includes connecting pump stations)	development of future capital improvement plan for sanitary sewer system	Connect City Assets; Dig Once – Conduit Installation, crucial for "difficult" crossings; SMART City Applications
		TRAFFIC	
TR2203	E101 Transit Shelter and Bulbout	New Bus Stops in SSF Biotechnology hub	Connect City Assets; Install infrastructure for wireless/Wi-Fi connectivity; SMART City applications

Project No.	Project Title	Project Description	Broadband Opportunities
TR1602	Oyster Point and East Grand Corridor Improvements	Per traffic improvement plan, current configurations do not handle traffic efficiently	Connect City Assets; Dig Once – Conduit Installation for intersections; SMART City Applications
TR1801	Commercial and Spruce Signalized Intersection	Signalization will improve intersection traffic flow and reduce number of accidents	Connect City Assets; Dig Once – Conduit Installation for intersections; SMART City Applications
TR2102	DNA Way at E. Grand, and Allerton Ave. at E. Grand Signalizations	signal interconnect installation	Connect City Assets; Dig Once – Conduit Installation for intersections; SMART City Applications
TR1404	Utah Ave Over Crossing Project	construction of new interchange on US-101 at Produce Avenue	Connect City Assets; Dig Once – Conduit Installation, crucial for "difficult" crossings; SMART City Applications
	STREETS, BRIDGES AND CROSSINGS		
SD2202	Colma Creek Oak Avenue Pedestrian Bridge	Demolition of existing Colma Creek pedestrian bridge at Oak Avenue and construction of a new pedestrian bridge within the vicinity that will not impede Colma Creek flood flows	Connect City Assets; Dig Once – Conduit Installation, crucial for "difficult" crossings; SMART City Applications
ST1004	South Linden Avenue Grade Separation	This is the last remaining at-grade Caltrain/Union Pacific railroad crossing in South San Francisco. Separating the vehicles and trains will prevent crossing accidents and improve traffic flow.	Connect City Assets; Dig Once – Conduit Installation, crucial for "difficult" crossings; SMART City Applications
ST1204	Underground utility district, Spruce Avenue	Underground overhead wires, design and construct new street lighting system	Install infrastructure for wireless/Wi-Fi connectivity; SMART Lighting/SMART City applications, Dig Once - Conduit Installation
ST1301	South Airport Boulevard Bridge Replacement	Replace bridge at North Access Road	Connect City Assets; Dig Once – Conduit Installation, crucial for "difficult" crossings; SMART City Applications
ST1403	Grand Boulevard Phase I	Improve El Camino Real between Chestnut and Arroyo Way	Install infrastructure for wireless/Wi-Fi connectivity; SMART City applications, Dig Once - Conduit Installation

Project No.	Project Title	Project Description	Broadband Opportunities
ST1502	Grand Boulevard Phase II	Improve El Camino Real between Kaiser Way and McLellan Drive, SSF BART station	Install infrastructure for wireless/Wi-Fi connectivity; SMART City applications, Dig Once - Conduit Installation
ST1807	Grand Boulevard Phase III	Improve El Camino Real between Arroyo Drive and Kaiser Way	Install infrastructure for wireless/Wi-Fi connectivity; SMART City applications, Dig Once - Conduit Installation
ST1603	Caltrain Station Enhancements	Includes furnishing, shelter, lighting and amenity upgrades to station	Connect City Assets; Install infrastructure for wireless/Wi-Fi connectivity; SMART City applications
		PUBLIC FACILITIES	
PF1801	Parking Garage Number 2	new parking garage in downtown South San Francisco	Connect City Assets; Install infrastructure for wireless/Wi-Fi connectivity; SMART City applications
PF1903	Electric Vehicle Charging Stations	Charging stations at various City Locations for internal vehicle and public facing use	Connect City Assets; Install infrastructure for wireless/Wi-Fi connectivity; SMART City applications
PF2101	Westborough Pre-K Design and construction, Main Library Conversion to Preschool project (included in Kimley-Horn design)	New Licensed preschool facility to serve growing need in the community	Connect City Assets; Install infrastructure for wireless/Wi-Fi connectivity; SMART City applications

Appendix C: Business Models

As outlined in Magellan's 2022 "Broadband and Wireless Feasibility Study", the City may choose among several business models to improve broadband infrastructure, ultra-high speed broadband availability, and broadband affordability in South San Francisco. The choice of business model needs to align with the vision of the community and its leadership and be one that fits organizationally into the City's municipal operation. The selected business model will also align with the City's risk/reward tolerance to achieve its broadband goals.

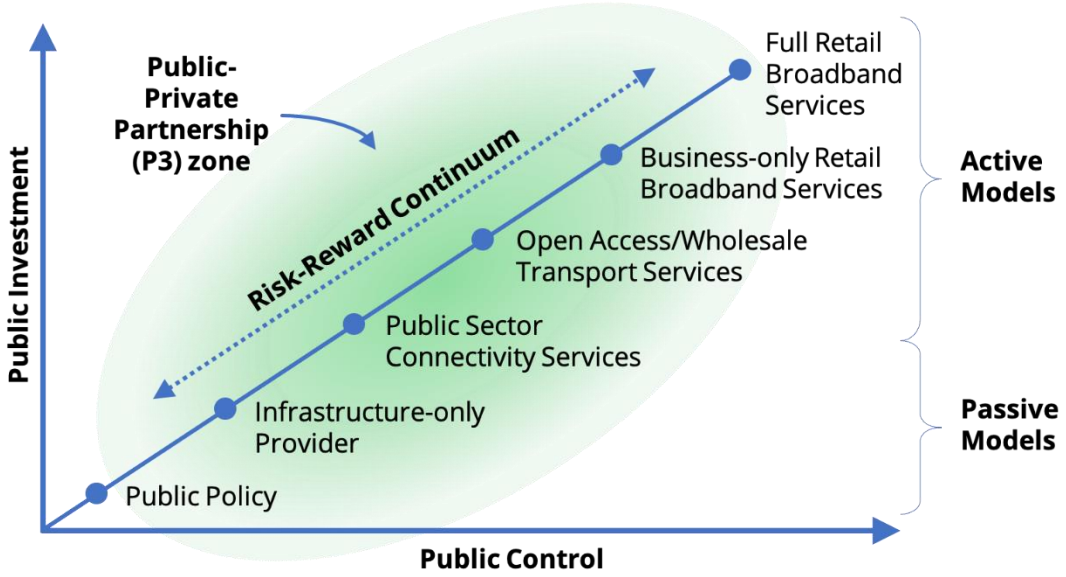

Figure 17. Business Model Risk/Reward Continuum

More than one option may be selected by an organization. For example, local governments generally utilize public policy with any of the business models, as the policies implemented by a local government will complement all the other business model options. South San Francisco's adoption of joint trench policies to aid its broadband networking is a clear example of this. Conversely, a local government would not likely implement a retail model and public-private partnerships together, as there are conflicting goals between the two models, including that the result of competition between the local government and one or more private partners.

Policy Participation Only

Public policy tools influence how broadband services are likely to develop in the community. This includes permitting, right of way access, construction, fees, and franchises that regulate the cost of constructing and maintaining broadband

infrastructure within its jurisdiction. This option is not considered a true business model but does significantly affect the local broadband environment and is therefore included as one option.

Infrastructure Provider

Municipalities lease and/or sell physical infrastructure, such as conduit, dark fiber, poles, tower space, and property to broadband service providers that need access within the community. These providers are often challenged with the capital costs required to construct this infrastructure, particularly in high-cost urbanized environments. The utility infrastructure provides a cost-effective alternative to providers constructing the infrastructure themselves. In these cases, municipalities generally use a utility model or enterprise fund model to develop programs to manage these infrastructure systems and offer them to broadband service providers using standardized rate structures.

Government Services Provider

Since South San Francisco already operates its fiber optic network to provide needed fiber connections to City departments, it could expand operational scope and services to include other community anchor institutions needing additional internet connectivity. These community anchors include local governments, public safety organizations, utilities, and occasionally healthcare providers. Many of these anchors require connectivity and often, the municipal network provides higher capacity at lower costs than these organizations are able to obtain commercially. Municipal and utility networks across the country have been built to interconnect cities, counties, school districts, and utilities to one another at lower costs and with long-term growth capabilities that support these organizations' future needs and protect them from rising costs. In these cases, government service providers may be cities, counties, or consortia that build and maintain the network. The providers utilize inter-local agreements between public agencies to establish connectivity, rates, and the terms and conditions of service.

Open Access Provider

Municipalities that adopt open-access generally own a substantial fiber-optic network in their communities. Open access allows these municipalities to "light" the fiber and equip the network with the electronics necessary to establish a "transport service" or "circuit" to service providers interconnecting with the local network. Service providers are connected from a common interconnection point with the open-access network and have access to all customers connected to that network.

Open access refers to a network that is available for any qualified service providers to utilize to connect with their customers. It allows municipalities to provide an aggregation of local customers on a single network that they can compete for and provide services. The concept of open access is designed to enable competition among service providers across an open network that is owned by the municipality. The municipality retains neutrality and non-discriminatory practices with the providers who operate on the network. The municipality establishes a standard rate structure and terms of service for use by all participating service providers.

Retail Service Provider/Business Only

Municipalities that provide end users services to business customers are considered retail service providers. Most commonly, municipalities provide voice and Internet services to local businesses. In many cases, a municipality may have built a fiber network for the purposes of connecting the City's primary sites that has been expanded to connect local businesses, in effort to support local economic development needs for recruitment and retention of businesses in the City. Municipalities that provide these services are responsible for managing customers at a retail level. They manage all operational functions necessary to connect customers to the network and provide Internet and voice services. Municipalities compete directly with service providers in the local business market, which requires the municipality to manage an effective sales and marketing function to gain sufficient market share to operate at a break-even or better.

Retail Service Provider/Business and Residential

Municipalities that provide end user services to businesses and residential customers are also considered retail service providers. Most commonly, municipalities provide services to their businesses and residents through a municipally owned public utility or enterprise fund of the City. As a retail service provider that serves businesses and residents, the municipality is responsible for a significant number of operational functions, including management of its retail offerings, network operations, billing, provisioning, network construction, installation, general operations, and maintenance. The municipality competes with service providers in the business and residential markets and must be effective in its sales and marketing program to gain sufficient market share to support the operation. Many of these markets are rural or underserved in areas that have not received significant investments by broadband service providers. Retail service providers must comply with state and federal statutes for any regulated telecommunications services. These organizations must also comply with state statutes concerning municipal and public utility broadband providers; a set

of rules has been developed in most states that govern the financing, provision, and deployment of these enterprises.

Public-Private Partnerships ("P3")

Public-private partnerships are an emerging business model that provides an innovative solution to an ongoing municipal broadband issue: how does a local government invest in municipal broadband without operating a broadband network? The key factors that define a public-private partnership, as opposed to simply a customer-vendor relationship, is that: (a) all parties contribute, (b) each parties' benefits are shared based on their contributions, and (c) one partner does not pay another; there are few or limited transactions between partners.

Generally, P3s create a cooperative platform for a local government and one or more private organizations to plan, fund, build, and maintain a broadband network within the municipality's jurisdiction. To make a P3 successful, each organization should align on negotiable agreements, which can include:

- Who has rights to access the network – is it exclusive or non-exclusive?
- What are the public and private partners' goals and how are they incentivized?
- What roles and responsibilities does each partner have?
- What assets are financed through the public?
- What revenue model is used to recoup investment?
- What requirements must the private partner meet, in terms of service availability, speed, price, build locations, and performance schedules?
- How will the partners determine future buildouts and who pays for them?
- What happens if the private assets are sold or acquired?

The essence of such a partnership is that for-profit and for-people entities collaborate to achieve complementary, if not common, objectives. The bottom line for private entities is profit, while it is quality of place for public agencies. In concept, private entities can flexibly mobilize resources where there is money to be made and public agencies can redistribute resources to ensure no one is left out. A P3 can help realize both these outcomes: public involvement reduces risk to private investment, and private involvement enables faster and more extensive execution. The table below illustrates the differences among the business models that can be utilized to achieve municipal broadband goals.

Table 7. Comparison of Municipal Broadband Business Models

COMPARISON OF BROADBAND BUSINESS MODELS							
	Government Passive Models			Government Active Models			
	Public Policy Only	Infrastructure Only	Public-Private Partnerships (P3)	Public Services Provider	Open Access Wholesale	Retail Provider Business-Only	Retail Provider Residential & Business
Services Provided	None	Dark Fiber Only	None	Dark Fiber, Transport, Internet, Phone	Transport	Internet & Phone	Internet, TV, Phone & Value-Added Services
Customers	None	Broadband Providers	None	Public Organizations Only	Broadband Providers	Businesses	Businesses & Residents
Funding Required	Low	Moderate	Low to High	Moderate	Moderate	High	High
Competing with Broadband Providers	No	No	No	No	No	Yes	Yes
Operational Requirements	Low	Low	Low	Low	Moderate	High	Very High
Regulatory Requirements	Low	Low	Low	Low	Moderate	High	Very High
Revenue Generation	Low	Low	Low to High	Low	Moderate	High	Very High
Operational Costs	Low	Low	Low	Low	Moderate	High	Very High
Financial Risk	Low	Low	Low	Low	Moderate	High	Very High
Execution Risk	Low	Low	Moderate	Low	Moderate	High	Very High

Appendix D: Transport and Access Network Equipment

Beyond leasing dark fiber, use of network infrastructure involves offering services. There are two general classes or types of services that can be provided over modern network infrastructure. ***Access services*** are relatively inexpensive, "best effort" services that do not include any solid performance guarantees. Generally, access services are considered "retail broadband." ***Transport services*** are "dedicated" services that typically come with guaranteed bandwidth and uptime commitments, which are contained in *service level agreements* (SLAs). Transport services are variously referred to as "backhaul," "bulk IP," "carrier-class," "enterprise," "long-haul," "managed," "metro," or "middle-mile" services depending on the context. Generally, they are used by large organizations, including retail service providers.

Access and transport services are complementary but involve different components and costs as well as customers. As the City of South San Francisco is most likely to offer transport as part of public sector connectivity business, we describe transport services infrastructure first, followed by information about co-location, a related service. We include a reasonably comprehensive consideration of access service infrastructure for informational purposes since the City of South San Francisco is seeking partners to offer those services. Improved access services for the community would directly achieve key results for this plan and address one or more of the City's strategic goals.

Transport Services

Transport services involve relatively few, stable but high-performance connections. Users are major businesses and institutions, including network service providers. The service is moving information from one point to another, rather than leasing an asset, so the value comes from ensuring the information keeps moving. This requires equipment that lights the fiber, maintains connections, and transmits data as diagrammed in Figure 18. A form of hand-off to other networks or services, which additional equipment, is commonly a part of transport service.

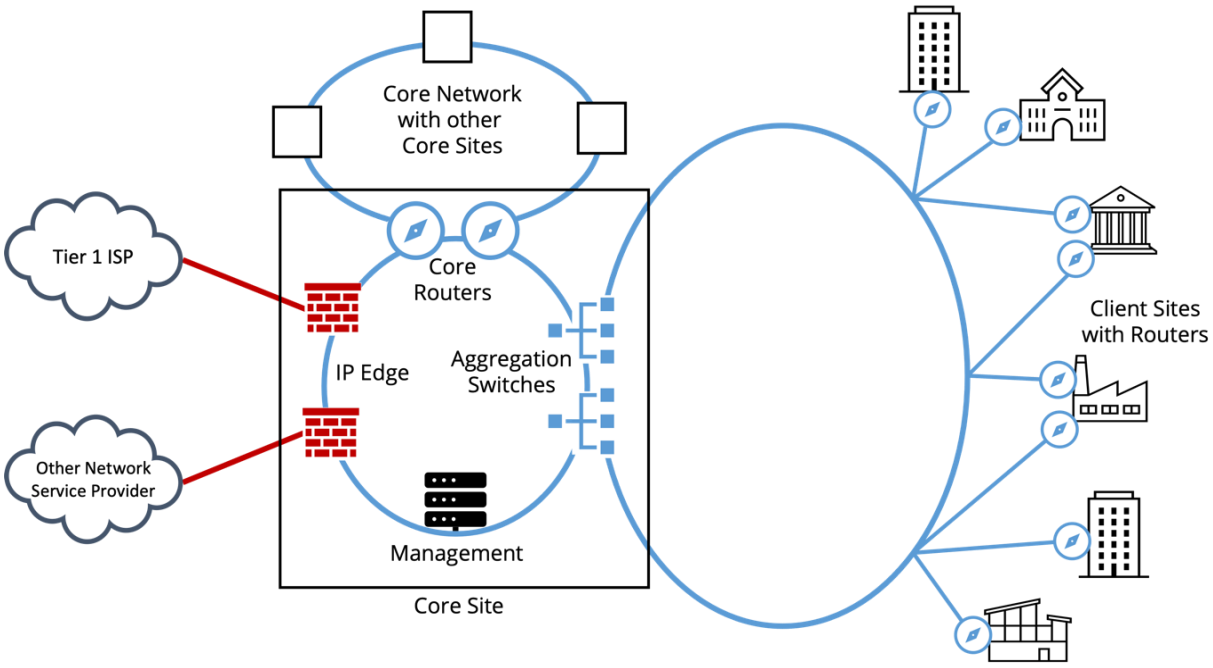

Figure 18. Transport Networks Architecture

Networks typically have a core network composed of a few centralized core sites—called central offices, data centers, or headends depending on type of ISP—interconnected by fiber in a ring architecture. Core sites contain the most powerful equipment to connect the local network to the global network. They must be secure, with high reliability power, and preferably centrally located. At least one, ideally two, sites must connect to high-capacity dedicated internet services, ideally via different providers with fiber following separate routes, for bulk IP.

Transport customers typically have substantial network operations of their own that incorporate transport services where needed, which requires next generation technologies—specifically software-defined wide-area networks (SD-WAN) and sophisticated management systems. Customers may require dual-homed connections, which connect to the core site via two diverse routes, and redundant connections to cloud services, tier 1 ISPs, and other service providers.

Transport service providers often co-locate in other companies' data centers to reduce costs. Access service providers generally prefer to own their core network sites, known as "central offices" or "headend" facilities, and access infrastructure called "pedestals" or "points of presence" (POP). This is changing somewhat with the emergence of wholesale open access infrastructure. Interconnection sites between different providers range from massive data centers to relatively small huts.

The network equipment required to deliver broadband services to customers is comprised of several functional groups and multiple components. All business models

beyond infrastructure-only require core equipment, similar to what most cities currently use for their enterprise WANs. This must be supplemented with additional core capacity and various types of access equipment and infrastructure.

Core Equipment

The core equipment aggregates traffic from all access equipment, connecting customers and routing their data to and from the IP edge equipment or other end-point destinations. Standard network protocols provide link redundancy and dynamic traffic re-routing in the event of an equipment failure or fiber cut. Core equipment can easily support thousands of customers and hundreds of gigabits of traffic throughput at deployment and will accommodate future system growth through the addition of service modules, optical interfaces, and/or software licenses.

Internet Protocol Edge (IP Edge) Equipment

Separate from the core switches, the network must maintain an "internet perimeter." The internet perimeter will include internet routers and internet firewalls to be used to manage routing throughout the network. Firewalls will be utilized to protect critical back-office systems, including provisioning, network management, data storage, and other information. The two core switches will be interconnected to two internet routers providing redundancy for internet services in the event of a single interface or equipment failure. As mentioned above, bulk IP should be acquired from at least two providers using diverse paths, one of which should be a Tier 1 provider.

The estimated one-time capital costs for equipment and services to establish a transport network for the conceptual design, based on vendor-provided pricing, would be about $530K as summarized in Table 8. The core network in this scenario would consist of the City's data center as the "central office" and a secondary, backup site, which we assume would be an existing site. We assume that each site would have a single router combining edge/core functionality, an aggregation switch, cloud service/firewall appliance for security, Internet Protocol services, and management software for server, network elements, and back-office functions.

Table 8. One-Time Capital Costs for a Transport Network

Item	Unit Cost	Quantity	Total
Core/Edge Routing	$80,000	2	$160,000
Switching	$7,500	2	$15,000
Software	$15,000	2	$30,000
Security	$50,000	2	$100,000
Management	$30,000	2	$60,000

Item	Unit Cost	Quantity	Total
IP Services	$5,000	2	$10,000
Spares	$15,000	1	$15,000
		Subtotal	$390,000
CPE	$1,200	51	$61,200
		Subtotal	$451,200
Pro Services	$78,000	1	$78,000
		Total Capital Cost	**$529,200**

Estimated costs for the two core network sites' equipment alone are $390K. Expect professional services at approximately 20% of the total equipment costs to be required. All the City's sites would get 1 Gbps connections, scalable to 10 Gbps. Each site requires customer premise equipment (CPE) that terminates the transport network and provides an interface to the site's local area network (LAN). We assume there is existing LAN equipment capable of 1 Gbps connections. Sites without connections or legacy equipment would involve additional site-specific costs. Budget around $47K annually for maintenance and other recurring equipment costs.

The central office would house core and edge equipment for ISPs serving customers within the area. Other carriers could be co-located in these sites so circuits and traffic could be connected and routed to the rest of the world. Equipment and facilities requirements are reasonably modest—primarily separate, secure cages for providers and major network users to place equipment, along with environmental controls and clean, reliable power. We assume the central office would be the City's data center. Otherwise, plan to spend approximately $500K to build out a data center, not including property acquisition or construction costs.

Access Services

Discussion of access service considerations is included here for informational purposes since the City is considering pursuit of partnerships with service providers who would incur these costs to serve customers.

The major difference between a local transport network and a fiber access network is the addition of access and distribution infrastructure, including hubs and multi-site terminals, illustrated in Figure 19. The core network delivers much the same functionality to broadband distribution hubs—also called points-of-presence (POP)—as to transport service customer sites. The dedicated connections function as feeder lines, which are also typically deployed in rings, between the core sites and distribution hubs. The core and feeder networks and hubs comprise the "transport"

network. Access requires additional equipment that supports connections to many customers.

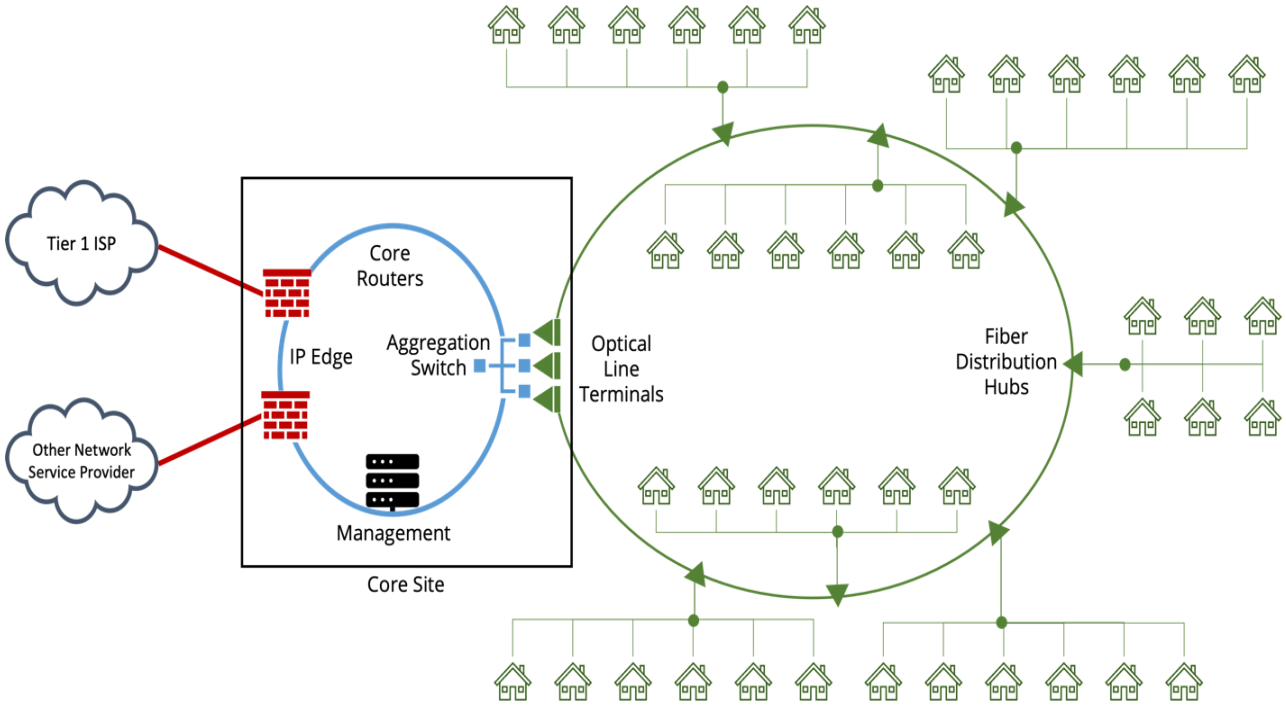

Figure 19. Passive Optical Network (PON) Architecture

Feeder fiber connects optical line terminators (OLT) in the core sites to passive splitters called fiber distribution hubs (FDHs), typically in outdoor cabinet enclosures placed strategically throughout the service area. Splitters may also be located within the access POP itself. In areas where aerial fiber deployment may be used, FDHs may be placed aerially or transitioned from the aerial pole to a ground mounted FDH. As this plan is limited to assessing major corridors as fiber routes, we assume coverage is limited to customer premises within 500 feet of the backbone. This requires only a single FDH.

The distribution network branches out from the FDHs. Multiple access lines drop off the distribution lines—hence the term “fiber drops”—via drop terminals into customer premises. Major sites can be directly and diversely connected to the core sites via “laterals,” basically putting them on the feeder network. The backbone fiber may be used for a distribution, feeder network, and/or laterals, as well as core network. The particular use of specific fiber strands is a matter of how they are spliced together and where they terminate. Indeed, a single fiber cable can accommodate multiple physically separate networks for purposes such as SCADA or traffic signal interconnection.

Hubs may be powered cabinets, prefabricated shelters, or existing structures with sufficient space for equipment racks and other components. Feeder and Distribution Fiber

Feeder infrastructure that extends from the POPs to neighborhoods and business districts typically requires only a few fibers, at most a single 24-strand buffer tube. The backbone typically consists of 288-strand fiber therefore at least a hundred strands would be available for use as distribution. The estimated costs are based on feeder fibers are sized based on the demand forecast and sizing of each enclosure to ensure that each service area is well equipped for broadband services. These details are addressed in engineering design to get optimal coverage for the least practical costs.

Each OLT serves 512 subscribers at a 1:32 split. The number of POPs and OLTs per POP depends on the number subscribers. The cost includes OLT and backhaul hardware necessary to connect each POP to the core routers. In an actual design/implementation, each OLT would not need backhaul hardware, two line cards, 16 optical interfaces, etc.

Distribution fiber extends from the splitters in the FDHs to network access points (NAPs), or drop terminals, which connect individual fibers entering customers' premises. NAPs may be attached to aerial strand, located in ground level pedestals or placed in underground vaults or hand holes located near the sidewalk or curb in residential neighborhoods or business districts. NAPs are costed as an integral component of the distribution infrastructure estimates. Fiber distribution to NAPs will be sized based on the service area density to provide service to between 8-12 premises per NAP.

Fiber Service Drops

Fiber drops connect from each NAP to the customer premise equipment that delivers broadband service. At the customer premise, the drop cable terminates in a protective "clamshell" enclosure attached to a home or building for storage of slack and connection to the home equipment. Drop fiber may be installed aerially or underground, typically for a flat fee. Providers may charge additional drop costs for special circumstances such as burying fiber through difficult landscapes or under driveways. The average cost of a fiber drop in Magellan's experience, including all these components and labor, and recognizing that drops can vary greatly in complexity and distance, is approximately $2,500.

Optical Network Terminal

An Optical Network Unit (ONU), sometimes called an Optical Network Terminal (ONT), serves as the demarcation point between the retail ISP's fiber network and the router

or firewall connecting to the customer's local area network (LAN). There are two general methods for installing ONTs. The first method involves mounting an outdoor rated ONT on an exterior wall of the structure and extending service wiring inside the premise. The second method involves extending the fiber into the premise and installing an indoor-rated ONU inside. In either case, the ONT is typically installed somewhere near the fiber entrance and an AC power source. The ONT terminates the fiber-based PON signals and provides customers with access to their services through traditional copper interfaces. XGS-PON ONT's supporting greater than 1 Gbps data service may also support optical small form-factor pluggable (SFP) interfaces for connection to enterprise-class LAN equipment.

Access, Distribution, and Transport Costs

Fiber in the routes analyzed above could connect retail ISPs' POPs anywhere in City of South San Francisco with backhaul via diverse routes to multiple upstream service providers for maximum fault protection. Additional equipment, infrastructure, and software will be required to connect homes and businesses to the network. In practice, most access and distribution infrastructure can and should be built in a phased manner in response to consumer demand and/or in conjunction with other capital projects.

Discussion of these access service costs are included here for informational purposes since the City is considering pursuit of partnerships with service providers – who do incur these costs to serve customers. Therefore, it is important to understand the scale of investment required. For cost estimation, we assume:

- 3500 Customer Premises Served per Hub
- 50%[27] Prospective Customer Take Rate
- 1,750 Total Subscribers (Drops) per Hub
- 0 Video Subscribers
- 1 Data Center
- 1:32 Split ratio

The size of the subscriber base impacts the types, quantity, and costs of central office equipment. Core routing and edge routing are assumed to be separated due to increased capacity required. An optical line terminal (OLT), which establishes connections over access infrastructure to subscriber premises, is also required along with equipment for each subscriber site. For estimating costs, we assume that each customer requires a separate broadband/Wi-Fi router, enclosure, and interface

[27] Take rate in the context is used to estimate costs only, not revenues, and is set to a level intended to result in conservative cost estimates.

(optical network unit or ONU). Required professional services will be approximately 20% of total equipment costs. If additional FDHs were required beyond the central office, plan to spend about $460K per remote hub to serve up to 2,250 subscribers.

Table 9. Capital Costs for Access Services

Item	Unit Cost	Quantity	Total
Central Office and Distribution Equipment			
Edge Routing	$80,000	2	$160,000
Core Routing	$125,000	2	$250,000
Switching	$7,500	2	$15,000
Access Network	$50,000	2	$100,000
Software	$10,000	1	$10,000
Security	$30,000	2	$60,000
Management	$75,000	2	$150,000
IP Services	$15,000	2	$30,000
Spares	$25,000	1	$25,000
		Subtotal	$800,000
Customer Premises Equipment			
ONU	$275	1,750	$481,250
NID enclosure	$50	1,750	$87,500
Residential Gateway	$159	1,750	$278,250
RG Management	$6,000	1	$6,000
		Subtotal	$853,000
Pro Services	$160,000	1	$160,000
		Subtotal	$1,813,000
Software/Systems			
Billing	$50,000	1	$50,000
Subscriber/Provisioning	$25,000	1	$25,000
		Subtotal	$75,000
		Total Capital Expenses	**$1,888,000**

Appendix E: Technical Specifications and Cost Estimates

Construction Methods and Costs

There are many different construction methods to deploy a fiber optic network, some use existing infrastructure and other methods are new and require substantially more labor, materials, and expertise. There are types of construction that are better to use when a speedy deployment is desired. The baseline cost for fiber construction in major metropolitan areas is approximately $120 per foot.[28] The specific type of construction depends on the built and natural environment and the location of sites to be connected. Table 10 summarizes the construction methods available and estimated cost for each.

Table 10. Fiber Construction Methods Compared[29]

Construction Methods	Estimated Cost/Foot	Brief Description
EXISTING INFRASTRUCTURE		
Existing City owned Fiber Optic Cable	$5 – $10	Re-splicing, adding splice cases, testing, and documenting existing fiber
Existing City owned empty conduit	$20-25	Placing new cable in existing conduit, splicing, splice cases, testing and documenting fiber
Remove and replace City owned Fiber or Cooper cables	$25 – $35	Removing working circuits, splicing, adding splice cases, testing, and documenting existing fiber
Upgrade traffic interconnect conduit	$35-45	Removing interconnect cables, upgrade handholes and sweeps, pull new cable, splice, test, document
AERIAL CONSTRUCTION		
Over lash aerial cable	$20 – $25	Pole Loading, place new cable on existing strand (over lash), splice, test, and document

[28] Based on Magellan Advisors' information about current market conditions in the region and state, including local prevailing wages.

[29] Cost estimates per foot range depending on local environment, existing infrastructure and utilities, complexity of installation, permitting and ROW access, and local and regional standards and specifications.

Construction Methods	Estimated Cost/Foot	Brief Description
New attachment aerial cable	$45-55	Pole load, build new attachments, place strand, lash cable, splice, test, and document
New aerial with new poles	$110 – $130	Same as above but must permit and place new telephone poles first.
UNDERGROUND CONSTRUCTION		
Vibratory Plow	$35 – $45	Using a vibratory plow with 4' stinger to place conduit prior to new cable placement
Micro trenching	$40 – $50	Micro trenching uses a thin 1" – 2" by 12" deep to cut a trench into the ground, pavement, or other and place conduit in the trench and seal it with special material to prevent cable from coming out of the trench.
Rock Wheel	$150 – $160	Uses a 6" – 8" blade to cut a trench up to 36" deep through any material including rock, gravel, asphalt, dirt etc.
Boring/Directional Drilling	$100 – $130	Uses rods and a machine to drill a hole under the surface of the earth at any depth needed with minimal disturbance
Open trench	$125 - $150	Using machines like mini excavators, backhoes, shovels to open a trench to place conduit and back fill over conduit

Assumptions used for the City of South San Francisco conceptual network design include:

- New construction will be underground when possible
- Aerial construction will only be used for difficult crossings, railroads, water ways, or highways
- The unit rates are the best current estimation and are subject to change
- The city does not intend to build an FTTX[30] network and serve as a retail provider
- The construction occurs in a phased deployment over multiple years
- Routing is based on road access; easements may be available to lessen the footages and cost of deployment
- Existing Conduits are suitable for fiber optic cable placement

[30] Generic term for Fiber to the Home (FTTH), Fiber to the Node (FTTC), Fiber to the Curb (FTTC), etc.

- Existing city owned and future fiber optic cables will be of sufficient strand count to accommodate expansion
- Kimley Horn design is accurate and can be used to expand the City's network

Aerial or Overhead

Overhead deployment can cost 60% less than the baseline cost, assuming the cable can be attached to existing poles.[31] Poles must be inspected and engineered to make sure that a new cable does not "blow" the pole. A blown pole means that the pole is unsafe and has more weight on it than it can safely handle. If the engineering proves the pole can support new cable placement on an existing strand, then placing a new cable on an existing strand can be a desired method.

Boring/Directional Drilling

Direction drilling aka boring, requires a large, 4'x4'x4', hole to be dug for each 300'-500' segment. Locating the existing utilities is required and anytime the bore path crosses a utility, that utility must be "potholed" and physically located to verify the boring will not contact and damage existing utility facilities. Potholes slow the process of boring down, especially when numerous potholes are necessary. Next to open trench, boring is the most expensive construction method.

Microtrenching

Microtrenching is a method of creating a small trench approximately 2" wide and up to 24" deep. It is approximately a quarter of the baseline cost. A machine with a carbide tipped blade cuts through rock, asphalt, concrete, dirt, etc. to make the trench. Then a conduit is placed in the bottom and the trench is then backfilled and compressed. The top 2"-4" is capped with different sealants and substances to protect the trench from accidental damage and prevent moisture from seeping into the ground and causing other serious issues. While cities may be hesitant to use or allow microtrenching due to the shallow depth of the conduit and risk of damage from other excavation efforts including water emergencies as well as the poor restoration that can occur, recent State of California legislation[32] requires it to be accommodated.

[31] General Order 95 contains the California Public Utilities Commission regulations for attaching to utility poles, which specifies standards that must be adhered to for the safe co-existence of electric and telecom assets.

[32] See discussion below in the Utility Coordination and "Dig Once" section.

Open Trench/ Joint Trench

Open trench is when a trench is dug into the ground with shovels, backhoes, skid steers, or mini excavators. The width may vary, but the trench is usually 12" wide by 4' deep. Once the trench is "cut" conduit is placed in the bottom of the trench and backfilled to cover the conduit. In most cases it is the most expensive method for new construction. The high cost is due to cutting through asphalt, concrete, other hardscape, labor cost, and restoration cost. This is a labor-intensive method. Joint trench is the same as open trench except there are many participants from different telecom, power, and cable companies that all share the expense of construction making it more cost-effective.

Plowing

Plowing or vibratory plow is a method where a large machine drags a blade ranging between 2'-4' deep in the ground and vibrates up and down to "cut" through the ground. The blade is rounded but sharp on the leading edge and has a slot on the back edge that conduit is fed through as the blade is moved forward. The conduit is routed over the top of the machine into the slot on the backside of the blade and is placed as the machine moves along only leaving a line where the blade had been. The restoration is minimal, and this is a very effective method in open areas with wide easements and minimal utilities in the ground. For these reasons, plowing costs about half to three-quarters of the baseline, depending on existing infrastructure, soil conditions, and other factors.

Rock Drill and Rock Wheel

Rock drills are like giant jack hammers, which make holes as small as 4" in solid stone. Rock wheels use a carbide tipped saw blade that cuts through asphalt, concrete, dirt, rock, etc. just like microtrenching, and cuts a trench that is 6" wide and up to 36" deep. Both rock drill and rock wheel are very expensive—two to three times baseline cost—and slow methods of construction but when needed they are effective methods for placing conduit.

Traffic Signal Interconnect

Traffic signal interconnect conduit systems are built to utilize copper cables and are usually not able to accommodate fiber optic cables with the needed specifications. Copper cable can be bent in hard 90-degree angles and wrapped very tightly inside of handholes resulting in small handholes and 90-degree elbows. Fiber cables consist of strands of flexible glass that carry light from one end of the cable to the other. If the

strands are bent too tight the light cannot reach the other end. To use traffic signals, conduits may need to be upgraded to accommodate fiber. The hard elbows need to be changed to sweeps and handholes must be large enough to allow for the static minimum bend radius of the new fiber. This construction method is more expensive than overhead but cheaper than other underground construction methods.

Backbone fiber can be managed as a physical asset by assigning specific strands to specific users, commonly on a lease basis, and uses. Strands in various cables must be physically spliced together or optically interconnected, including via splitters, to form complete paths so that any light shone (transmitted) down the fiber is seen (received) at the other ends. This approach has relatively low cost because it doesn't require purchasing or operating equipment, but it can also be very inefficient.

For example, if two strands in a 10-mile-long backbone (20 strand-miles total) are used to connect two sites that are a mile apart (2 strand-miles), the other 18 strand-miles become stranded and can only be used on each side of the interconnected sites. This approach also misses the benefit of redundant paths: If the fiber is cut between the two sites, the connection is lost because the information cannot flow in other directions. The key to effectively managing capacity is detailed information about sites to be connected along with additional infrastructure to aggregate traffic onto the network without having to dedicate strands to particular sites or types of sites.

Tradeoffs Between Construction Methods

Construction methods cost very differently, and the inclination would be to use the least expensive methods to save on the up-front capital investment needed. However, all construction methods have their "pros and cons", and the tradeoffs are something that needs to be considered in advance of construction of a network. Below are some examples of tradeoffs when considering different construction methods.

Example 1, boring vs. micro-trenching: New underground construction can be done in a variety of ways with varying costs boring being one of the most expensive. Micro-trenching is one of the least expensive methods of underground construction, however, it has drawbacks that need to be evaluated and mitigated prior to use. Micro-trenching is a shallow underground technique that is a viable in neighborhoods where there is little traffic and little exposure to major emergencies, such as water main breaks, that require major excavation in a hurried manner possibly exposing the shallower fiber to possible damage and outages. However, in major intersections, heavily travelled roads, water mains, storm drains, side sidewalks and gutters micro-trenching presents a much higher risk to damage that using directional drilling/boring which is much deeper at 36" - 48" deep on average.

Example 2: When implementing a wireless network, it relies on a fiber backbone to operate effectively and setbacks with regards to tower and pole placement would need to be adjusted accordingly. The cost and speed of deployment may be the best possible tactic for network construction, below are possible tradeoffs:

- Aerial equipment is more exposed to the elements, destruction, wildfires, and as such can have a higher maintenance cost.
- Wireless networks are susceptible to line-of-sight issues with foliage, buildings, concrete structures, hills, and other blockages that change over time. Trees grow, buildings are constructed, and foliage changes over time which impede propagation of radio signals.
- Permitting and long-term cost of using other 3rd party telephone poles, PG&E for example, can make this method not the best choice.