CITY OF
VICTORVILLE

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AGENDA ITEM

CITY COUNCIL MEETING OF: August 2nd, 2005

SUBMITTED BY: Christopher P. Stathis CPS
Director of Information Services

DATE: July 25, 2005

SUBJECT: Fiber Optic Master Plan

RECOMMENDATION: It is the recommendation of the Information Services Department that the Honorable City Council accepts and adopts the Fiber Optic Master plan.

FISCAL IMPACT:

Budget Amount:
Budget Account No.:

--Finance Dept. Use Only--
Additional Appropriation:

✓ No
____ Yes/$Amount:

Finance Director Review and Approval ap/aom

DISCUSSION: The City of Victorville is committed to the planned implementation of new technology to ensure the efficient and effective delivery of City services to our community. In order to maximize efficiency of the city's technology and ensure appropriate growth potential within it, the honorable city council accepts and adopts the Fiber Optic master plan, which was contracted through Columbia Telecommunications Corporation through the competitive bid process.

CPS:ms, tt
Fiber optic masterplan

Written
#17
8-2-05

Victorville, California

Fiber Optic Network
Master Plan

REVISED
July 5, 2005

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Table of Contents

Table of Tables and Figures

1 Executive Summary

Columbia Telecommunications Corporation (CTC) has been retained by the City of Victorville to develop a master plan for a Citywide municipal fiber optic network. CTC engineers worked closely with the City's engineering and technical staff to examine the requirements for the network and to survey the specific facilities that are candidates for connection to the proposed network. Based on information obtained from city staff and our on location analysis of the network requirements, we provide the following recommendations for the City:

1. The City should construct and maintain a fully underground network of conduit suitable to install and operate multiple, independently operated fiber optic networks. The conduit system and access to the conduit network should be capable of supporting not only the City's needs but should also be available for use by the school system, other government entities, and commercial service providers. To meet this objective, the following key attributes are essential:

    - Standardize on a multi-conduit design with underground pull-boxes or vaults for conduit access placed at strategic intervals capable of supporting the City's long-term network requirements, as well as providing capacity to lease conduit or fiber optics to other participating organizations and telecommunications service providers;

    - Define a two-phase construction service area approach to coincide with budgetary constraints. The first phase should establish connectivity for Southern California Logistics Airport (SCLA) sites, and the second phase should consist of sites within the southern portions of the City;

    - Identify pertinent capital improvement projects, particularly roadway-related projects, which the City can leverage to build conduit at lower, incremental costs. These should include the upcoming rail line spur to SCLA and the roadway improvements on Nisqualli Road, which may allow for the construction of certain redundant paths in the network and provide potential connectivity to the Foxborough Industrial Park; and

    - Incorporate construction of the recommended standard configuration of conduit and conduit access as a design practice for all future City capital improvement projects.

2. Leverage existing City facilities within the City conduit infrastructure wherever possible, and meet the following key attributes:

    - Designate strategically located facilities such as SCLA Building 280 - Communications Center and Fire Station 314 as hub interconnection centers for the fiber network, with other network sites connected directly to one or more hub sites through a direct point-to-point fiber connection;

- Install fiber optic connectivity to the master traffic controller at Bear Valley Road and Ridgecrest Road to support future Intelligent Transportation System (ITS) applications; and

- Install a minimum of 72-count fiber cables wherever fiber is constructed within backbone conduit to provide flexibility for the addition of future sites.

The initial list of City sites contains a total of 18 sites as provided in Table 1 in Section 3. To service the 18 sites and to construct the backbone necessary to serve the entire City as currently constituted will require the construction of approximately 23 miles of conduit and fiber. We estimate the cost of this construction to be approximately $2.4 million. The route for the first phase to SCLA is approximately 12.3 miles at an estimated construction cost of $1.3 million. The route for the second phase to southern sites in the City is approximately 10.3 miles at an estimated construction cost of $1.1 million. This estimate only considers connection to the 18 City sites shown in Table 1.

2 INTRODUCTION

This report provides the technical specifications and guidelines for the construction of a fiber optic infrastructure to support the existing and future telecommunications requirements of the City of Victorville. Construction methodology, fiber routing, and conduit recommendations are based upon an on-site examination of the Victorville facilities conducted by Columbia Telecommunications Corporation (CTC) engineers during the week of March 21, 2005. This document is intended as a technical reference for the design of the fiber optic network, and is in no part intended to supercede national or local codes, the safety policies of the Victorville City government, or recommendations provided by manufacturers of any products or machinery to be utilized in the implementation of the project. Network construction may require Victorville City permits and must adhere to all pertinent construction codes and requirements.

The primary goal of this project is to develop a design that can be used to construct a network infrastructure with the capability to provide enhanced communications between the City's governmental and recreational facilities, particularly to meet the immediate communications needs at Southern California Logistics Airport (SCLA) facilities. In addition to serving City needs, the network has been designed to provide a framework to potentially support communications needs of San Bernardino County, local school districts, and commercial entities in the City. The scope of this report is limited to the construction and maintenance of physical fiber optic plant and related physical preparation of network facilities.

The fiber optic network design is intended to offer:

- The ability to provide high-capacity links with virtually unlimited scalability determined only by the connected electronic transmission equipment;
- A greater versatility of supported services, including all varieties of voice, data, and video communications;
- The flexibility to serve additional sites by incorporating sufficient spare fiber capacity and strategically located splice points for fiber access; and
- A physical path redundancy for critical sites and services where desired.

During the process of several visits to Victorville, our staff surveyed the sites and potential routing for the City's fiber optic network. Our survey revealed that the majority of the existing utilities are constructed underground. We also observed that the City's rights-of-way are available along the routes chosen for fiber optic connectivity. Given these observations and the City's desire to potentially provide communication services to other agencies, CTC strongly recommends underground construction wherever feasible.

The fiber optic network has been divided into two initial construction phases between which construction to particular sites can be divided to coincide with the City's identified priorities as needed for budgetary or time constraints. Network construction could potentially incorporate additional long-term phases in which redundant connectivity is extended from Old Town

Victorville to SCLA and from the southern section of Victorville to City Hall, and possibly to connect both government and commercial entities to a wider range of service providers and business partners.

This report includes the following:

- Schematics of recommended fiber routing within the City;
- Recommended underground fiber construction guidelines and methodologies, including the entry and exit of communications conduit into facilities;
- Material specifications for the fiber optic cable and related installation hardware;
- Cost estimates for recommended fiber construction; and
- Fiber optic cable testing guidelines.

3 FIBER TOPOLOGY

This section provides the recommended fiber optic physical routing and construction phasing. The fiber optic network design makes use of existing rights-of-way by locating the majority of the conduit adjacent to roadways maintained by the City of Victorville. Specific construction methodology and specifications are discussed in Sections 3 and 4.

3.1 Network Architecture

Figure 1 illustrates the proposed logical fiber topology, including splice locations, construction phasing, and length of each construction segment. The colors represent the construction phase, while each site is designated by a number corresponding to the site list in Table 1. The fiber network will make use of the existing right-of-way to the greatest extent possible.

Phase A construction will include all priority SCLA facilities for initial interconnection, including Hook Park. Phase B will provide service to the priority sites in the southern section of the City. The long-term construction phase could include the addition of certain links to provide redundant backbone paths and expansion of the number of sites served by the network.

Figure 1: Fiber Optic Logical Network Topology

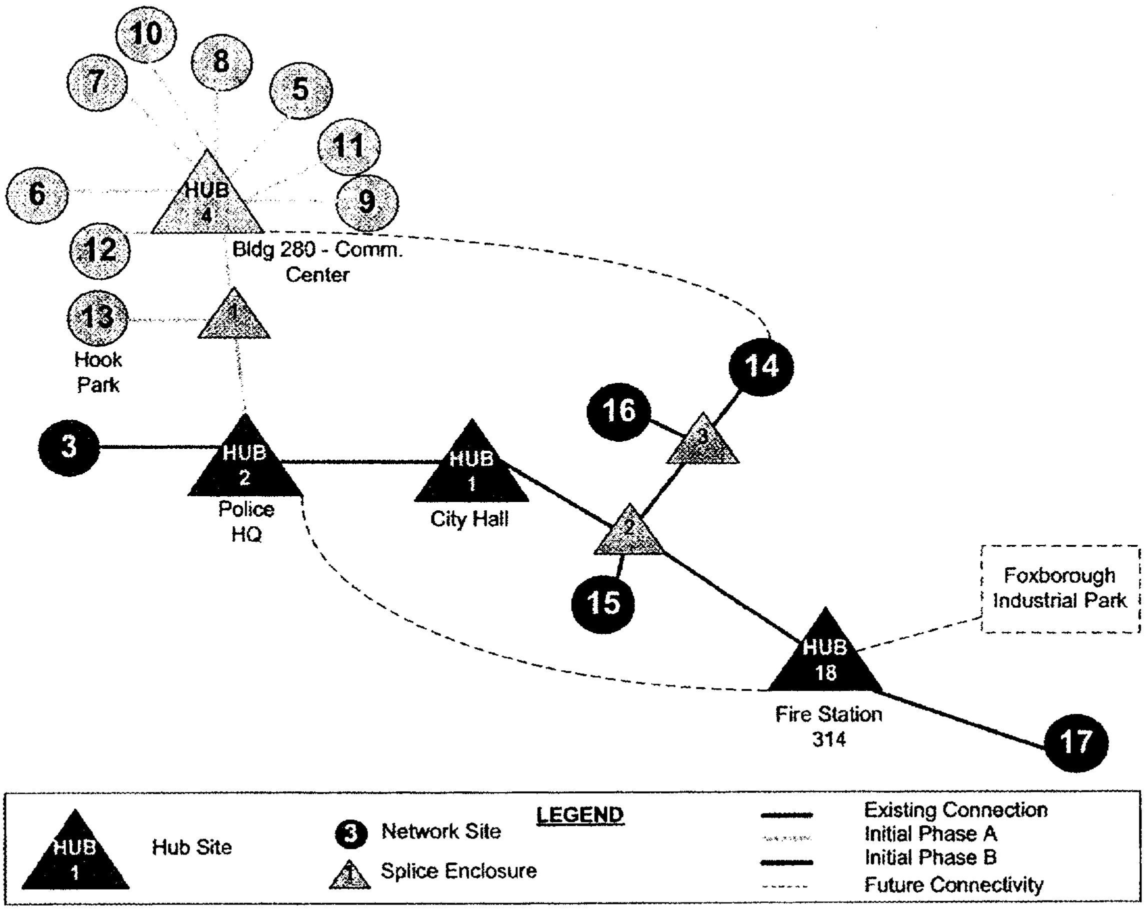


Table 1: Initial Phase Site Designations

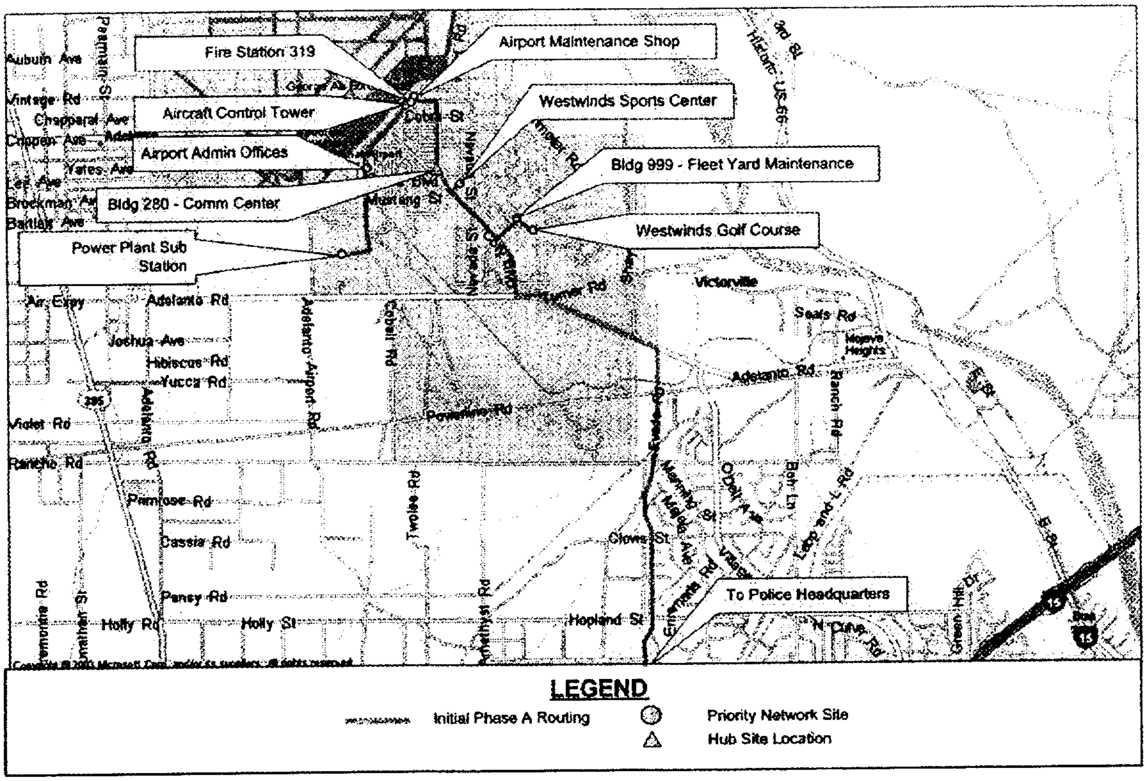
Site number	Site description	Site address	Construction Phase
1	City Hall	14343 Civic Dr	Existing
2	Victorville Police Headquarters	14200 Amargosa	Existing
3	Corp Yard	14177 McArt Rd	Existing
4	Bldg 280 – Comm. Center	13436 George Blvd	Phase A
5	Westwinds Sports Center	18241 George Blvd	Phase A
6	Airport Admin Offices	18374 Phantom St	Phase A
7	Aircraft Control Tower	18530 Readiness St	Phase A
8	Airport Maintenance Shop	18630 Readiness St	Phase A
9	Westwinds Golf Course	18003 Westwinds Dr	Phase A
10	Fire Station 319	18650 Readiness St	Phase A
11	Bldg 999 – Fleet Maintenance Yard	Green Tree Blvd	Phase A
12	SCLA Power Plant Substation		Phase A
13	Hook Park	14973 Joshua St	Phase A
14	Fire Station Headquarters - 311	16200 Desert Knolls	Phase B
15	Green Tree Golf Course	14144 Green Tree Blvd	Phase B
16	Parks Yard	15745 Lorene Dr	Phase B
17	Traffic Signal Master Controller for Bear Valley Road Signals	Bear Valley Rd and Ridgecrest Rd	Phase B
18	Fire Station 314	17008 Silica	Phase B

3.2 Initial Phase A Construction

Based on our analysis, we recommend Phase A routing of the fiber as shown in Figure 2, which includes the primary SCLA facilities and connects to the Victorville Police Headquarters at 16200 Amargosa. Construction of an estimated 12.3 miles of cable plant is required in this phase at an estimated cost of $1.3 million. Phase A extends fiber connectivity to the following sites:

- Building 280 – Communications Center;
- Westwinds Sports Center;
- Westwinds Golf Course;
- Airport Administrative Offices;
- Aircraft Control Tower;
- Airport Maintenance Shop;
- Fire Station 319;
- Building 999 – Fleet Maintenance Yard;
- SCLA Power Plant Substation; and
- Hook Park.

Figure 2: Phase A Fiber Optic Routing



A key objective of Phase A construction is to recommend routing that can immediately function as a backbone for the SCLA communications requirements and the communications needs of other City agencies. The Building 280 – Communications Center serves as an ideal hub site for the airport sites. All fibers for airport facilities should terminate within the Building 280 – Communications Center for greater flexibility in establishing connectivity to each individual site. Phase A should connect to Police Headquarters using a diverse entrance from the existing fiber interconnection. Diverse entrance points provide greater chance of network survivability in the event of inadvertent or purposeful damage to fiber over a single route.

The City's Engineering Department will determine the precise routing for the fiber optic cable installation based on existing rights-of-way and availability of conduit, where applicable. Minor modifications to the routing will not change the functionality of the fiber infrastructure.

3.3 Initial Phase B Construction

Phase B is an expansion to additional sites in the southern and western parts of the City. Based on our analysis, we recommend Phase B routing of the fiber as shown in Figure 3. This phase also expands to several private entities and educational organizations that are potential secondary tenants of the fiber optic network. The proposed routing can provide connectivity to the City's traffic signals along Bear Valley Road. Construction of an estimated 10.3 miles of cable plant is

Fiber optic connectivity to traffic signals will allow the City to expand the level of control and applications available at each traffic signal including full motion video for traffic surveillance and other Intelligent Transportation Systems (ITS).

3.4 Long-Term Construction Phases

Long-term construction plans include building redundancy into the fiber optic network and expanding the City's network to include additional sites and areas of the City, as shown in Figure 4.

Since the cost of constructing conduit infrastructure lies primarily in the labor and equipment for underground trenching and boring, every opportunity to add conduit should be explored as roadways are disrupted or trenching occurs for utilities and other projects. The widening of a roadway, installation of gas or utility pipelines, and commercial fiber optic construction projects are all examples of opportunities to share the construction costs between multiple City funded and commercially funded projects.

During our discussions with City officials, we were informed of the rail line extension from the BNSF main line, east of the National Trails Highway Air Expressway intersection to SCLA. We recommend using the construction of the rail spur as an opportunity to install conduit to SCLA to provide a redundant link from the airport back to City Hall. Constructing the conduit with the rail line construction can minimize the cost of the redundant link. An estimated 8.4 miles of cable plant is required for this rail line spur.

We recommend another redundant link be installed for the southern section of the fiber network. This link could travel across Bear Valley Road and up Armagosa to Police Department Headquarters. The link can provide fiber connectivity to the traffic intersections along Bear Valley Road for expanded ITS applications, such as full-motion traffic surveillance video, as well as provide redundancy for the southern parts of the City. An estimated 6.2 miles of cable plant is required for this redundant southern loop.

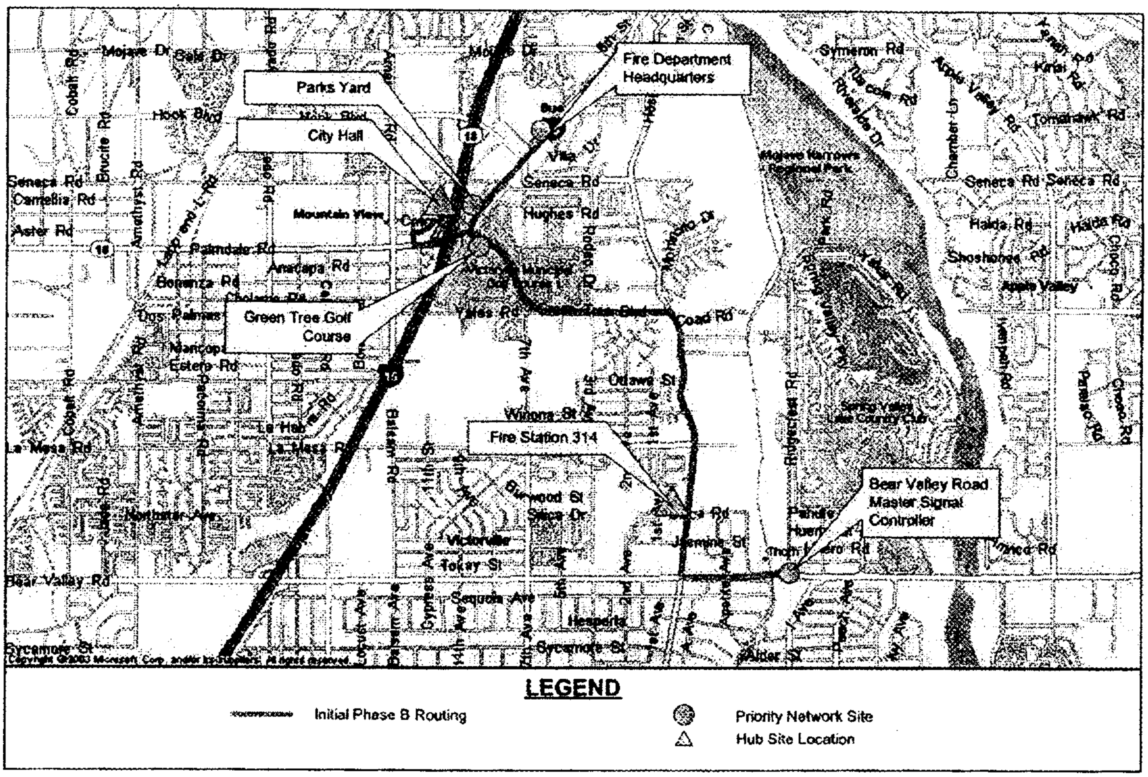
Other potentials for forming redundant links in the fiber network include the construction of the new Mojave Road bridge over I-15. Construction of conduit during the bridge construction would provide a crossing for future redundancy in the network at an incremental cost.

Spurs off the backbone link can be planned to provide fiber optic connectivity to areas deemed necessary by the City. One potential spur is the Foxborough Industrial Park located in the southwestern portion of the City. City officials identified the potential for commercial users of the conduit in the industrial park. The spur could provide conduit leasing to commercial providers and could be constructed as a ring if future need deems it necessary. The roadway repairs to Nisqualli Road may provide the City with an opportunity to expand conduit to the Foxborough Industrial Park at an incremental cost. The estimated plant mileage along Nisqualli Road between Balsam Road and Hesperia Road is 2.3 miles.

In addition to building fiber to new areas, sites may be added to the City's fiber optic network as needed. The proposed fiber routes pass many City-owned properties that may need connectivity required in this phase at an estimated cost of $1.1 million. This routing designates that the fiber will have access points at the following facilities:

- Green Tree Golf Course;
- Victorville Fire Department Headquarters;
- Victorville Fire Station 314;
- Parks Yard; and
- Bear Valley Road master traffic signal controller (Bear Valley Road and Ridgecrest Rd).

Figure 3: Phase B Fiber Optic Routing

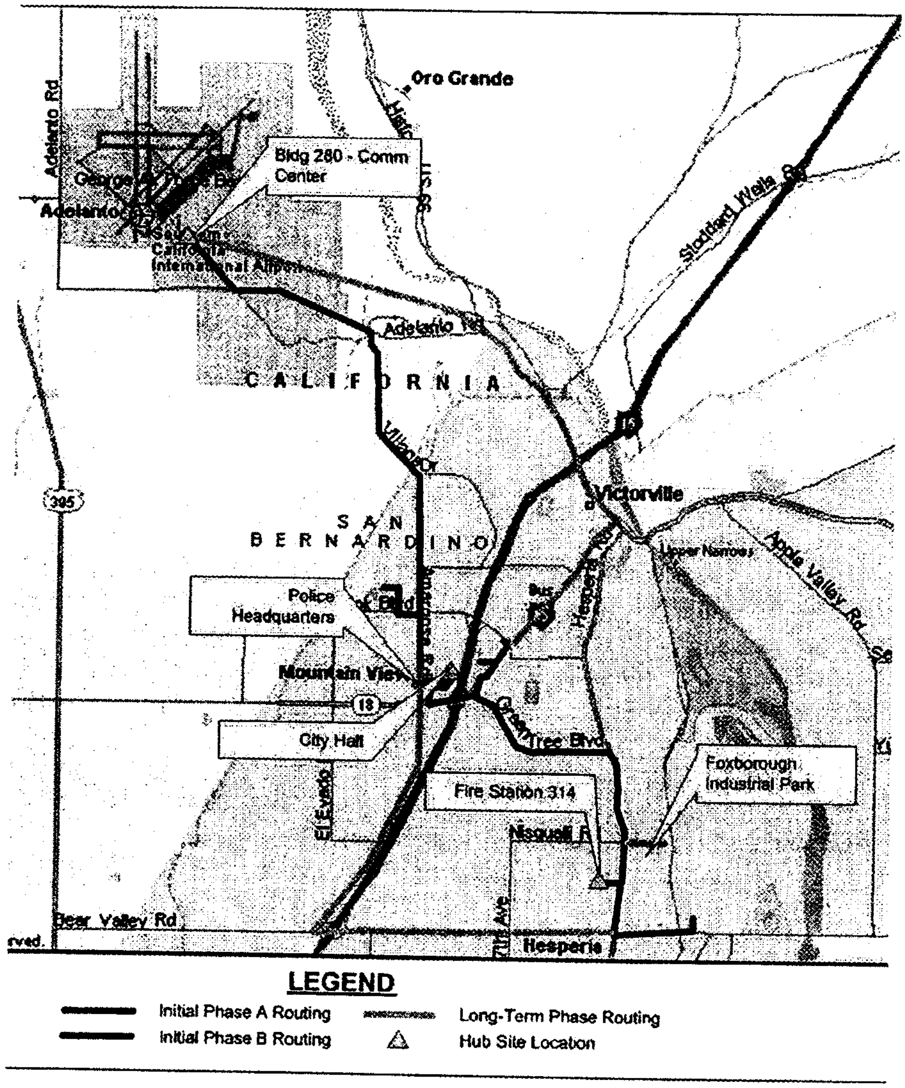


Fire Station 314 is an ideal location for a hub for sites located in the southern section of the City. Phase B construction should connect to City Hall using diverse entrance points and routing relative to existing fiber construction for added network survivability. The southern hub will also serve as a connectivity point for future fiber spurs to the Foxborough industrial park and other areas where fiber optic connectivity is needed. The City owned and operated Cogeneration Facility is expected to be completed mid-2006.

Furthermore, extending fiber to the traffic signal master controller at Bear Valley Road and Ridgecrest Road will provide connectivity from the Bear Valley Road traffic signals to City Hall.

to the network in the future. Several potential sites to be added to the network include the Foxborough Cogeneration Facility, new facilities at the SCLA, and the new animal shelter. The design of the network allows for the integration of new sites as needed by laterally building fiber drops from the main backbone fiber to individual sites. The cost of constructing fiber can be incorporated into renovations at facilities, other roadway projects, or as a separate project.

Figure 4: Long-Term Fiber Optic Routing



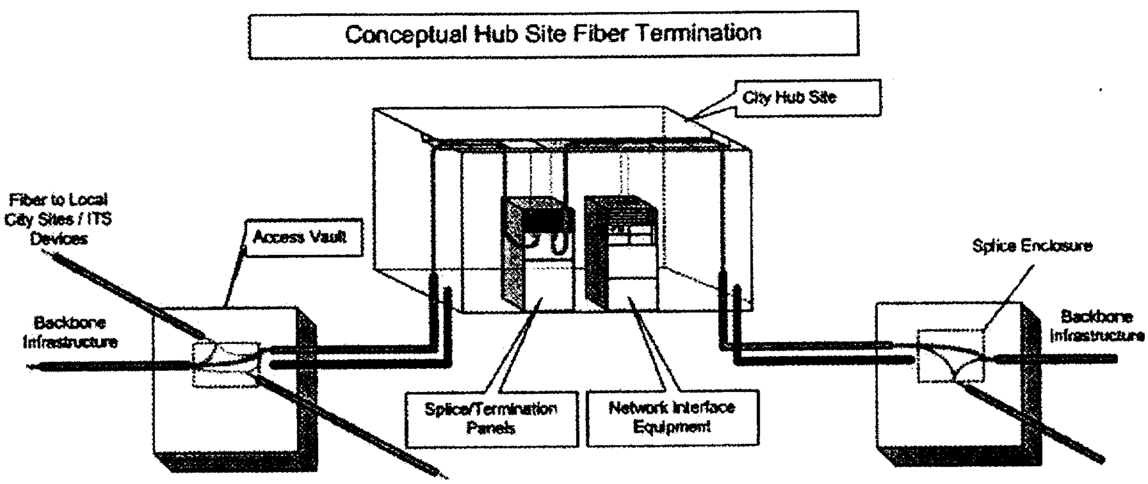
4 FIBER OPTIC ACCESS POINTS

This section provides an overview of the recommended network site characteristics in relation to the fiber optic termination and preparation for housing network electronics.

4.1 City Network Site Requirements

For each of the sites connected to the fiber optic network, it will be necessary to provision adequate physical space, air flow and conditioning, and power to support the electronic interface equipment and the fiber termination equipment. City Hall, Building 280 – Communications Center, and Fire Station 314 will serve as physical hubs for the fiber network, in which all backbone fiber optics will terminate, housed in rack-mounted termination patch panels as shown in figure five. In locations where ideal environmental conditions are difficult to maintain, ruggedized terminal equipment will need to be used.

Figure 5: Hub Site Configuration



If intended only for City users served in Phase A and Phase B construction, the requirements will be minimal for the hub location and can likely be accommodated within the existing facilities. The issue of physical security with regard to access of fiber and equipment will have to be individually addressed for each user. For instance, public safety applications may require a high level of security for fiber interface equipment, possibly necessitating that fibers be broken out from the cable and terminated in nearby secure rooms, room partitions, or locking rack enclosures.

For each network site, a 6-count fiber drop cable will be carried into the facility and terminated. In some cases, certain fiber strands will pass through a facility without being terminated, depending upon the particular use of the fiber.

The following specifications are provided as a guideline for a communications closet within each network facility (including the hub facilities), or for an onsite dedicated communications shelter, if preferred.

Structural and Architectural Recommendations:

- Minimum room dimensions of 7' (W) x 9' (L) x 7' (H);
- Roof should support structural loading of 60 psf;
- Building should support wind loading of 150 mph gusts (3 seconds);
- Floor should support structural loading of 200 psf;
- Openings must be provided in the floor or wall to feed a 2" conduit. Openings in exterior walls must be sealed to prevent water seepage; and
- Shelters must meet Victorville building codes.

Electrical Recommendations:

- Electrical system must be designed to comply fully with the NEC;
- Should include 100 Amp, single-phase main breaker;
- Must support at least four 120 Volt/20 Amp duplex outlets;
- Should provide auxiliary exterior generator receptacle (100 Amp), if needed for long-term backup power *(hub facilities only, or as needed)*;
- Should include a self testing, auto-start power generator with automatic transfer switch and uninterruptible power supplies (UPS) to provide one-half hour of backup power at full loading, to be determined based on network electronic equipment configuration *(as needed)*; and
- Electrical ground drops or grounding bar must be available for connection to equipment racks, with an 8' external ground drop.

HVAC Recommendations:

- Sufficient heating and air conditioning to maintain equipment operational requirements.

The main hub at the City Hall and any other sensitive locations should be equipped with smoke/fire detectors, door sensors, and temperature sensors, to be monitored by the Electric

Utility. Detection and sensing devices should be installed and tested, and can be monitored through interconnection over dedicated circuits on the fiber.

4.2 Expanded Co-location Hub Site Requirements

In the event that the City decides to house network electronics for commercial partners and other governmental entities, expanded hub site requirements must be met. The following specifications for the hub facility are provided as a guideline for a dedicated communications facility, although these recommendations can be applied to the preparation of space within an existing facility, if desired.

Structural and Architectural Recommendations:

- Minimum room dimensions of 15' (W) x 20' (L) x 8' (H), intended to facilitate up to 20 floor standing equipment racks for standard 19" equipment;
- Roof should support structural loading of 60 psf;
- Building should support wind loading of 150 mph gusts (3 seconds);
- Floor should support structural loading of 200 psf;
- Openings must be provided in the floor or wall to feed multiple 2" conduit. Openings in the wall must be sealed to prevent water seepage; and
- Shelters must meet Victorville building codes.

Electrical Recommendations:

- The electrical system must be designed to comply fully with the NEC;
- Should include 300 Amp, single-phase main breaker;
- Must support at least one dedicated 120 Volt/20 Amp circuit with duplex outlet per equipment rack (total of 20);
- Should provide auxiliary exterior generator receptacle (300 Amp);
- Should include a self testing, auto-start power generator with automatic transfer switch and UPS to provide one-half hour of backup power at full loading (approximately 40 kW); and
- Electrical ground drops or grounding bar must be available for connection to equipment racks, with an 8' external ground drop.

HVAC Recommendations:

- Sufficient heating and air conditioning to maintain equipment operational requirements, with redundantly configured air conditioning units (approximately 5-ton dual units, redundantly configured).

The hubs and any other sensitive locations should be equipped with smoke/fire detectors, door sensors, and temperature sensors, to be monitored by the Information Systems Department. Detection and sensing devices should be installed and tested, and can be monitored via the fiber network.

4.3 Fiber Termination Guidelines

CTC recommends that all fibers entering and exiting facilities be spliced in rack-mounted splice enclosures and fiber patch panels. Each location shall be equipped with splice enclosures and patch panels to accommodate a minimum of six fusion splices. The recommended fiber connectors shall be SC-APC connectors. Each patch panel shall be labeled to identify the termination point of the fiber.

The hub facilities will utilize splice enclosures to transition from the outside fiber optic cable to the patch panels. Multiple 72-fiber count patch panels shall be installed based upon the network construction requirements. Patch panels shall be rack mounted and labeled to identify the termination point of the fiber.

5 FIBER OPTIC CABLING AND INSTALLATION

This section provides a description of the recommended fiber optic installation methodology and related material specifications.

5.1 Fiber Recommendations

We recommend that the fiber meet the following minimum requirements:

- All-Dielectric loose tube cable with the outer jacket composed of a suitable material to prevent undo wear and aging;
- All cable shall be listed and accepted by the USDA RUS, as compliant with 7 CFR 1755.900, *Specification for Filled Fiber Optic Cable*;
- The network cable must contain 72 strand-count dispersion unshifted singlemode fiber, constructed in loose tubes containing 12 strands each;
- The drop cable must contain 6 strand-count dispersion unshifted singlemode fiber, constructed in a single loose tube;
- Optical performance shall be compliant with ANSI/EIA/TIA-568-A; and
- Cable and fiber manufacturer shall be current on their ISO 9001 registration.

A recommended example of cable meeting these criteria is Pirelli Multi Loose Tube cable. The fiber optic strand count of 72 is intended to maximize the cost-effectiveness of construction costs by building scalability into the network infrastructure. The fiber optics will be available to support the needs of the City above the current requirements so that additional capacity for both expansion of the City's communications and future networks can be supported without additional construction on the same backbone routes.

5.2 Conduit Recommendations

We recommend a two-conduit design using 3" conduit for underground construction wherever feasible. Two conduits will allow the City to populate the first conduit immediately for the City network and save the second conduit for backup or future use. A two-conduit system allows the City to switch to the other conduit in the event of an outage in the primary conduit, or to lease the second conduit to commercial providers.

We recommend that the conduit meet the following minimum requirements:

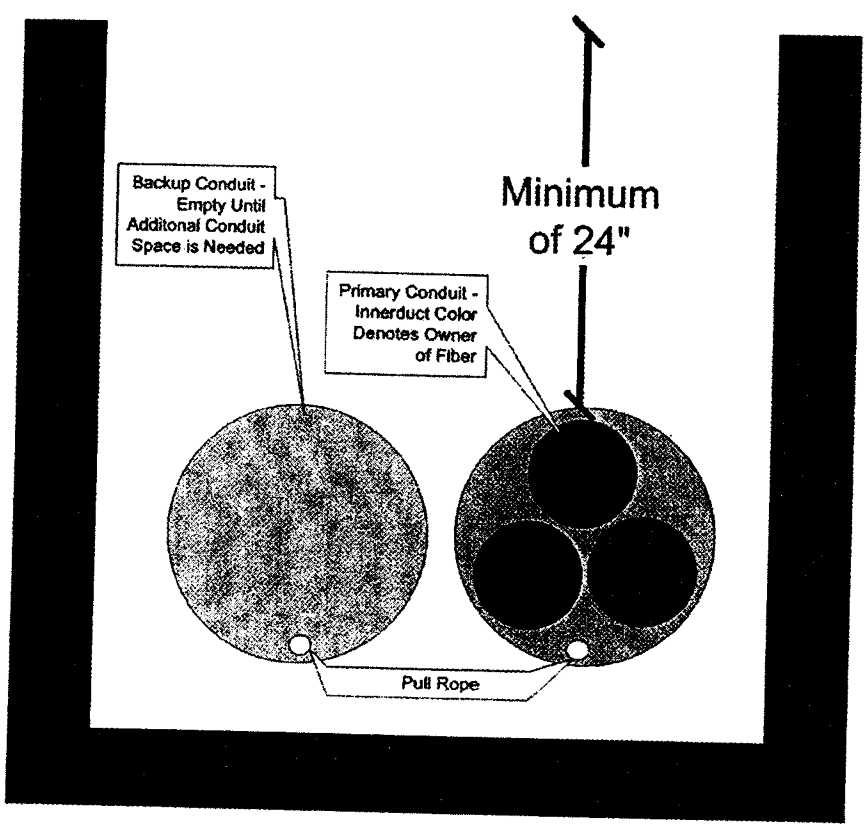
- Conduit must be UL approved;

- Two 3" schedule 40 PVC or two 3" polypipe conduit shall be used on the municipal fiber network backbone where the conduit is not located under a roadway;
- Two 3" schedule 80 PVC or two 3" polypipe conduit shall be used on the municipal fiber network backbone where the conduit is located under a roadway;
- One 2" schedule 40 PVC or one 2" polypipe conduit shall be used for site drops; and
- Conduit manufacturer shall be current on their ISO 9001 registration.

5.3 Inner Duct Recommendations

We recommend placing inner duct in the primary conduit during construction to facilitate multiple users in a single conduit. Three standard one-inch inner ducts will fit in a three-inch conduit. Each inner duct should be color coded to identify the user of the conduit. For example, the City may choose blue as the color of their inner duct and therefore fiber in blue inner duct is part of the City's municipal network.

Figure 6: Conduit and Inner Duct Layout



We recommend that the inner duct meet the following minimum requirements:

- The inner duct should consist of high-density polyethylene or equivalent material;
- Three 1" inner duct shall be installed in the primary conduit on the municipal fiber network backbone; and
- The inner duct should be color-coded per the City's specifications.

5.4 Vault Recommendations

We recommend placing vaults every 500 feet of conduit. Vaults allow access to the fiber and conduit for repair and installation, and as storage compartments for fiber and splice enclosures. Every two vaults or 1,000 feet, fiber optic coil should be stored in loops within the vault. The minimum recommended amount of fiber to be stored is 150 feet. The size of the vault must be large enough to accommodate the minimum bend radius of the fiber.

The following are standard types of underground communication vaults:

- Type 1: 20" x 20" Precast Concrete
- Type 4: 20" x 42.5" Precast Concrete
- Type 5: 24" x 36" Precast Concrete
- Type 6: 17" x 30" Composolite
- Type 7: 24" x 36" Composolite
- Type 8: 30" x 48" Composolite

One recommended example of a communications vault is Quazite Composolite "PG" Style Stackable Service Box Assembly. Composolite is a polymer concrete reinforced by heavy-weave fiberglass.

5.5 Underground Cable Installation

5.5.1 Installation of Conduit

Description

This item consists of installing PVC conduit or polypipe with all necessary fittings, under existing pavement, or in unpaved trench. Conduit installed on structures shall consist of drilling anchors into concrete, brick, stone, steel, or wood and mounting the conduit with the proper clamps or hangers. The contractor shall be responsible for correcting any existing conduit disturbed during installation. All risers shall be placed using schedule 80 rigid conduit or as approved by the City Engineer. All conduit existing under roadways shall be placed using schedule 80 conduit.

Materials

Materials shall include conduit, sweeps, couplings, and fittings as required.

Construction Methods

The City has the right to reject any installation method proposed for a given work site. Contractors must be familiar with Victorville utility construction requirements. Conduit installed in the ground shall be installed in a straight line between terminal points. If bends are required during installation, they must be sweeping bends. The City Engineer shall be consulted before any bends are installed to ensure that the proper arc is provided. Conduit shall have a minimum cover of 24 inches as measured from the finished grade. Conduit shall have a minimum separation of 12 inches of earth from any foreign substructures, where practicable.

The opening shall be filled halfway with the cover material, and tamped down firmly before filling in the remainder of the opening to 12 inches below grade. Cover material shall be compacted to the standards specified by the City Engineer. A fiber optic warning tape shall be installed and the remainder of the fill shall be added, tamping down the top layer. Conduit not terminated to a base or in a vault shall be terminated two feet beyond the edge of the pavement unless otherwise directed by the City Engineer. Conduit shall not extend more than three inches inside a vault or junction well. All conduit joints shall be sealed with the appropriate cement to ensure that the two conduit pieces bond to one another to form a solid waterproof link. If not already pre-installed by the manufacturer, a polyester or polypropylene pulling rope or tape with a minimum rated strength of 1250 pounds shall be installed in each conduit for future use. If not already pre-installed by the manufacturer, a metallic tracer wire shall be installed for locating the conduit. The contractor shall be responsible for correcting any existing conduits disturbed during installation.

Conduits may be stacked one on top of the other, side by side, or in a matrix. The orientation shall be at the contractor's discretion, but conduits shall not twist around one another or be allowed to deviate from straight-line paths except in the case of bend installations. Conduits installed at the same time in the same trench or slot shall remain oriented the same in relation to one another throughout the conduit run or as directed by the City Engineer via a change order.

All fiber shall be marked in the ground with a bright orange (preferably "ULCC" orange) or yellow warning tape at least 3 inches wide. The tape shall have integrated metallic mesh or cable to allow for easy detection. The marking tape shall be buried directly above the conduit run at a depth of approximately 12 inches below existing grade. The tape shall read "WARNING - OPTICAL CABLE" or other wording approved by the City Engineer that conveys the same message.

A. Installation Under Existing Pavement - Directional Bore

The conduit, not less than three inches in diameter, shall be installed by directional boring. Conduit must be at least 24" below pavement surface. The size of a bore shall not exceed the outside diameter of the conduit by more than one inch. If it does, cement grout shall be pumped into the void.

B. Installation Under Existing Pavement - Open Cut

The conduit, not less than 3" diameter, shall be installed by cutting a slot in the pavement with a masonry saw. The City must first approve all open cutting of roadways. The contractor shall be responsible for the removal of all cut pavement and the replacement and correction of any damaged pavement once the conduit(s) are installed.

C. Installation in Unpaved Trench

The conduit shall be installed by trenching or other approved method. In straight runs, vault spacing shall be 500 feet or as directed by the City Engineer.

E. Installation of Additional Conduit in Trench - Open Cut Pavement

In the case of slotted or trenched installations, the contractor shall install additional conduits at the same time as the initial installation if requested by the City Engineer. The City shall indicate the quantity of conduits to be installed during a build. Additional conduits may be stacked one on top of the other, side by side, or in a matrix. The orientation shall be at the contractor's discretion, but conduits shall not twist around one another or be allowed to deviate from straight-line paths except in the case of bend installations. Conduits installed at the same time in the same trench or slot shall remain oriented the same in relation to one another throughout the conduit run or as directed by the City Engineer via a change order.

F. Installation of Additional Conduit in Directional Bore

The contractor shall install additional conduits at the same time as the initial installation if requested by the City Engineer. The City shall indicate the quantity of conduits to be installed during a build. No more than one additional 4-inch conduit shall be placed, unless directed otherwise by the City Engineer.

5.5.2 Installation of Inner Duct

Description

This item consists of installing various sizes of inner duct in new or existing empty conduits. If a pull line is not already pre-installed in the conduit, Contractor shall jet in a pull line in new conduit prior to pulling inner duct. Contractor shall rod existing conduit to ensure that it is free of any obstructions before installing a pull line and pulling inner duct. If a pull line is not already pre-installed in the inner duct, Contractor shall jet in a pull line in each inner duct after installing the inner duct.

Materials

Materials shall include inner duct as necessary.

Construction Methods

Construction methods shall be in accordance with applicable standards.

5.6 Installation And Movement Of Vaults

A. Installation of Vaults

Description

This item consists of constructing and installing conduit vaults or junction wells.

Materials

Type 4 and Type 5 Precast Concrete vaults
Type 6, Type 7, & Type 8 Composolite vaults

Construction Methods

The conduit junction vault shall conform to the dimensions shown. Several conduits may extend into the vault. The vaults shall have a minimum 24" depth below surface that may be obtained by stacking vaults. All vault lids must be appropriate for the required loading. Iron vault lids are required for any locations in roadways. The base of the vault shall have gravel to a depth of one inch or as specified by the City Engineer to promote drainage of water. All conduit ends shall be sealed to minimize water ingress.

B. Relocation of Existing Vault

Description

This item consists of relocating an existing vault or junction well to clear utilities or other construction work. This item may consist of moving a vault or junction well from a few inches to several feet in sodded or dirt areas only. The maximum relocation shall be six feet in any direction from existing vault or junction well location, unless otherwise directed by the City Engineer.

Materials

The City Engineer shall determine the equipment needed to safely relocate a junction well within the specified area.

Construction Methods

The vault or junction well shall be relocated in a manner so as not to damage the junction well, lid, or frame. If the conduit that is connected needs to be moved with the vault or junction well, the conduit is to be exposed to the distance necessary to move the facility. Caution is to be used so as not to place excessive stress on the conduit or its couplings. The entire work area where the junction well and conduits are relocated shall be backfilled and tamped as directed by the City Engineer. Any extra fill needed to complete the backfill shall be considered part of this item.

5.7 Cable Installation In Conduit

Description

This item consists of installing fiber optic cable in existing conduits that may or may not contain an existing communications cable or electrical wire or cable(s).

General Items Of Work

The number of communications cables to be pulled through each conduit will be as shown on the plans or as directed by the City Engineer.

Materials

Materials shall include fiber optic cable and inner duct as required.

Construction Methods

Hand pulling methods are preferred. Prior written approval by the City Engineer is required for the use of any power assisted method of pulling fiber optic cable(s) into conduit. A short piece of material that will part if the strain exceeds 600 pounds shall be used for outdoor fiber optic cable between the pulling grip and the pulling medium.

Any and all cable(s) pulled into any conduit without the use of an acceptable pulling grip, kellems or equal, and without the use of a strain release element or by using methods which may have or did result in pulling forces in excess of strain release material, or using methods which may have or did result in pulling forces in excess of those set forth herein or prescribed by industry standards are hereby declared unacceptable.

Any and all unacceptable cable(s) shall be removed and replaced with new cable(s) using correct methods at no cost to the City.

General

The installation of cable(s) in existing conduits shall be accomplished by pulling the inner duct and cable(s) through the conduits. The cable(s) shall be prepared for pulling by reeling them from their respective reels as they enter the conduit or by taking sufficient length from the reel(s) to comprise the set to be pulled. Care shall be taken to eliminate any twists or kinks and to marry the cables in a straight lay. The cable(s) shall be hand fed into the conduit. When, in the opinion of the City Engineer, additional radius is required to prevent damage to the cable(s), a sleeve shall be used. Cable runs shall be started at one terminal point and shall be continuous without splices to the final terminal point. Cable(s) shall not be spliced in a vault or junction well unless required by design or without prior written approval of the City Engineer.

Additional excess cable(s) shall be left as noted:

1. When pulled through vaults or junction wells, 150 feet of cable or more as directed by the City Engineer shall be stored at locations not to exceed 1,000 linear feet of conduit; and

2. At the termination of each run, 150 feet of fiber, or as deemed necessary.

When cable already exists in a conduit, the contractor shall ensure that the placement of a fish tape does not damage or entangle the existing wire or cable(s). The lead end of a fish tape shall contain a blunt terminal. Bending and/or taping the end of the fish tape shall not be satisfactory nor shall any termination that contains rough edges or any sort of hook that might engage an existing wire or cable when the fish tape is extracted.

5.8 Fiber Splice and Termination Work

5.8.1 Installation of New Splice Enclosure

Description

This item consists of splice preparation of the cable ends, splicing, and installing the splice enclosure on aerial strand or in an underground pull box or vault.

Materials

Materials shall include a fiber optic splice case. A recommended example of a splice case is the 3m Type 2178-G.

Construction Methods

Construction methods shall be in accordance with applicable standards.

5.8.2 Reentry of Non-Encapsulated, Gasketed Splice Enclosure

Description

This item consists of reentering an existing non-encapsulated, gasketed type splice enclosure to make additional splices, install a new gasket, and reseal the enclosure after the splice work has been completed.

Materials

Materials shall include gaskets for the splice case. A recommended example of a gasket is the 3m Type 2178-Gskt.

Construction Methods

Construction methods shall be in accordance with applicable standards.

5.8.3 Installation of Mid Splice

Description

This item allows access to one or more fibers for splicing without cutting the entire cable. It consists of cutting away a section of cable jacketing to expose the buffer tubes, cutting a buffer tube or splitting open a buffer tube (depending on whether or not there are active fibers in that tube), splice preparation of the designated fibers, splicing, and installing a splice enclosure to house the exposed section of cable. Care shall be taken not to cut any fibers that are in active use. The work includes installing a splice enclosure on aerial strand or in an underground pull box or vault.

Materials

Materials shall include fiber optic splice case. A recommended example of a splice case is the 3m Type 2178-G.

5.8.4 Splicing of Fiber

Description

This item consists of splicing single-mode fibers, placing them in the splice trays, and placing the trays in the cases, wall mount housings or rack units.

Materials

Materials shall include single-mode splice trays. A recommended example of a single-mode splice tray is the Siecor Type M67.

Construction Methods

All fiber shall be fusion spliced. Splices shall have a loss of 0.3 db or better.

6 TESTING CRITERIA

The test must be successfully completed and must be conducted in the presence of the City's designated observer. The test shall be deemed successfully completed if: (1) maximum fiber losses do not exceed 0.5 dB/km at 1310 nm and 0.4 db/km at 1550 nm; (2) individual splice losses do not exceed 0.3 dB at both wavelengths; and (3) maximum mated connector losses do not exceed 0.75 dB at both wavelengths. These standards are based on the Telecommunications Industry Association (TIA) and the Electronic Industries Alliance (EIA) Optical Fiber Cabling Components Standard (EIA/TIA 568-B.3) for outside plant. Testing will be performed by Contractor personnel, and must be observed by designated representatives of the City. City personnel may request and perform additional testing.

6.1 OTDR Testing Procedure

An OTDR shall be used to measure and document splice losses and connector losses. To correctly identify abnormalities at a short range, a 330-feet or longer launch cable must be used between the OTDR and the fiber under test. Bi-directional traces shall be acquired for each fiber. If the connection of the launch cable to the patch panel requires optimization by the operator, sampling acquisition will commence upon completion of the optimization.

Each fiber will be identified, and the results of the test for each fiber will be recorded as indicated below in the section "Test Data File Names." The test will be repeated for each of the fibers linking a particular site. All tests will be made at 1310 nm and 1550 nm.

6.1.1 Optical Time Domain Reflectometer (OTDR) Settings

Settings on the OTDR shall reflect the following:

- The Refractive Index shall be set for the actual fiber utilized (commonly-used Corning SMF-28 single mode fiber has a refractive index of 1.4677 at 1310 nm and 1.4682 at 1550 nm);
- Pulse width no greater than 100 ns (10m) for all fiber lengths;
- Scattering coefficient specified by the fiber manufacturer for each wavelength tested;
- A minimum of 10,000 sampling acquisitions (averages);
- Maximum range set to no more than 10 km for all fiber length less than 10 km;
- Maximum range set to no more than 25 km for fiber lengths greater than 10 km; and
- Event threshold: 0.05 dB.

6.1.2 Test Data File Names

A uniform file-naming scheme for recorded data shall be used, complying with the following conventions:

Fiber Source and Destination	Naming Scheme
Hub Site to City Site	xAy
City Site to Hub Site	xBy

Where:
x = 2-digit Site Number
(A-B) = Source/Destination
y = 2-digit Fiber Number

For example, 02A01 would be the file name for the test for City site #2 from the hub site on fiber 1. Alternately, 02B01 would be the file name for the test from site # 2 to the hub site on fiber 1.

6.1.3 Test Documentation

Installed optical fiber OTDR test documentation shall include:

- Total fiber length;
- Individual fiber traces for complete fiber length;
- Paper and computer disk records of all traces;
- Losses of individual splices and connectors;
- Losses of other anomalies;
- Wavelength tested and measurement directions;
- Manufacturer, model and serial number of the test equipment; and
- Name, signature, and company of the engineer performing the tests.

All data collected at each location during the tests shall be recorded at the time of the tests using electronic means.

6.2 Optical Power Meter Test Procedure

Optical power meter measurements shall be made at the same time as the OTDR tests to determine overall fiber loss and to ensure that fibers have appropriate end-to-end continuity (fibers not crossed).

6.2.1 Calibration Procedure

Calibration readings shall be taken at the beginning and end of a testing day.

1. Power on both fiber optic power meter and laser light source;
2. Allow each instrument a minimum 10-minute warm-up period;

3. Clean all connectors, in-line adapters, and the source and meter connections with alcohol, lint-free wipes, and compressed air;

4. Connect a jumper to the light source, and a second jumper to the meter. Connect the jumpers using a bulkhead;

5. Ensure that the wavelength setting on the light source and the power meter is 1310nm;

6. Set the power meter to record absolute (ABS) readings;

7. To ensure that the jumpers are functional and that a proper connection has been established, observe the power reference reading on the meter's main display;

8. Record the measurement on the display, ensuring that the meter is set to display absolute measurements (ABS); and

9. Power down the light source and the power meter. Disconnect the light source jumper at the bulkhead ONLY. Cap the free connectors on both jumpers.

6.2.2 Test Procedures

1. Take the meter to the test site. The jumper cable shall remain connected to the meter for the duration of the testing until a post-calibration measurement is performed;

2. Clean the connectors on both jumpers and both fiber termination points with alcohol, lint-free wipes, and compressed air. This must be done before testing each fiber;

3. Connect the free end of the jumper connected to the light source to the fiber under test;

4. Connect the free end of the jumper connected to the power meter to the fiber under test;

5. Power on both the meter and light source;

6. Ensure that both the power meter and light source are set to 1310 nm. Relative measurements may be recorded if the power meter is selectable between absolute and relative measurements;

7. Observe the measurement on the main display of the power meter. Record the value shown after the reading stabilizes;

8. If inconsistent/erroneous readings are observed, re-clean the jumpers and fiber termination points and test again before recording final dB value;

9. Change the light source and power meter to 1550 nm and repeat tests;

10. Disconnect the jumpers from the fiber under test;

11. To test additional fibers, be sure to clean each connector and termination point with both alcohol and compressed air. This should be done before testing all fibers;

12. Connect the jumpers to the ends of the next fiber to be tested and observe the measurement on the main display;

13. The meter and light source should only be powered off when traveling to a new test site. At each new site, the meter and source must both be allowed a ten-minute warm up period. Follow steps 1-11 at each new site; and

14. Recalibrate the light source and meter after each day's testing is completed, following the calibration procedure.

7 BUDGETARY COST ESTIMATES

The cost estimates in this section are based upon construction of the system by a contractor specializing in fiber optic construction. Estimates are based on a competitive bid process and do not include the use of concrete slurry to cover the conduit. The actual hardware cost can be determined after a complete walk-out of all desired routes. Final costs can be determined after Requests for Proposals (RFP) are sent to vendors and accepted by the City.

7.1 Distances for Initial Phase A

Table 2: Initial Phase A Distance Estimates

Splice Locations	Total Footage
Hub 2 to Splice 1	7,400
Splice 1 to Hub 4	35,800
TOTALS	**43,200**

Table 3: Initial Phase A Site Drop Footage Estimates

Site Number	Description	Underground Footage
5	Westwinds Sports Center	360
6	Airport Admin Offices	2,250
7	Aircraft Control Tower	4,230
8	Airport Maintenance Shop	480
9	Westwinds Golf Course	4,580
10	Fire Station 319	500
11	Bldg 999 – Fleet Maintenance Yard	500
12	SCLA Power Plant Substation	5,970
13	Hook Park	3,100
TOTALS		**21,970**

Table 4: Budgetary Cost for Initial Phase A Materials

Description	Quantity	Cost Per Unit	Total
Splice Cases	10	$175.00	$1,750
Fiber Storage	60	$100.00	$6,000
Fiber Main line (72 Count)	43,200	$2.00	$86,400
3" Conduit – Backbone (2)	86,400	$2.50	$216,000
1" Inner Duct – (3)	129,600	$0.28	$36,288
2" Conduit – Site Drop	21,970	$0.90	$19,773
Splice Enclosure	12	700	$8,400
Vaults	130	$400	$52,000
Fiber Drops 6 (Count)	21,970	$0.60	$13,182
Patch Panels (6 count)	9	$600	$5,400
Hub Patch Panels	6	$5,000	$30,000
Hardware	Lot	$20,000	$20,000
TOTALS			**$495,193**

Table 5: Budgetary Cost for Initial Phase A Labor

Description	Quantity	Cost Per Unit	Total
Trenching and Conduit Installation	65,170	$8	$521,360
Install Inner Duct	129,600	$0.85	$110,160
Install Fiber	65,170	$1.00	$65,170
Install Vault	130	$650	$84,500
Install Fiber Storage Loop	60	$70	$4,200
Install Splice Enclosure	12	$150	$1,800
Splice Fiber	216	$60	$12,960
Test Fiber	126	$120	$15,120
TOTALS			**$815,270**

7.2 Distances and Construction Costs for Initial Phase B

Table 6: Initial Phase B Distance Estimates

Splice Locations	Footage
Hub 1 to Splice 2	5,500
Splice 2 to Splice 3	2,700
Splice 2 to Hub 15	21,500
TOTALS	**29,700**

Table 7: Initial Phase B Drop Footage Estimates

Site Number	Description	Footage
11	Fire Station Headquarters - 311	3,170
12	Green Tree Golf Course	600
13	Parks Yard	1,615
14	Traffic Signal Master Controller for Bear Valley Road Signals	21,070
TOTALS		**26,455**

Table 8: Budgetary Cost for Initial Phase B Materials

Description	Quantity	Cost Per Unit	Total
Splice Cases	5	$175.00	$875
Fiber Storage	60	$100.00	$6,000
Fiber Main line (72 Count)	29,700	$2.00	$59,400
3" Conduit	59,400	$2.50	$148,500
1" Inner Duct	89,100	$0.28	$24,948
2" Conduit	26,455	$0.90	$23,810
Splice Enclosure	6	700	$4,200
Vaults	120	$400	$48,000
Fiber Drops 6 (Count)	26,455	$0.60	$15,873
Patch Panels (6 count)	5	$600	$3,000
Hub Patch Panels	6	$5,000	$30,000
Hardware	Lot	$20,000	$20,000
TOTALS			**$384,606**

Table 9: Budgetary Cost for Initial Phase B Labor

Description	Quantity	Cost Per Unit	Total
Trenching and Conduit Installation	56,155	$8	$449,240
Install Inner Duct	89,100	$0.85	$75,735
Install Fiber	56,155	$1.00	$56,155
Install Vault	120	$650	$78,000
Install Fiber Storage Loop	60	$70	$4,200
Install Splice Enclosure	6	$150	$900
Splice Fiber	192	$60	$11,520
Test Fiber	96	$120	$11,520
TOTALS			**$687,270**

7.3 Cost Summary

Table 10 provides a summary of the estimated construction costs, including test and installation hardware and materials. This estimate does not include the labor value of City staff.

Table 10: Total Budgetary Cost Estimate

Description	Total
Initial Phase A Materials	$495,193
Initial Phase A Labor	$815,270
Initial Phase B Materials	$384,606
Initial Phase B Labor	$687,270
TOTALS	$2,382,339

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