

The Feasibility of Using Sewer Lines for Fiber-Optic Conduits

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The City of Portland
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Cover picture: The CityNet robot, ready to be loaded with conduit support bands before technicians lowered it into the sewer system.

Introduction

The demand for broadband communications facilities has become greater than telecommunications exchange carriers are able to provide. Most larger USA cities, like Portland, are already being served by several carriers who have brought fiber optic services into the core downtown areas. Although these fiber optic facilities may be located near their prospective customer base, a gap remains between the carriers and their prospective customers. This gap—*The Last Mile*—drives much of the construction activity affecting the streets of Portland and other metropolitan cities. More often than not, in order to gain access to a new customer, a carrier must install fiber optic facilities to link each customer's premises to the carrier's facilities.

The traditional way for the exchange carriers to resolve the last mile has been to cut trenches into and under city streets to install conduit, splice vaults, and building entrance facilities. However, in many cities, just as in Portland, the rate at which streets are cut and re-cut for each new carrier is accelerating wildly. These often repeated cuts take their toll on city streets. A trip along SW Broadway in downtown Portland offers a clear demonstration of the aftermath of unbridled cutting and trenching. Streets that once offered smooth, comfortable travel are becoming a deteriorating collage of manhole clusters, hastily covered trenches, patches, and crumbling asphalt. Not only are these streets uncomfortable and difficult to travel on, but the oft-repeated cuts, digs, and trenches are seriously reducing the expected life span of the affected city streets. The taxpayers and local businesses ultimately pay the cost to rebuild and resurface these streets years after the fiber has been installed.

A side effect of this activity in the streets is congestion. City streets are already congested due to growing traffic levels. These congested streets become dramatically more congested when lanes or entire streets are closed to accommodate last-mile construction activity. Commuters are frustrated by traffic delays, and downtown shops along the affected streets lose business when customers stay away to avoid the traffic congestion.

In the past, trenching and digging have been the only affordable means to implement connections between the exchange carriers and their prospective customers. There is, however, another option available in the market today.

Every building, every facility and every business in a city's downtown area is connected to a common sewer system. This common sewer system is already in place and has existing routes beneath the city streets. Within the last year the technology required to safely, successfully, and

economically install fiber optic cables inside existing sewer lines has become available in the U.S.A.

Installation Methods

The methods and tools used to install fiber optic cables in sewer facilities vary depending upon the size of the sewer pipe. The size of pipe is categorized into two classes—those large enough to be man-accessible and those too small to be man-accessible.

Man-Accessible

Man-accessible sewer pipes or facilities are generally 27 in. (69.58 cm) in diameter or larger. This is a generally accepted definition but varies somewhat among vendors. Two companies that manufacture products designed to assist in the installation of fiber cables in man-accessible sewers are CableRunner and CA-Botics. Each vendor manufactures a two-man modular and portable robotic cart, similar to each other in its make. This wheeled and powered cart or sled provides rolling transportation through the sewer line and carries the installation materials, precision power drills, and other tools required by the technicians to complete the fiber installation.

The component parts of the cart are lowered into the sewer selected and assembled inside the pipe. Each manufacturer has designed its cart to function reliably within the harsh conditions found in the sewers. The cart provides lighting and, if necessary, has the means to carry oxygen tanks to provide life-support for the technicians.

Man-Inaccessible

Sewers smaller than 27 in. (69.58 cm) in diameter are inaccessible to human technicians. To install fiber cables and conduits in facilities this small, robotic installation is used. Two robots are being used in the industry for these purposes are explained below.

SAM

CityNet Telecommunications Inc., in partnership with CableRunner, uses a device they call SAM, or Sewer Access Module. It is a small robot manufactured by another CityNet partner Ka-Te System AG. Based in Zurich, Switzerland, Ka-Te System AG is a recognized leader in robotic technologies. The SAM device is capable of installing fiber facilities in pipes ranging from 8 to 20 in. (20.3 to 50.8 cm).

Technicians working from the control vehicle parked on the surface streets can remotely control SAM. As SAM passes through the selected sewer

line it fits stainless steel alloy bands flush against the interior sewer pipe walls. There is no drilling or modification of the sewer to accommodate the bands pressed flush along the walls of the sewer. Clips on the ring maintain its diameter, holding the ring securely to the sewer wall.

Once the bands have been installed, SAM travels the selected line again, installing small stainless steel conduits (approximately 11 mm in diameter) to the bands. These conduits protect the fibers that are later pulled into the conduits. The number of steel conduits varies depending on the size of the pipe and the needs of the area being served. Slightly larger conduits are also used in larger pipes to afford greater fiber densities. An important distinction to this technology and the steel conduits is placement. This system is designed to be utilized in either sanitary or storm sewers. The stainless steel conduits protect the fibers from rodents, harsh chemicals, and from high-pressure washing.

CLR (STAR)

CA-Botics, in partnership with Stream Intelligent Networks, uses a device referred to as CLR (Cable Laying Robot) or STAR (Sewer Telecommunications Access by Robot); the two names CLR and STAR are used interchangeably. The Marubeni Corp. of Japan originally designed this device, later modified by a combined German and Japanese company called Robotics Cabling Co. of Berlin into its present configuration. The CLR (or STAR) shares some of the characteristics of CityNet's SAM but differs significantly in how and where fiber is installed.

CA-Botics' CLR does not use stainless steel conduits as does the CityNet SAM. CLR drills and positions J-hook anchors along the length of the sewer. The 0.24-in. (6-mm) diameter hooks are drilled into the sewer structure to a depth of 0.6-in. (15 mm). When the J-hooks are in place, an armored, submarine fiber cable is pulled the length of the sewer segment. The CLR then travels the sewer again, lifting the cable from the sewer floor and fastening it to the J-hooks. The J-hooks are designed to withstand water-jetting pressures of up to 10,000 psi (pounds per square inch).

The CLR installed fiber cable is intended for use only in storm sewers as it lacks the protection a stainless steel or other conduit would afford in the far more caustic environment of a sanitary sewer.

Maintenance Effects

Pressure washing and using root saws, finishing brushes and tap cutters are methods used in the regular maintenance of a sewer system. Installing

fiber optic cable or conduit in a sewer or storm drain system raises questions about (1) whether the mounting system or conduit affects the integrity of the sewer/drain system and (2) whether the sewer/drain system can be maintained without compromising the integrity of the fiber and its conduit. The following considerations should be taken into account when installing fiber cable in a sewer or storm drain system.

Sewer Integrity

The CityNet installation, detailed below in the Installation Detail section, is designed not to interfere with the integrity of the sewer system. In an 8-in. pipe, for example, the installed system consists of a series of stainless steel bands mounted on the inside of the pipe. Attached to the bands are clips designed to secure small stainless steel conduits. In the case of an 8-in. pipe, a maximum of four 11-mm conduits are installed. Larger pipes may support more than four conduits or larger conduits capable of supporting cables with higher fiber counts. The cross-section of the bands, conduit hanger, and conduit in all installations is kept to between 3% and 5% of the total cross-sectional area of the pipe. The conduits are generally installed at or near the top of the pipe. According to CityNet personnel, extensive testing and observation of installed systems have demonstrated that the small reduction in cross-sectional area does not impede the flow of a normal sewer system, nor do the conduit hangers interfere with or cause debris to collect.

Pressure Washing

Pressure washing uses a large, truck-mounted pressure washer and vacuum cleaning system (known as a Vactor Truck) for 8- to 48-in. sewer pipes. A high-pressure cleaning head connected to the truck with a high-pressure water line is placed in the sewer. The cleaning head has a number of jets arranged to point downstream of the flow to apply high-pressure streams of water in a 360-deg arc. Vanes arrayed on the body of the cleaning head provide stability in the sewage flow and help to maintain the cleaning head's depth in the flow. Different sized cleaning heads for different sized pipes are used.

Water pressure from the cleaning head propels the head upstream through the flow the length of the high-pressure line connecting it to the truck on the surface. Full water pressure is applied to the cleaning head, and the cleaning head is slowly pulled back downstream, towards the cleaning truck and crew on the surface. As the cleaning head is pulled back downstream, the cleaning jets loosen and remove debris from the pipe walls until it returns to the starting point. During this process, a large pipe is placed down the manhole entrance into the sewer pipe and is connected

to the vacuum portion of the Vactor truck. Excess debris is removed from the sewer as the pressure cleaning heads break it free.

In general, sewer lines are cleaned every couple of years. However, certain lines—grease lines—are cleaned far more frequently. Grease lines are often formed downstream from restaurants and are named after the grease that accumulates on the bottom and walls of the pipe. Active grease lines may require cleaning twice a year. Therefore, any fiber or conduit placed in a sewer would need to withstand the rigors of the pressure wash as frequently as twice a year.

Root Saw

Cutting heads come in various sizes and are used interchangeably, depending on the pipe being serviced. The cutting blade itself is a band of metal, slightly convex to the outside, with cutting teeth on both edges. The metal band is bent into a circular shape for use with the power head. However, not all lines are serviced with a root saw, only those known to be root lines. A root line is a sewer line with a history of root problems. Sometimes, the root infiltration is light enough that a chemical foaming agent is used to control the root infiltration. In lines with significant infiltration, the root saw is used to cut the roots. The blade of the root saw comes within 1 in. of the full diameter of pipe, anything that protrudes more than 1 in. from the sewer wall would be likely be damaged by the root saw. The chemical foaming agents used would not adversely affect the fiber cables. In general, however, root lines should be avoided either by microtunneling around the affected section or by selecting an alternate route.

Finishing Brush

For detailed cleaning work, the finishing brush attachment is used after the pressure washer and, if necessary, after using the root saw.

The finishing brush is ½ to 1 in. smaller than the diameter of the pipe being cleaned and operates on a principle similar to the bottlebrush. Since the brush is a little smaller than the sewer pipe, it is pulled along the sewer pipe, loosening debris remaining after the high-pressure washing.

Tap Cutter

Contractors tapping into the sewer mains to connect a new lateral sewer connection are sometimes not as careful as could be hoped. The lateral connection pipe may not be flush with the inside of the sewer pipe. Many times, they extend several inches—or feet—into the sewer main. These lengths of pipe often impede the flow, acting as collection points for debris. More importantly, though, they block the ability of the sewer

maintenance hardware from traversing the pipe. The tap cutter trims the extra, unneeded lengths of lateral tap pipe to within ½ in. of the sewer pipe. A tap cutter could not be used in a pipe with fiber and conduit.

A lateral connection is higher than the centerline of the sewer main to facilitate gravity flow. The lateral will connect to and enter a sewer main generally somewhere between the 10 and 2 o'clock positions on the sewer main. The precise location of a lateral connection along a pipe and the angle the lateral intersects the pipe are usually unknown. This information is important, however, to avoid potentially obstructing a lateral connection with the fiber conduit.

For this reason, the sewer system should be carefully inspected and mapped before any fiber facilities are installed. Once fiber has been installed, it is important to monitor all permit applications for new lateral sewer connections to ensure these new connections are made correctly and without damaging the installed fiber facilities.

Slip Lining

Slip lining damaged sections of a sewer line can be done on lines carrying fiber optic cable. However, the curing temperature is a concern. The maximum temperature for installed cables is 150 deg F. The slip lining manufacturer installation instructions must be verified to ensure proper curing can occur at this temperature.

Vendor Review

There are currently only two organizations in North America actively installing fiber optic cables in city sewer systems. Among them, Stream Intelligent Networks is currently active in Canada and is seeking to expand to the rest of North America. CityNet Telecommunications, Inc., is actively installing fiber optic cables in sewer systems in U.S. cities like Indianapolis and Albuquerque. The Stream technology is limited to storm sewers and does not install the fiber cable into conduit to protect it. CityNet's fiber can be installed in either storm or sanitary sewer lines. The stainless steel conduit CityNet installs will provide adequate protection from debris, rodents, and high-pressure cleaning. CityNet, therefore, offers more diverse installation options, and superior protection for the fiber cable. We therefore focus on CityNet Telecommunications as the primary vendor for this review.

CityNet Telecommunications Inc.

As mentioned previously, CityNet Telecommunications Inc. uses a robot manufactured by one of its partners to install fiber conduit and fiber in man-accessible pipes. Their services are available in 24-year-long franchise contracts.

Partnering with CityNet are the following companies:

- Ka-Te System AG manufactures the robot for the man-inaccessible sewer pipes for CityNet.
- Alcatel manufactures fiber and steel conduits for CityNet.
- Carter-Burgess provides architecture, engineering, and project management.
- Cable Runner manufactures the installation cart for man-accessible sewers.

CityNet Franchise in Albuquerque

A recent field trip to Albuquerque, N.M. provided a wealth of detail about costs and benefits associated with installing telecommunications fiber in the sewer system using CityNet. Our key findings are described below.

Installation Detail

The standard agreement with CityNet is for a period of 24 years. It takes about 10 months from the time a city like Albuquerque signs an agreement with CityNet until the installation is completed. Albuquerque is currently installing the first of its three-planned fiber rings. The first ring is scheduled to be completed in the fall of 2001. (Ring sizes vary from 1 to 3 or more miles.)

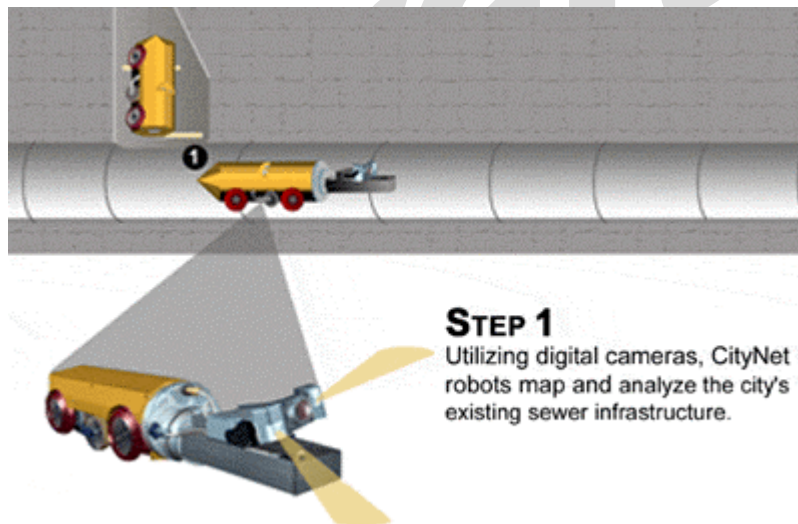
CityNet first determines whether a sewer line is appropriate for its fiber installation. CityNet works with the host City to select the route. The integrity of the pipe is very important—CityNet plans to use the route, sewer pipe, and fiber conduit for the 24-year term of the franchise. CityNet must also be able to get their robots into the pipe.

Mapping and Inspection Phase

Once a potential route has been established, the mapping and inspection phase is initiated (see Figures 1 and 2) The robot CityNet uses to install the fiber systems is placed into the sewer and run along the length of the pipe along the selected route. Video cameras on-board the robot record all aspects of the sewers. The exact locations of manholes, pipe junctions, and location and orientation of lateral connections are recorded and accurately mapped.



Figure 1. The CityNet robot, ready to inspect sewer lines



(Diagram provided by CityNet)

Figure 2. Using the CityNet robot to map and inspect sewer lines.

During this phase, lines with severe root and/or grease problem are discovered and mapped. These lines are not used – CityNet will determine a route around these sections. A CityNet installation can easily tolerate high-pressure washing; however, root and tap cutters jeopardize their installation. Any taps of excessive length are trimmed with standard

tap cutters. Lines that are found with *minor* root infiltration are treated with chemicals.

At times during this inspection phase, older sewer system construction is discovered that may be incompatible with the stainless steel mounting bands. During the Albuquerque inspection, a variety of unusual, non-standard pipe sizes was discovered. In some instances, CityNet opted to switch routing from the sanitary to the storm system to avoid sections that were too difficult to use. It is not unusual for CityNet to rediscover manhole entrances lost when they were paved over.

All the mapping and video data gathered during this phase is turned over to the Host City—in whatever format the city requests. This provides the city with invaluable as-built information about their underground infrastructure.

Conduit Hanger Phase

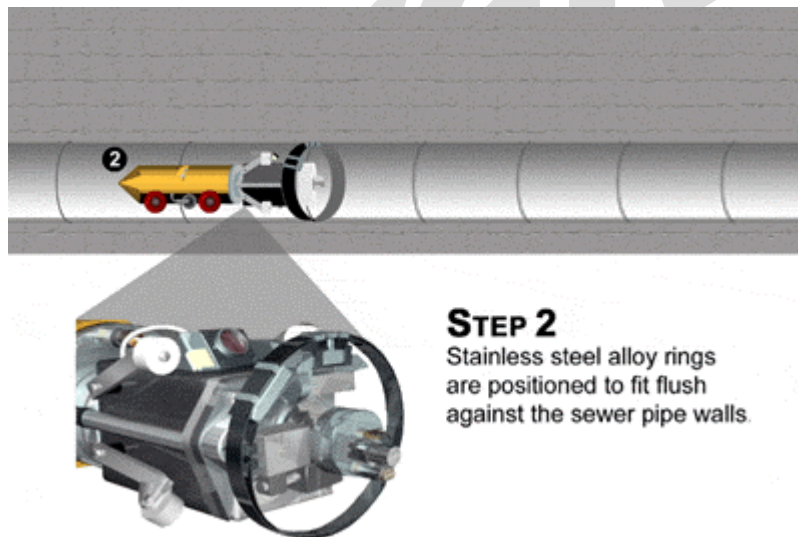
Once the selected route has been verified and mapped—and any route deviations planned for—the second phase begins: The conduit hangers are installed (see Figures 3 and 4). The robot's steel hanger magazine is loaded with steel bands and lowered into the sewer.



Figure 3. The robot's conduit hanger magazine is loaded with steel bands

The bands or clamps installed inside the sewer pipe are stainless steel. They resemble a large hose clamp. A small, smooth box with four springs holds the band in place securely and tightly against the inside sewer wall. Cameras and microphones onboard the robot allows the operating technician to properly place and inspect the installation of each band within the pipe. The mounting clips for the conduits are positioned close to this spring box. The conduit mounting clips are generally positioned at the top of the pipe to keep the conduits and fiber cable as high in the pipe as possible. Each band may be rotated to avoid existing lateral connections mapped out during the inspection phase. The position of the conduit mounting clips may be rotated 45 degrees from the top of the pipe to keep the conduits from interfering with a lateral sewer connection. Bands are generally spaced five feet apart (see Figure 4), but that can vary to accommodate existing lateral connections and seam joints of the pipe.

The conduit mounting clips are an integral part of each band (see the clips holding the conduit to the inside of the band in Figure 5). The clips cannot be upgraded after the fact without removing each ring. In situations where future expansion may be necessary, CityNet installs additional conduits but does not populate them with fiber.



STEP 2
Stainless steel alloy rings
are positioned to fit flush
against the sewer pipe walls.

(Diagram provided by CityNet)

Figure 4. The steel bands, or rings, are positioned in the sewer pipes



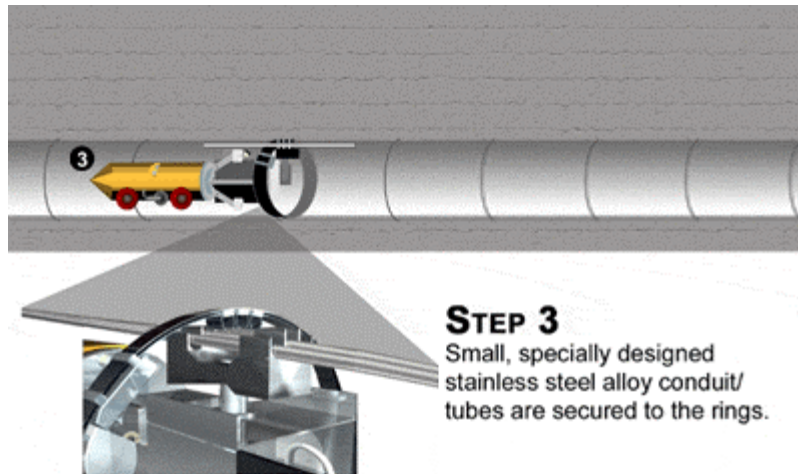
The conduit mounting clip with four sample pieces of conduit shown

Figure 5. The steel band, mounting clips, and sections of conduit

Removing the bands is possible, but this is somewhat difficult. The bands are installed so tightly to the inside of the pipe that they can not be slipped or pulled out. The robot is equipped with an arm that can grasp the band and pull it away from the pipe wall, destroying the band in the process. Sometimes, for example, a band is installed incorrectly (such as when debris hidden under the flow, on the bottom of the pipe, interferes with the installation of the band). The operator discovers this problem and removes the band to install another one correctly. Each band is visually inspected after it is installed. The bands must last the 24+ years of the anticipated life of the system, so if it does not appear perfect, the installation technician will remove a band and reinstall a new one.

Conduit Installation Phase

Once all the bands have been installed, the next phase is to install the stainless steel conduits. Technicians pull the bundle of conduits from manhole to manhole, laying the conduits on the bottom of the sewer pipe. The robot is reconfigured with a tool guide that holds and aligns the conduits as they are lifted and pressed into the conduit holders on the bands (see Figure 6).



(Diagram provided by CityNet)

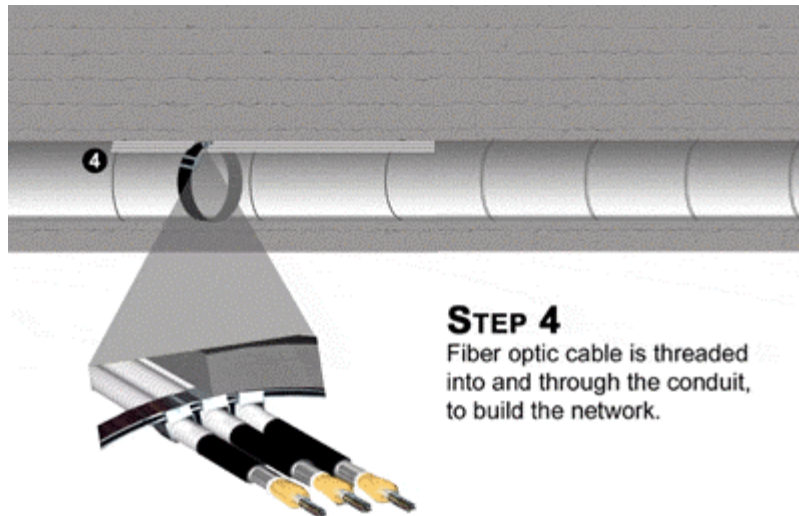
Figure 6. The conduit for the fiber optic cable is secured to the bands

Stainless steel hardware installed around the inside diameter of the manhole protects and transitions the fiber cables out of the sewer. The hardware includes a two-piece stainless steel cable tray. The cable tray is a two piece system that locks together, enclosing the fiber cable. The cable tray is not waterproof, nor does it need to be since the fiber cables used are all submarine cables. This hardware is designed and installed so it will not reduce the limited space inside the manhole.

To exit the manhole, CityNet microtunnels from the manhole to a handhole located near the manhole, usually in an adjacent sidewalk. From there, building entrance installations are negotiated between the building owner and CityNet. The partner city is neither responsible nor involved with the building entrances—unless the city wants to be. Just as the customer owns the lateral connection in a sewer system, connections to the CityNet conduit system are owned by the customer who is responsible for it.

Fiber Cable Installation Phase

In the final phase of installation (see Figure 7), human crews pull the submarine fiber-optic cable through the installed conduits, landing them in the handholes installed outside the sewer entrance manhole. Once all the fiber has been pulled between handholes, spliced, and terminated (completing the fiber ring), the primary installation effort is complete. The only installation effort that remains is to construct the building entries for those businesses or carriers who have leased CityNet's dark fiber.



(Diagram provided by CityNet)

Figure 7. The fiber optic cable installed in the conduit

Damage to Installed Systems

In case of an emergency repair to a fiber equipped sewer line, how do City workers respond? Do they wait for CityNet representatives? Do they carefully work around the installed fiber conduits? What tool should City workers be equipped with in the event a section of fiber equipped sewer pipe must be repaired or replaced?

City sewer workers are asked to simply cut the cables and conduits in the damaged area. CityNet always installs fiber rings so that if the cable is damaged, traffic is instantly routed the other way around the ring to avoid any loss of communication. No prior notice to CityNet is necessary. After the sewer line has been repaired and the emergency resolved, CityNet then arrives to replace the damaged cable and conduit. City workers do not have to wait for CityNet personal, nor do they have to keep the street open for CityNet. The City workers can get in, do their job, and get out—without being concerned by the fiber installed in the sewer pipe. According to CityNet Personnel, sewer repair will never be delayed because of CityNet.

Cost Detail

The only direct costs that Albuquerque, New Mexico, experienced were incurred during the contract negotiation phase with CityNet. Support from city engineers and members of the legal staff was required to draft and negotiate the franchise agreement with CityNet, a process that can take

several weeks. The City of Albuquerque appointed a single point of contact to interface with CityNet. This person devoted 100% of her time to the CityNet project for a week or two. Once the actual installation phase began, the time dropped to 10–20% of her time to oversee the ongoing project.

Also notable, Albuquerque did not need to do any sewer maintenance work to prepare for CityNet.

As for state-level regulatory efforts, Albuquerque neither consulted nor informed New Mexico's state regulatory agencies. As stated by City Staff, “They did what they thought best for the city.”

Benefit Detail

Before Installation

Once the agreements have been signed and preliminary ring routes have been determined, the inspection and mapping phase begins. CityNet inspects and videotapes the selected route, mapping every access point, manhole, and lateral connection, including the relative orientation of the laterals to the main line. CityNet provides complete copies of all data and video records along with a complete set of as-built drawings to the partner city. All gathered data is provided to the host city in whatever format the city requests, MapInfo, ArcView, etc. This provides the host city with data that would be prohibitively expensive to obtain or assemble on its own.

After Installation

Historically, CityNet pays a 2.5% annual Franchise Fee to the partner city granting access to their sewers for a period of 24 or more years.

CityNet typically provides four dark fibers per ring to the host city for their use. In Albuquerque’s case, CityNet is building three distinct fiber rings. Therefore, The City of Albuquerque will be receiving a total of twelve dark fibers across three areas of their city for their use.

When a franchise has been established, CityNet opens a local office, staffed with a crew to install new customer connections, to monitor the system on an ongoing basis, and to respond to emergencies. The office and staff are available on a 24 × 7 basis.

CityNet assumes responsibility for inspection and cleaning of the sewer lines where they have installed systems for the duration of their contract. Options for this include CityNet staff (or hired contractors) doing the

cleaning work, or, if the city prefers, CityNet will pay the city to have city workers perform the task. This choice is left to the host city.

For the first two years, CityNet inspects and videotapes the sewer lines every every six-months. This is to verify their installation is not negatively affecting proper operation of the sewer lines. Copies of the videos are provided to the partner cities. After the two-year period, CityNet adopts the inspection and cleaning schedule normally followed by the host city.

CityNet closely monitors all building/construction permits. If work is being done near a sewer lines with fiber cables, CityNet will have a representative on site to monitor and photograph work being done. This includes all new lateral connections made. (CityNet believes having someone on hand with a camera usually instills needed caution in workers digging near or connecting to sewer lines.)

Conclusion

The benefits CityNet offers are many.

- The up front costs are minimal.
- The city receives detailed mapping and video data about the selected portions of their sewer system.
- Maintenance of the selected sewer lines becomes the financial responsibility of CityNet, resulting in some cost savings to the city.
- The city receives four dark fibers (or two pair) for their own use per installed fiber ring.
- City streets are spared repeated pavement cuts, preserving the life span of the streets, thus saving the city considerable future cost brought about from diminished street life.
- Finally, the city income is increased through the franchise fees earned once CityNet completes the installation and begins signing up customers.

Downtown Portland streets are becoming increasingly congested with underground communications facilities. Furthermore, repeated street cuts impose direct and indirect costs to the City and its citizens. In response to these issues, the City has placed moratoriums on assorted streets and has investigated various regulatory alternatives that may result in additional moratoriums. Installing fiber optics in sewer lines, as described here, provides a workable technology, capable of meeting the needs of the City, its citizens, and the telecommunications providers: Although

telecommunications providers may prefer to own their own facilities, the presence of fiber optic infrastructure on a street under a moratorium provides them with a low-cost, fast-track method of reaching customers. Overall, this approach should be viewed as a compromise that will benefit all parties.

The technical requirements of telecommunications providers varies from carrier to carrier and evolves as customer bases change and grow. Because of this, a one-time sewer installation is unlikely to allow a widespread moratorium throughout an area. In fact, the presence of fiber in the sewer should not become the driving factor in placing a moratorium on a street. This method should in part be in response to existing or planned moratoriums, or the expansion of a moratorium program. The City could define moratorium plans and determine the major street improvement projects planned for the next several years. Working with this background information, the marketability of various proposed routes could be weighed and become a factor in choosing the routes likely to provide the most value to carriers (potential CityNet customers), the City, and the public.

Since telecommunications providers normally prefer to own and control their own facilities, sewer-line installed fiber optics will rarely be perceived by a carrier as a primary service-delivery facility. However, it may become a practical alternative if deployed in the City's effort to become more aggressive in its street moratorium program.

W&H Pacific recommends the City evaluate these points among the affected agencies (Bureau of Environmental Services, Portland Department of Transportation, The Office of Cable Communications and Franchise Management, Portland Development Commission, and ComNet). It is recommended that this alternative be viewed in a positive light, capable of helping address some of the street disruption issues the City faces. Although fiber in the sewer will not be a cure-all in all areas of the City, it can be a silver bullet, used where needed and where it provides the most value. Furthermore, based on the information reviewed under this study, the risks and costs to the City appear to be negligible. W&H Pacific recommends that the City of Portland prepare to enter into planning and negotiations with CityNet, first to allow the Company to review the feasibility of placing fiber in the City's sewer lines and then (if feasible) to proceed with a Franchise.

Any questions regarding this report can be directed to Brian Nordlund at W&H Pacific. He can be reached by e-mail at bnordlund@whpacific.com or by phone at (503) 372-3632.