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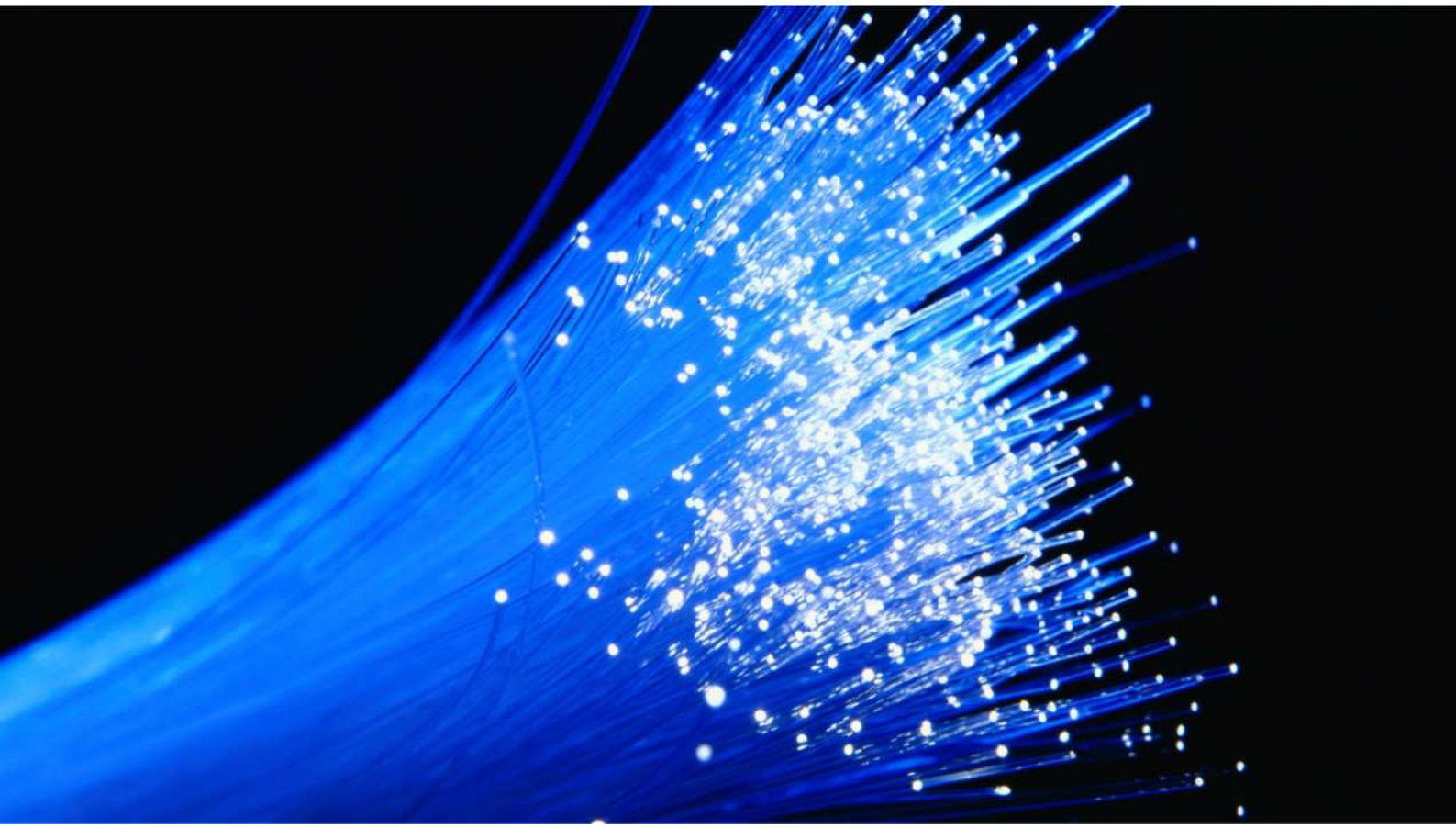

Dig-Once Specification

Prepared for the City and County Of San Francisco
Department of Technology
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Columbia Telecommunications Corporation

10613 Concord Street • Kensington, MD 20895 • Tel: 301-933-1488 • Fax: 301-933-3340 • www.ctcnet.us

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1 Executive Summary

The Board of Supervisors and Mayor of the City and County of San Francisco adopted a "Dig Once Ordinance" in November 2014.[1] The Dig Once Ordinance requires "the installation of City-owned communications infrastructure in excavation projects where the City has determined that it is both financially feasible and consistent with the City's long-term goals to develop the City's communications infrastructure."

The ordinance accomplishes this by:

1. Requiring all municipal utilities to take communications infrastructure into account in their planning process, and
2. Requiring the establishment of a process for the Department of Technology (DT) to participate in utility excavation.

The Dig Once Ordinance modifies the City's Public Works Code provisions governing utility excavation and its requirements for coordination.[2] The Department of Public Works (DPW) can only approve an application for an excavation permit if the applicant's plans include the installation of communications facilities (e.g., conduit) that meet DT specifications, unless DT has opted out of the excavation project. DPW has adopted "Accela Right of Way Management" (formerly Envista), a map-based application, for coordinating construction in the public right-of-way.

The purpose of this engagement is to assist DT in developing requirements for compliance with Dig Once. As requested by the City, CTC Technology and Energy met with the DT staff and officials managing the initiative, City and non-City excavators, potential users of conduit installed through this initiative, and City users of communications conduit. We also reviewed construction projects in the Accela system and the construction plans related to selected projects.

We worked with stakeholders to develop:

1. Technical specifications for Dig Once,
2. Criteria for prioritizing projects, and
3. A methodology for estimating incremental costs.

[1] Ordinance No. 220-14, available at: http://tinyurl.com/oaz2qly
[2] "Article 2.4: Excavation in the Public Right-of-Way," Public Works Code, available at: http://tinyurl.com/kqqqop5

In Section 2, we recommend a standard technical specification for conduit to be installed during excavation projects. This standardized approach balances the competing needs to accommodate the largest number of potential uses of the conduit while not adding excessive incremental costs to the construction. Specifically, we propose:

- A standard construction of four two-inch conduit, in order to provide capacity for a wide range of City and non-City uses, to provide separation between potential users of the conduit, and to enable use of the widest variety of fiber types;
- A standard configuration of vaults and handholes to provide access as needed; and
- Scenarios for placement of conduit in the same trench with the infrastructure of another excavator, and where a trench cannot be shared, placement in a dedicated trench.

In Section 3, we propose criteria for prioritization of Dig Once builds. Although Dig Once provides substantial savings relative to a standalone excavation, the incremental cost is still significant, and we recommend prioritization of projects in order to achieve the most value for the money spent, and to maximize the likelihood of the conduit being used. We propose prioritization based on a range of factors including:

- Proximity of the project to City facilities requiring increased connectivity
- Potential interest in conduit from City departments, service providers, or developers
- Ability to place conduit to cover long, continuous corridors across the City
- Lack of utility poles in the area
- Incremental cost of the proposed excavation

We provide maps of proposed projects from the City's GIS system and Accela to identify areas where the potential benefit is greatest.

In Section 4, we illustrate recommended processes for Dig Once.

In Section 5, we propose a method for estimating the incremental costs of complying with Dig Once requirements. We estimate unit costs for materials, labor, excavation, and other items based on costs for similar projects in similar environments. Based on this analysis, we estimate incremental construction costs of $13.60 to $24.29 per foot. We outline a procedure for exemption from these costs and suggest the types of situations where an exemption might apply, or where an excavator may propose an alternative method.

2 Standard Specification

The challenge in developing a standard specification for a Dig Once project is to incorporate the requirements of known and unknown users, and to provide sufficient capacity and capability without excessive costs.

We considered the following factors in developing a conduit specification:

1. Capacity—sufficient conduit needs to be installed, and that conduit needs to have sufficient internal diameter, to accommodate future users' cables and to be segmented to enable conduit to be shared or cables added at a future date

2. Segmentation—users need to have the appropriate level of separation from each other for commercial, security, or operational reasons

3. Access—vaults and handholes need to be placed to provide access to conduit and the ability to pull fiber. Vaults need to be spaced to minimize the cost of extending conduit to buildings and other facilities that may be served by fiber

4. Costs—materials beyond those which are likely to be needed will add cost, as will the incremental labor to construct them. Beyond a certain point, trenches need to be widened or deepened to accommodate conduit

5. Robustness—the materials, construction standards, and placement need to reasonably protect the users' fiber, and not unduly complicate maintenance and repairs

6. Architecture—sweeps, bend radius, and vault sizes need to be appropriate for all potential sizes of fiber

To address these factors, we discussed conduit and fiber requirements with potential users of the conduit. These included representatives of the City Department of Technology Division of Public Safety, who install and maintain conduit and fiber for City facilities and community anchor institutions, AT&T, Comcast, the San Francisco Chamber of Commerce, and Sonic.net.

The City will also issue an RFI to potential users of conduit and fiber and is awaiting more information.

Based on these discussions and our analysis, we propose a single standardized approach in order to simplify pricing, planning, and inventory. The approach should adequately take into account the above considerations and service provider needs. It can also be modified based on needs in specific corridors (for example, by adding conduit or vaults).

The standard specification is:

- Four 2-inch conduit, minimum Schedule 40 PVC or HDPE SDR 11, each of a separate color or unique striping to simplify identification of conduits within vaults and between vaults, in the event conduit must be accessed or repaired at intermediate points
- Composite vaults having dimensions of 30" x 48" x 36" (W x L x D), placed in the sidewalk or available green space within the City right-of-way, as close to the curb or gutter as possible
- Vaults spaced at intervals of 600 feet or less, typically at the intersection of a city block
- Sweeping conduit bends with a minimum radius of 36-inches to allow cable to be pulled without exceeding pull-tension thresholds when placing high-count fiber cables (e.g. 864-count)
- Conduit placed in the same trench directly above the excavator's infrastructure, or, where this is not possible, placed with minimum horizontal offset, to minimize cost

It is important to note that the proposed approach is designed to create consistency and predictability in costs and deployment and, of necessity, is a compromise among the potential users. If an excavation project has a long time horizon and sufficient budget, it is possible to customize the Dig Once build, potentially adding conduit or adding vaults at particular locations. This plan provides a baseline approach.

As noted, the approach is a compromise among the different users. Some users expressed interest in larger conduit for consistency with earlier builds. Others sought a larger count of smaller conduit, to provide more flexibility and the capability for more providers to participate with smaller cable counts.

Two-inch conduit has become a standard size for a wide range of construction projects, and was chosen to support the widest range of use cases. A single two-inch conduit can accommodate a range of multi-cable configurations, while retaining recommended fill ratios, allowing a single user to serve its backbone and "lateral" / access cable requirements with a single, dedicated conduit. A few example cable configurations supported by a single two-inch conduit, which are not supported by smaller conduit, includes:

- Two medium backbone cables (e.g. 144-strand to 288-strand cables) and one smaller "feeder" cable (e.g. 24-strand cable);
- Large backbone cable (e.g. 864-strand) and two or more smaller feeder cables; or
- Three medium backbone cables.

Compared to placing fewer, larger conduits segmented with innerduct, this standard provides greater opportunity for individual conduit to be intercepted and routed for future vault installation by a particular user. Additionally, two-inch conduit is substantially cheaper to install and physically more flexible than larger varieties, offering more options to route around existing utilities and other obstructions. Placing four conduit will provide a standard allotment of one or two conduit for City use and provide capacity for other use and for spares.

We recommend Schedule 40 PVC or SDR 11 HDPE in all cases except where conduit is exposed in to the elements (for example, as a riser to building entry), or under extreme levels of pressure (such as under a train or trolley track). Schedule 40 conduit is designed to withstand railway live loads at 24-inch depth at up to 1 degree deflection. It also has a higher internal diameter than Schedule 80 conduit.

Detailed specifications are described below, followed by details from a sample project.

2.1 Conduit installation not coordinated with another trench

Figure 1 below depicts the layout and trench details for conduit installation that is not coordinated with another trench. This may be the case where a Dig Once opportunity emerges because of road resurfacing, traffic changes for bicycle lanes, or streetscaping changes. This may also be the case if the excavator cannot allow City conduit in the trench.

Ideally the conduit is placed under the sidewalk, outside of vehicular travel lanes and in proximity to the potential conduit users for increased ease of maintenance and access. This can be done cost effectively if the sidewalk is being replaced or resurfaced as part of the excavation. If the excavation only includes road resurfacing, whether for some or all travel lanes, the conduit should be placed as close as possible to the curb within the limits of the resurfacing project.

The conduit should sweep from the alignment to the vault at the intersection with 45 degree bends and 36-inch minimum radius. There should be space for third-party vaults for use by non-City users, adjacent to the main vaults. Third-party service providers will have access to the conduit at their vaults; all other vaults and conduit will only be accessible by the City or by contractors managing the conduit for the City.

In this specification, the conduit is placed in a 2x2 configuration and surrounded by flowable fill or crushed rock. Above that layer is at least 18 inches of compacted aggregate base or filtered backfill. Above that is the finished roadway surface.

2.2 Conduit installation coordinated with another trench

Figure 2 below depicts the layout and trench details for conduit installation that can be coordinated with another trench. This may be the case where a Dig Once opportunity emerges because of trenching for other utilities. City excavators include Public Utilities Commission (water, power, and sewer). Non-City excavators include Pacific Gas & Electric (PG&E; gas, electric) and communications utilities. These collectively are referred to as Joint Utility Infrastructure.

Ideally, in this specification, the Dig Once conduit is placed over the excavator utilities. This reduces or eliminates the need for additional trenching and would incur the lowest incremental cost. Again, the conduit should sweep from the alignment to the vault at the intersection with 45 degree bends and 36-inch minimum radius. There should be space for third-party vaults for use by non-City users, adjacent to the main vaults. Third-party service providers will have access to the conduit at their vaults; all other vaults and conduit will only be accessible by the City or by contractors managing the conduit for the City.

In this specification, the conduit is placed in a 2x2 configuration, 12 inches above the Joint Utility Infrastructure and surrounded by flowable fill or crushed rock. Above that layer is at least 18 inches of compacted aggregate base or filtered backfill. Above that is the finished roadway surface.

In some scenarios, the conduit may need to be offset horizontally from the Joint Utility Infrastructure. This may be the case where the infrastructure is a water pipe that DT and SFPUC agree should be offset for ease of maintenance of the water pipe, for example. Offsetting the Dig Once conduit may reduce the risk of it being damaged by a broken water pipe or by the repair to the broken pipe.

A detail from a candidate Dig Once project design is shown in Figure 3. This is MTA communications conduit to be installed as part of the Van Ness Bus Rapid Transit Project. The MTA Joint Construction conduit is designed to be installed underneath the sidewalk. According to the specifications, the Dig Once conduit can be placed on top of the MTA conduit, and the Dig Once vaults placed near the MTA vaults at the intersections.

Figure 1: Typical Configuration for Conduit in Repaving Dig Once Opportunity (Standalone Trench)

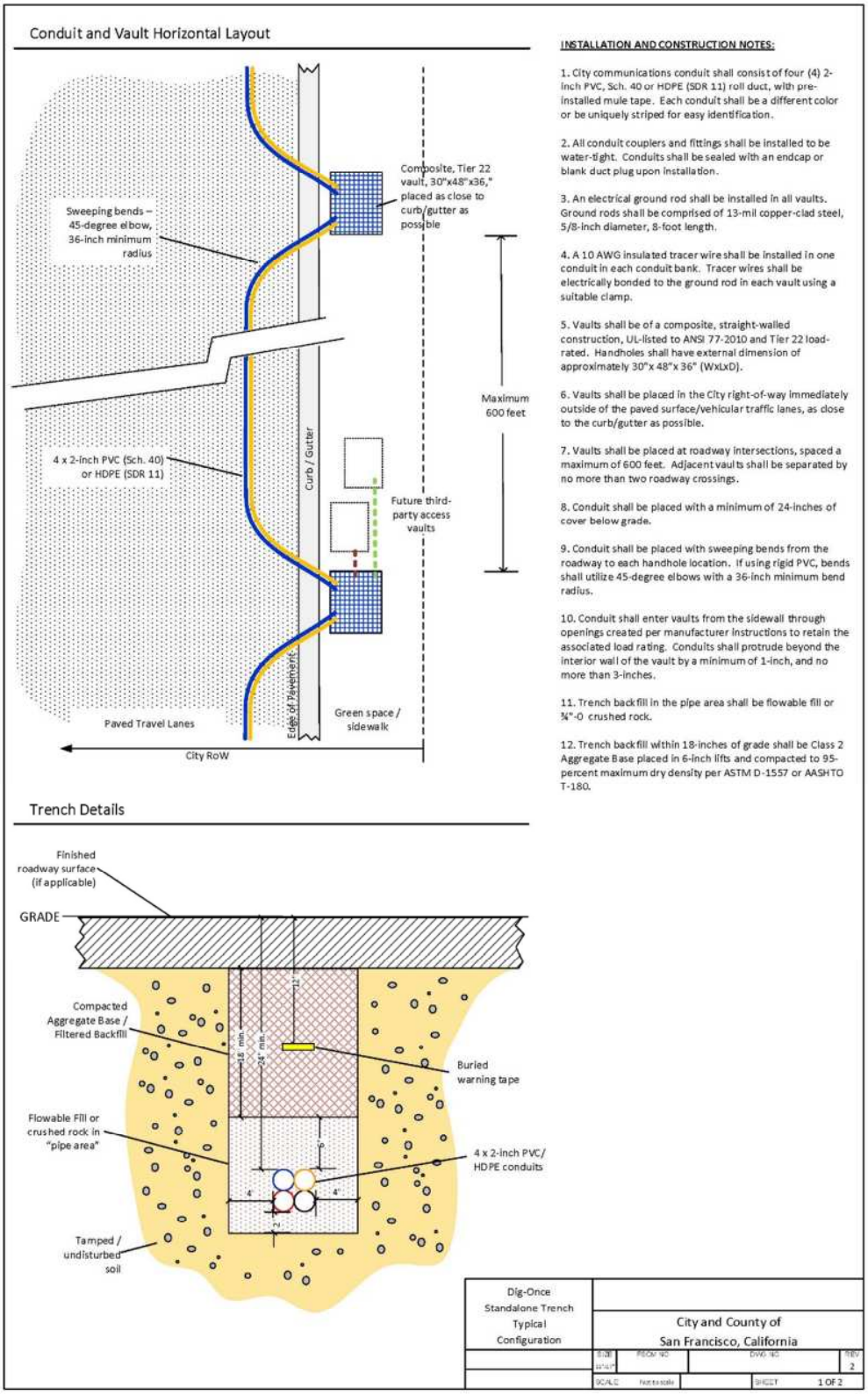


Figure 2: Typical Configuration for Conduit in Dig Once Trench Opportunity

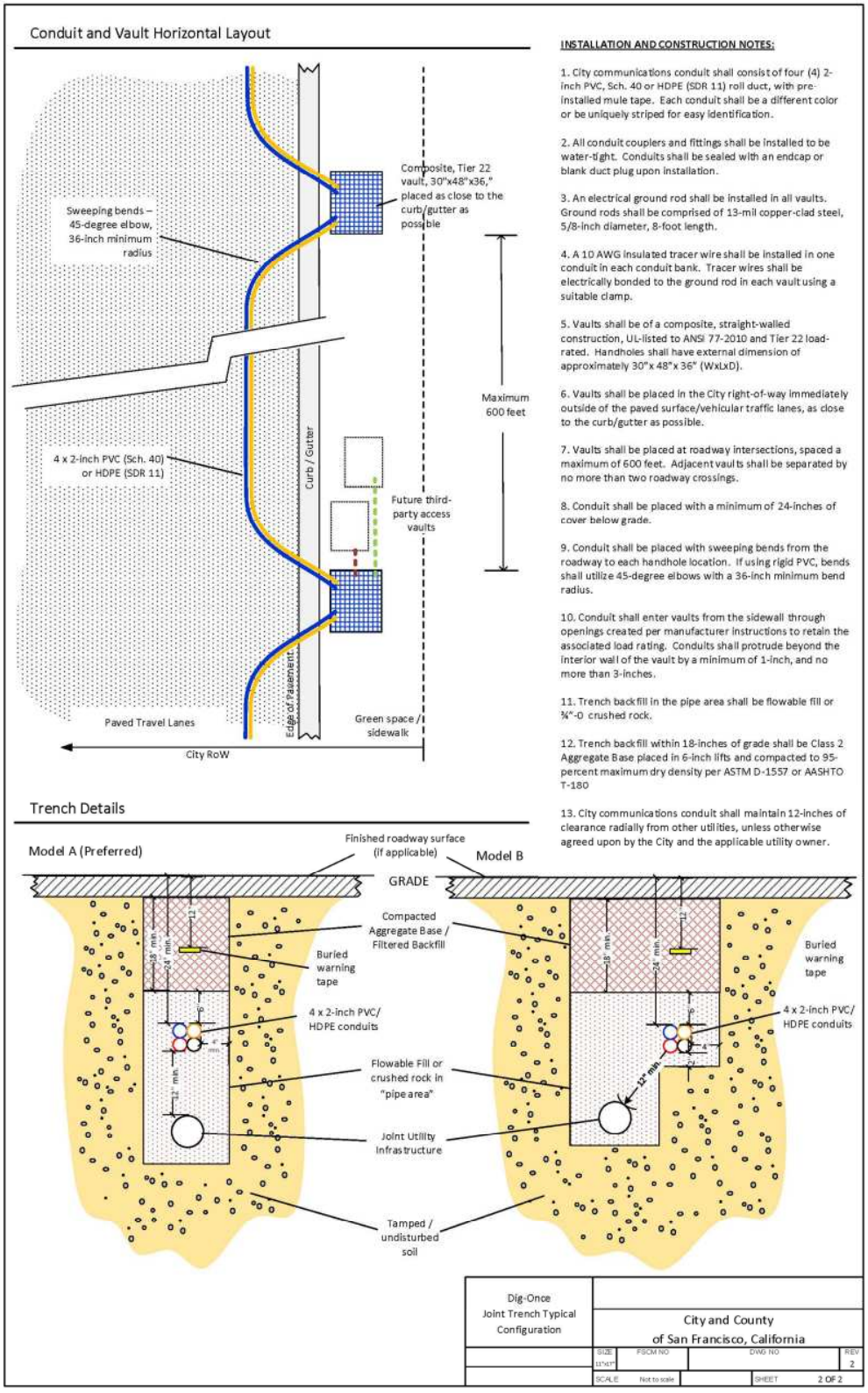
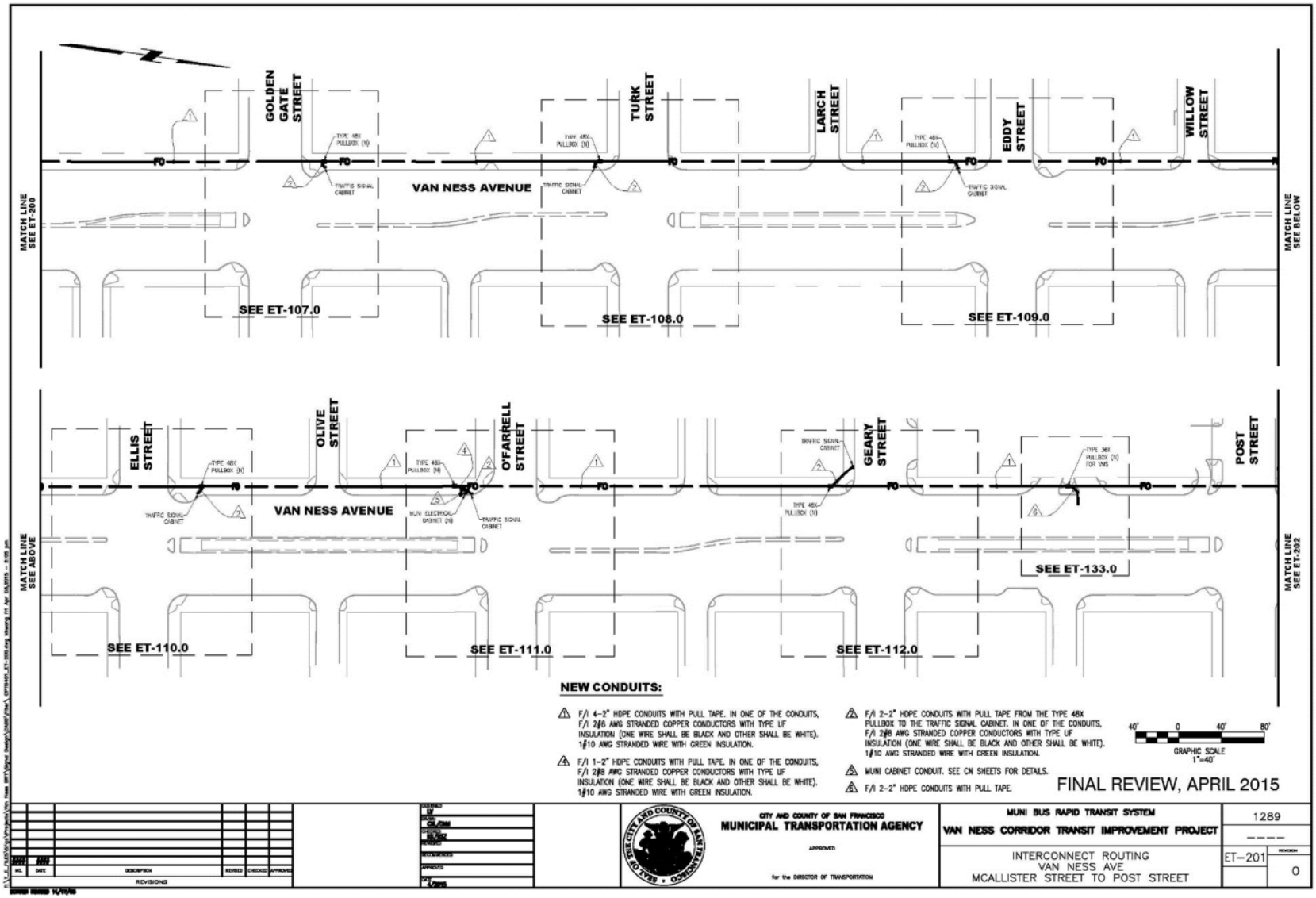


Figure 3: MTA Van Ness Bus Rapid Transit Design Excerpt



3 Criteria for Prioritization

Because of the cost of conduit installation, even in a Dig Once opportunity, it is necessary to prioritize construction to ensure that 1) no City priorities are missed when Dig Once opportunities emerge but 2) resources are not wasted in building conduit that is unlikely to be used. We observe the following based on our discussions with excavators and DT, and our experience in other cities and Dig Once settings:

1. A substantial percentage of the City has utility poles with space for additional utilities and reasonable cost of attachment;
2. Many excavation projects extend only for a few City blocks;
3. Many excavation projects are isolated from other projects and existing fiber and conduit infrastructure—and are likely to remain so;
4. Many excavation projects are in low- and medium-density residential areas, not in proximity to City locations or large developments;
5. The cost of conduit construction is approximately 50 percent higher in Dig Once opportunities where the excavator is not digging a trench, or where the trench cannot be shared or needs to be widened for placement of the Dig Once conduit; and
6. A fiber-to-the-premises build, either citywide or limited, will require a more extensive type of conduit construction that is more extensive and costly than what can be built through simply leveraging the trench or repaving from an excavation project. This is because fiber to the premises will require access to all the premises from the conduit, requiring drop connections to each house, and conduit on both sides of larger streets.

Therefore we propose the following criteria for prioritization:

1. Construction opportunities that extend over long distances and offer a wide range of possibilities for immediate and future use, such as the MTA bus rapid transit projects
2. Opportunities that are in proximity to City and community anchor locations requiring service, such as a new health clinic or hospital.
3. Opportunities in areas where non-City users have expressed interest in conduit
4. Areas where new commercial developments are likely to require City and non-City broadband connectivity

5. Areas that are targeted for economic development

6. Areas where there are no aerial utility poles on or near the project, or where utilities are scheduled to be buried

~~5.~~7. Targets of opportunity such as bridges or freeway underpasses

As opportunities emerge, or as existing opportunities are reviewed, we recommend they be evaluated or scored based on the above prioritization. We recommend developing a weighting scheme for the above criteria and scoring each project on a scale of 0 to 100.

We reviewed at a high level the proposed excavation projects in the Accela right-of-way management system. We selected only the projects that were designated as not complete, and were designated as planned, proposed, or committed. We selected projects that included paving and/or excavation. We used other filters to eliminate very small projects where conduit was not a consideration (for example, single sewer replacement). Finally, we removed projects that were less than 900 feet (the lower limit established by the Ordinance, approximately two City blocks).

Our analysis in progress separates projects based on type (Transit, Electrical, Gas, Water, Sewer, Traffic, Communications, and Combined) and plots the projects along with City facilities, community anchor facilities, existing City fiber and conduit, and other points of interest. We also note where the telecommunications and power utilities are aerial and service providers have options other than excavation.

Based on our analysis, we recommend putting the highest priority on Transit projects, because they typically:

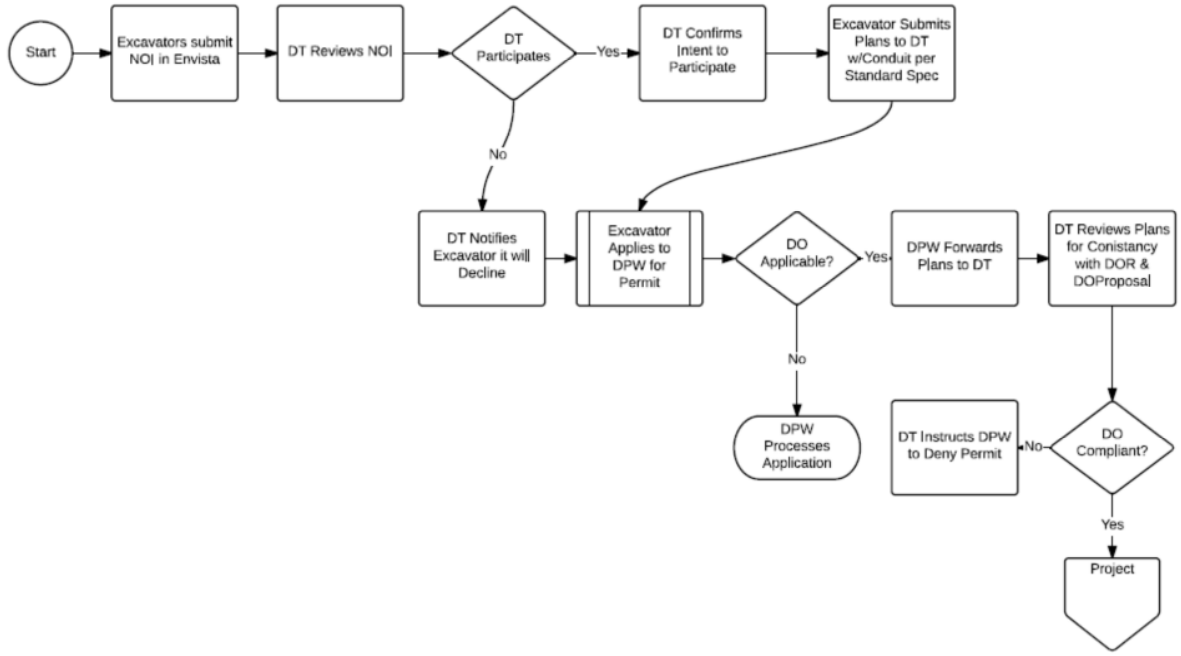
- Provide long conduit routes
- Cover major corridors of value to City and non-City conduit users
- Pass near City facilities
- Are the lowest cost per foot, because MTA is installing conduit and is able to share the trench

In short, these projects provide the collective advantage of lower cost and highest potential value.

4 Process Recommendations

Figure 4 illustrates the recommended process for reviewing projects for Dig Once consideration. First, as is done now by municipal excavators, excavators submit a Notice of Interest (NOI) by placing information about their projects in Accela. This submittal includes information about the type of construction and the pathway; provides sufficient detail to determine whether the location and route are desirable; and enables DT to estimate the incremental cost of the conduit, per the method described in Section 5.

Figure 4: Dig Once Review Process



Per the Ordinance, the excavator must provide the information in Accela at least 14 days prior to filing a permit with DPW. DT has seven days to decline to participate or to confirm its intent to participate. If DT participates, the excavator must submit plans to DT that include conduit, per the specification in Section 2.

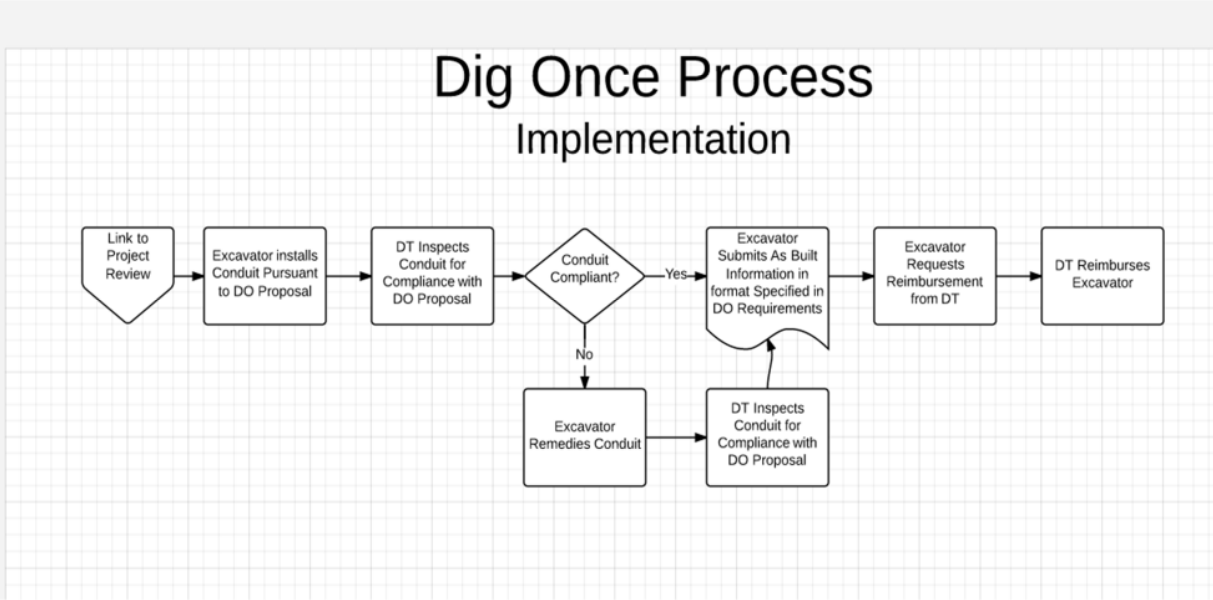
If Dig Once conduit is to be constructed, DT reviews the plans for consistency with the Dig Once requirements. If the plans are compliant, the project may proceed; otherwise DPW denies the permit.

In practice, the NOI is typically submitted much further in advance of permitting. This provides the excavator a healthy interval to add the conduit to the plans.

One significant change will be necessary, relative to current practice. Some excavators currently enter into Accela a wide range of potential projects. For these excavators, there needs to be a procedural change, requiring them to notify DT when a contemplated project in Accela is actually approved to proceed.

Figure 5 illustrates the process once the project is approved. After the excavator installs the conduit, DT inspects the conduit for compliance with the Dig Once requirements. If the conduit is compliant, the excavator submits as-built information and requests reimbursement per the cost estimations in Section 5. If the conduit is not compliant, the excavator remedies any problems before submitting the as-built information and requesting reimbursement.

Figure 5: Dig Once Process—Implementation



At the end of the project, the Excavator must provide scale plans of the completed project, for inclusion in Accela and in City databases, including:

1. vertical and horizontal position of conduit and vaults;
2. GPS coordinates for manholes;
3. edge-of-curb offset measurement every 50 feet; and
4. colors, diameters and materials of conduit.

5 Method for Determining Incremental Cost

5.1 Cost Estimation

As defined in the Ordinance, the incremental cost is the cost of additional materials (conduit, vaults, location tape, building materials) and labor (incremental engineering, incremental design, placement and assembly of incremental conduit, placement of incremental vaults, interconnection, testing, and documentation).

We propose a mechanism for estimating the cost of the proposed Dig Once infrastructure, based on prevailing labor and materials costs and our experience with similar projects.

The cost in this model does not include roadway or sidewalk restoration or paving (which we assume to be part of the original project) beyond that which is specifically required for the placement of vaults for City communications conduit within paved or concrete surfaces outside of the original project boundaries.

Where trenches are joint, the cost does not include trenching or backfilling. Where the Dig Once trench is separate from the original trench, the incremental cost includes trenching and backfill, but does not include repaving or restoring the road surface (again, assumed to be part of the original project).

Unit material and labor cost estimates are based on similar projects in urban areas requiring Davis-Bacon wages. We derived average costs based on an ensemble of contractor pricing schedules.

Table 1 provides an estimate for the cost of construction of a dedicated trench and placement of four 2-inch conduit and associated vaults. The labor table provides, in the first row, the labor cost of trenching and placing a single conduit in the trench. The second row is the labor cost for placement of the three additional conduit. The remaining rows are the labor costs for placing vaults and removing and replacing affected sidewalk and curb.[3] The materials table provides the cost of all required materials. The estimated cost per foot is $24.29, which represents the high end of a Dig Once project according to the specifications in Section 2, with vaults spaced every 300 feet, on average.

[3] Based on San Francisco DPW Sidewalk Inspection and Repair Schedule of Bid Prices (http://www.sfdpw.org/modules/showdocument.aspx?documentid=2199)

Table 1: Incremental Cost of Dedicated Trench, No Roadway Restoration (Figure 1)

Labor					
Item	Unit	Unit Price	Qty per Mile	Cost Per Street Mile	Cost Per Street Foot
Trench and installation of single 2" conduit *(includes standard backfill, installation of a tracer wire, and installation of all necessary conduit couplings and fittings)*	LF	$ 8.45	5,808	$ 49,077.60	$ 9.30
Installation of a 2" conduit in an existing trench *(no additional excavation required)*	LF	$ 1.58	17,424	$ 27,442.80	$ 5.20
Installation of a 30"x48"x36" vault	EA	$ 303.44	17.60	$ 5,340.50	$ 1.01
Installation of a ground rod	EA	$ 65.94	17.60	$ 1,160.50	$ 0.22
Remove and replace sidewalk *(assumes removal and repair of four (4) 3'x3' sidewalk flags)*	SF	$ 10.40	457.60	$ 4,759.04	$ 0.90
Remove and replace curb *(assumes removal of 6 linear feet of curb adjacent to vault)*	LF	$ 25.00	105.60	$ 2,640.00	$ 0.50
		Labor Subtotals:		***$ 90,420.44***	***$ 17.13***
Material					
Item	Unit	Unit Price	Qty per Mile	Cost Per Street Mile	Cost Per Street Foot
2" HDPE conduit, SDR 11 *(includes all fittings and couplings)*	LF	$ 0.87	23,232	$ 20,211.84	$ 3.83
Vault, Tier 22, 30"x48"x36"	EA	$ 770.52	17.60	$ 13,561.15	$ 2.57
Tracer wire, insulated, 10 AWG	LF	$ 0.34	5,280.00	$ 1,795.20	$ 0.34
Warning tape, orange, 3-inch width	LF	$ 0.35	5,280.00	$ 1,848.00	$ 0.35
Ground rod, 13 mil copper-clad steel (RUS listed), 5/8" diameter, 8' length, including clamp	EA	$ 22.20	17.60	$ 390.72	$ 0.07
		Material Subtotals:		***$ 37,806.91***	***$ 7.16***
				Cost Per Street Mile	Cost Per Street Foot
				$ 128,227.35	**$ 24.29**

Table 2 provides an estimate for the cost of placement of four 2-inch conduit and associated vaults, leveraging a trench constructed for another project. The labor table provides, in the first row, the labor cost for placement of four additional conduit. The remaining rows are the labor costs for placing vaults and removing and replacing affected sidewalk and curb.[4] The materials table provides the cost of all required materials. The estimated cost per foot is $13.60, which represents the low end of a Dig Once project according to the specifications in Section 2, with vaults spaced every 300 feet, on average.

[4] Based on San Francisco DPW Sidewalk Inspection and Repair Schedule of Bid Prices (http://www.sfdpw.org/modules/showdocument.aspx?documentid=2199)

Table 2: Incremental Cost of Shared Trench, No Roadway Restoration (Figure 2)

Labor

Item	Unit	Unit Price	Qty per Mile	Cost Per Street Mile	Cost Per Street Foot
Installation of a 2" conduit in an existing trench *(no additional excavation required - includes installation of a tracer wire, and installation of all necessary conduit couplings and fittings)*	LF	$ 1.58	22,176	$ 34,927.20	$ 6.62
Installation of a 30"x48"x36" vault	EA	$ 303.44	8.80	$ 2,670.25	$ 0.51
Installation of a ground rod	EA	$ 65.94	8.80	$ 580.25	$ 0.11
Remove and replace sidewalk *(assumes removal and repair of four (4) 3'x3' sidewalk flags)*	SF	$ 10.40	228.80	$ 2,379.52	$ 0.45
Remove and replace curb *(assumes removal of 6 linear feet of curb adjacent to vault)*	LF	$ 25.00	52.80	$ 1,320.00	$ 0.25
			Labor Subtotals:	***$ 41,877.22***	***$ 7.93***

Material

Item	Unit	Unit Price	Qty per Mile	Cost Per Street Mile	Cost Per Street Foot
2" HDPE conduit, SDR 11 *(includes all fittings and couplings)*	LF	$ 0.87	22,176	$ 19,293.12	$ 3.65
Vault, Tier 22, 30"x48"x36"	EA	$ 770.52	8.80	$ 6,780.58	$ 1.28
Tracer wire, insulated, 10 AWG	LF	$ 0.34	5,280.00	$ 1,795.20	$ 0.34
Warning tape, orange, 3-inch width	LF	$ 0.35	5,280.00	$ 1,848.00	$ 0.35
Ground rod, 13 mil copper-clad steel (RUS listed), 5/8" diameter, 8' length, including clamp	EA	$ 22.20	8.80	$ 195.36	$ 0.04
			Material Subtotals:	***$ 29,912.26***	***$ 5.67***

Cost Per Street Mile	Cost Per Street Foot
$ 71,789.48	**$ 13.60**

The pricing is based on bid pricing for a range of fiber optic construction projects and should cover the majority of Dig Once opportunities in San Francisco. Therefore the costs should be suitable for reimbursement for the addition of incremental conduit as part of projects in the City. The City may increment these estimates on a regular basis to take into account changes in prevailing construction costs.

5.2 Exemptions and Alternative Methodologies

It is possible that an unusual Dig Once opportunity may deviate from this model. For example, projects in unusual corridors where space for additional conduit is limited, or in highly congested areas where it is difficult to avoid utilities and other obstructions, may be more expensive.

It is also possible that an excavator may propose another approach to providing the incremental conduit that provides the same capacity and functionality. In these situations there needs to be a process for the excavator to make its case, and for the City to consider the alternative.

In all cases where the excavator claims a deviation from the pricing model or specifications, the Dig Once Coordinator must approve the exception and evaluate the alternative pricing. To support the claim, the excavator's project engineer should be required to provide to the Dig Once Coordinator its detailed design and the itemized bid pricing for the alternative approach, and indicate in writing how the project owner has made its determination and what steps were taken to determine the pricing (including all bids obtained for the work). Bid pricing should be provided at the level of detail of Tables 1 and 2.

The Dig Once Coordinator will only consider a deviation and a different reimbursement amount if the Coordinator considers that the excavator faces extraordinary challenges in complying, such as extremely high congestion of existing utilities or obstructions or environmental hazards. It will not be sufficient for the excavator to show that its construction bids or other costs are high relative to the City estimate.

The Dig Once Coordinator will evaluate alternate approaches based on the technical merits of an alternative approach. The alternate approach needs to provide capacity and functionally equivalent or superior to the approach presented in Section 2.