Lead Service Line Replacement Costs and Strategies for Reducing Them

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Executive Summary

Where present, lead service lines (LSLs) are the largest source of lead in drinking water (Sandvig et al., 2008), and they provide a constant risk of exposure to lead even in water systems with corrosion control treatment (USEPA, 2023d). The U.S. Environmental Protection Agency's (USEPA) proposed requirement to remove all LSLs from water systems in the United States (USEPA, 2023d), known as the Lead and Copper Rule Improvements (LCRI), is an important and effective intervention for reducing and preventing exposure to lead in drinking water. Protective public health policy requires realistic cost estimates to ensure all LSLs are identified and removed quickly and efficiently. Inflated cost predictions slow health protective policy and provide an environment where contractors are enabled to overcharge for their services, further delaying public health protection for vulnerable populations who have had no option but to drink water from LSLs for decades.

In December 2022, the American Water Works Association (AWWA) presented a cost estimate for lead service line replacement (LSLR), which it submitted to USEPA as an attachment to comments concerning USEPA's development of the LCRI. This new full lead service line replacement (FLSLR) cost estimate (CDM Smith, 2022) was two times the previous average cost estimate provided by USEPA and 23% larger than the previous average provided by AWWA, which were both presented in the Lead and Copper Rule Revisions (LCRR) Economic Analysis in 2020 (USEPA, 2020). In November 2023, USEPA proposed the LCRI, which includes a requirement to replace all estimated 10.5 million lead service lines (LSL) and galvanized requiring replacement (GRR) service lines in the United States. The proposed LCRI is supported by a new Economic Analysis, which presents USEPA's own updated cost estimates (USEPA, 2023b).

This report was prepared to assist with evaluation of LSLR costs, for the purposes of developing Safe Drinking Water Act regulations and implementing local LSLR programs. This report analyzes the most recent AWWA and USEPA LSLR cost estimates, compares similarities and differences, and provides an additional literature review to further contextualize available data. This report's purpose is to understand current and reasonable cost ranges for LSLR at the unit scale.

This report also presents independent construction cost estimates using data from RS Means, an industry standard construction cost tracking database. The results of this analysis provide the relative magnitude of individual line-item costs to identify major LSLR cost drivers, allowing for exploration of opportunities to reduce those costs.

This cost analysis serves not only to inform policy makers, municipalities, and water systems, but also to allow community members to hold local decision makers accountable for LSLR projects so that funding is spent wisely and efficiently to complete the most LSLRs as quickly as possible. The information presented here is necessary to support efficient planning and procurement, and to ensure that public health protection is prioritized throughout the LSLR process.

Historically, cost estimates for water distribution renewal needs have not included LSLR, making the cost of LSLR appear to be "extra" even though the service line is the final critical pipe that affects the quality of all water delivered to an individual home. Although replacing 10.5 million LSLs and GRRs will be a large task, LSLR represents a small percentage of overall water infrastructure replacement needs that

the utility sector has estimated as being in the multiple trillions of dollars (AWWA, 2013). LSLR costs represent an even smaller percentage of utilities' total budgetary needs when operating expenses are also considered (Value of Water Campaign, 2020). Adding LSLR to our water infrastructure needs does not represent the last, singular cost that makes water unaffordable – it is merely one of many costs necessary to continue providing safe drinking water in community water systems. According to previous estimates (Betanzo, 2022) adding the cost of replacing all LSLs to water distribution needs estimates results in a mere 3% increase in the national cost estimate for water main renewal. In contrast to most water infrastructure funding needs, the need to remove the health hazard of LSLs represents a one time, all at once cost. While service lines will need to be maintained and replaced in the future on a maintenance schedule, the need to remove this urgent health risk is a one-time cost.

Analysis

AWWA Cost Estimate Analysis

In November 2022, CDM Smith published a report, *Considerations when Costing Lead Service Line Identification and Replacement* (CDM Smith, 2022), that analyzed data collected by phone interview with 9 water utilities and a literature review of reported costs. This report's analysis of the CDM Smith dataset focuses on the full lead service line replacement (FLSLR) projects and considers both construction and auxiliary cost estimates for engineering services, internal labor administration, customer outreach, permitting, and post-replacement provisions.

The CDM Smith analysis established a baseline estimate for minimum, average, and maximum construction costs using historical (from literature) and survey data. Auxiliary costs were then identified based on the type of activity and applied to the construction cost as a percentage multiplier (26.5%) to arrive at an estimated total LSLR cost. While the report discusses the options and costs for preparing a lead service line inventory, these costs were not included in the final CDM Smith LSLR cost estimate. Costs for restoration were also estimated but not included.

Findings from this evaluation of the data sources and approach taken in the CDM Smith report include:

- *Selective inclusion of projects in baseline construction cost estimate*: The projects included in the baseline construction cost estimate appear to have been selective, with criteria for exclusion of costs from the literature unclear. Most estimates appeared to have a similar degree of missing information, even those that were included. Information about the 9 utilities that were surveyed is not provided so it is difficult to contextualize that data and understand how it might relate to other LSLR replacement programs across the country. In all, 31 projects were included from a survey of 9 utilities, resulting in oversampling from the utilities that were selected on the basis of undisclosed criteria.
- *Averaging per project versus per LSLR*: The CDM Smith analysis does not use a weighted average approach because limited data on the quantity of LSLRs was reported. As a result, for example, the $13,213 LSLR cost for an unknown quantity of LSLRs has equal weight to $8,014 that was averaged over 206 replacements.
- *Auxiliary costs may be double counted*: In many cases, some of the noted auxiliary costs such as permitting or engineering services are likely already included in the baseline construction cost

estimate. The lack of a detailed breakdown of cost components in the literature makes this difficult to estimate and this fact should be acknowledged.

- *Using a percentage of construction cost results in an overestimate of auxiliary costs*: While there is precedent for using a percentage of the total construction cost as an estimate of engineering services costs, this is not the case for other auxiliary costs. For per-replacement services like permitting, outreach, and post replacement provisions, the cost will not be related to the construction costs, which are largely driven by factors such as depth of service line and soil conditions.

CDM Smith reported an average FLSLR construction cost of $9,900 and an average total cost including auxiliary items of $12,500, with a range from $7,600 to $37,800 (2022$). Recalculating that baseline average construction cost using all 25 FLSLR projects listed by CDM Smith, the average construction cost becomes $8,700. Further, using the auxiliary costs delineated by CDM Smith but adding them as fixed costs rather than a percentage, the resulting average total LSLR cost would be $10,800, with a range from $4,400 to $24,600.

EPA Lead and Copper Rule Improvements Economic Analysis

EPA estimated LSLR cost for the LCRI based on information submitted for the 7th Drinking Water Infrastructure Needs Survey (DWINSA) (USEPA, 2023a). To be included in the LCRI Economic Analysis (USEPA 2023b; USEPA 2023c), USEPA required adequate documentation with information on the number of service lines and replacement costs. As such, the inclusion criteria were clearly defined and 33 projects were included covering 13 states, 6 USEPA regions, and include states in the Northeast, Midwest, and the West. Populations ranged from 3,000 to 2,000,000 and covered a period from 2012 to 2022. The resulting average USEPA cost estimate for FLSLR was $6,930 (2020$).

Figure ES- 1 presents a histogram for the DWINSA and CDM Smith data, showing the frequency distribution of reported FLSLR costs by total number of LSLs replaced, grouped into $2,000 cost bins. Figure ES- 1 includes only those projects that reported the number of services replaced (n=12 for FLSLR projects included in the CDM Smith dataset). The histogram clearly demonstrates that the vast majority of LSLRs fell within the $8,000 to $10,000 cost range. Further analysis of these datasets reveals that:

- The highest reported FLSLR costs are associated with a very small number of LSLRs relative to other projects,
- Average FLSLR cost can be less than $10,000 for projects addressing a small or very large number of LSLRs, and
- Larger quantities of LSLRs do not drive up the average LSLR cost.

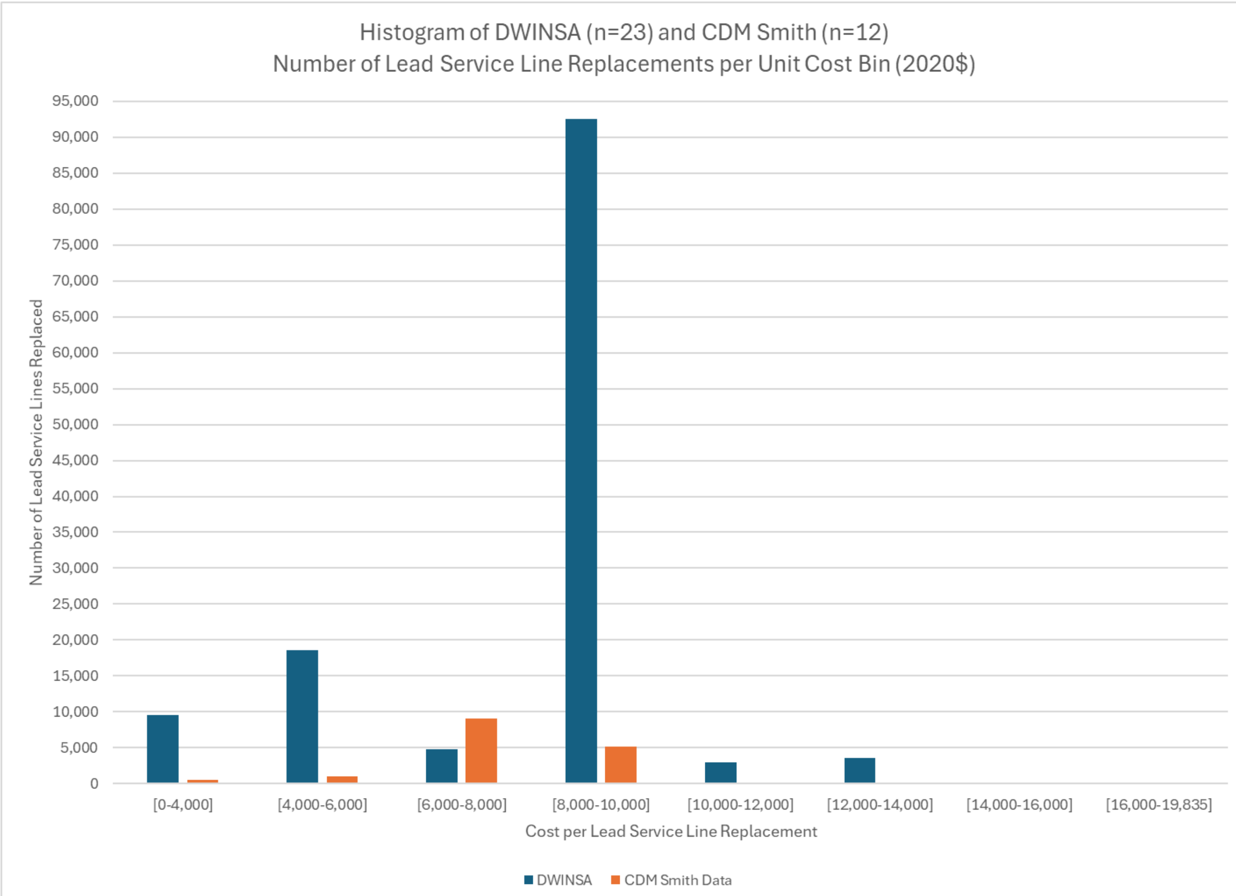

Figure ES- 1: Histogram of DWINSA and CDM Smith Number of Lead Service Line Replacements per Unit Cost Bin 2020$ (Source: USEPA, 2023b; CDM Smith, 2022)

Literature Review

An independent literature review was conducted for this study to further explore the range of published costs for LSLR projects. The literature from CDM Smith (2022) was collected, along with a literature review focused on AWWA publications, USEPA analyses, court testimony, and media reports regarding cities with publicized LSLR programs. This literature review is valuable in that it illustrates the range of real and potential outlier LSLR program costs given a sufficiently broad spectrum of reported programs.

The findings of the independent literature review are consistent with the observed trend that very high FLSLR costs are real but limited. The majority of FLSLR unit costs are substantially lower than the maximum and reliably below $10,000. The outlier project costs in CDM Smith (2022) are, in fact, outliers. Although the maximum LSLR cost for the independent literature review is higher than the DWINSA or CDM Smith data, the median and mean FLSLR costs are not. The different cost estimates from the different datasets are summarized in Figure ES- 2. For consistency with numbers published by USEPA, Figure ES- 2 includes only the 18 CDM Smith projects that USEPA included in its comparison published in the LCRI Economic Analysis Appendix A (USEPA, 2023c).

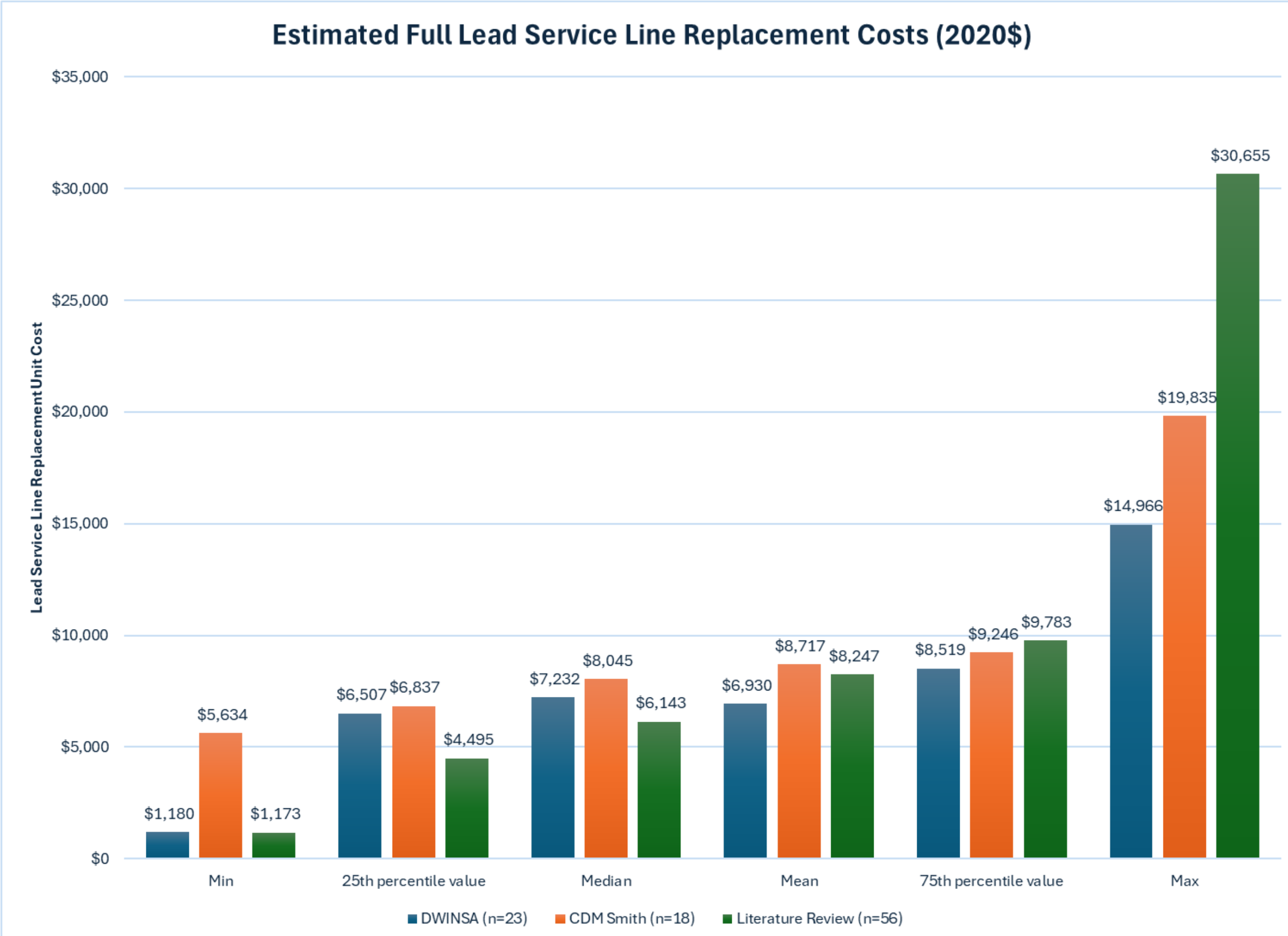

Figure ES- 2: Estimated Full Lead Service Line Replacement Costs (Sources: USEPA, 2023c; CDM Smith, 2022; literature as listed in Table 4)

In summary, this analysis finds that the USEPA estimates for FLSLR construction cost are reasonable in comparison to the values reported in the literature.

Independent Cost Estimate

An independent cost estimate was prepared as described in the full report using the industry standard RS Means Online Construction Cost Database, Year 2024 edition (www.rsmeans.com). A set of scenarios was developed to estimate typical costs for different configurations of LSLRs that might be encountered by utilities. The scenarios were developed as examples of typical construction costs, excluding auxiliary items such as inventories, permits, traffic control, and program management. In reality, the conditions encountered and degree of restoration needed will be highly site specific, so these examples are intended to provide benchmark reference values to help utilities understand the components of the work and relative costs.

Low, medium, and high cost scenarios were created to illustrate a range of cost estimates. Figure ES- 3 provides the results of the RS Means cost estimation across the different scenarios, ranging from $2,096 for low cost scenario, short-side, open trench polyethylene (PE) pipe to $33,408 for the high cost scenario long-side, open trench copper pipe with extensive road restoration. Comparing the results for different low-cost scenarios, copper pipe adds approximately $900 to the cost for a short side replacement, or $1,400 for a long side replacement (copper is $23.41 per foot installed versus $5.40 per foot installed for PE).

The independent cost estimates exclude auxiliary costs. The DWINSA values were developed to minimize auxiliary costs, and the literature values include unspecified auxiliary costs. The independent construction cost estimates are consistent with the values reported in the literature and DWINSA, considering low and high cost scenarios as comparable to the minimum and maximum reported costs, respectively. The alignment of the DWINSA values and independent cost estimates that both exclude auxiliary costs further validate the USEPA cost estimate.

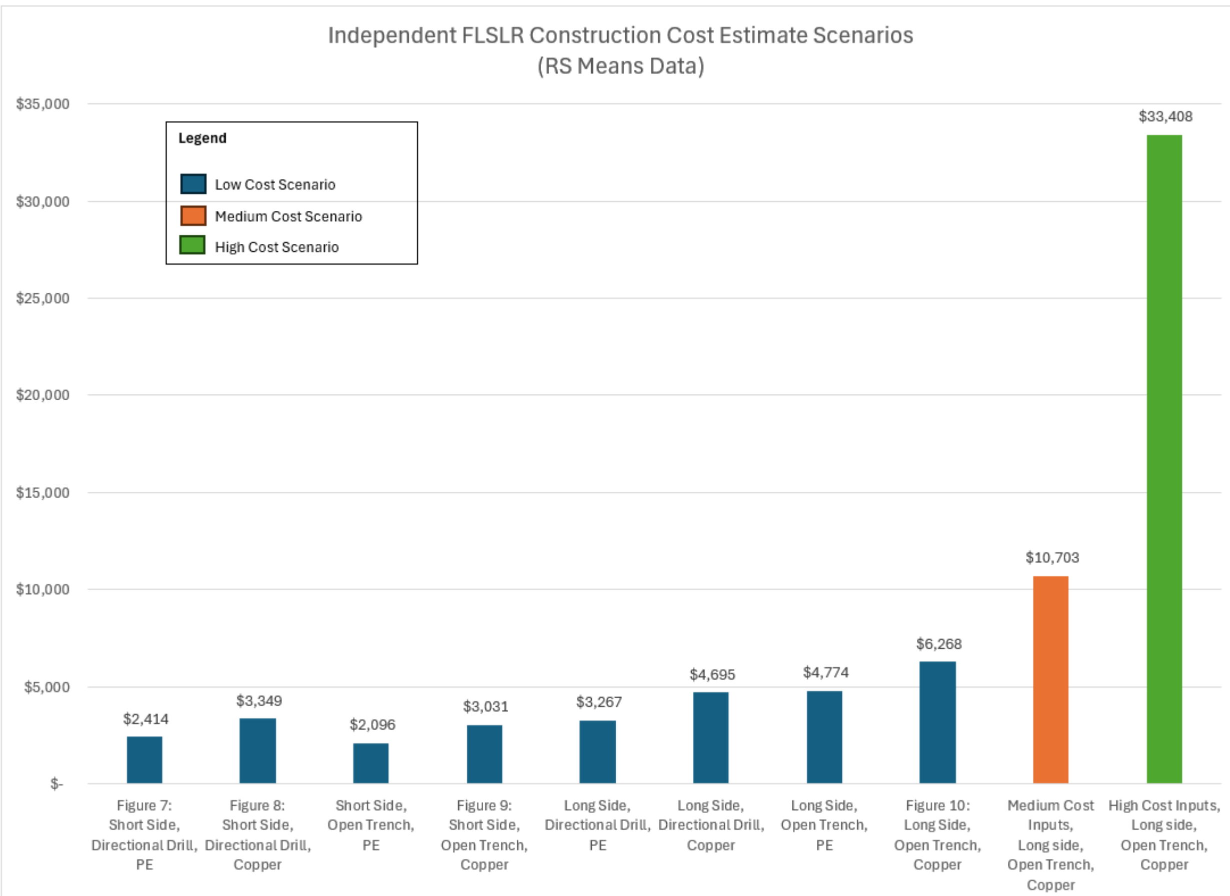

Figure ES- 3: Independent FLSLR Construction Cost Estimate Scenarios

Conclusions

This section summarizes the report findings and conclusions related to the multiple cost estimates presented in this report, the significant cost factors that tend to drive LSLR costs, and important LSLR program design considerations that can bring down overall LSLR cost at both the program scale and at the individual replacement scale.

LSLR Costs and the LCRI

The LCRI as proposed would require public water systems to replace all LSLs and GRRs within 10 years, with some exceptions. The cost of LSLR includes the planning, program, and construction tasks shown in Figure ES- 4. Restoration after LSLR to backfill all excavations, patch any disturbed interior wall, patch disturbed sidewalk and street, and lay grass seed is essential and inherent to any LSLR. However, additional paving, sewer line, and finished basement restoration is not compelled by the LCRI. For example, paving an entire street after LSLRs is not an essential cost to obtain the public health benefits of LSLR. Consolidating LSLRs to maximize the benefit of planned paving programs is strongly encouraged as an asset management and customer relations benefit to that community and will also bring down the cost of LSLR when the cost is shared with other capital improvements. Full restoration is encouraged but not required in the LCRI proposal.

Unit Cost Analyses and Construction Costs

1. Overall, there is a large degree of consistency across the USEPA, literature, and independent RS Means construction cost estimates, as can be seen in Figure ES- 2 and Figure ES- 3. The CDM Smith cost estimates as published are higher than the other estimates presented here, but when the CDM Smith data are adjusted to avoid selective inclusion of projects and more accurately reflect fixed auxiliary costs they are also consistent with the other unit cost estimates presented here.

2. The DWINSA analysis for the USEPA's LCRI proposal provided more information on inclusion and screening criteria for the DWINSA LSLR cost estimates. This dataset emphasizes the lower to mid-range of cost data that are found in the CDM Smith estimate and is consistent with our analysis of the published literature costs.

3. Our independent cost estimate shows that, in practice, most of the construction costs do not vary substantially. There is a small set of construction conditions that can drive up costs, but as reflected in the literature review cost estimates, these conditions are not experienced in the majority of replacements.

4. The low unit cost values in the independent cost estimates indicate that several auxiliary costs are likely already included in the cost estimates and literature review presented here.

5. Important construction cost considerations for LSLR planning:
   - Numerous predetermined factors affect construction cost including the depth of the water main and service line, the soil type and subsurface conditions, the need to excavate and restore hard surfaces like driveways and sidewalks, the configuration and accessibility of internal plumbing including when homeowners have refinished basements and other modifications.
   - The largest factor influencing construction costs is the degree of restoration needed and/or required. While it is to be expected that some LSLRs will encounter extensive restoration on public or private property, it would be an overestimate to use those high costs as a basis for modelling nationwide costs of complying with the LCRI.

- The cost of the replacement pipe can be a large percentage of the construction cost, especially for copper pipe in cases where restoration costs are low. Lifecycle estimates suggest copper service lines will last twice as long as PE, effectively doubling the cost of PE service line replacement over longer time horizons. The longevity and public health protection benefits of copper pipe may make this investment worthwhile (Beyond Plastics, 2023).

Program Design Strategies to Reduce Costs

1. Program decisions and cost inputs should be carefully considered in the design of an LSLR program. There are generally more opportunities to reduce overall LSLR cost through non-construction costs compared to construction costs because they reflect project planning and policy decisions.

2. Planning and policy decisions that affect costs include:
    - Engineering services
    - Outreach
    - Cumulative impact of unit costs across large numbers of LSLRs
    - Local policy driven costs
        - Maintenance of traffic (including police)
        - Permitting
        - Plumbing codes and requirements
        - Procurement approaches and procedures
        - Paving
    - Federal policy driven costs
        - Service line material inventory
        - Post replacement provisions

3. LSLR bids can have widely varying line item costs, even when total project costs are approximately equal. Large variability can reflect ambiguity in the bid documents in the best case or of gamesmanship by bidders in the worst case. A large unit cost difference multiplied across hundreds of LSLRs can add up quickly and can result in excessive overall project costs. Clarity in bid documents, scrutiny of bids, and making bids and final contracts publicly available can help build cost transparency and support better decision making.

4. A lack of transparency in bid documents, project reports, and financial accounting can result in LSLR funds being diverted to co-located non-LSLR infrastructure projects that do not maximize LSLR with LSLR funding (e.g., paving, stormwater, sewer line replacement). There is a need for transparency and better data tracking of the different project cost components to ensure that only LSLR is being completed with funding intended for LSLR.

5. Completing LSLR in tandem with other CIP projects can reduce the cost per LSLR but may draw out the timeline necessary to replace all LSLs because planning decisions are not driven solely based on the presence of LSLs. It is important to balance the priorities of reducing cost per infrastructure project with the public health benefits of removing LSLs as quickly as possible.

6. Developing LSLR program plans in consultation with community members can identify efficient strategies to reach impacted community members.

7. Programs that require homeowners to pay for LSLR under private property slow progress and drive up the unit LSLR cost due to intense one-on-one outreach and one-off replacements being the primary type of LSLR. LSLR funding should be used to maximize the public health protection gained through LSLR.

8. Using water utility funding to pay for FLSLR at all properties, including the portion of LSL that runs under private property, allows more money to go directly to public health protection and reduces the overall cost of FLSLR.

9. Prioritizing simultaneous inventory verification and LSLR may reduce the duplicative cost of completing a standalone service line inventory while improving cost efficiencies and public health protection.

10. The full report includes a comprehensive description of the elements of program design in Figure 16 and Appendix A. It also provides a detailed discussion of the most impactful program design strategies for reducing costs, which are outlined here in Figure ES- 4.

11. The analysis presented here demonstrates that LSLR costs have *not* skyrocketed since USEPA's cost estimates published with the 2020 LCRR (USEPA, 2020). The LSLR cost increases documented between 2020 and now reflect inflation.

The cost analyses presented in this report provide a clear basis for understanding and estimating the current construction cost of LSLR, and it provides many strategies for controlling LSLR costs. Several water systems with planned LSLR programs, including Cincinnati, Milwaukee, and Denver, have found that adapting programs based on experience allows them to bring down the cost of LSLR over time even as some materials costs increased due to inflation (Moening, 2020; Dettmer and Beversdorf, 2019; A. Woodrow, personal communication, March 8, 2022). This documented cost reduction over time further demonstrates the important role of LSLR program planning and adaptation in controlling the cost of LSLR programs and ensuring that LSLR funding and spending results in the most LSLRs possible.

LSLR Planning Costs	Opportunities for Reducing Costs
LSLR Program Planning and Design	Fully fund LSLR; Adopt municipal ordinances to support FLSLR; Revisit local policies
Community Engagement and Consultation	Engage customers in LSLR program planning and implement proactive customer engagement and outreach strategies
Contract Planning	Consolidate contracts by geography or replacement type; increase bid transparency; Completion incentives and termination conditions
Legal Review	Adopt municipal ordinances to support FLSLR
LSLR Public Education and Outreach Design	Consult with community to identify effective outreach strategies; Share information widely

LSLR Program Plan

Program Scale (Auxiliary) Costs
Project and/or Contract management
Engineering Services
Construction Management (e.g., Inspections)
Misc. Repairs (e.g., Water Main)
Support Software (Work order management, GIS)
Program Wide Outreach and Education

Construction Tasks	Opportunities for Reducing Costs
Mobilization	Geographic consolidation of projects; group as many replacements and inventory inspections together as possible
Permitting	Batch permit processing, LSLR funded dedicated permit staff
Inventory excavation	Verify all service line materials within a neighborhood while mobilized for LSLR in that location
Customer Outreach	Community engagement to design LSLR Outreach; Hire trusted community members
Replacement Construction	Revisit traffic control policies
Household flushing	
Restoration	Consolidate LSLRs; Revisit local paving policies
Completion services	
Demobilization	

Figure ES- 4: LSLR Program Planning and Implementation Opportunities for Reducing Costs

Introduction

Where present, lead service lines (LSLs) are the largest source of lead in drinking water (Sandvig et al., 2008), and they provide a constant risk of exposure to lead even in water systems with corrosion control treatment (USEPA, 2023d). The U.S. Environmental Protection Agency's (USEPA) proposed requirement to remove all LSLs from water systems in the United States (USEPA, 2023d), known as the Lead and Copper Rule Improvements (LCRI), is an important and effective intervention for reducing and preventing exposure to lead in drinking water. Protective public health policy requires realistic cost estimates to ensure all LSLs are identified and removed quickly and efficiently. Inflated cost predictions slow health protective policy and provide an environment where contractors are enabled to overcharge for their services, further delaying public health protection for vulnerable populations who have had no option but to drink water from LSLs for decades.

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Purpose of this report

This report was prepared to assist with evaluation of LSLR costs, for the purposes of developing Safe Drinking Water Act regulations and implementing local LSLR programs.

First, the report analyzes the most recent per-line cost estimates developed separately by AWWA and USEPA, compares similarities and differences, and provides an additional literature review to further contextualize available data. Our purpose is to understand current and reasonable cost ranges for LSLR at the unit scale. Because specific conditions and requirements vary greatly across communities, this estimate may not match precise costs for any specific community, but it gives a sense of magnitude for planning purposes. It also identifies underlying assumptions that can result in low or inflated cost projections that may not reflect real life situations.

Second, this report presents an independent construction cost estimate using RS Means data, an industry standard construction cost estimating database, to be compared to AWWA and USEPA estimates. By doing so, we identify relatively consistent LSLR cost inputs and those inputs that fluctuate widely in differing conditions. We provide the relative magnitude of line-item costs to identify major LSLR cost drivers. In doing so, it will be possible for public water systems looking to comply with the LCRI to explore opportunities to reduce those costs to drive down the overall cost of LSLR.

The range of realistic costs presented here can be used to inform public comment on the proposed LCRI and by USEPA to evaluate various cost estimates in developing a final LCRI. It also allows municipalities and water system decision makers to compare their own cost estimates to these ranges and identify where bids are reasonable and where they are not.

This cost analysis serves not only to inform policy makers, municipalities, and water systems, but also to allow community members to hold local decision makers accountable for LSLR projects so that funding is spent wisely and efficiently to complete the most LSLRs as quickly as possible. The information presented here is necessary to support efficient planning and procurement, and to ensure that public health protection is prioritized throughout the LSLR process.

Analysis

This report analyzes four approaches to calculating the cost of lead service line replacement (LSLR):

1. CDM Smith (2022) Approach
2. USEPA Lead and Copper Rule Improvements Economic Analysis Approach (2023)
3. Literature review
4. Independent construction cost estimate developed using RS Means data

LSLR costs are further explored through targeted sensitivity analyses for major cost drivers.

Each cost estimating approach is discussed below, along with a discussion comparing approaches.

CDM Smith Report

In November 2022, CDM Smith published a report, *Considerations when Costing Lead Service Line Identification and Replacement* (CDM Smith, 2022), that analyzed data collected by phone interview with 9 water utilities and a literature review. The compiled dataset consisted of 45 projects: 31 from the phone survey and 14 from the literature review. This analysis of the CDM Smith dataset focuses on the full lead service line replacement (FLSLR) projects summarized in that report. CDM Smith reported 25 FLSLR projects but excluded 6 from their analysis because they did not clearly specify whether the scope of replacements included full, private, or public side replacements.

There is a lack of documentation and inconsistencies in the approach of the CDM Smith Report that result in unquantified bias in the analytical results:

- The report does not describe the criteria that were used to select the 9 utilities for a telephone interview. Without further information, it is difficult to contextualize the cost data, understand how the 9 were chosen, or determine how they relate to other LSLR programs across the country.
- The expanded literature review added 14 LSLR projects. The projects included were selective – for example, costs for Denver were reported in Hawthorne (2021) and included in Table 4-2, but costs for Detroit ("Detroit replaced 1,100 pipes costing an average of $5,000 per line in 2018") and Chicago ("Chicago officials estimate it will cost $27,000 to replace each of the 650 lead service lines") were reported in Hawthorne (2021) but not included in Table 4-2. Cost inclusions and exclusions appear to be arbitrary or not explained in the report.
- Thirty-one projects were included from a survey of 9 utilities, resulting in oversampling from the utilities that were selected on the basis of undisclosed criteria.
- The report does not use a weighted average approach because limited quantity data were reported or collected. As a result, the $13,213 LSLR cost for an unknown quantity of LSLRs has equal weight to $8,014 that was averaged over 206 replacements.
- The report identified 25 FLSLR projects but excluded 6 of these from the cost analysis because the original sources did not clearly specify whether the scope of replacements included full, private, or public side replacements. However, the documentation for the scope of the 6 excluded FLSLR projects did not differ significantly from the documentation available for the included projects.

Given the vague, high level cost data reported in media articles from the literature review and lack of quantity data from the survey, it seems the determination of when cost data is relevant or not is arbitrary. The CDM Smith report provides a construction cost estimate derived from the collected data and calculates additional auxiliary costs for expenses assumed not included in the published cost. However, the literature cited provides no clear reporting that auxiliary programmatic and engineering costs are NOT included in the published costs. Given the lack of documentation in the cited literature, it is difficult to conclude that the published costs are limited to construction only.

For example, Sweeney (2020) is included in CDM Smith (2022) Table 4-2 but not in the average construction cost calculation with the justification that equipment, restoration, traffic control, permitting, and environmental protection were excluded from the scope of the reported cost. Yet, the source article is not any less specific in its published documentation than other data points that are included in the overall average, such as Jeznach and Goodwill (2021) and Hawthorne (2021). The media reports of LSLR costs are vague across the spectrum of projects presented in the literature review, which is typical of media reporting about engineering projects. However, the exclusion of specific projects in the CDM Smith Report because they might include ancillary costs is not consistent. It is just as likely that the projects that were included account for ancillary costs that were not mentioned in the media.

As shown in Table 1, CDM Smith reported an average FLSLR construction cost of $9,900 (in 2022$). However, if all 25 FLSLR projects are included in the calculation, the average construction cost becomes $8,700.

The CDM Smith report calculates auxiliary costs as a percentage of the LSLR construction cost equal to 26.5% overall. These auxiliary costs include restoration, engineering services to support bidding, funding applications, construction management and project management, internal labor administration, customer outreach, permitting, and post-replacement provisions such as sampling and water filter provision. As mentioned above, the data sources are not clear or consistent on whether these auxiliary costs are included in the construction cost numbers reported.

Most of these auxiliary costs do not vary based on the magnitude of construction costs and therefore, using a percentage of construction cost overestimates the impact of auxiliary costs by $500 in the average cost scenario and up to $5,600 in the max cost scenarios presented. Engineering services are relatively fixed for project initiation and per individual replacement. If the construction cost is driven up due to extensive pavement requirements (e.g., a municipality that requires complete street repaving for a small percentage of LSLRs on the street), there may be a slight increase in project management costs, but not in proportion to the complete cost of paving. Likewise, internal labor administration, permitting, and post-replacement provisions are relatively fixed costs per LSLR. The costs of water quality sampling and household flushing do not increase due to a deeply buried service line and they do not decrease for a simple, short replacement. Outreach costs can vary significantly from household to household, but this variability is typically due to the ownership status or employment schedule of the resident and has nothing to do with construction cost.

Based on our familiarity with some of the projects reported, it is clear that some but not all auxiliary costs are included in reported literature. Media reports do not provide a sufficient level of detail, and project design strategies in different utilities use different terminology making it difficult to definitively separate construction costs from all other project costs and compare consistently across water utilities and projects. For example, Hawthorne (2021) states "Denver replaced 5,200 lead service lines at an average cost of $10,000 per line last year..." Previous analysis of the Denver program indicated that the Denver program costs reported around the same time includes the auxiliary costs of street paving, outreach, and permit fees (Betanzo, 2022). As a result, some auxiliary costs are double counted to some degree in the CDM Smith cost estimate. Engineering services and outreach appear to some degree in both the survey and construction cost literature and again in the auxiliary assumptions applied on top. The lack of detail in media reporting is true of all literature reviews presented in this report and is not unique to the CDM Smith estimate.

Table 1 below presents a reproduction of CDM Smith's summary table showing their estimated minimum, average, and maximum per-LSLR costs.

Table 1: CDM Smith Full Replacement Summary Costs (2022$) (Source: Table 4-10, CDM Smith, 2022)

LSLR Component	Min Cost ($/LSLR)	Average Cost ($/LSLR)	Max Cost ($/LSLR)
Full Replacement (Utility and Private Side)	$ 6,000	$ 9,900	$ 30,000
Restoration (not included in calculation)	$ 1,769	$ 8,847	$ 2,919
Engineering Services	$ 660	$ 1,090	$ 3,300
Internal Labor Administration	$ 175	$ 289	$ 876
Customer Outreach	$ 108	$ 178	$ 539
Permitting	$ 576	$ 950	$ 2,879
Post-Replacement Provisions)	$ 78	$ 118	$ 158
Totals	$ 7,600	$ 12,500	$ 37,800

Table 1 was recalculated and presented in Table 2 using the following revisions to CDM's approach:

1. The actual low, average, and max cost of all 25 FLSLR projects listed in CDM Smith (2022) Table 4-2 (using the average cost for projects that were reported as a range) are used, for consistent treatment of all reported projects,
2. CDM Smith's average estimate of reported engineering services as a fixed cost of $1,090 is applied to all three cost levels, rather than calculating engineering costs as a uniform percentage of construction costs (note: much of this cost is likely already included in the reported construction cost but documentation is inconsistent),
3. The middle estimate ($289) of internal labor administration is applied to both the middle and high cost levels, rather than calculating engineering costs as a uniform percentage of construction costs,
4. The weighted average of Customer Outreach ($78) and Permitting ($543) calculated from costs as reported in CDM Smith (2022) Tables 4-6 and 4-7 are applied to all three cost levels, rather than calculating outreach and permitting costs as a uniform percentage of construction cost, and
5. The post-replacement provisions cost ($118) from CDM Smith (2022) Table 4-8 is applied to all three cost levels, rather than 1.2% of construction cost as described in CDM Smith (2022).

On this basis, the average LSLR cost would be $10,800, with a range from $4,400 to $24,600. These average calculated costs are 14-42% less than CDM Smith's reported estimate indicating that CDM Smith's flawed interpretation of the data resulted in significantly inflated cost estimates relative to what the data they selected and included in their report actually suggest.

Table 2: Recalculated CDM Smith Full Replacement Summary Costs (2022$) (Source: Table 4-10, CDM Smith, 2022)

LSLR Component	**Min Cost ($/LSLR)**	**Average Cost ($/LSLR)**	**Max Cost ($/LSLR)**
Full Replacement (Utility and Private Side)	$ 2,400	$ 8,700	$ 22,500
Engineering Services	$ 1,090	$ 1,090	$ 1,090
Internal Labor Administration	$ 175	$ 289	$ 289
Customer Outreach	$ 78	$ 78	$ 78
Permitting	$ 543	$ 543	$ 543
Post-Replacement Provisions	$ 118	$ 118	$ 118
Totals	$ 4,400	$ 10,800	$ 24,600

EPA Lead and Copper Rule Improvements Economic Analysis (2023)

EPA estimated LSLR cost for the LCRI based on information submitted for the 7th Drinking Water Infrastructure Needs Survey (DWINSA) (USEPA, 2023a). To be included in the LCRI Economic Analysis (USEPA 2023b; USEPA 2023c), USEPA required adequate documentation with information on the number of service lines and replacement costs. For consistency with USEPA's documentation, the Economic Analysis data presented here is referred to as the DWINSA dataset.

From the DWINSA reported data, six projects were excluded because the cost was less than $700 without explanation, or they included activities other than LSLR that could not be separated. USEPA excluded projects that explicitly included auxiliary activities since the cost of these activities were quantified separately in the Economic Analysis. After these adjustments were made, USEPA included 33 (23 full replacements plus 10 customer/utility side partial replacements) of 275 projects for which information was submitted. These projects cover 13 states, 6 USEPA regions, and include states in the Northeast, Midwest, and the West. Populations ranged from 3,000 to 2,000,000 and they covered the period of 2012-2022.

USEPA converted the costs to 2020 dollars and adjusted for regional differences. USEPA weighted the resulting summary statistics by the number of service lines and the DWINSA sampling weight. For FLSLR, the number of replacements per project ranged from 12 to 58,668 and the cost per replacement ranged from $1,248 to $15,837.

Compared to the CDM Smith analysis, a more consistent description for the scope of activities included (or excluded) from the total cost is available for each project. This dataset is more geographically representative and less biased compared to projects included in the CDM Smith Report. These are direct reports from water utilities that responded to USEPA's mandated survey, rather than selected reports from utilities that have a high public profile or the means to publish journal articles about their work. Table 3 presents a reproduction of Exhibit A-3 in the *Economic Analysis Appendices for the Proposed Lead and Copper Rule Improvements.* It should be noted that Table 3 shows CDM Smith (2022) values converted from their original 2022$ to 2020$ for comparison purposes.

Table 3: USEPA Economic Analysis Comparison of LSLR Costs (2020$) (Source: Exhibit A-3, USEPA, 2023c)

Statistic	Full Replacement		Customer-Side Replacement		Utility-Side Replacement	
	DWINSA	CDM Smith	DWINSA	CDM Smith	DWINSA	CDM Smith
Number of	23	18	10	8	10	12
Min	$1,180	$5,634	$1,677	$2,512	$1,677	$3,658
25th percen	$6,507	$6,837	$1,920	$3,572	$1,920	$4,613
Median	$7,232	$8,045	$3,273	$4,155	$3,273	$5,295
Mean	$6,930	$8,717	$3,803	$4,399	$3,803	$6,300
75th percen	$8,519	$9,246	$5,400	$4,905	$5,400	$6,997
Max	$14,966	$19,835	$8,099	$6,612	$8,099	$15,427

As USEPA (2023c) observes and we concur,

> *"Notably, the median full replacement cost and customer-side replacement cost from this [CDM Smith] report are almost $1,000 higher than that of EPA's estimates based on the DWINSA data. The utility-side replacement is also approximately $2,000 higher than that of EPA's estimates based on the DWINSA data.*
>
> *There are several possible reasons why the CDM Smith report's findings for the median LSLR unit cost are higher than the findings calculated from the 7th DWINSA data. First, the data from the CDM Smith report were derived from fewer systems and regions, i.e., from only nine systems in five states and three regions, as well as project data from five American studies and one Canadian study via literature review. The 7th DWINSA data were derived from 31 systems in 13 states and six regions, which include the states and regions observed in the CDM Smith phone survey. Therefore, it is possible that the DWINSA data may have collected a wider geographic range of responses and potential project costs.*
>
> *Additionally, the survey data collected from the CDM Smith study were only from systems that served populations over 10,000 and, therefore, may not be factoring in LSLR unit costs for smaller systems. The utilities surveyed by CDM Smith may represent more dense, urban areas that have higher costs for traffic coordination and pavement removal or replacement compared to more rural areas. The 7th DWINSA captured systems serving populations ranging from 3,000 to 2,000,000. The DWINSA also applies a system sampling weight and is weighted by the number of service lines replaced per project to ensure that these small- and medium-system costs are properly represented in a national value. In addition, it does not appear that the CDM Smith report regionally indexed estimates to reflect a national cost. The 7th DWINSA estimates calculated under this analysis, conversely, are adjusted to reflect both inflation and regional construction cost differences among states. "*

It is important to note that any summary level published LSLR cost value from a water utility is not going to provide enough detail to analyze with precision the number of known lead and unknown services included, or to know which itemized costs are included or not in the published project cost. Although notes are more consistently provided, USEPA's projects are almost as ambiguous as the documentation for projects included in the CDM Smith report regarding what costs are included. The following two graphs (Figure 1**Error! Reference source not found.** and Figure 2) present histograms for the DWINSA and CDM Smith data, showing the frequency distribution of reported FLSLR costs. DWINSA and CDM Smith project data were converted to 2020 dollars (ENR, 2024) for consistency with USEPA's presentation. All 25 CDM Smith projects that included FLSLRs were included in the histograms (see discussion above for more information). The first histogram shows the distribution of the average FLSLR cost per utility project and the second shows the cost distribution by total number of LSLs replaced, using only those projects that reported the number of services replaced (n=12 for FLSLR projects included in the CDM Smith dataset).

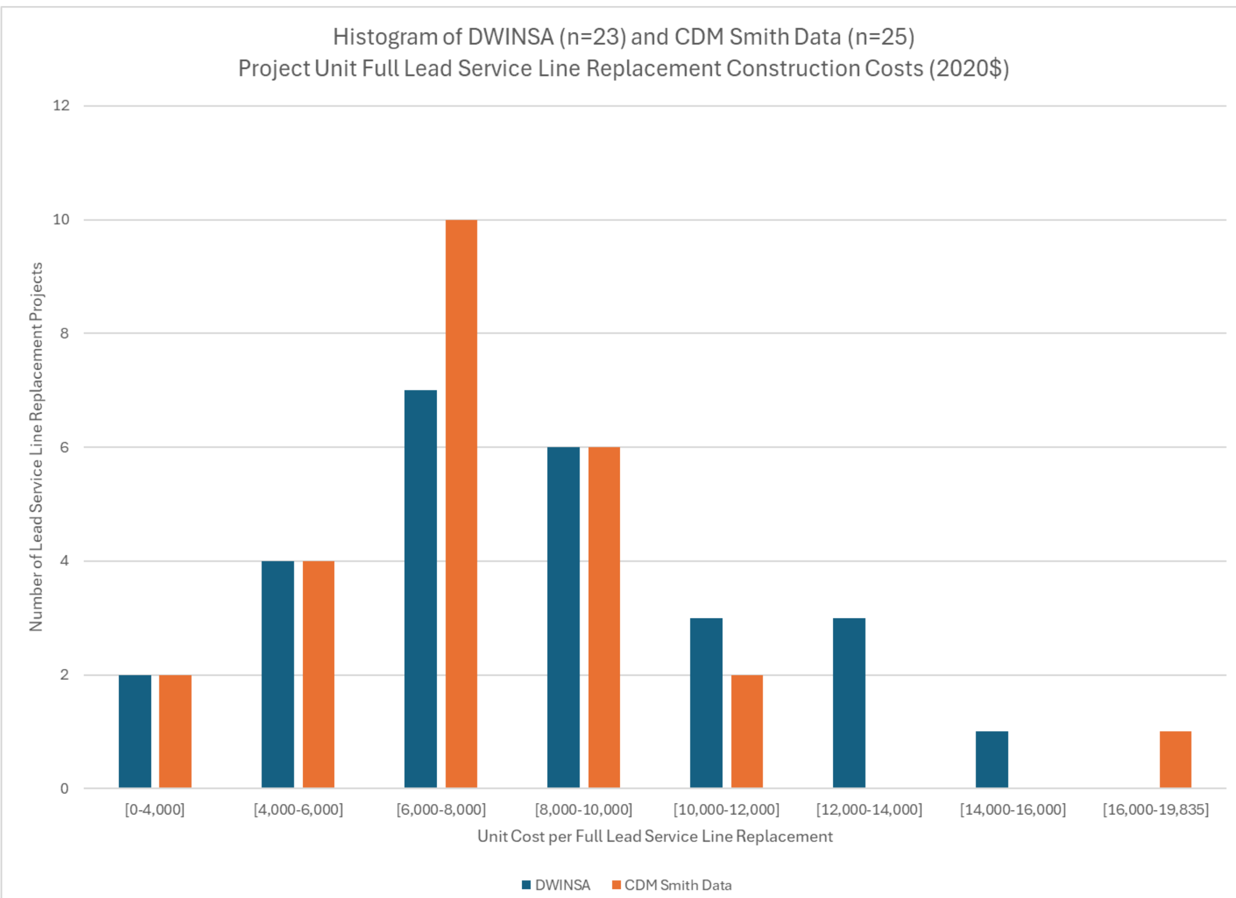

Figure 1: Histogram of DWINSA and CDM Smith Data Project Unit Full Lead Service Line Replacement Construction Costs (2020$) (Source: USEPA, 2023b; CDM Smith, 2022)

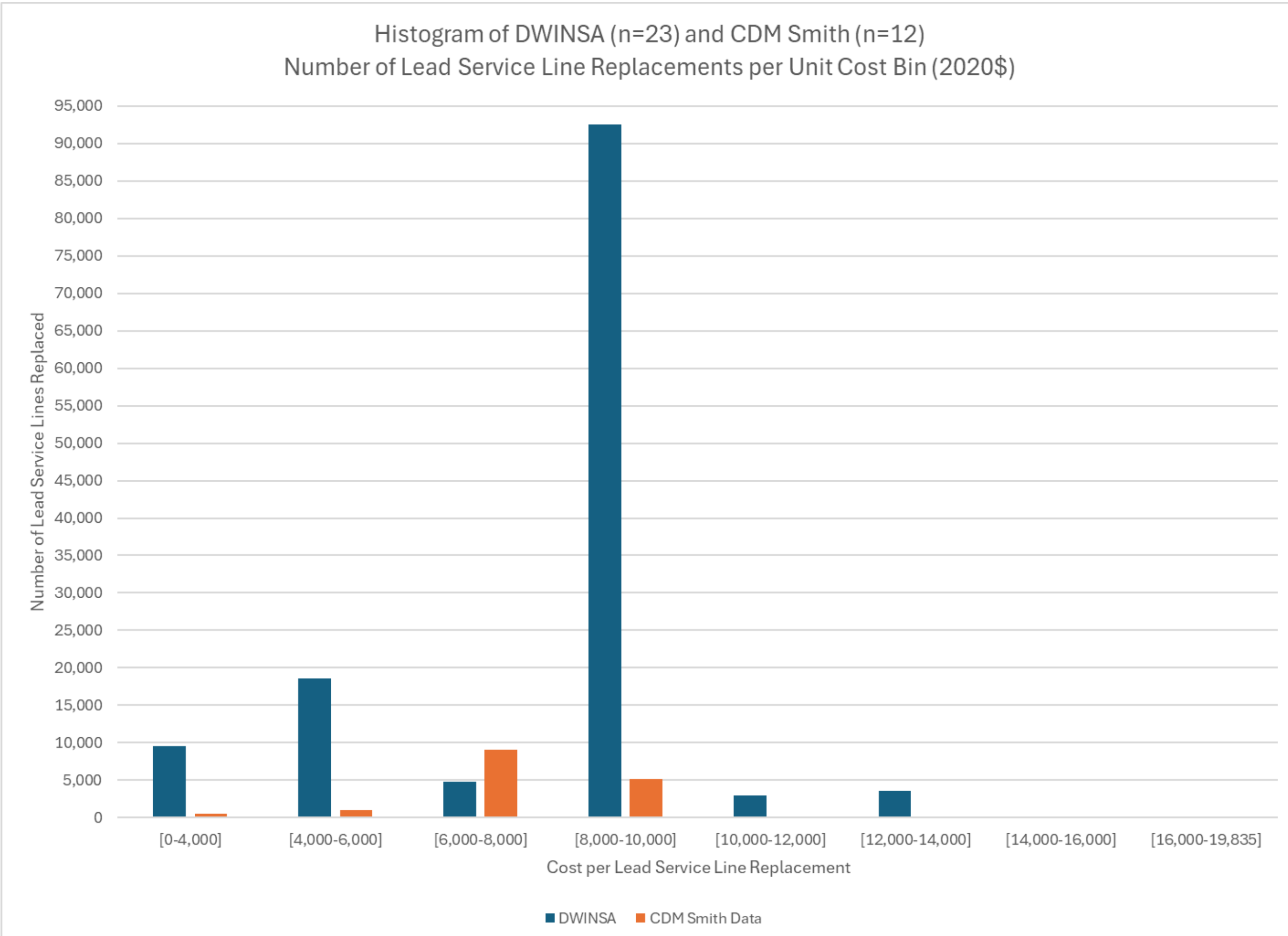

Figure 2:Histogram of DWINSA and CDM Smith Number of Lead Service Line Replacements per Unit Cost Bin (2020$) (Source: USEPA, 2023b; CDM Smith, 2022)

These graphs demonstrate that the majority of projects have an average FLSLR cost less than $10,000. While significantly higher costs do exist, they are outliers compared to the majority of data.

An analysis of FLSLR unit cost versus the number of LSLs replaced is shown in Figure 3, combining both datasets. The DWINSA dataset identifies the specific utilities that provided project data, but the CDM Smith dataset does not provide this information. Denver, CO appears to be included in both datasets, but at different costs and quantities. There may be other duplicates displayed in this graph. The figure indicates:

1. The majority of reported projects include fewer than 4,000 LSLRs,
2. The highest reported FLSLR costs are associated with a very small number of LSLRs relative to other projects,
3. Average FLSLR cost can be less than $10,000 for projects addressing a small or very large number of LSLRs, and
4. Larger quantities of LSLRs do not drive up the average LSLR cost.

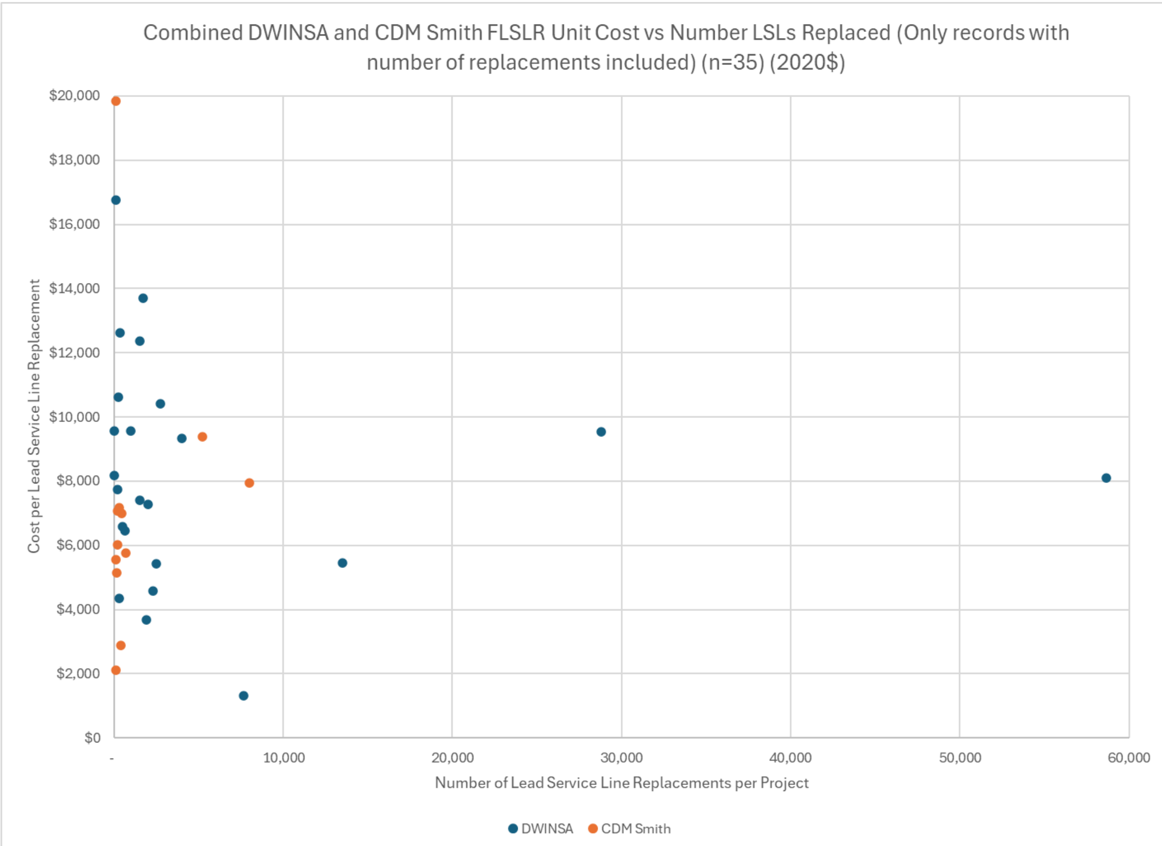

Figure 3:Combined DWINSA and CDM Smith FLSLR Unit Cost vs Number LSLs Replaced (2020$) (Source: USEPA, 2023b; CDM Smith, 2022)

Literature Review

An independent literature review was conducted for this study to further explore the range of published costs for LSLR projects. The literature from CDM Smith (2022) was collected, along with a literature review focused on AWWA publications, USEPA analyses, court testimony, and media reports regarding cities with publicized LSLR programs. A literature review for cost data is inherently biased. The literature is going to be biased toward high profile projects that were captured in the national media or had sufficient budget to write articles about the project. A literature review is still valuable in that it begins to illustrate the range of real and potential outlier LSLR program costs if it covers a sufficiently broad spectrum of programs. It is less likely to represent program costs for disadvantaged water systems that do not have the budget to publish or share public relations information about their infrastructure programs. This literature review includes multiple entries for the same cities, because different projects are reported in multiple years. For example, there are three LSLR costs from Washington, DC from 2022 that reflect three different ongoing projects. Survey data and summarized statewide data are also included in this literature review. This literature review is summarized in Table 4 and produced data points for 56 LSLR projects.

Table 4: Literature Review Results

Type	Total LSLRs	Unit LSL Costs ($ per LSL) Reported	Year of Cost Data	Unit LSL Costs (2020$ per LSL) Calculated	Data Source
Full	n/a	850	2008	1,173	Sandvig *et al.*, 2008
Full	n/a	1,600	2020	1,600	Smalley and Peckinpaugh, 2020
Full		2,000	2019	2,033	NYDOH, 2019
Full	115	2,000	2016	2,218	Sweeney, 2020
Full	1,600	2,700	2017	2,883	Welter, 2018
Full	460,000	3,765	2022	3,319	Read *et al.*, 2022
Full	1,782	3,367	2020	3,367	AWWA, 2020
Full	13,000	3,150	2016	3,494	AWWA, 2016
Full	12,000	3,667	2018	3,800	Beitsch, 2018
Full	37,000	4,054	2020	4,054	Catalini, 2020
Full		4,000	2019	4,065	NYDOH, 2019
Full	4,000	4,750	2022	4,187	Astolfi, 2022
Full		4,978	2022	4,388	CDM Smith, 2022
Full		5,140	2022	4,531	CDM Smith, 2022
Full	1,100	5,000	2021	4,725	Hawthorne, 2021
Full		4,700	2019	4,777	USEPA, 2020
Full	6,256	4,800	2018	4,975	Welter, 2018
Full		5,753	2022	5,071	Betanzo, 2022
Full		3,150	2004	5,076	Welter, 2018
Full	3,600	4,920	2018	5,100	Welter, 2018
Full	156	5,100	2018	5,286	MWRA, 2023
Full		5,800	2020	5,800	Bukhari *et al.*, 2020
Full		6,584	2022	5,804	Betanzo, 2022
Full		6,000	2020	6,000	Smalley and Peckinpaugh, 2020
Full	176	5,835	2018	6,048	MWRA, 2023
Full	18,500	6,486	2021	6,130	Campbell and Wessel, 2021
Full		7,172	2023	6,156	USEPA, 2023a
Full		6,145	2018	6,369	Welter, 2018
Full	300	6,960	2018	7,214	MWRA, 2023
Full		7,936	2018	8,226	Welter, 2018
Full		9,900	2022	8,727	CDM Smith, 2022
Full		6,226	2007	8,961	Welter, 2018
Full		9,000	2019	9,147	NYDOH, 2019
Full	5,600	5,047	2000	9,302	Welter, 2018
Full	5,200	10,000	2021	9,450	Hawthorne, 2021
Full		7,000	2008	9,658	Sandvig *et al.*, 2008

Type	Total LSLRs	Unit LSL Costs ($ per LSL) Reported	Year of Cost Data	Unit LSL Costs (2020$ per LSL) Calculated	Data Source
Full	2,310	11,835	2023	10,158	New Jersey American Water, 2023
Full		11,000	2019	11,180	NYDOH, 2019
Full		12,541	2018	12,999	Welter, 2018
Full		12,675	2018	13,138	Welter, 2018
Full	610	12,675	2018	13,138	Gonda, 2018
Full		14,949	2022	13,178	Betanzo and Attal, 2022
Full		9,300	2004	14,987	Welter, 2018
Full		16,100	2021	15,214	Shields, 2022
Full	11,000	15,545	2019	15,800	Twiddy, 2019
Full		15,527	2018	16,094	Welter, 2018
Full		18,774	2022	16,549	Betanzo and Attal 2022
Full		24,535	2022	21,628	Betanzo and Attal 2022
Full	650	27,000	2021	25,515	Hawthorne, 2021
Full	42,000	35,714	2023	30,655	Bonk, 2023
Full or partial	433	6,930	2017	7,400	MWRA, 2023
Full or partial	206	6,860	2017	7,326	MWRA, 2023
Full or partial	3,100	4,871	2023	4,181	13 On Your Side, 2023
Full or partial	470	8,298	2023	7,122	May, 2023
Full or partial	3,900	8,111	2022	7,150	Fleming, 2022
Full or partial		5,100	2018	5,286	MWRA, 2023

This independent literature review reiterates that the outlier project costs in CDM Smith (2022) are in fact outliers. As shown below in Figure 8, although the maximum LSLR cost for the independent literature review is larger than the DWINSA or CDM Smith data (drawn from Table 3), the median and mean FLSLR costs are not. This is consistent with the observed trend of real but limited very high FLSLR costs. The majority of FLSLR costs are substantially lower and reliably below $10,000.

For consistency with numbers published by USEPA, Figure 4 includes only the 18 CDM Smith Projects that USEPA included in its comparison published in the LCRI Economic Analysis Appendix A (USEPA, 2023c).

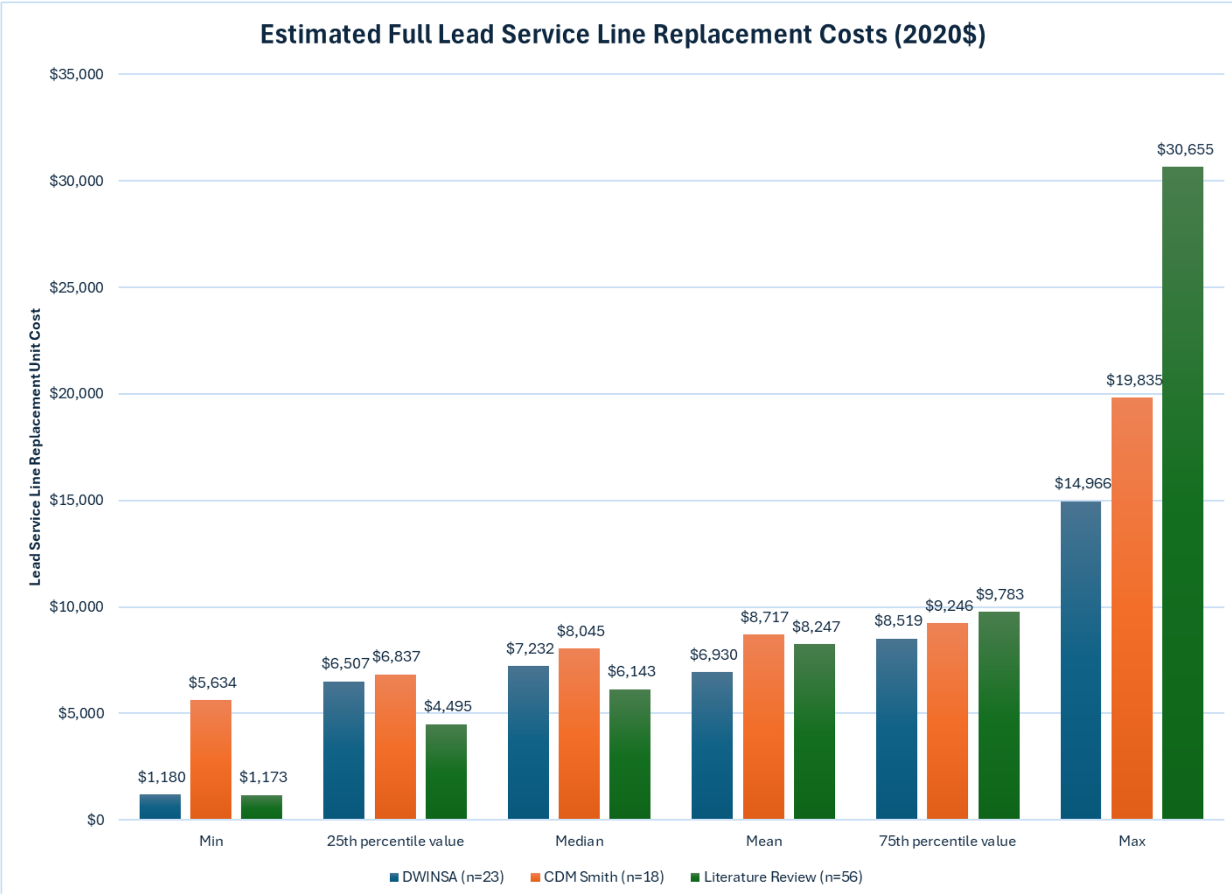

Figure 4: Estimated Full Lead Service Line Replacement Costs (2020$) (Source: USEPA, 2023a; CDM Smith, 2022, literature as listed in Table 4)

Independent Cost Estimate

A set of scenarios was developed to estimate typical costs for different configurations of LSLs that might be encountered by utilities. Construction costs for each component of the LSLR were taken from the industry standard RS Means Online Construction Cost Database, Year 2024 edition (www.rsmeans.com), with the exception of directional drilling costs as discussed below. RS Means data is compiled from across the US for more than 92,000 material, labor, and equipment cost items, and includes overhead and profit at prevailing rates. US national average costs with standard union rates were used for this analysis. Note that RS Means data projects forward to year 2024$ while historical costs can only be corrected to the nearest ENR historical cost index, which is December 2023. A full breakdown of all costs is provided in Appendix C.

The scenarios were developed as examples of typical construction costs, excluding ancillary items such as inventories, permits, traffic control, and program management. The scenarios differed in LSL configuration by considering short- versus long-side replacement (short meaning not crossing a street, long meaning crossing a street), different construction methods (open trench excavation, directional drilling/trenchless), different pipe materials (polyethylene or PE, copper) and different quantities of restoration of pavement and sidewalks. In reality, the conditions encountered in the subsurface (soil, rock, etc.) and degree of restoration will be highly site specific so these examples are intended to provide benchmark reference values to help utilities understand the components of the work and relative costs.

There are a number of trenchless pipe replacement technologies now in use. RS Means data does not include specific cost components for small diameter (generally less than 6 inches) directional drilling or similar trenchless construction options such as pneumatic mole or pulling. Therefore, a typical cost for this component of work was estimated from the literature and a web search for household-sized service line or communication (cable, phone) line installation. Allouche et al. (2005) reports a cost from $5 to $7 per foot which equates to $8.95 to $12.53 as of the end of 2023 (ENR Construction Cost Index, 2024; note the 2024 ENR cost indices were not available at the time of writing). The Federal Highway Administration lists urban installation of communications cable as ranging from $8 to $19 per foot (FHWA, n.d.). HomeGuide, a web-based home contractor recommendation service, lists water line directional drilling as $10 to $20 per foot (Carlson, 2023). Based upon these values, a reasonable estimate of $20 per foot was used in all scenarios for directional drilling. Other trenchless construction options are considered to be of similar cost, possibly less expensive (Bloetscher, 2019), so the directional drilling scenario is also meant to represent a reasonable estimate for all types of trenchless LSLR.

Field engineering staff are included in all estimates, with one full time junior engineer as field engineer plus one 50% time project manager. Labor costs for construction cost line item are included based on the typical crew skills required as part of the RS Means database. Additional staff time for detailed design, recordkeeping, and program management is considered an ancillary item, not a core construction cost. Several references (e.g. Sweeney, 2020; City of Newark, 2019) report an average LSLR time as 4 hours so this was used as a replacement rate (2 replacements per day, or 10 per week, per crew) for all scenarios except the high-cost scenario, where 1 replacement per day (5 per week, per crew) was used to account for the extensive pavement restoration taking additional time. Two replacements per day may also be a conservative estimate; more replacements per crew per day have been discussed (City of Newark, 2019). This is an opportunity where improving efficiency over time can increase the number replaced per crew per day, further driving down unit cost from the estimate provided here. A water utility can hire as many crews per day; cost per line is minimized by maximizing the number of LSLRs per crew.

A number of other site-specific factors can affect the cost of a specific LSLR such as house layout (e.g. water connection at rear of house), plumbing configurations, homeowner features including driveways and landscaping, repeat visits required to obtain access, and complications with other buried utilities. These complexities would be illustrated by the high cost scenario which examines the cost of only 1 LSLR per crew per day. Contingency funding should be allowed to cover these situations, which will typically occur at a fraction of LSLR locations.

As described here, where an option was available, the higher cost option was used for the analysis. Cumulatively this means that the independent cost estimate presented here may represent higher costs than those experienced in the field.

The following sections summarize the assumptions for each set of scenarios, with the summary provided in Table 5 and Table 6 along with the resulting cost estimates.

Low-Cost Scenarios

These scenarios were selected to represent the simplest configurations with the least excavation and restoration to develop a minimum benchmark cost estimate and understand the cost implications of pipe material and construction method choices. In these scenarios, the water main is assumed to be located in a grassy utility strip between the street and sidewalk based upon a typical suburban street layout (VDOT, 2009). Low cost scenarios represent both short-side LSLR with a length of 40 feet (Figure 5) and long side LSLR with a length of 71 feet (Figure 6), which includes 3 additional feet of utility strip and 28 feet of roadway width (VDOT, 2009). Figure 5 and Figure 6 indicate the service line alignment on a standard cross section drawing. In an urban layout which lacks the grassy utility strip, the water main can be located in the roadway, under the sidewalk, or in a grassy easement. The first two urban situations would not qualify as low cost scenarios given the need to do more pavement and sidewalk restoration.

For directional drilling (DD) installation, only pits are excavated. A shallow LSL depth of 3 feet was assumed. This estimate assumes that the curb stop is replaced but corporation stop and water meter are reused. All sod is assumed to be replaced but fill material is reused. There is no pavement demolition or restoration in the short-side replacement scenarios, even in the open trench (Open) installation. The long-side replacement scenarios include trench restoration only. An urban layout (lacking a utility strip) with the water main located in the roadway would result in a higher cost for the pavement excavation and therefore was not considered as a low cost scenario for directional drilling, although the open trench long side scenario does include the pavement excavation and restoration costs.

The two materials evaluated that water utilities tend to use for water service line construction are polyethylene (PE) and copper (Cu), although some regional differences may exist due to plumbing codes and local regulations (Bloetscher, 2019). These two materials were estimated in the low cost scenarios to understand the difference in cost. The medium and high cost scenarios include only copper.

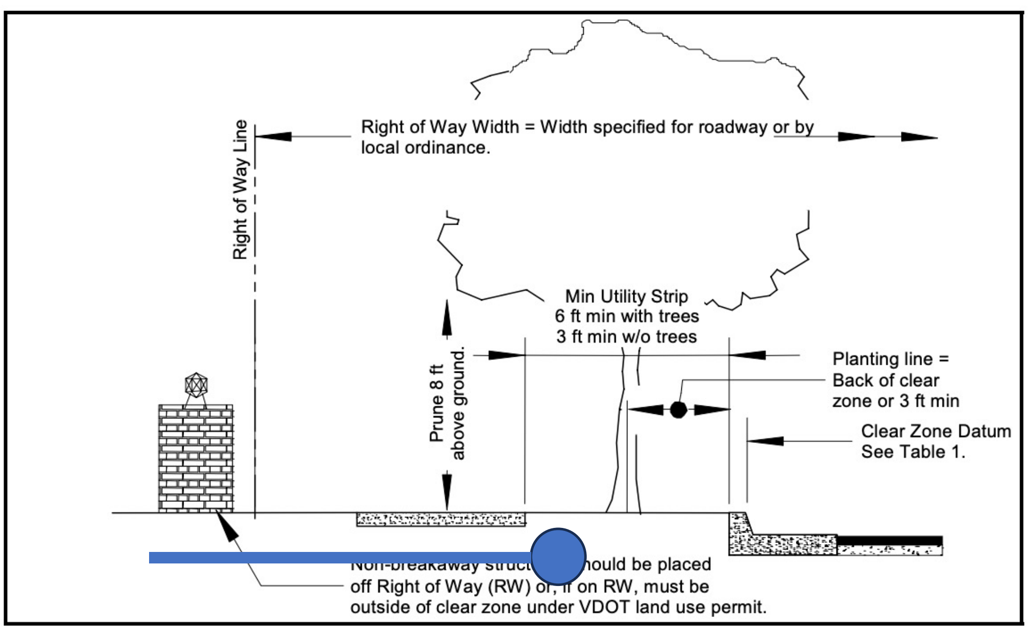

Figure 5: Low cost, short side scenario diagram (adapted from VDOT, 2009)

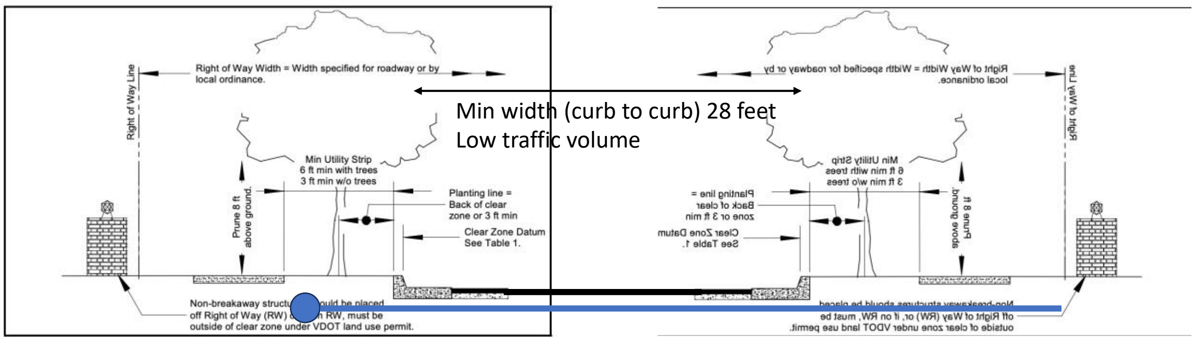

Figure 6: Low cost, long side scenario diagram (adapted from VDOT, 2009)

Medium and High Cost Scenarios

A medium cost scenario was developed to represent a long-side replacement with a 6-foot burial depth and open trench installation with a 6-foot trench to accommodate the excavation. This estimate assumes that a new curb stop and corp stop are required but that the water meter is reused. All sod is assumed to be replaced but fill material is reused. Sidewalk and roadway restoration of the trench are included. Only copper pipe was considered for these scenarios.

The high-cost scenario considers the same long-side replacement configuration as the medium scenario. Given that the majority of cost difference between all scenarios will be the costs for restoration of sidewalk and roadway (excluding homeowner features that would be case specific), only the open trench excavation option was considered for the high-cost scenario. Extensive road and sidewalk restoration was included for this option, with requirements to repave an entire city block (typical length 660 feet) and replace the curb and gutter on both sides of the block, with new fill material. Sidewalks are repaired at trenches only. The rate of installation was reduced to 1 LSLR per day to allow for the additional restoration work, so the resulting restoration cost was allocated across 5 LSLRs per week in this scenario.

Scenario Results for Full LSLR

Table 5 summarizes the input values for different elements of the low-cost scenarios and the resulting cost (rounded to nearest dollar) for each scenario. Table 6 summarises the medium and high-cost scenarios. Full details of each scenario's cost breakdown are provided in Appendix B.

Table 5: Summary of inputs and results for low-cost scenarios

		Value in Scenario							
Item	Unit	Low Short DD PE	Low Short DD Cu	Low Short Open PE	Low Short Open Cu	Low Long DD PE	Low Long DD Cu	Low Long Open PE	Low Long Open Cu
Length of Service Line	LF	40	40	40	40	71	71	71	71
Width of trench	LF	0	0	3	3	0	0	3	3
Depth	LF	3	3	3	3	3	3	3	3
Fittings	EA	2	2	2	2	2	2	2	2
Excavation	CY	1	1	13.33	13.33	1	1	23.67	23.67
Backfill	CY	1	1	13.33	13.33	1	1	23.67	23.67
New fill material required	CY	0	0	0	0	0	0	0	0
Hauling	CY	0	0	0	0	0	0	2.05	2.05
New curb stop	EA	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
New corp stop	EA	No	No	No	No	No	No	No	No
New water meter	EA	No	No	No	No	No	No	No	No
Sod replacement	SF	18	18	120	120	18	18	129	129
Sidewalk restoration	SF	0	0	15	15	0	0	15	15
Curb and gutter restoration	LF	0	0	0	0	0	0	3	3
Pavement demolition	SY	0	0	0	0	0	0	9.33	9.33
Pavement restoration	SY	0	0	0	0	0	0	9.33	9.33
Number of LSLRs per week	EA	10	10	10	10	10	10	10	10
Field staff, junior engineer	FTE	1	1	1	1	1	1	1	1
Field/office staff, project manager	FTE	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total Construction Cost (2024$)		**2,414**	**3,349**	**2,096**	**3,031**	**3,267**	**4,695**	**4,774**	**6,268**

Comparing the results for different low-cost scenarios, it can be seen that copper pipe adds approximately $900 to the cost for a short side replacement, or $1,400 for a long side replacement (copper is $23.41 per foot installed versus $5.40 per foot installed for PE). However, an independent analysis of the longevity and public health protection benefits of copper pipe has found that this investment is worthwhile (Beyond Plastics, 2023). In the simplest short side configuration with little or no pavement excavation involved, open cut trench installation is approximately $300 cheaper than directional drilling given that it uses more inexpensive equipment. However, as soon as pavement excavation becomes involved in the long side options, directional drilling becomes less expensive due to the avoidance of pavement repairs which add about $1,300.

Figure 7 and Figure 8 present a breakdown of construction cost elements for low scenario, short side replacement using directional drilling with PE and copper pipes, respectively. For the PE case, the cost is dominated by directional drilling costs (33%) because the pipe is relatively inexpensive (9%). For the copper case, the pipe becomes a larger cost element (28%), closer to the cost of the directional drilling (24%).

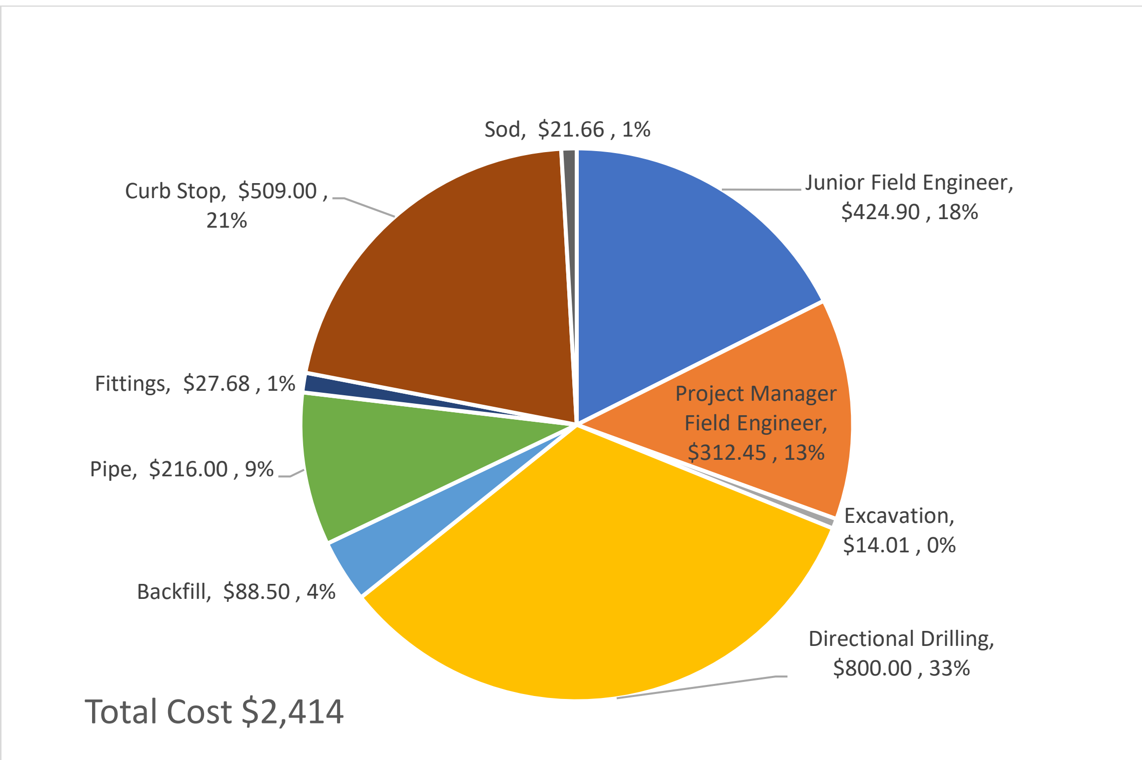

Figure 7. Breakdown of costs (2024$) for low scenario short side, directional drill PE

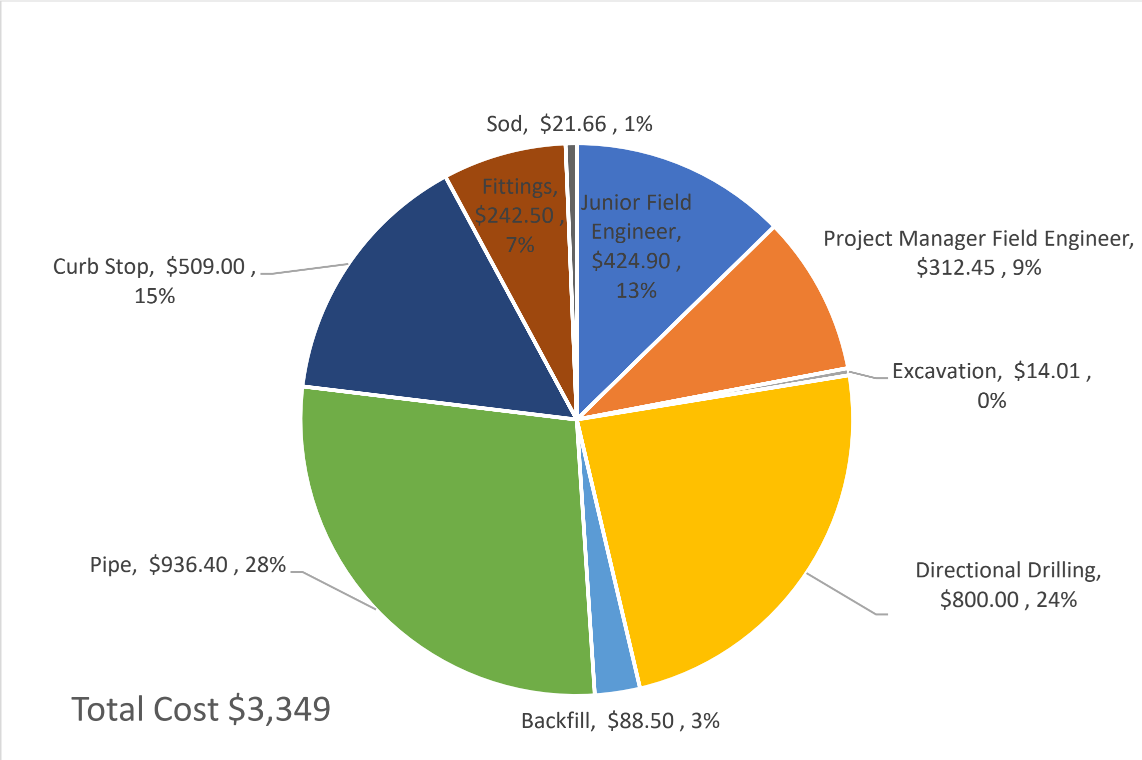

Figure 8: Breakdown of costs (2024$) for low scenario short side, directional drill copper

Comparing the low scenario short side replacement using open cut trench (Figure 9) to the directional drilling option (Figure 8), the simple excavation of grassed areas can be seen as a less expensive option than directional drilling, under ideal conditions. For long side replacement using open cut trench and copper pipe (Figure 10), the dominance of pavement demolition and restoration costs can be seen (3% + 31% = 34% overall). Sidewalk, curb and gutter restoration represent another 5% of the construction cost.

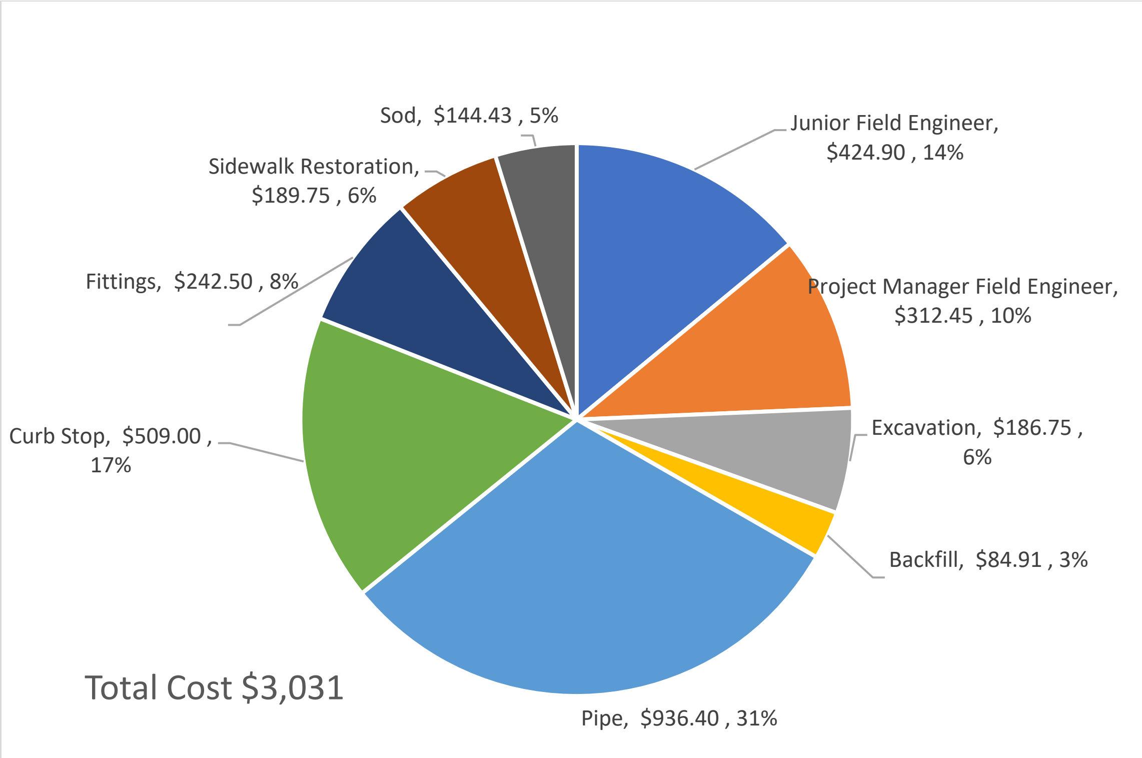

Figure 9: Breakdown of costs (2024$) for low scenario short side, open cut trench copper

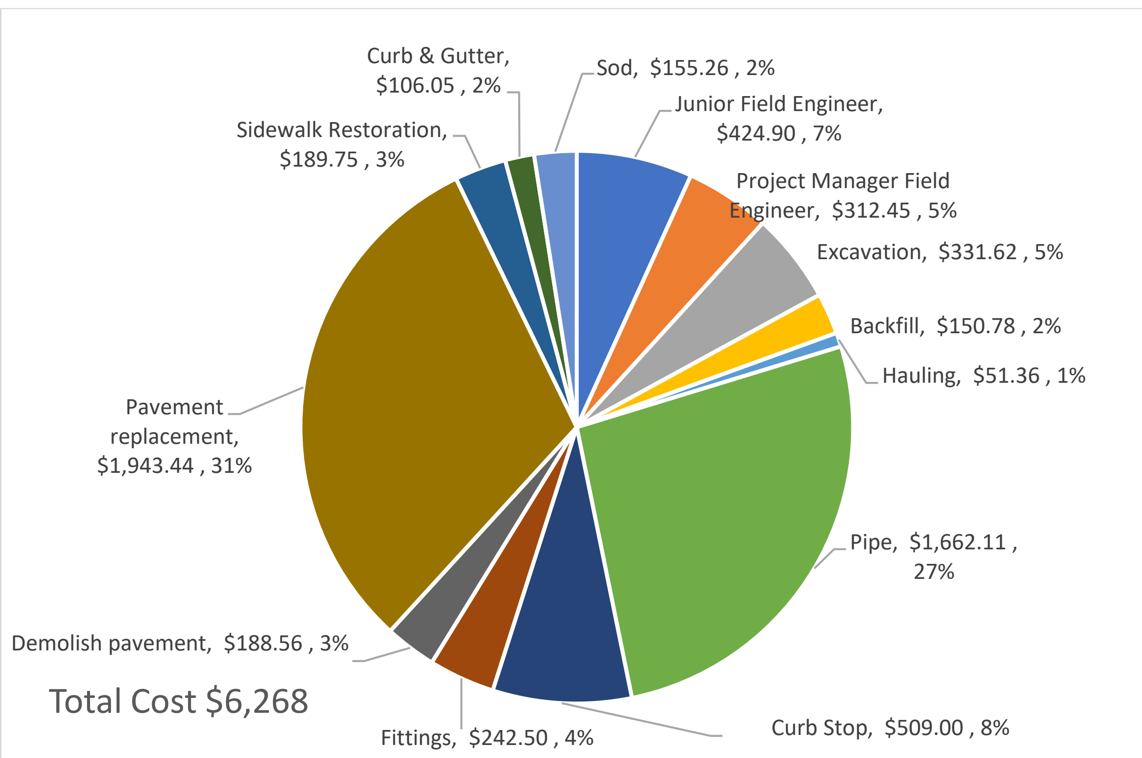

Figure 10: Breakdown of costs (2024$) for low scenario long side, open cut trench copper

The medium and high scenarios of open trench LSLR with copper pipe involving increasingly larger amounts of excavation and pavement restoration result in costs exceeding $10,000 and in the extreme case, more than $33,000 (Table 6). With only 5 replacements happening per week in this high scenario, this cost represents a block with both complex replacements and extra paving requirements. These scenarios demonstrate the need for LSLR approaches that maximize replacements by single work crews while minimizing pavement restoration needs, such as coordination with road paving schedules.

Table 6: Summary of inputs and results for medium and high-cost scenarios

		Value in Scenario	
Item	Unit	Medium Open Cu	High Open Cu
Length of Service Line	LF	71	71
Width of trench	LF	6	6
Depth	LF	6	6
Fittings	EA	2	2
Excavation	CY	94.67	94.67
Backfill	CY	94.67	94.67
New fill material required	CY	0	94.67
Hauling	CY	4.11	141.89
New curb stop	EA	Yes	Yes
New corp stop	EA	Yes	Yes
New water meter	EA	No	Yes
Sod replacement	SF	258	258
Sidewalk restoration	SF	30	30
Curb and gutter restoration	LF	6	264
Pavement demolition	SY	18.67	18.67
Pavement restoration	SY	18.67	410.67
Number of LSLRs per week	EA	10	5
Field staff, junior engineer	FTE	1	1
Field/office staff, project manager	FTE	0.5	0.5
Total Construction Cost (2024$)		**10,703**	**33,408**

It should be noted that these cost estimates represent construction costs only, and do not include ancillary items such as inventories, permits, traffic control, and program management. RS Means does provide estimates for traffic control options, including a flagger for non-intersection low traffic roads ($121.50 per hour), a flasher truck for intersection and medium traffic roads ($189.50 per hour), and police ($247.50 per hour).

Figure 11 summarizes the FLSLR Construction Cost Scenarios detailed in Table 5 and Table 6. The low scenario costs are consistent with the cost estimate range from minimum to 25th percentile by USEPA while the high scenario costs are consistent with the maximum value reported in the literature. Because the high scenario estimate is driven by the high road restoration costs, it would be expected to be found only in a few cases where such restoration is required. The USEPA analysis lists a maximum cost estimate of less than half of the high scenario cost estimate.

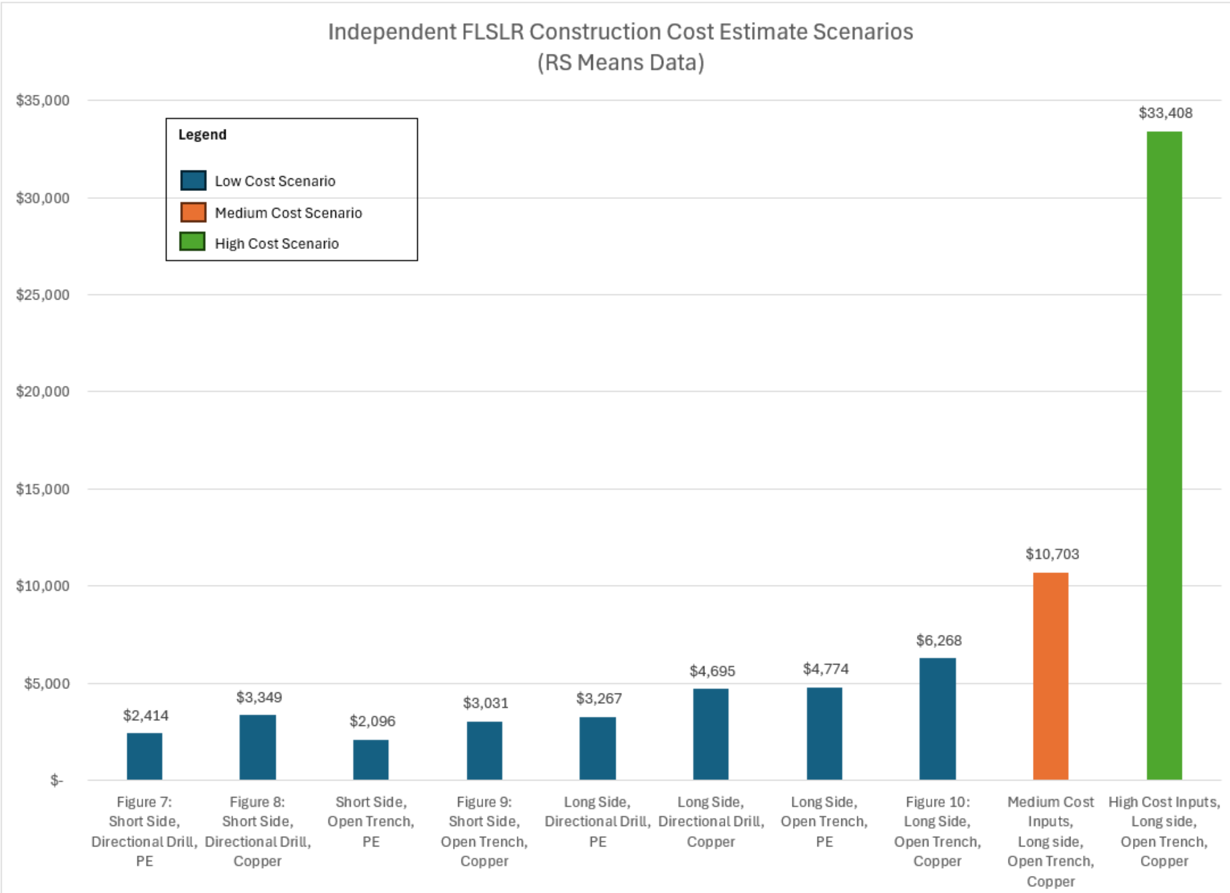

Figure 11: Independent FLSLR Construction Cost Estimate Scenarios

Customer Side Lead Service Line Replacements

In this report, the term "customer side" LSLR refers to replacement of the portion of the service line that runs under private property, regardless of ownership of that portion of the line.

To consider the benchmark costs of customer side LSLR, the low scenario estimates were modified to reflect work in the customer yard only with no restoration of sidewalk or pavement required. A typical length of 30 feet was used. Table 7 summarizes the inputs and results for the customer side replacement scenarios for directional drilling and open cut trenching of both PE and copper pipe. The resulting costs range from $1,748 to $2,915 for straightforward working conditions that do not require extensive restoration.

Table 7: Summary of inputs and results for customer side replacement scenarios

Item	Unit	DD PE	DD Cu	Open PE	Open Cu
Length of Service Line	LF	30	30	30	30
Width of trench	LF	0	0	3	3
Depth	LF	3	3	3	3
Fittings	EA	2	2	2	2
Excavation	CY	1	1	10	10
Backfill	CY	1	1	10	10
New fill material required	CY	0	0	0	0
Hauling	CY	0	0	0	0
New curb stop	EA	Yes	Yes	Yes	Yes
New corp stop	EA	n/a	n/a	n/a	n/a
New water meter	EA	No	No	No	No
Sod replacement	SF	18	18	90	90
Sidewalk restoration	SF	0	0	0	0
Curb and gutter restoration	LF	0	0	0	0
Pavement demolition	SY	0	0	0	0
Pavement restoration	SY	0	0	0	0
Number of LSLRs per week	EA	10	10	10	10
Field staff, junior engineer	FTE	1	1	1	1
Field/office staff, project manager	FTE	0.5	0.5	0.5	0.5
Total Construction Cost (2024$)		**2,160**	**2,915**	**1,748**	**2,503**

For comparison, national home services providers track the costs of water service line replacement across their network of contractors. HomeServe, one such home services provider, reported average customer water service line replacement costs by state ranging from $1,552 to $6,299, adjusted to end of 2023 costs using ENR construction cost index (Schmitz, 2021; ENR, 2024). The median value of these state average costs for all states excluding Alaska and Hawaii is $3,389 based on thousands of individual replacements. These values are slightly higher than the benchmark costs calculated with the RS Means data but are likely to include restoration on customer property which was excluded from the Table 7 calculations.

The average depth of service line was also reported by state in the HomeServe data, which ranged from 2.49 to 8.27 feet reflecting warmer and colder climates, respectively (Schmitz, 2021). Figure 12 plots the relationship between cost of replacement and service line depth from this data set, showing a slight trend (R^2 = 0.46) toward higher cost as depth increases but not a robust relationship.

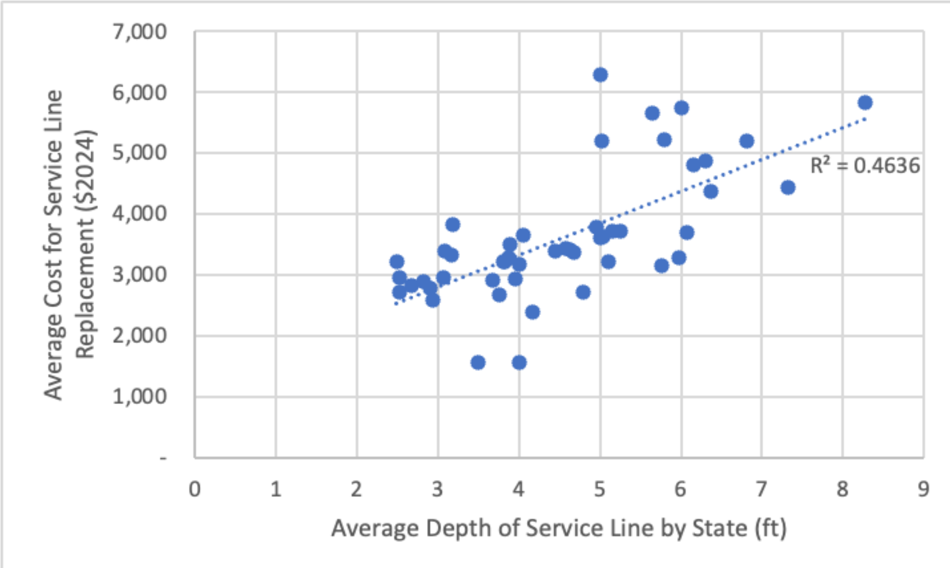

Figure 12: State average cost for customer side water line replacement vs depth of service line (data source: Schmitz, 2021)

HomeAdvisor, a similar home services provider reports an average water service line installation cost of $1,705 (2022$) equivalent to $1,938 (2024$) adjusted using ENR cost indices (Botelho, 2022; ENR, 2024). The HomeAdvisor website offers a summary of 5,163 individual project costs as can be seen in Figure 13, showing that most replacements cost between $646 and $2,816 (year of cost basis unknown).

Figure 13: HomeAdvisor cost summary for water service line replacement (source: HomeAdvisor, 2024).

In contrast, water main side replacements are more likely to affect pavement and sidewalks, resulting in a cost greater than half the cost of a FLSLR. Many of the per-LSLR auxiliary costs would be incurred for customer side or utility side replacements (e.g. outreach, post replacement provisions) the same as for full LSLR. Figure 14 presents a graph of these customer side replacement cost scenarios.

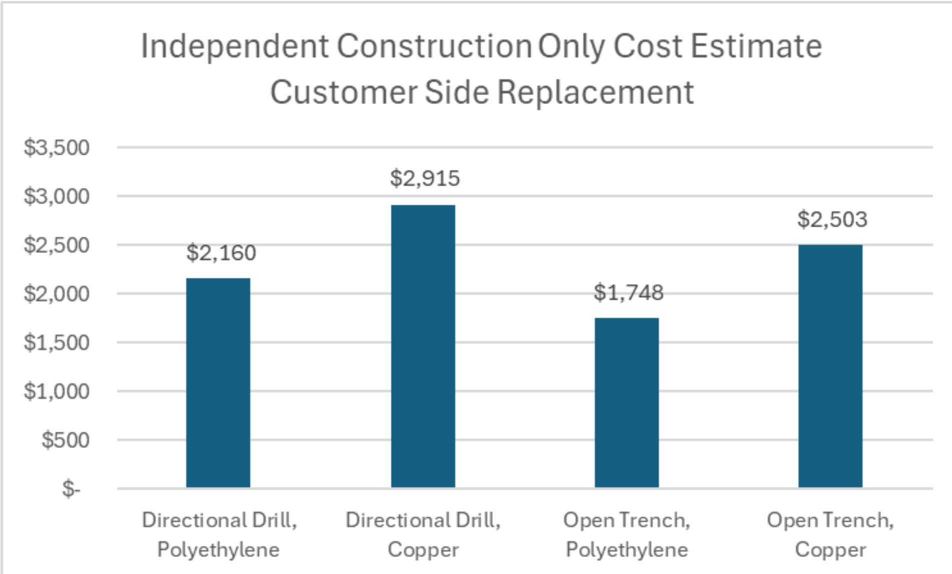

Figure 14: Summary of Customer Side Replacement Construction Cost Scenarios 2024$

Because the costs summarized in Figure 14 are construction costs only, they do not represent equivalent costs to those summarized in USEPA (2023c) that may include some auxiliary costs, summarized in Figure 15. The independent construction cost estimates are consistent with the minimum to median range reported by USEPA (2023c) and are slightly lower but well aligned with the ranges given by national home service providers but are significantly lower than those estimated by CDM Smith (2022).

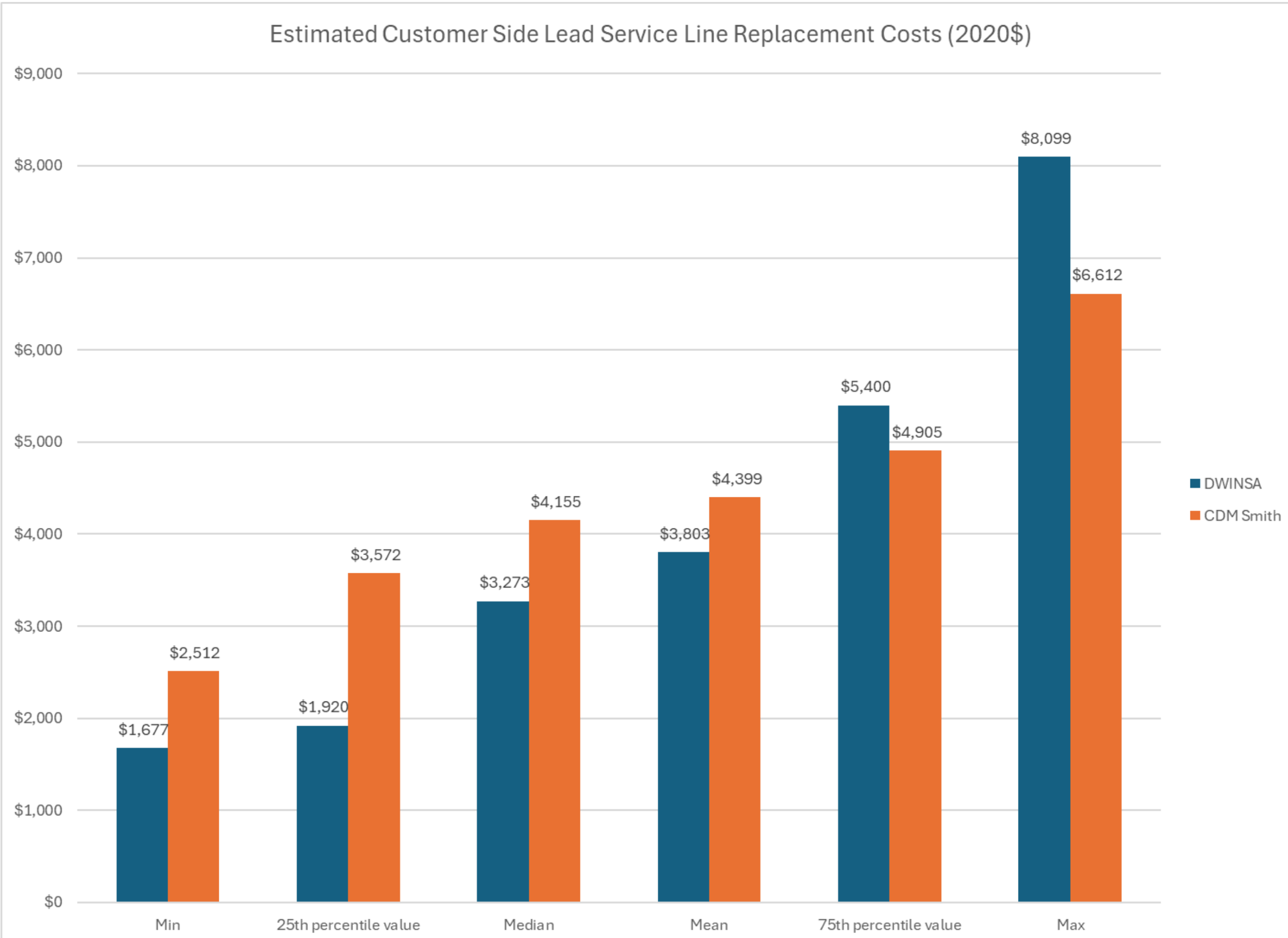

Figure 15: Estimated Customer Side Lead Service Line Replacement Costs 2020$ (Source: USEPA, 2023c; CDM Smith, 2022)

Discussion

This discussion section compares and discusses the results from multiple cost estimates presented in this report, summarizing important takeaways from evaluating the different approaches. It then goes on to discuss the significant cost factors that tend to drive construction and LSLR costs. Finally, the discussion covers LSLR program design considerations that can bring down overall LSLR cost at both the program scale and at the individual replacement scale.

Comparison of cost estimates

Considering the range of data sources and analyses conducted for this report, there is remarkable consistency across the FLSLR cost estimates from the literature, USEPA, and our independent cost estimate using RS Means data, despite the uncertainties introduced by lack of transparency in the inclusion of various auxiliary cost elements. The CDM Smith (2022) average costs are higher than the other data sources, but when the CDM Smith data are adjusted and reanalyzed to avoid selective inclusion of projects and more accurately reflect fixed auxiliary costs they also become more consistent with the other sources. The USEPA estimates are reasonable and the basis for their calculation was clearly presented in the LCRI documentation (USEPA, 2023b; USEPA, 2023c). The findings of this analysis show that very high FLSLR costs are real but outliers occur in very limited circumstances. The majority of FLSLR costs are substantially lower than the maximum and reliably below $10,000. The outlier project costs in CDM Smith (2022) are, in fact, outliers. The data presented in this report demonstrate that there are many ways that costs can be reduced, so the outliers likely represent cases where these methods of reducing costs have not been applied. Although the maximum LSLR cost for the independent literature review is higher than the DWINSA or CDM Smith data, the median and mean FLSLR costs are not.

Although they exclude auxiliary costs, the independent construction cost estimates are consistent with the values reported in the literature and DWINSA. The low scenario costs are consistent with the cost estimate range from minimum to 25th percentile by USEPA while the high scenario costs are consistent with the maximum value reported in the literature. The independent construction cost estimates for customer side LSLRs are also consistent with USEPA estimates, with the independently calculated values aligning with the minimum to median range by USEPA but lower than the CDM Smith (2022) customer side estimates.

LSLR Costs and the LCRI

The LCRI as proposed would require public water systems to replace all LSLs and GRRs within 10 years, with some exceptions. The cost of LSLR includes a wide range of planning, program, and construction tasks. Restoration after LSLR to backfill all excavations, patch any disturbed interior wall, patch disturbed sidewalk and street, and lay grass seed is essential and inherent to any LSLR. However, additional paving and restoration is not compelled by the LCRI. For example, paving an entire street after one or more LSLRs is not an essential cost to obtain the public health benefits of LSLR. Consolidating LSLRs to maximize the benefit of planned paving programs is strongly encouraged as an asset management and customer relations benefit to that community and will also bring down the cost of LSLR when the cost is shared with other capital improvements. Full restoration is encouraged but not required in the LCRI proposal.

Significant Cost Factors

This section discusses factors that influence the overall cost of LSLR in two categories: construction costs and non-construction costs. For non-construction costs, several further cost element categories are presented including engineering services, outreach, permits, internal administration, local policy driven costs, and federal policy driven costs.

Construction costs

Construction costs are difficult to estimate in advance without full knowledge of site conditions, and site conditions can limit options for reducing construction costs. Some construction costs, like paving, may be defined based on local policy requirements rather than site conditions. Working on private property and with buried infrastructure makes this estimation task even more difficult. Numerous predetermined factors affect construction cost including the depth of the water main and service line, the soil type, the need to excavate and restore hard finishes like driveways and sidewalks on private property, the configuration and accessibility of internal plumbing including when homeowners have refinished basements and other modifications. When considering an LSLR program across a utility, different factors will come into play for different areas or individual replacements. In areas with a high density of LSLRs on a given block, the number of pavement excavations may warrant restoration of the full block of pavement.

The largest factor influencing construction costs is the degree of restoration needed and/or required. While it is to be expected that some LSLRs will encounter extensive restoration on public or private property, it would be an overestimate to use these high costs as a basis for modelling national compliance costs for the LCRI.

The cost of the replacement pipe can be a large percentage of the construction cost, especially for copper pipe in cases where restoration costs are low (e.g. 27% of construction cost in Figure 6). Although copper pipe is initially more expensive than PE, it is expected to have a longer service life. Lee and Meehan (2017) found that plastic service lines including PE were most likely to fail after 20 to 40 years in service while copper service lines were most likely to fail after 50 to 60 years. Considering this differential in service life on a 50-year basis, it is plausible that utilities and homeowners may need a second replacement of the PE if that material is used for an LSLR now, effectively doubling the lifecycle cost of a PE service line.

Construction costs are also affected by global market trends and inflation. Copper pipe and tube in particular is expected to be in high demand in the coming decade for applications in plumbing, utilities, devices, heat exchangers, and heat/ventilation. Growth in China, US, Canada, Germany, and Japan is projected to keep global copper pipe demand high and cost of pipe is expected to continue to increase (Global Industry Analysts, 2022). Considering a long side, open trench copper pipe construction cost as shown in Figure 6, an increase in copper pipe cost of 10% would add $166 to the total cost of $6,268, making it $6,434 (an increase of 2.6%). Doubling of the cost of copper for the same scenario would add $1,662 to the total cost, making the total cost $7,930 (an increase of 26.5%).

Non-construction costs

In contrast with construction costs, non-construction costs (also referred to as auxiliary costs) typically depend on program design and local policies. Many of these costs have greater flexibility for change than construction related costs.

Non-construction costs, including engineering support, outreach and working with households, permits, inventories, and internal administrative costs for recordkeeping and compliance with local, state, and federal regulations can have a large impact on overall costs for LSLR programs and these cost elements can explain much of the variability in cost estimates that is seen across the country. These non-construction costs depend heavily on planning decisions for how the program is structured, who will staff the program, and how the water utility interacts with other municipal agencies that set local policies. The extent of these non-construction costs included in overall average LSLR costs in the literature has not been well documented and has hindered the comparison of costs across utilities. Many of the non-construction costs involve hiring of external expertise, especially for smaller utilities without large staff resources to draw upon.

Engineering services may be required to develop standard designs and specifications for LSLR, perform the inventory analysis, and oversee construction. CDM Smith (2022) provided a range of potential engineering services costs from 2% (without construction management) to 20% (including construction management) of total construction cost, with an average of 11%. RS Means provides estimates of engineering services based on a percentage of the total construction cost, as shown in Table 8.

Table 8: Summary of Engineering Fees for Construction Projects (data source: RS Means)

Project Total Construction Cost	Percentage Engineering Fees
For work to $100,000	10
$100,001 to $250,000	9
$250,001 to $1,000,000	6
$1,000,001 to $5,000,000	5
$5,000,001 to $10,000,000	4

However, the engineering design element of overall engineering services for LSLR is fundamentally different from designing traditional water infrastructure projects. Typical water plant or water main design requires highly site-specific detailed drawings. LSLR is fundamentally a simple project based on a standard specification that is repeated over and over at several to thousands of locations. Standard drawings and specifications reflecting the design considerations for the specific utility will be sufficient for the overwhelming majority of LSLRs within a single community water system. It will be rare that site conditions are so unique and complex that a site-specific design will be required for an LSLR. In this case, it is appropriate to include engineering design services in overall LSLR program engineering services with the percentage applied reflecting the overall project magnitude, rather than as a percentage of every LSLR.

Customer outreach, including scheduling appointments, signing forms, getting access to building interiors, and conducting follow up activities, is also often an outsourced activity. The fees for this outreach sometimes are included in the engineering fees or as a separate cost with a defined staff or separate contractor. RS Means reports the cost for educational planning consultants, which would include the outreach type of expertise, as 0.5% to 2.5% of the project total construction cost. For example, Milwaukee Water Works reported that their outreach plan cost $100,000 annually and 1 full-time staff member (Gonda, 2018). For many LSLR projects a fixed cost per replacement would be appropriate, especially when there are fewer than about 1,000 LSLRs involved.

Likewise, it is important to examine the cumulative cost of outreach across an entire LSLR program because at some point there will be economies of scale, similar to the decreasing percentage allocated to engineering fees as the total construction budget increases shown in Table 4. For example, DC Water's allocation of 10% of their LSLR program would have created a budget double the entire water utility's outreach budget to serve only their LSLR program (Betanzo and Attal, 2022).

Household access and coordination has been reported as requiring significant time and cost in completed or ongoing LSLR programs, with some homeowners refusing to participate in the program regardless of financial incentives (Beitsch, 2018). Raising awareness and participation in LSLR programs has been reported as a significant process, even when costs are not borne by the residents/homeowners. Depending on the need to access basements or internal plumbing to perform the LSLR, the time required to set up appointments and reschedule missed appointments can be significant, as is the burden on the resident who may suffer financial consequences to attend such appointments during work hours.

It is important to cross check the cumulative impact of non-construction costs when they are multiplied to scale. At small quantities, applying non-construction costs as a percentage makes sense, especially when that percentage does not add up to a full employee's time. But any time unit costs are multiplied to scale (especially for programs with thousands of replacements) the result should be checked for reasonableness. For example, DC Water's construction management allocation would have provided at least 12 construction inspectors reviewing as few as 3 LSLRs per inspector per construction day (Betanzo and Attal, 2022).

Local policy driven costs

A number of local policies can affect the non-construction costs, including traffic control requirements, permits, plumbing codes and other plumbing requirements.

Maintenance of Traffic

While maintenance of traffic is typical for most water infrastructure projects that require work in public areas, there are varying degrees of additional requirements that individual municipalities have put into place. Basic maintenance of traffic involves placement of cones or barriers to indicate the areas of work to drivers and pedestrians, along with signage and possibly a flagger. Depending on the level of traffic in the work area, more advanced traffic control measures may be required such as temporary street closures (with detours), the use of flasher or signal trucks (which also provide a physical barrier for workers), and police presence with or without flashing lights. These advanced traffic control measures are more expensive than basic ones with average costs (from RS Means) for a flagger for non-intersection low traffic roads of $121.50 per hour, a flasher truck for intersection and medium traffic roads at $189.50 per hour, and police at $247.50 per hour. Some municipalities require police at a large proportion of construction sites (New Jersey American Water, 2023), which increases the non-construction cost of a multi-year program significantly. While public and worker safety should be assured as a priority, there are opportunities to scale the requirements for maintenance of traffic according to the neighborhoods under construction at any given time to reduce the overall costs associated with traffic policies.

Permitting

Permitting procedures and costs vary significantly from municipality to municipality, and requirements are typically set at the local level. Permits are usually an important source for funding municipal inspector positions. It creates an interesting dynamic when another municipal department or public water supply creates the demand for permits and additional municipal staff. Permits and permit fees are important to ensure that all service line replacements are properly completed and recorded. CDM Smith reports a range of $231-$3,400 for the permits necessary for LSLR, resulting in a weighted average of $543 for these fees. Jersey Water Works (2023) reports $100 for a plumbing fee, plus charges ranging from $265 to $790 where road work is necessary.

Plumbing Codes and Requirements

Depending on the local house construction configuration and plumbing codes, an LSLR may require additional work in the interior of the building. For example, LSLRs that connect to a water meter located in the basement of a house may incur higher costs for plumbing work than those that connect to an outdoor water meter. Certified plumbers with an understanding of local codes may be required to perform the LSLR connection. Local codes may also require the use of copper pipe in any piping replacement.

Federal policy driven costs

Federal rule requirements add costs beyond construction costs for LSLR, mainly for development of a service line material inventory and for post-replacement services such as sampling and filters. Many utilities have already started and/or completed their service line inventories (Kutzing *et al*., 2023; Liggett *et al*., 2022). CDM Smith (2022) included a detailed analysis of the cost of developing a service line material inventory using several different methods and projecting example costs for fictional utilities of different sizes. The range of costs reported per service line (SL) evaluated for different methods is large, from $0.10 for historical record review up to $1,140 for sequential water quality sampling and as much as $2,500 for mechanical excavation. Combining these methods into a program for the fictional utilities resulted in a total cost of $42.73 per SL for a utility with 100,000 LSLs to $96.96 per SL for a utility with 5,000 LSLs.

Post-LSLR costs to protect public health are also specified in federal regulations. CDM Smith (2022) provide a range of costs for sampling and filter provision. A single follow-up sample was reported to cost from $20 to $100 per LSLR and a pitcher style filter with 6 months of cartridges was reported to cost approximately $60. Additional outreach to customers affected by LSLRs might also be conducted, with some of those costs potentially included in the LSLR outreach budget.

The vagaries of procurement

The majority of municipal water infrastructure is procured using a low bid system. The efficiency of low-bid procurement versus other procurement options is a continuing field of study in business research around the world, with several other models gaining popularity including design-build and best value options (Gransberg and Ellicott, 1996; Lines *et al*., 2022). In typical low bid procurement, a set of quantities and specifications are provided to bidders and winners are determined from the total cost or from a subset of costs (as specified in the bid documents). Depending on the bid requirements, bidders may be asked to provide a breakdown of certain cost categories or unit costs per item. Bidders are then free to assign their total costs across these categories to develop an advantageous yet competitive bid package. This type of system means that bids can have widely varying line item costs, even when total costs are approximately equal. Large variability can be a reflection of ambiguity in the bid documents in the best case or of gamesmanship by bidders in the worst case.

For example, Table 9 below shows the high degree of variability in bid line items from 5 contractors on the exact same project. In Table 9, for line items with a large difference between the highest and lowest bid on each line item, the highest line-item bid is shaded red and the lowest line-item bid is shaded green. The largest magnitude difference for a single line item is for maintenance of traffic, where this a difference of $315,650 between the highest and lowest bid. However, this is a one-time cost for the entire project. On the other hand, the difference of $3,473 between the highest and lowest bids for a curb stop and box results in a total $1,084,000 difference when multiplied across 312 potential LSLRs. Cost differences at the unit cost scale add up quickly when multiplied across large LSLR projects. Clarity in bid documents, scrutiny of bids, and making bids and final contracts publicly available can help build cost transparency and support better decision making.

Table 9: Five Independent Bids for the Same LSLR Project for the replacement of approximately 312 LSLRs in Benton Harbor, Michigan a Community Water System Serving <10,000 People (Source: City of Benton Harbor, 2021)

	Contractor A	Contractor B	Contractor C	Contractor D	Contractor E
Mobilization	$ 100,000	$ 70,000	$ 65,000	$ 100,000	$ 100,000
maintaining traffic	$ 335,100	$ 25,000	$ 19,450	$ 92,222	$ 53,500
pavement, rem	$ 13	$ 2	$ 25	$ 20	$ 6
sidwalk, rem	$ 12	$ 2	$ 2	$ 7	$ 6
curb and gutter, rem	$ 14	$ 2	$ 5	$ 11	$ 4
aggregate base, 8 inch	$ 8	$ 8	$ 18	$ 19	$ 5
hand patching	$ 296	$ 125	$ 375	$ 185	$ 0
conc pavt, miscillaneous	$ 59	$ 20	$ 61	$ 50	$ 46
curb and gutter, concrete	$ 34	$ 25	$ 28	$ 18	$ 22
driveway	$ 53	$ 20	$ 50	$ 45	$ 44
sidewalk, 4 inch	$ 5	$ 3	$ 5	$ 4	$ 4
slope restoration	$ 8	$ 3	$ 12	$ 7	$ 1
public water service trenchless, per foot	$ 49	$ 80	$ 23	$ 50	$ 29
private water service, trenchless, per foot	$ 33	$ 80	$ 23	$ 50	$ 33
curb stop and box	$ 732	$ 1,800	$ 1,357	$ 1,200	$ 4,205
private service, connection to residence	$ 1,864	$ 1,800	$ 1,050	$ 800	$ 1,500
water service, complete	$ 877	$ 340	$ 229	$ 100	$ 750
Total	**$ 3,211,190**	**$ 3,164,393**	**$ 2,486,044**	**$ 2,599,744**	**$ 3,087,210**
Right of entry form	$ 2,000	$ 300	$ 215	$ 125	$ 250
water service, investigation	$ 500	$ 800	$ 350	$ 1,000	$ 2,000
subbase	$ 53	$ 40	$ 24	$ 15	$ 25
non hazardous contaminated material	$ 70	$ 50	$ 105	$ 150	$ 150
public water service, 1 inch	$ 75	$ 165	$ 34	$ 95	$ 175
public water service 1.5 inch	$ 114	$ 240	$ 45	$ 105	$ 225
public water service 2 in	$ 136	$ 310	$ 70	$ 120	$ 350
water meter replacement	$ 1,024	$ 1,200	$ 425	$ 500	$ 1,000
private service cut and cap	$ 319	$ 1,000	$ 550	$ 1,250	$ 2,700

Note: for emphasis, the highest line-item bid is shaded red and the lowest line-item bid is shaded green.

Program Design Strategies to Reduce Costs

Many decisions go into designing a comprehensive LSLR program. It is this upfront planning (or lack of planning) that sets most of the boundaries around how much LSLR costs within a community. Figure 16 provides an illustration of the upfront planning steps and costs that are needed to make the decisions for an LSLR Program Plan. A conscientious investment in planning can be very effective for controlling costs in the long run.

An inclusive list of the decisions that must be made in designing an LSLR Program Plan can be found in Appendix A. Figure 16 then lists the program scale and construction scale costs that may be part of an LSLR program.

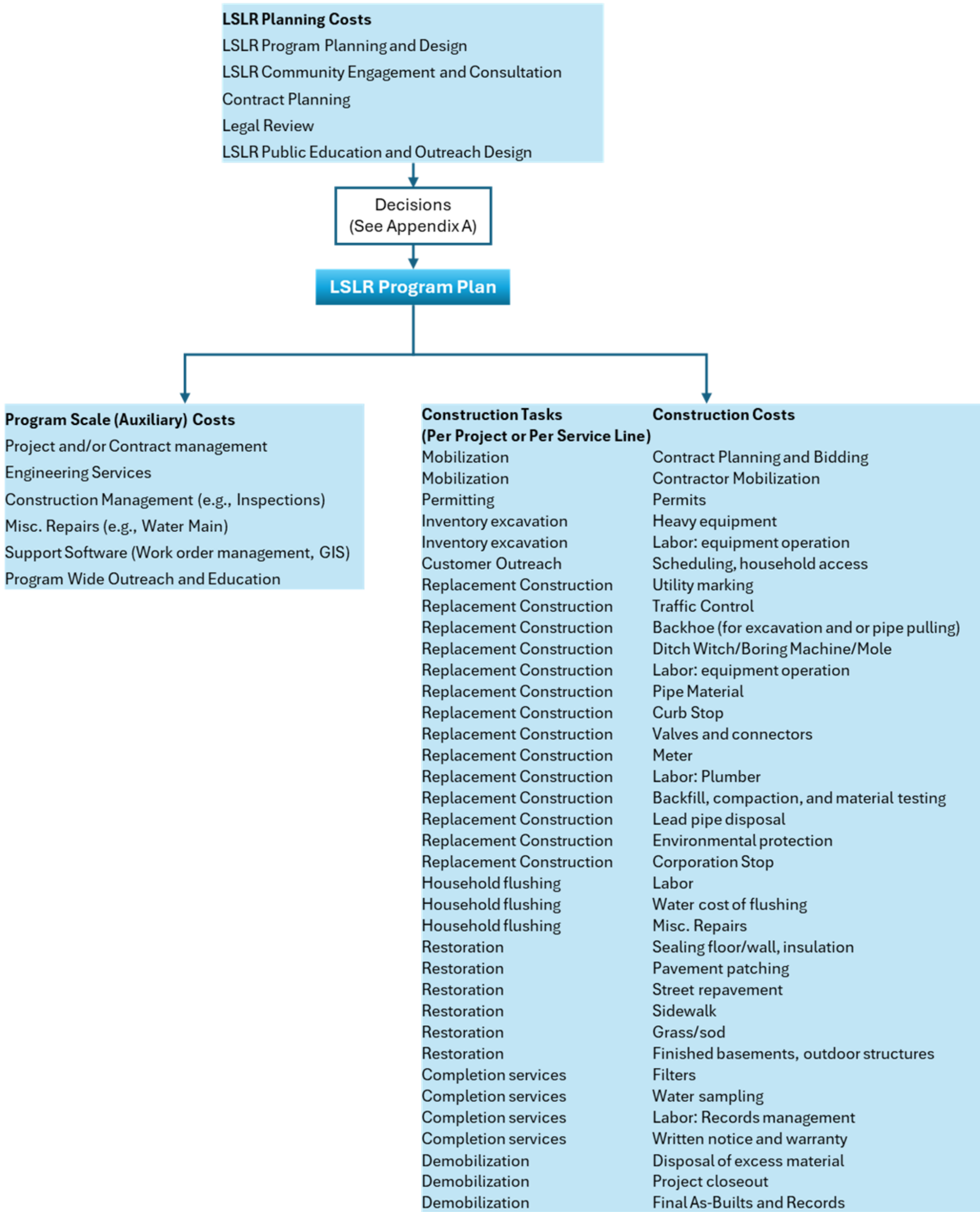

Figure 16: Inclusive List of LSLR Planning Costs, Programmatic Costs, and Construction Costs

The program decisions and opportunities to reduce the overall cost of LSLR are discussed in further detail below. A summary of the key cost reduction strategies is provided in Figure 17.

LSLR through Capital Improvement Planning

Consolidating LSLR programs with other capital improvement programs (CIP) can reduce the cost of LSLR because many of the auxiliary costs are shared with other infrastructure projects and the cost of paving can be split between multiple infrastructure projects. Coordinating LSLR with water main replacement is frequently recommended as a strategy for reducing the cost of LSLR (Betanzo, 2022). However, at least one study found that using asset management plans and CIPs as the only means for achieving LSLR goals can slow LSLR and draw out replacement timelines (Betanzo, 2024). Completing LSLR in tandem with other CIP projects can reduce the cost per LSLR but may draw out the timeline necessary to replace all LSLs because planning decisions are not driven solely based on the presence of LSLs. It is important to balance the priorities of reducing cost per infrastructure project with the public health benefits of removing LSLs as quickly as possible.

An additional consideration for co-locating LSLR with other essential infrastructure projects like sewer line replacement, stormwater management, and street renewal projects is that a management decision must be made to allocate costs to each project. This is an opportunity to improve transparency in project accounting and bidding. A lack of transparency can result in LSLR funds being diverted to co-located non-LSLR infrastructure projects that do not maximize LSLR with LSLR funding. Consolidating infrastructure projects has many benefits and should be accompanied by transparent accounting practices to ensure LSLR funds are preserved for completing LSLRs.

Engage Customers in LSLR Program Planning and Implement Proactive Customer Engagement and Outreach Strategies

Developing LSLR program plans in consultation with community members can identify effective strategies to reach impacted community members. The strategies that will be effective for a municipality or a community within a larger water system can vary greatly. This will be an important step in every community to design a program that meets the unique community needs. This is an important opportunity to engage with the impacted community to identify messages, methods, and approaches that will reach customers and break down any barriers to participation. Hiring trusted community members to perform the outreach may result in faster, more efficient access to customer homes to complete LSLRs. Although community planning and engagement processes present an upfront investment, this extra effort will likely pay dividends for increasing program participation. The Lead Service Line Replacement Collaborative has developed an Equity Toolkit (https://www.lslr-collaborative.org/equity-tools-and-data-sources.html) that describes several strategies and approaches for reaching impacted community members.

Fully Fund LSLR

Many communities have required homeowners to pay to replace the portion of an LSL that runs under private property, and some of those communities have funding assistance available for low-income residents to participate in FLSLR. Substantial paperwork may be required to access funding assistance, continuing to make these programs difficult to access even if assistance resources are available. Programs that require homeowners to pay for LSLR under private property establish a significant barrier to participation and completing LSLR goals. This drives up the cost of outreach as the water utility needs to convince each customer to pay for LSLR. A single block of replacements cannot be completed at once and work ends up scattered across the water utility through a series of expensive one-off replacements.

The increased one-on-one customer contact and unconsolidated replacements slow down the pace of LSLR, which increases the overall cost of LSLR for the entire community (Betanzo and Attal, 2022).

Rather than using LSLR funding to encourage homeowners to pay for replacing the portion of the LSL that runs under their property, the money could be used more directly for public health protection and achieving more LSLRs if the water utility uses funding to pay for FLSLR, including the portion of LSL that runs under private property. Steps that can be taken to fully fund LSLR include using (or where necessary seeking) authority to use water rate revenues for replacement under private property and maximizing use of external funding for replacement under private property.

Adopt Municipal Ordinances that Facilitate FLSLR

Ordinances that mandate participation and authorize access to private property

Newark, NJ and Benton Harbor, MI adopted LSLR mandates that required all building owners to get their LSLs replaced, and authorized the water system to conduct and pay for the full costs of LSLR if the building owners choose not complete LSLR themselves. These mandates reduced the number of residents that refused to participate or did not respond to contact by the water utility or its contractor to replace an LSL at a property. "The Newark City Council passed an ordinance that made it mandatory for property owners to sign up for the program and empowered the City to enter a property to replace an LSL even if the owner did not sign up for the program" (Rebovich, 2020). These ordinances are now options throughout New Jersey, and they greatly reduced the barriers to participation and reduced the costs for convincing building owners to participate. The participation mandates also make it possible for utilities to pursue legal avenues to ensure compliance (Beitsch, 2018).

The complimentary policies of mandating LSLR and providing funding for verification and replacement of all potential LSLs, including those on private property, allow and encourage all residents to readily participate in the program. Once the funding barrier is removed and the mandate for LSLR is established, the program can be further accelerated by an ordinance that authorizes access to private property. These ordinances and funding policies work together to reduce outreach and auxiliary costs for LSLR.

Additional ordinances that facilitate LSLR, and reduce barriers and costs include the following (Jersey Water Works, 2023):

- Requiring replacement upon sale of a property,
- Requiring disclosure of an LSL at the time of sale,
- Requiring replacement upon a new rental lease agreement or new certificate of occupancy,
- Requiring replacement for renewal of a business operating license, and
- Requiring all new plumbing permits to report existing material removed and new material installed.

Hybrid Inventory and LSLR Program

The LCRR and LCRI require development of an LSL Inventory to support an LSLR program. The inventory begins with a records review to understand changes in service line practices over time and to understand the current status of service line recordkeeping. This information is critical for quantifying overall LSLR needs, prioritizing neighborhoods for LSLR, and meeting regulatory requirements. When it comes down to excavating service lines to verify materials, most of the inventory steps duplicate LSLR costs: mobilization, heavy equipment, labor, household access, and record keeping. The initial inventory as required in the LCRR and LCRI provides an important foundation for an effective LSLR program. This initial inventory should be robust enough to identify the areas to work first to remove the most LSLs as soon as possible.

The proposed LCRI would require regular inventory updates and identifying all unknown service lines by the replacement date. However, rather than using limited LSLR funding to complete this inventory work in parallel with LSLR, developing a hybrid inventory/replacement program can reduce costs by digging once and replacing when LSLs are found. Identifying unknown service lines and updating inventories as a separate step from actually replacing LSLs can drive up the overall LSLR cost by duplicating tasks, diverting funding from achieving public health protection, and increasing the overall timeline for replacing all LSLs. Further, replacing LSLs at the time they are discovered via inventory excavation improves public health protection by preventing exposure to lead released from a disturbed LSL that remains in service. Benton Harbor, Michigan and Newark, New Jersey both used this approach. Benton Harbor was able to identify and replace all LSL and GRRs in its system of about 4,500 service lines in about one year (Betanzo *et al.*, 2023).

Consolidating inventory validation and updates with LSLR may add cost in the short term due to excavation of non-lead services that do not require replacement. For water utilities with minimal service line documentation, it may be necessary to excavate every service to verify its composition. Prioritizing simultaneous inventory verification and LSLR may reduce the duplicative cost of completing a standalone service line inventory while improving cost efficiencies and public health protection.

Consolidating Geographies for LSLR

Designing LSLR Programs at the neighborhood scale can bring down the cost of LSLR by consolidating work in a single area, completing more LSLRs and inventory excavations by the same crews on the same workdays.

- This approach ensures economies of scale, especially in comparison to programs where LSLs are replaced as one-off projects, jumping around to different locations where residents identified an LSL for replacement.
- Visiting every known and unknown service line in a neighborhood during a defined project schedule period reduces the cost of multiple mobilizations for a single project area and facilitates the hybrid inventory/replacement strategy.
- Completing all the work at one time reduces the cost of multiple paving projects and provides the opportunity for a full street paving project, if appropriate based on the number of LSLRs and quantity of pavement disturbed, after all service lines are replaced or verified non-lead on a given street.

Betanzo and Attal (2022) estimated that DC Water could save $29 million by consolidating LSLRs at the neighborhood scale. Geographically consolidated LSLR programs can include LSLR associated with Capital Improvement Projects (CIP), typically water main replacement projects, or LSLR within a defined geographic area.

In addition to reducing construction costs, consolidating work in a geographic area also helps reduce outreach and communications costs. Consolidated, obvious construction activity can increase customer awareness because they see and experience evidence of the LSLR program daily while work is ongoing in the neighborhood. This improves the reach and timeliness of neighborhood visibility programs, such as yard signs and neighborhood meetings that might otherwise go unnoticed. With high neighborhood activity increasing conversations and awareness between community members, there may be a reduced need for outreach efforts aimed at convincing customers to participate in the LSLR program.

Grouping Related Replacement Programs and Matching with Appropriate Funding Sources

While the most cost effective LSLR programs will be through neighborhood scale projects, all water utilities have additional LSLR needs that will be completed efficiently at lower cost if a program is ready to meet those needs.

In addition to neighborhood scale CIP projects and consolidated LSLR projects, the two following needs are typically present:

Individual Replacement Program

There will always be a need for individual scale, high priority replacements for a variety of reasons including day care centers, homes where children with Elevated Blood Lead Levels (EBLLs) live, and emergency LSL repairs. There will always be a need to address these types of situations, so it is most efficient for a water utility to build the structure and process for these replacements up front to complete the work efficiently when needed, even though the cost per individual replacement will be greater than geographically consolidated programs. Anticipating this need and identifying appropriate funding sources will reduce the cost difference between the individual replacement program and the geographically consolidated program.

Resident Initiated LSLRs

Building and renovation is typically ongoing in most communities, and when new construction or remodeling happens at a property with an LSL, the builder or owner will want to address this during construction. It will be helpful for processes to be in place so these LSLRs can happen without delay and contribute to meeting the water utility's overall LSLR goals. By having a process in place for these the builder to complete the replacement, it will decrease the number of LSLRs the water utility needs to complete and decrease the overall cost of the LSLR program.

Revisit Paving Policies

Completing all the LSLRs on one street at the same time reduces the cost of multiple pavement patches and provides the opportunity for a full street paving project. Some municipalities have paving requirements, such as Washington, DC where the entire street must be repaved when four or more utility services are replaced (Betanzo and Attal, 2022). This particular policy did not consider the percentage of street disturbed or the length of the block. If Washington, DC was permitted to use the least cost method for every block of LSLRs, selecting between full street replacement and individual site restoration, they could save up to $148 million (Betanzo and Attal, 2022). One strategy for exploring LSLR paving policies to reduce the restoration cost of LSLR would be to evaluate the number of LSLRs per 100 ft of road that should trigger a full street replacement given typical LSL densities and community infrastructure needs.

Revisit Permitting Policies

Because of the repetitive nature of LSLR programs where the same contractor or staff members may be overseeing hundreds if not thousands of LSLRs, there are opportunities to bulk process permits or issue waivers in certain conditions, especially when projects are confined to the same geographic area or types of properties. This can reduce the impact of permit fees on overall LSLR program costs while still ensuring that all appropriate recordkeeping procedures are used. One example of this is Newark, NJ where a batch processing permit option was allowed (Jersey Water Works, 2023).

Another approach would be for the LSLR program to fund dedicated permit staff to ensure sustained and adequate staffing rather than be charged a fee per replacement. When small numbers of permits are processed a fee per permit makes sense, but at scale it may be more cost effective to fund dedicated staff.

Revisit Traffic Control Policies

While public and worker safety should be assured as a priority, there are opportunities to scale the requirements for maintenance of traffic according to the neighborhoods under construction at any given time to reduce the overall costs associated with traffic policies. It is important to review local policies to ensure that the traffic maintenance requirements are appropriate for the work environment. Urban streets will require more advanced measures, whereas residential streets require less intervention. Blanket requirements that do not consider site specific conditions are likely to drive up costs without increasing public health protection.

Contract and Bid Practices to Increase Transparency and Improve Contract Cost Controls

In Newark, to keep prices low, contracts were bid out every other day, by zone or area. This approach allowed each company to sharpen their pencil with each public bid opening, and the prices went down with each bid. Each of the bids was published for 20 days, allowing competing firms to know the prices they would have to beat to win the next contract (Kareem Adeem, Personal Communication, 11/12/21).

Contracting Strategies to Accelerate LSLR Programs

Newark's LSLR program changed considerably after one contractor originally had 9 months to replace 1,000 lines, but they ended up completing *all* lines in the contract in 180 days. This experience led Newark to give contractors requirements to complete 10, 15, or 25 services/day based on company size, not including test pits/potholing. Their timeline per thousand-line contract went from 9 months to 180 days to 120 days. At the peak of their replacement program, 120 LSLs were replaced each day across the city. (Kareem Adeem, Personal Communication, 11/12/21).

To ensure that all LSLs were replaced and there was no incentive to skip potential lead lines, Newark required all inventory potholing at the same time as LSLR. If no lead service line was found, contractors charged $0.01 or $1.00 for the pothole and moved on. If a replacement had to be done, the cost of potholing was rolled up into replacement and not charged as a separate line item. This created all the incentives to find and replace as many LSLs to maximize contractor pay. Newark also added to their contracts the right to terminate a contract for cause if a contractor did not meet their required number of LSLRs per day (Kareem Adeem, Personal Communication, 11/12/21).

Benton Harbor, MI included a $1,000 incentive for each day prior to the mandatory completion date that all contracted LSLs were removed, at a value up to $100,000 (City of Benton Harbor, 2021). This approach can be very effective, but it requires clear contract specifications that all contract requirements are met, and no shortcuts are taken. In this case, comprehensive contract enforcement and recordkeeping are essential if incentives are to be used.

Figure 17: LSLR Program Planning and Implementation Opportunities for Reducing Costs

LSLR Planning Costs	**Opportunities for Reducing Costs**
LSLR Program Planning and Design	Fully fund LSLR; Adopt municipal ordinances to support FLSLR; Revisit local policies
Community Engagement and Consultation	Engage customers in LSLR program planning and implement proactive customer engagement and outreach strategies
Contract Planning	Consolidate contracts by geography or replacement type; increase bid transparency; Completion incentives and termination conditions
Legal Review	Adopt municipal ordinances to support FLSLR
LSLR Public Education and Outreach Design	Consult with community to identify effective outreach strategies; Share information widely

LSLR Program Plan

Program Scale (Auxiliary) Costs
Project and/or Contract management
Engineering Services
Construction Management (e.g., Inspections)
Misc. Repairs (e.g., Water Main)
Support Software (Work order management, GIS)
Program Wide Outreach and Education

Construction Tasks	**Opportunities for Reducing Costs**
Mobilization	Geographic consolidation of projects; group as many replacements and inventory inspections together as possible
Permitting	Batch permit processing, LSLR funded dedicated permit staff
Inventory excavation	Verify all service line materials within a neighborhood while mobilized for LSLR in that location
Customer Outreach	Community engagement to design LSLR Outreach; Hire trusted community members
Replacement Construction	Revisit traffic control policies
Household flushing	
Restoration	Consolidate LSLRs; Revisit local paving policies
Completion services	
Demobilization	

Conclusions

Where present, LSLs are the largest source of lead in drinking water (Sandvig et al., 2008), and they provide a constant risk of exposure to lead even in water systems with corrosion control treatment (USEPA, 2023d). The USEPA's proposed LCRI requirement to remove all LSLs from water systems in the United States (USEPA, 2023d) is an important and effective intervention for reducing and preventing exposure to lead in drinking water.

The purpose of a comprehensive LSLR requirement is to protect public health. In considering LSLR costs, it is important to ensure that three fundamental principles underlie any LSLR program to ensure that it meets the intended purpose:

- Public health protection should be the guiding principle for every LSLR program. Work at every individual home must be conducted in a manner that protects residents and workers.
- LSLR programs must plan for the identification and removal of *all* potential lead and galvanized service lines. If service line material records are incomplete, this likely means every service line will need to be checked individually to verify material during the LSLR program.
- All LSLs should be replaced as quickly and efficiently as possible. The sooner every LSL is removed, the greater the public health benefits and a more equitable outcome is achieved for the entire community.

This report analyzed two different LSLR cost estimates, incorporated an additional literature review, and provided an independent LSLR construction cost estimate based on RS Means data, a widely used industry cost estimating dataset.

1. Overall, there is a large degree of consistency across the USEPA, literature, and independent RS Means construction cost estimates, as can be seen in Figure ES- 2 and Figure ES- 3. The CDM Smith cost estimates as published are higher than the other estimates presented here, but when the CDM Smith data are adjusted to avoid selective inclusion of projects and more accurately reflect fixed auxiliary costs they are also consistent with the other unit cost estimates presented here

2. The DWINSA analysis for the USEPA's LCRI proposal provided more information on inclusion and screening criteria for the DWINSA LSLR cost estimates. This dataset emphasizes the lower to mid-range of cost data that are found in the CDM Smith estimate and is consistent with our analysis of the published literature costs.

3. Our independent cost estimate shows that, in practice, most of the construction costs do not vary substantially. There is a small set of construction conditions that can drive up costs, but as reflected in the literature review cost estimates, these conditions are not experienced in the majority of replacements. Table 5 through Table 7 and Figure 7 through Figure 10 show the relative magnitude of line-item costs in different construction scenarios to assist decision makers in evaluating the reasonableness of LSLR bids for construction projects.

4. The analysis presented here demonstrates that LSLR costs have *not* skyrocketed since USEPA's cost estimates published with the Lead and Copper Rule Revisions in 2020 (USEPA, 2020). The LSLR cost increases documented here reflect nothing substantial beyond inflation.

5. The literature review and cost input tables demonstrate how program design decisions are critical drivers for LSLR costs. These costs are essential to an effective LSLR program, but the costs can have a large variation based on programmatic decisions, or conditions in the LSLR community. This study demonstrates the necessity for good planning and coordination to drive down costs at the unit scale.

6. Figure 16 and Appendix A identify the program decisions and cost inputs that should be considered in the design of an LSLR program. Municipalities and water system decision makers can use these tools to develop their own cost estimates for their specific communities, and they can use the construction cost inputs Table 5 through Table 7 and Figure 7 through Figure 10 to identify where bids are reasonable and where they are not.

7. A large unit cost difference multiplied across hundreds of LSLRs can add up quickly and can result in excessive overall project costs. Clarity in bid documents, scrutiny of bids, and making bids and final contracts publicly available can help build cost transparency and support better decision making.

8. A lack of transparency in bid documents, project reports, and financial accounting can result in LSLR funds being diverted to non-LSLR infrastructure projects that do not maximize LSLR with LSLR funding (e.g., paving, stormwater, sewer line replacement). There is a need for transparency and better data tracking of the different project cost components to ensure that only LSLR is being completed with funding intended for LSLR.

9. Completing LSLR in tandem with other CIP projects can reduce the cost per LSLR but may draw out the timeline necessary to replace all LSLs because planning decisions are not driven solely based on the presence of LSLs. It is important to balance the priorities of reducing cost per infrastructure project with the public health benefits of removing LSLs as quickly as possible.

10. Programs that require homeowners to pay for LSLR under private property slow progress and drive up the unit LSLR cost due to intense one-on-one outreach and one-off replacements being the primary type of LSLR. LSLR funding should be used to maximize the public health protection gained through LSLR.

11. Community members can also use the data presented here as a benchmark for evaluating the cost effectiveness of LSLR projects. They can compare local LSLR project costs to the cost estimates and literature review data presented here to make sure money is spent wisely and efficiently to get the most LSLs removed as quickly as possible to protect public health within their communities.

Finally, it is important to recognize that, as for all water infrastructure needs, LSLR costs will continue to change over time. This cost analysis provides a clear basis for understanding and estimating the current (2024) construction cost of LSLR, and it provides many strategies for controlling LSLR costs. Several water systems with planned LSLR programs, including Cincinnati and Denver found that as they grew and adapted their LSLR programs based on experience they were able to bring down the cost of LSLR over time even as some materials costs increased due to inflation (Moening, 2020; A. Woodrow, personal communication, March 8, 2022). Another example is Milwaukee, WI where they reported replacing 600 LSLs in 2017 at $13,100 each (Gonda, 2018) and a cumulative total of 1,893 replacements from 2017 through 2019 at $10,683 each (Dettmer and Beversdorf, 2019). This documented cost reduction over time further demonstrates the important role of LSLR program planning and adaptation in controlling the cost of LSLR programs and ensuring that LSLR spending results in the most LSLRs possible.

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Appendices

1. Appendix A: Program planning and design decisions that define LSLR program costs
2. Appendix B: Independent Cost Estimate
3. Appendix C: ENR Annual Construction Cost Indices

Appendix A: List of LSLR Planning and Design Decisions that Define LSLR Program Costs

LSLR Program Planning and Management Decisions

- Who will manage the program, staff or consultants?
- How many replacements will be completed each year?
- Do we have/Will we seek a LSLR mandate for our community?
- Will we cover the cost of replacement under private property for all or a subset of customers?
- What funding sources will we use for our LSLR program and what administrative staff do we need to support funding?
- How many different LSLR programs do we need? How many LSLs will be replaced in each?
    - Neighborhood scale
    - Associated with Water Main Replacement or other CIP projects
    - Individual/High priority
    - Customer initiated
- Using what methods and how often will we consult with community on development and progress for the LSLR program?
- What paperwork or documentation will we require from our customers for this program and how will we manage it? (agreements/waivers, financial qualifications for assistance, etc.)
- How will we do large scale community outreach for our LSLR program? How often, using what methods?
- What strategies will we use to reach and access every building that needs an LSLR?
- How many contracts, contract managers, and program managers do we need? How many FTE do we need to staff the program?
- Will we need to develop contractor capacity to meet our replacement goals?
- What software do we need to manage the program? Is this a new expense or can we use a tool we've already licensed?
- How will we capture, maintain, and share our service line inventory?

Construction/LSLR decisions/considerations

Local requirements (program and unit cost drivers)

- What permits are needed? Are there opportunities for bulk permits or waivers?
- Where will we need to plan for traffic control? What opportunities are there to modify requirements to optimize LSLR safely and efficiently?
- What erosion control or dewatering requirements must we comply with?
- What pavement restoration is required? Are there opportunities for modifying requirements to optimize LSLR?
- What lead disposal requirements must we comply with?

Property Scale Decisions (unit cost drivers)

- Will we expose every service to confirm material?
- Will contractor or staff be responsible for getting forms signed, scheduling appointments, and getting access to each building for replacement?
- Will we allow open cut methods? Can we require trenchless in all locations?
- Will we require copper pipe?
- Will we require replacement of curb stop at every property?
- Will we reuse corporation stops or require new ones?
- Do we want to coordinate the LSLR program with a meter replacement program?
- Who will complete flushing after LSLR, staff or contractor? Will we credit the cost of flushing from the resident's water bill?
- What filters will we provide after LSLR? Who will deliver them, staff or contractor?
- Who will conduct sampling after LSLR? Staff or contractor?
- Who will be in charge of record keeping, staff or contractor?

Restoration decisions (unit cost drivers)

- Will we use grass seed or sod for restoration?
- Will we complete exterior restoration under the same or a separate contract from LSLR?
- To what extent will we restore interior property (minimum = sealing wall or floor, and patching insulation)?
- Will pavement restoration happen through the same or a different contract?
- How many LSLRs on a block should be enough to trigger full street repaving?

Appendix B: Independent Cost Estimate Scenarios

Low Scenario, Short DD PE

Quantity	LineNumber	Description	Crew	Daily Output	Labor Hours	Unit	Material	Labor	Equipment	Total	Ext. Mat.	Ext. Labor	Ext. Equip.	Ext. Total	Mat. O&P	Labor O&P	Equip. O&P	Total O&P	Ext. Mat. O&P	Ext. Labor O&P	Ext. Equip. O&P	Ext. Total O&P	Grand Total
0.10	013113200100	Field personnel, field engineer, junior engineer		0	0	Week	$ -	$ 1,700.00	$ -	$ 1,700.00	$ -	$ 170.00	$ -	$ 170.00	$ -	$ -	$ -	$ 2,549.00	$ -	$ -	$ -	$ 254.90	$ 424.90
0.05	013113200200	Field personnel, project manager, average		0	0	Week	$ -	$ 2,500.00	$ -	$ 2,500.00	$ -	$ 125.00	$ -	$ 125.00	$ -	$ -	$ -	$ 3,749.00	$ -	$ -	$ -	$ 187.45	$ 312.45
1.00	312316130110	Excavating, trench or continuous footing, common earth, 3/4 C.Y. excavator, 4' to 6' deep, excavator, excludes sheeting or dewatering	B12F	300	0.053	B.C.Y.	$ -	$ 3.14	$ 2.96	$ 6.10	$ -	$ 3.14	$ 2.96	$ 6.10	$ -	$ 4.65	$ 3.26	$ 7.91	$ -	$ 4.65	$ 3.26	$ 7.91	$ 14.01
40.00	Derived elsewhere	Directional drilling, utility, <4" diameter				L.F.				$ 20.00				$ 800.00									$ 800.00
1.00	312323130100	Backfill, heavy soil, by hand, no compaction	1 Clab	11	0.727	L.C.Y.	$ -	$ 35.50	$ -	$ 35.50	$ -	$ 35.50	$ -	$ 35.50	$ -	$ 53.00	$ -	$ 53.00	$ -	$ 53.00	$ -	$ 53.00	$ 88.50
40.00	331413201120	Water supply distribution piping, polyethylene pipe, 160 psi, 1" diameter, C901, excludes excavation or backfill	Q1A	485	0.021	L.F.	$ 0.74	$ 1.55	$ -	$ 2.29	$ 29.60	$ 62.00	$ -	$ 91.60	$ 0.81	$ 2.30	$ -	$ 3.11	$ 32.40	$ 92.00	$ -	$ 124.40	$ 216.00
2.00	331413202240	Water supply distribution piping, fittings polyethylene insert type, nylon, cold water, clamp ring, stainless steel, 160 & 250 psi, 1" diameter, C901, excludes excavation or backfill	Q1A	321	0.031	Ea.	$ 3.82	$ 2.34	$ -	$ 6.16	$ 7.64	$ 4.68	$ -	$ 12.32	$ 4.20	$ 3.48	$ -	$ 7.68	$ 8.40	$ 6.96	$ -	$ 15.36	$ 27.68
1.00	331413457171	Water supply distribution piping, copper, curb stops, no lead, 1" diameter, excludes excavation or backfill	1 Plum	16	0.5	Ea.	$ 198.00	$ 37.50	$ -	$ 235.50	$ 198.00	$ 37.50	$ -	$ 235.50	$ 218.00	$ 55.50	$ -	$ 273.50	$ 218.00	$ 55.50	$ -	$ 273.50	$ 509.00
0.02	329223100020	Sodding, bluegrass sod, on level ground, 1" deep, 8 M.S.F.	B63	22	1.818	M.S.F.	$ 450.00	$ 94.00	$ 12.20	$ 556.20	$ 8.10	$ 1.69	$ 0.22	$ 10.01	$ 495.00	$ 139.00	$ 13.40	$ 647.40	$ 8.91	$ 2.50	$ 0.24	$ 11.65	$ 21.66
Grand Total														***$ 1,486.03***								***$ 928.17***	***$ 2,414.20***

Low Scenario, Short DD Cu

Quantity	LineNumber	Description	Crew	Daily Output	Labor Hours	Unit	Material	Labor	Equipment	Total	Ext. Mat.	Ext. Labor	Ext. Equip.	Ext. Total	Mat. O&P	Labor O&P	Equip. O&P	Total O&P	Ext. Mat. O&P	Ext. Labor O&P	Ext. Equip. O&P	Ext. Total O&P	Grand Total
0.10	013113200100	Field personnel, field engineer, junior engineer		0	0	Week	$ -	$ 1,700.00	$ -	$ 1,700.00	$ -	$ 170.00	$ -	$ 170.00	$ -	$ -	$ -	$ 2,549.00	$ -	$ -	$ -	$ 254.90	$ 424.90
0.05	013113200200	Field personnel, project manager, average		0	0	Week	$ -	$ 2,500.00	$ -	$ 2,500.00	$ -	$ 125.00	$ -	$ 125.00	$ -	$ -	$ -	$ 3,749.00	$ -	$ -	$ -	$ 187.45	$ 312.45
1.00	312316130110	Excavating, trench or continuous footing, common earth, 3/4 C.Y. excavator, 4' to 6' deep, excavator, excludes sheeting or dewatering	B12F	300	0.053	B.C.Y.	$ -	$ 3.14	$ 2.96	$ 6.10	$ -	$ 3.14	$ 2.96	$ 6.10	$ -	$ 4.65	$ 3.26	$ 7.91	$ -	$ 4.65	$ 3.26	$ 7.91	$ 14.01
40.00		Directional drilling, utility, <4" diameter				L.F.				$ 20.00				$ 800.00									$ 800.00
1.00	312323130100	Backfill, heavy soil, by hand, no compaction	1 Clab	11	0.727	L.C.Y.	$ -	$ 35.50	$ -	$ 35.50	$ -	$ 35.50	$ -	$ 35.50	$ -	$ 53.00	$ -	$ 53.00	$ -	$ 53.00	$ -	$ 53.00	$ 88.50
40.00	331413452200	Water supply distribution piping, copper tubing, 20' joints, 1" diameter, type K, excludes excavation or backfill	Q1	320	0.05	L.F.	$ 7.15	$ 3.36	$ -	$ 10.51	$ 286.00	$ 134.40	$ -	$ 420.40	$ 7.90	$ 5.00	$ -	$ 12.90	$ 316.00	$ 200.00	$ -	$ 516.00	$ 936.40
1.00	331413457171	Water supply distribution piping, copper, curb stops, no lead, 1" diameter, excludes excavation or backfill	1 Plum	16	0.5	Ea.	$ 198.00	$ 37.50	$ -	$ 235.50	$ 198.00	$ 37.50	$ -	$ 235.50	$ 218.00	$ 55.50	$ -	$ 273.50	$ 218.00	$ 55.50	$ -	$ 273.50	$ 509.00
2.00	221113250130	Elbow, 90 Deg., copper, wrought, copper x copper, 1"	1 Plum	16	0.5	Ea.	$ 13.45	$ 37.50	$ -	$ 50.95	$ 26.90	$ 75.00	$ -	$ 101.90	$ 14.80	$ 55.50	$ -	$ 70.30	$ 29.60	$ 111.00	$ -	$ 140.60	$ 242.50
0.02	329223100020	Sodding, bluegrass sod, on level ground, 1" deep, 8 M.S.F.	B63	22	1.818	M.S.F.	$ 450.00	$ 94.00	$ 12.20	$ 556.20	$ 8.10	$ 1.69	$ 0.22	$ 10.01	$ 495.00	$ 139.00	$ 13.40	$ 647.40	$ 8.91	$ 2.50	$ 0.24	$ 11.65	$ 21.66
Grand Total														***$ 1,904.41***								***$ 1,445.01***	***$ 3,349.42***

Low Scenario, Short Open PE

Quantity	LineNumber	Description	Crew	Daily Output	Labor Hours	Unit	Material	Labor	Equipment	Total	Ext. Mat.	Ext. Labor	Ext. Equip.	Ext. Total	Mat. O&P	Labor O&P	Equip. O&P	Total O&P	Ext. Mat. O&P	Ext. Labor O&P	Ext. Equip. O&P	Ext. Total O&P	Grand Total
0.10	013113200100	Field personnel, field engineer, junior engineer		0	0	Week	$ -	$ 1,700.00	$ -	$ 1,700.00	$ -	$ 170.00	$ -	$ 170.00	$ -	$ -	$ -	$ 2,549.00	$ -	$ -	$ -	$ 254.90	$ 424.90
0.05	013113200200	Field personnel, project manager, average		0	0	Week	$ -	$ 2,500.00	$ -	$ 2,500.00	$ -	$ 125.00	$ -	$ 125.00	$ -	$ -	$ -	$ 3,749.00	$ -	$ -	$ -	$ 187.45	$ 312.45
13.33	312316130110	Excavating, trench or continuous footing, common earth, 3/4 C.Y. excavator, 4' to 6' deep, excavator, excludes sheeting or dewatering	B12F	300	0.053	B.C.Y.	$ -	$ 3.14	$ 2.96	$ 6.10	$ -	$ 41.86	$ 39.46	$ 81.31	$ -	$ 4.65	$ 3.26	$ 7.91	$ -	$ 61.98	$ 43.46	$ 105.44	$ 186.75
13.33	312316133020	Excavating, trench backfill, 1 C.Y. bucket, minimal haul, front end loader, wheel mounted, excludes dewatering	B10R	400	0.03	L.C.Y.	$ -	$ 1.79	$ 0.92	$ 2.71	$ -	$ 23.86	$ 12.26	$ 36.12	$ -	$ 2.65	$ 1.01	$ 3.66	$ -	$ 35.32	$ 13.46	$ 48.79	$ 84.91
40.00	331413201120	Water supply distribution piping, polyethylene pipe, 160 psi, 1" diameter, C901, excludes excavation or backfill	Q1A	485	0.021	L.F.	$ 0.74	$ 1.55	$ -	$ 2.29	$ 29.60	$ 62.00	$ -	$ 91.60	$ 0.81	$ 2.30	$ -	$ 3.11	$ 32.40	$ 92.00	$ -	$ 124.40	$ 216.00
2.00	331413202240	Water supply distribution piping, fittings polyethylene insert type, nylon, cold water, clamp ring, stainless steel, 160 & 250 psi, 1" diameter, C901, excludes excavation or backfill	Q1A	321	0.031	Ea.	$ 3.82	$ 2.34	$ -	$ 6.16	$ 7.64	$ 4.68	$ -	$ 12.32	$ 4.20	$ 3.48	$ -	$ 7.68	$ 8.40	$ 6.96	$ -	$ 15.36	$ 27.68
1.00	331413457171	Water supply distribution piping, copper, curb stops, no lead, 1" diameter, excludes excavation or backfill	1 Plum	16	0.5	Ea.	$ 198.00	$ 37.50	$ -	$ 235.50	$ 198.00	$ 37.50	$ -	$ 235.50	$ 218.00	$ 55.50	$ -	$ 273.50	$ 218.00	$ 55.50	$ -	$ 273.50	$ 509.00
15.00	320610100310	Sidewalks, driveways, and patios, sidewalk, concrete, cast-in-place with 6 x 6 - W1.4 x W1.4 mesh, broomed finish, 3,000 psi, 4" thick, excludes base	B24	600	0.04	S.F.	$ 3.41	$ 2.22	$ -	$ 5.63	$ 51.15	$ 33.30	$ -	$ 84.45	$ 3.75	$ 3.27	$ -	$ 7.02	$ 56.25	$ 49.05	$ -	$ 105.30	$ 189.75
0.12	329223100020	Sodding, bluegrass sod, on level ground, 1" deep, 8 M.S.F.	B63	22	1.818	M.S.F.	$ 450.00	$ 94.00	$ 12.20	$ 556.20	$ 54.00	$ 11.28	$ 1.46	$ 66.74	$ 495.00	$ 139.00	$ 13.40	$ 647.40	$ 59.40	$ 16.68	$ 1.61	$ 77.69	$ 144.43
Grand Total														***$ 903.04***								***$ 1,192.83***	***$ 2,095.87***

Low Scenario, Short Open Cu

Quantity	LineNumber	Description	Crew	Daily Output	Labor Hours	Unit	Material	Labor	Equipment	Total	Ext. Mat.	Ext. Labor	Ext. Equip.	Ext. Total	Mat. O&P	Labor O&P	Equip. O&P	Total O&P	Ext. Mat. O&P	Ext. Labor O&P	Ext. Equip. O&P	Ext. Total O&P	Grand Total
0.10	013113200100	Field personnel, field engineer, junior engineer		0	0	Week	$ -	$ 1,700.00	$ -	$ 1,700.00	$ -	$ 170.00	$ -	$ 170.00	$ -	$ -	$ -	$ 2,549.00	$ -	$ -	$ -	$ 254.90	$ 424.90
0.05	013113200200	Field personnel, project manager, average		0	0	Week	$ -	$ 2,500.00	$ -	$ 2,500.00	$ -	$ 125.00	$ -	$ 125.00	$ -	$ -	$ -	$ 3,749.00	$ -	$ -	$ -	$ 187.45	$ 312.45
13.33	312316130110	Excavating, trench or continuous footing, common earth, 3/4 C.Y. excavator, 4' to 6' deep, excavator, excludes sheeting or dewatering	B12F	300	0.053	B.C.Y.	$ -	$ 3.14	$ 2.96	$ 6.10	$ -	$ 41.86	$ 39.46	$ 81.31	$ -	$ 4.65	$ 3.26	$ 7.91	$ -	$ 61.98	$ 43.46	$ 105.44	$ 186.75
13.33	312316133020	Excavating, trench backfill, 1 C.Y. bucket, minimal haul, front end loader, wheel mounted, excludes dewatering	B10R	400	0.03	L.C.Y.	$ -	$ 1.79	$ 0.92	$ 2.71	$ -	$ 23.86	$ 12.26	$ 36.12	$ -	$ 2.65	$ 1.01	$ 3.66	$ -	$ 35.32	$ 13.46	$ 48.79	$ 84.91
40.00	331413452200	Water supply distribution piping, copper tubing, 20' joints, 1" diameter, type K, excludes excavation or backfill	Q1	320	0.05	L.F.	$ 7.15	$ 3.36	$ -	$ 10.51	$ 286.00	$ 134.40	$ -	$ 420.40	$ 7.90	$ 5.00	$ -	$ 12.90	$ 316.00	$ 200.00	$ -	$ 516.00	$ 936.40
1.00	331413457171	Water supply distribution piping, copper, curb stops, no lead, 1" diameter, excludes excavation or backfill	1 Plum	16	0.5	Ea.	$ 198.00	$ 37.50	$ -	$ 235.50	$ 198.00	$ 37.50	$ -	$ 235.50	$ 218.00	$ 55.50	$ -	$ 273.50	$ 218.00	$ 55.50	$ -	$ 273.50	$ 509.00
2.00	221113250130	Elbow, 90 Deg., copper, wrought, copper x copper, 1"	1 Plum	16	0.5	Ea.	$ 13.45	$ 37.50	$ -	$ 50.95	$ 26.90	$ 75.00	$ -	$ 101.90	$ 14.80	$ 55.50	$ -	$ 70.30	$ 29.60	$ 111.00	$ -	$ 140.60	$ 242.50
15.00	320610100310	Sidewalks, driveways, and patios, sidewalk, concrete, cast-in-place with 6 x 6 - W1.4 x W1.4 mesh, broomed finish, 3,000 psi, 4" thick, excludes base	B24	600	0.04	S.F.	$ 3.41	$ 2.22	$ -	$ 5.63	$ 51.15	$ 33.30	$ -	$ 84.45	$ 3.75	$ 3.27	$ -	$ 7.02	$ 56.25	$ 49.05	$ -	$ 105.30	$ 189.75
0.12	329223100020	Sodding, bluegrass sod, on level ground, 1" deep, 8 M.S.F.	B63	22	1.818	M.S.F.	$ 450.00	$ 94.00	$ 12.20	$ 556.20	$ 54.00	$ 11.28	$ 1.46	$ 66.74	$ 495.00	$ 139.00	$ 13.40	$ 647.40	$ 59.40	$ 16.68	$ 1.61	$ 77.69	$ 144.43
Grand Total														***$ 1,321.42***								***$ 1,709.67***	***$ 3,031.09***

Low Scenario, Long DD PE

Quantity	LineNumber	Description	Crew	Daily Output	Labor Hours	Unit	Material	Labor	Equipment	Total	Ext. Mat.	Ext. Labor	Ext. Equip.	Ext. Total	Mat. O&P	Labor O&P	Equip. O&P	Total O&P	Ext. Mat. O&P	Ext. Labor O&P	Ext. Equip. O&P	Ext. Total O&P	Grand Total
0.10	013113200100	Field personnel, field engineer, junior engineer		0	0	Week	$ -	$ 1,700.00	$ -	$ 1,700.00	$ -	$ 170.00	$ -	$ 170.00	$ -	$ -	$ -	$ 2,549.00	$ -	$ -	$ -	$ 254.90	$ 424.90
0.05	013113200200	Field personnel, project manager, average		0	0	Week	$ -	$ 2,500.00	$ -	$ 2,500.00	$ -	$ 125.00	$ -	$ 125.00	$ -	$ -	$ -	$ 3,749.00	$ -	$ -	$ -	$ 187.45	$ 312.45
1.00	312316130110	Excavating, trench or continuous footing, common earth, 3/4 C.Y. excavator, 4' to 6' deep, excavator, excludes sheeting or dewatering	B12F	300	0.053	B.C.Y.	$ -	$ 3.14	$ 2.96	$ 6.10	$ -	$ 3.14	$ 2.96	$ 6.10	$ -	$ 4.65	$ 3.26	$ 7.91	$ -	$ 4.65	$ 3.26	$ 7.91	$ 14.01
71.00		Directional drilling, utility, <4" diameter				L.F.				$ 20.00				$ 1,420.00									$ 1,420.00
1.00	312323130100	Backfill, heavy soil, by hand, no compaction	1 Clab	11	0.727	L.C.Y.	$ -	$ 35.50	$ -	$ 35.50	$ -	$ 35.50	$ -	$ 35.50	$ -	$ 53.00	$ -	$ 53.00	$ -	$ 53.00	$ -	$ 53.00	$ 88.50
71.00	331413201120	Water supply distribution piping, polyethylene pipe, 160 psi, 1" diameter, C901, excludes excavation or backfill	Q1A	485	0.021	L.F.	$ 0.74	$ 1.55	$ -	$ 2.29	$ 52.54	$ 110.05	$ -	$ 162.59	$ 0.81	$ 2.30	$ -	$ 3.11	$ 57.51	$ 163.30	$ -	$ 220.81	$ 383.40
2.00	331413202240	Water supply distribution piping, fittings polyethylene insert type, nylon, cold water, clamp ring, stainless steel, 160 & 250 psi, 1" diameter, C901, excludes excavation or backfill	Q1A	321	0.031	Ea.	$ 3.82	$ 2.34	$ -	$ 6.16	$ 7.64	$ 4.68	$ -	$ 12.32	$ 4.20	$ 3.48	$ -	$ 7.68	$ 8.40	$ 6.96	$ -	$ 15.36	$ 27.68
1.00	331413457171	Water supply distribution piping, copper, curb stops, no lead, 1" diameter, excludes excavation or backfill	1 Plum	16	0.5	Ea.	$ 198.00	$ 37.50	$ -	$ 235.50	$ 198.00	$ 37.50	$ -	$ 235.50	$ 218.00	$ 55.50	$ -	$ 273.50	$ 218.00	$ 55.50	$ -	$ 273.50	$ 509.00
0.07	329223100020	Sodding, bluegrass sod, on level ground, 1" deep, 8 M.S.F.	B63	22	1.818	M.S.F.	$ 450.00	$ 94.00	$ 12.20	$ 556.20	$ 32.40	$ 6.77	$ 0.88	$ 40.05	$ 495.00	$ 139.00	$ 13.40	$ 647.40	$ 35.64	$ 10.01	$ 0.96	$ 46.61	$ 86.66
Construction Cost														***$ 2,207.06***								***$ 1,059.54***	***$ 3,266.60***

Low Scenario, Long DD Cu

Quantity	LineNumber	Description	Crew	Daily Output	Labor Hours	Unit	Material	Labor	Equipment	Total	Ext. Mat.	Ext. Labor	Ext. Equip.	Ext. Total	Mat. O&P	Labor O&P	Equip. O&P	Total O&P	Ext. Mat. O&P	Ext. Labor O&P	Ext. Equip. O&P	Ext. Total O&P	Grand Total
0.10	013113200100	Field personnel, field engineer, junior engineer		0	0	Week	$ -	$ 1,700.00	$ -	$ 1,700.00	$ -	$ 170.00	$ -	$ 170.00	$ -	$ -	$ -	$ 2,549.00	$ -	$ -	$ -	$ 254.90	$ 424.90
0.05	013113200200	Field personnel, project manager, average		0	0	Week	$ -	$ 2,500.00	$ -	$ 2,500.00	$ -	$ 125.00	$ -	$ 125.00	$ -	$ -	$ -	$ 3,749.00	$ -	$ -	$ -	$ 187.45	$ 312.45
1.00	312316130110	Excavating, trench or continuous footing, common earth, 3/4 C.Y. excavator, 4' to 6' deep, excavator, excludes sheeting or dewatering	B12F	300	0.053	B.C.Y.	$ -	$ 3.14	$ 2.96	$ 6.10	$ -	$ 3.14	$ 2.96	$ 6.10	$ -	$ 4.65	$ 3.26	$ 7.91	$ -	$ 4.65	$ 3.26	$ 7.91	$ 14.01
71.00		Directional drilling, utility, <4" diameter				L.F.				$ 20.00				$ 1,420.00									$ 1,420.00
1.00	312323130100	Backfill, heavy soil, by hand, no compaction	1 Clab	11	0.727	L.C.Y.	$ -	$ 35.50	$ -	$ 35.50	$ -	$ 35.50	$ -	$ 35.50	$ -	$ 53.00	$ -	$ 53.00	$ -	$ 53.00	$ -	$ 53.00	$ 88.50
71.00	331413452200	Water supply distribution piping, copper tubing, 20' joints, 1" diameter, type K, excludes excavation or backfill	Q1	320	0.05	L.F.	$ 7.15	$ 3.36	$ -	$ 10.51	$ 507.65	$ 238.56	$ -	$ 746.21	$ 7.90	$ 5.00	$ -	$ 12.90	$ 560.90	$ 355.00	$ -	$ 915.90	$ 1,662.11
1.00	331413457171	Water supply distribution piping, copper, curb stops, no lead, 1" diameter, excludes excavation or backfill	1 Plum	16	0.5	Ea.	$ 198.00	$ 37.50	$ -	$ 235.50	$ 198.00	$ 37.50	$ -	$ 235.50	$ 218.00	$ 55.50	$ -	$ 273.50	$ 218.00	$ 55.50	$ -	$ 273.50	$ 509.00
2.00	221113250130	Elbow, 90 Deg., copper, wrought, copper x copper, 1"	1 Plum	16	0.5	Ea.	$ 13.45	$ 37.50	$ -	$ 50.95	$ 26.90	$ 75.00	$ -	$ 101.90	$ 14.80	$ 55.50	$ -	$ 70.30	$ 29.60	$ 111.00	$ -	$ 140.60	$ 242.50
0.02	329223100020	Sodding, bluegrass sod, on level ground, 1" deep, 8 M.S.F.	B63	22	1.818	M.S.F.	$ 450.00	$ 94.00	$ 12.20	$ 556.20	$ 8.10	$ 1.69	$ 0.22	$ 10.01	$ 495.00	$ 139.00	$ 13.40	$ 647.40	$ 8.91	$ 2.50	$ 0.24	$ 11.65	$ 21.66
Grand Total														***$ 2,850.22***								***$ 1,844.91***	***$ 4,695.13***

Low Scenario, Long Open PE

Quantity	LineNumber	Description	Crew	Daily Output	Labor Hours	Unit	Material	Labor	Equipment	Total	Ext. Mat.	Ext. Labor	Ext. Equip.	Ext. Total	Mat. O&P	Labor O&P	Equip. O&P	Total O&P	Ext. Mat. O&P	Ext. Labor O&P	Ext. Equip. O&P	Ext. Total O&P	Grand Total
0.10	013113200100	Field personnel, field engineer, junior engineer		0	0	Week	$ -	$ 1,700.00	$ -	$ 1,700.00	$ -	$ 170.00	$ -	$ 170.00	$ -	$ -	$ -	$ 2,549.00	$ -	$ -	$ -	$ 254.90	$ 424.90
0.05	013113200200	Field personnel, project manager, average		0	0	Week	$ -	$ 2,500.00	$ -	$ 2,500.00	$ -	$ 125.00	$ -	$ 125.00	$ -	$ -	$ -	$ 3,749.00	$ -	$ -	$ -	$ 187.45	$ 312.45
23.67	312316130110	Excavating, trench or continuous footing, common earth, 3/4 C.Y. excavator, 4' to 6' deep, excavator, excludes sheeting or dewatering	B12F	300	0.053	B.C.Y.	$ -	$ 3.14	$ 2.96	$ 6.10	$ -	$ 74.32	$ 70.06	$ 144.39	$ -	$ 4.65	$ 3.26	$ 7.91	$ -	$ 110.07	$ 77.16	$ 187.23	$ 331.62
23.67	312316133020	Excavating, trench backfill, 1 C.Y. bucket, minimal haul, front end loader, wheel mounted, excludes dewatering	B10R	400	0.03	L.C.Y.	$ -	$ 1.79	$ 0.92	$ 2.71	$ -	$ 42.37	$ 21.78	$ 64.15	$ -	$ 2.65	$ 1.01	$ 3.66	$ -	$ 62.73	$ 23.91	$ 86.63	$ 150.78
2.05	312323200024	Cycle hauling(wait, load, travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 10 min wait/load/unload, 8 C.Y. truck, cycle 8 miles, 15 MPH, excludes loading equipment	B34A	88	0.091	L.C.Y.	$ -	$ 5.20	$ 5.75	$ 10.95	$ -	$ 10.66	$ 11.79	$ 22.45	$ -	$ 7.75	$ 6.35	$ 14.10	$ -	$ 15.89	$ 13.02	$ 28.91	$ 51.36
71.00	331413201120	Water supply distribution piping, polyethylene pipe, 160 psi, 1" diameter, C901, excludes excavation or backfill	Q1A	485	0.021	L.F.	$ 0.74	$ 1.55	$ -	$ 2.29	$ 52.54	$ 110.05	$ -	$ 162.59	$ 0.81	$ 2.30	$ -	$ 3.11	$ 57.51	$ 163.30	$ -	$ 220.81	$ 383.40
2.00	331413202240	Water supply distribution piping, fittings polyethylene insert type, nylon, cold water, clamp ring, stainless steel, 160 & 250 psi, 1" diameter, C901, excludes excavation or backfill	Q1A	321	0.031	Ea.	$ 3.82	$ 2.34	$ -	$ 6.16	$ 7.64	$ 4.68	$ -	$ 12.32	$ 4.20	$ 3.48	$ -	$ 7.68	$ 8.40	$ 6.96	$ -	$ 15.36	$ 27.68
1.00	331413457171	Water supply distribution piping, copper, curb stops, no lead, 1" diameter, excludes excavation or backfill	1 Plum	16	0.5	Ea.	$ 198.00	$ 37.50	$ -	$ 235.50	$ 198.00	$ 37.50	$ -	$ 235.50	$ 218.00	$ 55.50	$ -	$ 273.50	$ 218.00	$ 55.50	$ -	$ 273.50	$ 509.00
9.33	024113175050	Demolish, remove pavement & curb, remove bituminous pavement, 4" to 6" thick, excludes hauling and disposal fees	B38	420	0.095	S.Y.	$ -	$ 5.25	$ 3.41	$ 8.66	$ -	$ 48.98	$ 31.82	$ 80.80	$ -	$ 7.80	$ 3.75	$ 11.55	$ -	$ 72.77	$ 34.99	$ 107.76	$ 188.56
9.33	321216131050	Plant-mix asphalt paving, for highways and large paved areas, pavement replacement over trench, 4" thick, no hauling included	B17C	70	0.686	S.Y.	$ 18.00	$ 37.00	$ 37.50	$ 92.50	$ 167.94	$ 345.21	$ 349.88	$ 863.03	$ 19.80	$ 55.00	$ 41.00	$ 115.80	$ 184.73	$ 513.15	$ 382.53	$ 1,080.41	$ 1,943.44
15.00	320610100310	Sidewalks, driveways, and patios, sidewalk, concrete, cast-in-place with 6 x 6 - W1.4 x W1.4 mesh, broomed finish, 3,000 psi, 4" thick, excludes base	B24	600	0.04	S.F.	$ 3.41	$ 2.22	$ -	$ 5.63	$ 51.15	$ 33.30	$ -	$ 84.45	$ 3.75	$ 3.27	$ -	$ 7.02	$ 56.25	$ 49.05	$ -	$ 105.30	$ 189.75
3.00	321613130404	Cast-in place concrete curbs & gutters, concrete, wood forms, straight, 6" x 18", includes concrete	C2A	500	0.096	L.F.	$ 10.25	$ 5.60	$ -	$ 15.85	$ 30.75	$ 16.80	$ -	$ 47.55	$ 11.25	$ 8.25	$ -	$ 19.50	$ 33.75	$ 24.75	$ -	$ 58.50	$ 106.05
0.13	329223100020	Sodding, bluegrass sod, on level ground, 1" deep, 8 M.S.F.	B63	22	1.818	M.S.F.	$ 450.00	$ 94.00	$ 12.20	$ 556.20	$ 58.05	$ 12.13	$ 1.57	$ 71.75	$ 495.00	$ 139.00	$ 13.40	$ 647.40	$ 63.86	$ 17.93	$ 1.73	$ 83.51	$ 155.26
Construction Cost														***$ 2,083.98***								***$ 2,690.27***	***$ 4,774.25***

Low Scenario, Long Open Cu

Quantity	LineNumber	Description	Crew	Daily Output	Labor Hours	Unit	Material	Labor	Equipment	Total	Ext. Mat.	Ext. Labor	Ext. Equip.	Ext. Total	Mat. O&P	Labor O&P	Equip. O&P	Total O&P	Ext. Mat. O&P	Ext. Labor O&P	Ext. Equip. O&P	Ext. Total O&P	Grand Total
0.10	013113200100	Field personnel, field engineer, junior engineer		0	0	Week	$ -	$ 1,700.00	$ -	$ 1,700.00	$ -	$ 170.00	$ -	$ 170.00	$ -	$ -	$ -	$ 2,549.00	$ -	$ -	$ -	$ 254.90	$ 424.90
0.05	013113200200	Field personnel, project manager, average		0	0	Week	$ -	$ 2,500.00	$ -	$ 2,500.00	$ -	$ 125.00	$ -	$ 125.00	$ -	$ -	$ -	$ 3,749.00	$ -	$ -	$ -	$ 187.45	$ 312.45
23.67	312316130110	Excavating, trench or continuous footing, common earth, 3/4 C.Y. excavator, 4' to 6' deep, excavator, excludes sheeting or dewatering	B12F	300	0.053	B.C.Y.	$ -	$ 3.14	$ 2.96	$ 6.10	$ -	$ 74.32	$ 70.06	$ 144.39	$ -	$ 4.65	$ 3.26	$ 7.91	$ -	$ 110.07	$ 77.16	$ 187.23	$ 331.62
23.67	312316133020	Excavating, trench backfill, 1 C.Y. bucket, minimal haul, front end loader, wheel mounted, excludes dewatering	B10R	400	0.03	L.C.Y.	$ -	$ 1.79	$ 0.92	$ 2.71	$ -	$ 42.37	$ 21.78	$ 64.15	$ -	$ 2.65	$ 1.01	$ 3.66	$ -	$ 62.73	$ 23.91	$ 86.63	$ 150.78
2.05	312323200024	Cycle hauling(wait, load, travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 10 min wait/load/unload, 8 C.Y. truck, cycle 8 miles, 15 MPH, excludes loading equipment	B34A	88	0.091	L.C.Y.	$ -	$ 5.20	$ 5.75	$ 10.95	$ -	$ 10.66	$ 11.79	$ 22.45	$ -	$ 7.75	$ 6.35	$ 14.10	$ -	$ 15.89	$ 13.02	$ 28.91	$ 51.36
71.00	331413452200	Water supply distribution piping, copper tubing, 20' joints, 1" diameter, type K, excludes excavation or backfill	Q1	320	0.05	L.F.	$ 7.15	$ 3.36	$ -	$ 10.51	$ 507.65	$ 238.56	$ -	$ 746.21	$ 7.90	$ 5.00	$ -	$ 12.90	$ 560.90	$ 355.00	$ -	$ 915.90	$ 1,662.11
1.00	331413457171	Water supply distribution piping, copper, curb stops, no lead, 1" diameter, excludes excavation or backfill	1 Plum	16	0.5	Ea.	$ 198.00	$ 37.50	$ -	$ 235.50	$ 198.00	$ 37.50	$ -	$ 235.50	$ 218.00	$ 55.50	$ -	$ 273.50	$ 218.00	$ 55.50	$ -	$ 273.50	$ 509.00
2.00	221113250130	Elbow, 90 Deg., copper, wrought, copper x copper, 1"	1 Plum	16	0.5	Ea.	$ 13.45	$ 37.50	$ -	$ 50.95	$ 26.90	$ 75.00	$ -	$ 101.90	$ 14.80	$ 55.50	$ -	$ 70.30	$ 29.60	$ 111.00	$ -	$ 140.60	$ 242.50
9.33	024113175050	Demolish, remove pavement & curb, remove bituminous pavement, 4" to 6" thick, excludes hauling and disposal fees	B38	420	0.095	S.Y.	$ -	$ 5.25	$ 3.41	$ 8.66	$ -	$ 48.98	$ 31.82	$ 80.80	$ -	$ 7.80	$ 3.75	$ 11.55	$ -	$ 72.77	$ 34.99	$ 107.76	$ 188.56
9.33	321216131050	Plant-mix asphalt paving, for highways and large paved areas, pavement replacement over trench, 4" thick, no hauling included	B17C	70	0.686	S.Y.	$ 18.00	$ 37.00	$ 37.50	$ 92.50	$ 167.94	$ 345.21	$ 349.88	$ 863.03	$ 19.80	$ 55.00	$ 41.00	$ 115.80	$ 184.73	$ 513.15	$ 382.53	$ 1,080.41	$ 1,943.44
15.00	320610100310	Sidewalks, driveways, and patios, sidewalk, concrete, cast-in-place with 6 x 6 - W1.4 x W1.4 mesh, broomed finish, 3,000 psi, 4" thick, excludes base	B24	600	0.04	S.F.	$ 3.41	$ 2.22	$ -	$ 5.63	$ 51.15	$ 33.30	$ -	$ 84.45	$ 3.75	$ 3.27	$ -	$ 7.02	$ 56.25	$ 49.05	$ -	$ 105.30	$ 189.75
3.00	321613130404	Cast-in place concrete curbs & gutters, concrete, wood forms, straight, 6" x 18", includes concrete	C2A	500	0.096	L.F.	$ 10.25	$ 5.60	$ -	$ 15.85	$ 30.75	$ 16.80	$ -	$ 47.55	$ 11.25	$ 8.25	$ -	$ 19.50	$ 33.75	$ 24.75	$ -	$ 58.50	$ 106.05
0.13	329223100020	Sodding, bluegrass sod, on level ground, 1" deep, 8 M.S.F.	B63	22	1.818	M.S.F.	$ 450.00	$ 94.00	$ 12.20	$ 556.20	$ 58.05	$ 12.13	$ 1.57	$ 71.75	$ 495.00	$ 139.00	$ 13.40	$ 647.40	$ 63.86	$ 17.93	$ 1.73	$ 83.51	$ 155.26
Construction Cost														***$ 2,757.18***								***$ 3,510.60***	***$ 6,267.78***

Medium Scenario, Open Cu

Quantity	LineNumber	Description	Crew	Daily Output	Labor Hours	Unit	Material	Labor	Equipment	Total	Ext. Mat.	Ext. Labor	Ext. Equip.	Ext. Total	Mat. O&P	Labor O&P	Equip. O&P	Total O&P	Ext. Mat. O&P	Ext. Labor O&P	Ext. Equip. O&P	Ext. Total O&P	Grand Total
0.10	013113200100	Field personnel, field engineer, junior engineer		0	0	Week	$ -	$ 1,700.00	$ -	$ 1,700.00	$ -	$ 170.00	$ -	$ 170.00	$ -	$ -	$ -	$ 2,549.00	$ -	$ -	$ -	$ 254.90	$ 424.90
0.05	013113200200	Field personnel, project manager, average		0	0	Week	$ -	$ 2,500.00	$ -	$ 2,500.00	$ -	$ 125.00	$ -	$ 125.00	$ -	$ -	$ -	$ 3,749.00	$ -	$ -	$ -	$ 187.45	$ 312.45
94.67	312316130110	Excavating, trench or continuous footing, common earth, 3/4 C.Y. excavator, 4' to 6' deep, excavator, excludes sheeting or dewatering	B12F	300	0.053	B.C.Y.	$ -	$ 3.14	$ 2.96	$ 6.10	$ -	$ 297.26	$ 280.22	$ 577.49	$ -	$ 4.65	$ 3.26	$ 7.91	$ -	$ 440.22	$ 308.62	$ 748.84	$ 1,326.33
94.67	312316133020	Excavating, trench backfill, 1 C.Y. bucket, minimal haul, front end loader, wheel mounted, excludes dewatering	B10R	400	0.03	L.C.Y.	$ -	$ 1.79	$ 0.92	$ 2.71	$ -	$ 169.46	$ 87.10	$ 256.56	$ -	$ 2.65	$ 1.01	$ 3.66	$ -	$ 250.88	$ 95.62	$ 346.49	$ 603.05
4.11	312323200024	Cycle hauling(wait, load, travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 10 min wait/load/unload, 8 C.Y. truck, cycle 8 miles, 15 MPH, excludes loading equipment	B34A	88	0.091	L.C.Y.	$ -	$ 5.20	$ 5.75	$ 10.95	$ -	$ 21.37	$ 23.63	$ 45.00	$ -	$ 7.75	$ 6.35	$ 14.10	$ -	$ 31.85	$ 26.10	$ 57.95	$ 102.95
71.00	331413452200	Water supply distribution piping, copper tubing, 20' joints, 1" diameter, type K, excludes excavation or backfill	Q1	320	0.05	L.F.	$ 7.15	$ 3.36	$ -	$ 10.51	$ 507.65	$ 238.56	$ -	$ 746.21	$ 7.90	$ 5.00	$ -	$ 12.90	$ 560.90	$ 355.00	$ -	$ 915.90	$ 1,662.11
1.00	331413457166	Water supply distribution piping, fittings, brass, corporation stops, no lead, 1" diameter, excludes excavation or backfill	1 Plum	16	0.5	Ea.	$ 123.00	$ 37.50	$ -	$ 160.50	$ 123.00	$ 37.50	$ -	$ 160.50	$ 135.00	$ 55.50	$ -	$ 190.50	$ 135.00	$ 55.50	$ -	$ 190.50	$ 351.00
1.00	331413457171	Water supply distribution piping, copper, curb stops, no lead, 1" diameter, excludes excavation or backfill	1 Plum	16	0.5	Ea.	$ 198.00	$ 37.50	$ -	$ 235.50	$ 198.00	$ 37.50	$ -	$ 235.50	$ 218.00	$ 55.50	$ -	$ 273.50	$ 218.00	$ 55.50	$ -	$ 273.50	$ 509.00
2.00	221113250130	Elbow, 90 Deg., copper, wrought, copper x copper, 1"	1 Plum	16	0.5	Ea.	$ 13.45	$ 37.50	$ -	$ 50.95	$ 26.90	$ 75.00	$ -	$ 101.90	$ 14.80	$ 55.50	$ -	$ 70.30	$ 29.60	$ 111.00	$ -	$ 140.60	$ 242.50
18.67	024113175050	Demolish, remove pavement & curb, remove bituminous pavement, 4" to 6" thick, excludes hauling and disposal fees	B38	420	0.095	S.Y.	$ -	$ 5.25	$ 3.41	$ 8.66	$ -	$ 98.02	$ 63.66	$ 161.68	$ -	$ 7.80	$ 3.75	$ 11.55	$ -	$ 145.63	$ 70.01	$ 215.64	$ 377.32
18.67	321216131050	Plant-mix asphalt paving, for highways and large paved areas, pavement replacement over trench, 4" thick, no hauling included	B17C	70	0.686	S.Y.	$ 18.00	$ 37.00	$ 37.50	$ 92.50	$ 336.06	$ 690.79	$ 700.13	$ 1,726.98	$ 19.80	$ 55.00	$ 41.00	$ 115.80	$ 369.67	$ 1,026.85	$ 765.47	$ 2,161.99	$ 3,888.97
30.00	320610100310	Sidewalks, driveways, and patios, sidewalk, concrete, cast-in-place with 6 x 6 - W1.4 x W1.4 mesh, broomed finish, 3,000 psi, 4" thick, excludes base	B24	600	0.04	S.F.	$ 3.41	$ 2.22	$ -	$ 5.63	$ 102.30	$ 66.60	$ -	$ 168.90	$ 3.75	$ 3.27	$ -	$ 7.02	$ 112.50	$ 98.10	$ -	$ 210.60	$ 379.50
6.00	321613130404	Cast-in place concrete curbs & gutters, concrete, wood forms, straight, 6" x 18", includes concrete	C2A	500	0.096	L.F.	$ 10.25	$ 5.60	$ -	$ 15.85	$ 61.50	$ 33.60	$ -	$ 95.10	$ 11.25	$ 8.25	$ -	$ 19.50	$ 67.50	$ 49.50	$ -	$ 117.00	$ 212.10
0.26	329223100020	Sodding, bluegrass sod, on level ground, 1" deep, 8 M.S.F.	B63	22	1.818	M.S.F.	$ 450.00	$ 94.00	$ 12.20	$ 556.20	$ 116.10	$ 24.25	$ 3.15	$ 143.50	$ 495.00	$ 139.00	$ 13.40	$ 647.40	$ 127.71	$ 35.86	$ 3.46	$ 167.03	$ 310.53
Construction Cost														***$ 4,714.32***								***$ 5,988.39***	***$ 10,702.71***

High Scenario, Open Cu

Quantity	LineNumber	Description	Crew	Daily Output	Labor Hours	Unit	Material	Labor	Equipment	Total	Ext. Mat.	Ext. Labor	Ext. Equip.	Ext. Total	Mat. O&P	Labor O&P	Equip. O&P	Total O&P	Ext. Mat. O&P	Ext. Labor O&P	Ext. Equip. O&P	Ext. Total O&P	Grand Total
0.20	013113200100	Field personnel, field engineer, junior engineer		0	0	Week	$ -	$ 1,700.00	$ -	$ 1,700.00	$ -	$ 340.00	$ -	$ 340.00	$ -	$ -	$ -	$ 2,549.00	$ -	$ -	$ -	$ 509.80	$ 849.80
0.10	013113200200	Field personnel, project manager, average		0	0	Week	$ -	$ 2,500.00	$ -	$ 2,500.00	$ -	$ 250.00	$ -	$ 250.00	$ -	$ -	$ -	$ 3,749.00	$ -	$ -	$ -	$ 374.90	$ 624.90
94.67	312316130110	Excavating, trench or continuous footing, common earth, 3/4 C.Y. excavator, 4' to 6' deep, excavator, excludes sheeting or dewatering	B12F	300	0.053	B.C.Y.	$ -	$ 3.14	$ 2.96	$ 6.10	$ -	$ 297.26	$ 280.22	$ 577.49	$ -	$ 4.65	$ 3.26	$ 7.91	$ -	$ 440.22	$ 308.62	$ 748.84	$ 1,326.33
94.67	312316133020	Excavating, trench backfill, 1 C.Y. bucket, minimal haul, front end loader, wheel mounted, excludes dewatering	B10R	400	0.03	L.C.Y.	$ -	$ 1.79	$ 0.92	$ 2.71	$ -	$ 169.46	$ 87.10	$ 256.56	$ -	$ 2.65	$ 1.01	$ 3.66	$ -	$ 250.88	$ 95.62	$ 346.49	$ 603.05
94.67	312323154000	Borrow, common earth, 1 C.Y. bucket, loading and/or spreading, shovel	B12N	840	0.019	B.C.Y.	$ 22.00	$ 1.12	$ 1.69	$ 24.81	$ 2,082.74	$ 106.03	$ 159.99	$ 2,348.76	$ 24.50	$ 1.66	$ 1.86	$ 28.02	$ 2,319.42	$ 157.15	$ 176.09	$ 2,652.65	$ 5,001.41
141.89	312323200024	Cycle hauling(wait, load, travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 10 min wait/load/unload, 8 C.Y. truck, cycle 8 miles, 15 MPH, excludes loading equipment	B34A	88	0.091	L.C.Y.	$ -	$ 5.20	$ 5.75	$ 10.95	$ -	$ 737.83	$ 815.87	$ 1,553.70	$ -	$ 7.75	$ 6.35	$ 14.10	$ -	$ 1,099.65	$ 901.00	$ 2,000.65	$ 3,554.35
71.00	331413452200	Water supply distribution piping, copper tubing, 20' joints, 1" diameter, type K, excludes excavation or backfill	Q1	320	0.05	L.F.	$ 7.15	$ 3.36	$ -	$ 10.51	$ 507.65	$ 238.56	$ -	$ 746.21	$ 7.90	$ 5.00	$ -	$ 12.90	$ 560.90	$ 355.00	$ -	$ 915.90	$ 1,662.11
1.00	331413457166	Water supply distribution piping, fittings, brass, corporation stops, no lead, 1" diameter, excludes excavation or backfill	1 Plum	16	0.5	Ea.	$ 123.00	$ 37.50	$ -	$ 160.50	$ 123.00	$ 37.50	$ -	$ 160.50	$ 135.00	$ 55.50	$ -	$ 190.50	$ 135.00	$ 55.50	$ -	$ 190.50	$ 351.00
1.00	331413457171	Water supply distribution piping, copper, curb stops, no lead, 1" diameter, excludes excavation or backfill	1 Plum	16	0.5	Ea.	$ 198.00	$ 37.50	$ -	$ 235.50	$ 198.00	$ 37.50	$ -	$ 235.50	$ 218.00	$ 55.50	$ -	$ 273.50	$ 218.00	$ 55.50	$ -	$ 273.50	$ 509.00
2.00	221113250130	Elbow, 90 Deg., copper, wrought, copper x copper, 1"	1 Plum	16	0.5	Ea.	$ 13.45	$ 37.50	$ -	$ 50.95	$ 26.90	$ 75.00	$ -	$ 101.90	$ 14.80	$ 55.50	$ -	$ 70.30	$ 29.60	$ 111.00	$ -	$ 140.60	$ 242.50
18.67	024113175050	Demolish, remove pavement & curb, remove bituminous pavement, 4" to 6" thick, excludes hauling and disposal fees	B38	420	0.095	S.Y.	$ -	$ 5.25	$ 3.41	$ 8.66	$ -	$ 98.02	$ 63.66	$ 161.68	$ -	$ 7.80	$ 3.75	$ 11.55	$ -	$ 145.63	$ 70.01	$ 215.64	$ 377.32
410.67	321216130080	Plant-mix asphalt paving, for highways and large paved areas, binder course, 1-1/2" thick, no hauling included	B25	7725	0.011	S.Y.	$ 6.60	$ 0.61	$ 0.42	$ 7.63	$ 2,710.42	$ 250.51	$ 172.48	$ 3,133.41	$ 7.30	$ 0.90	$ 0.46	$ 8.66	$ 2,997.89	$ 369.60	$ 188.91	$ 3,556.40	$ 6,689.81
30.00	320610100310	Sidewalks, driveways, and patios, sidewalk, concrete, cast-in-place with 6 x 6 - W1.4 x W1.4 mesh, broomed finish, 3,000 psi, 4" thick, excludes base	B24	600	0.04	S.F.	$ 3.41	$ 2.22	$ -	$ 5.63	$ 102.30	$ 66.60	$ -	$ 168.90	$ 3.75	$ 3.27	$ -	$ 7.02	$ 112.50	$ 98.10	$ -	$ 210.60	$ 379.50
264.00	321613130404	Cast-in place concrete curbs & gutters, concrete, wood forms, straight, 6" x 18", includes concrete	C2A	500	0.096	L.F.	$ 10.25	$ 5.60	$ -	$ 15.85	$ 2,706.00	$ 1,478.40	$ -	$ 4,184.40	$ 11.25	$ 8.25	$ -	$ 19.50	$ 2,970.00	$ 2,178.00	$ -	$ 5,148.00	$ 9,332.40
1.00	221119382100	Water supply meter, domestic/commercial, bronze, threaded, to 50 GPM, 1" diameter	1 Plum	12	0.667	Ea.	$ 700.00	$ 50.00	$ -	$ 750.00	$ 700.00	$ 50.00	$ -	$ 750.00	$ 770.00	$ 74.00	$ -	$ 844.00	$ 770.00	$ 74.00	$ -	$ 844.00	$ 1,594.00
0.26	329223100020	Sodding, bluegrass sod, on level ground, 1" deep, 8 M.S.F.	B63	22	1.818	M.S.F.	$ 450.00	$ 94.00	$ 12.20	$ 556.20	$ 116.10	$ 24.25	$ 3.15	$ 143.50	$ 495.00	$ 139.00	$ 13.40	$ 647.40	$ 127.71	$ 35.86	$ 3.46	$ 167.03	$ 310.53
Construction Cost														***$ 15,112.51***								***$ 18,295.50***	***$ 33,408.01***

Customer Side, DD PE

Quantity	LineNumber	Description	Crew	Daily Output	Labor Hours	Unit	Material	Labor	Equipment	Total	Ext. Mat.	Ext. Labor	Ext. Equip.	Ext. Total	Mat. O&P	Labor O&P	Equip. O&P	Total O&P	Ext. Mat. O&P	Ext. Labor O&P	Ext. Equip. O&P	Ext. Total O&P	Grand Total
0.10	013113200100	Field personnel, field engineer, junior engineer		0	0	Week	$ -	$ 1,700.00	$ -	$ 1,700.00	$ -	$ 170.00	$ -	$ 170.00	$ -	$ -	$ -	$ 2,549.00	$ -	$ -	$ -	$ 254.90	$ 424.90
0.05	013113200200	Field personnel, project manager, average		0	0	Week	$ -	$ 2,500.00	$ -	$ 2,500.00	$ -	$ 125.00	$ -	$ 125.00	$ -	$ -	$ -	$ 3,749.00	$ -	$ -	$ -	$ 187.45	$ 312.45
1.00	312316130110	Excavating, trench or continuous footing, common earth, 3/4 C.Y. excavator, 4' to 6' deep, excavator, excludes sheeting or dewatering	B12F	300	0.053	B.C.Y.	$ -	$ 3.14	$ 2.96	$ 6.10	$ -	$ 3.14	$ 2.96	$ 6.10	$ -	$ 4.65	$ 3.26	$ 7.91	$ -	$ 4.65	$ 3.26	$ 7.91	$ 14.01
30.00	Derived elsewhere	Directional drilling, utility, <4" diameter				L.F.				$ 20.00				$ 600.00									$ 600.00
1.00	312323130100	Backfill, heavy soil, by hand, no compaction	1 Clab	11	0.727	L.C.Y.	$ -	$ 35.50	$ -	$ 35.50	$ -	$ 35.50	$ -	$ 35.50	$ -	$ 53.00	$ -	$ 53.00	$ -	$ 53.00	$ -	$ 53.00	$ 88.50
30.00	331413201120	Water supply distribution piping, polyethylene pipe, 160 psi, 1" diameter, C901, excludes excavation or backfill	Q1A	485	0.021	L.F.	$ 0.74	$ 1.55	$ -	$ 2.29	$ 22.20	$ 46.50	$ -	$ 68.70	$ 0.81	$ 2.30	$ -	$ 3.11	$ 24.30	$ 69.00	$ -	$ 93.30	$ 162.00
2.00	331413202240	Water supply distribution piping, fittings polyethylene insert type, nylon, cold water, clamp ring, stainless steel, 160 & 250 psi, 1" diameter, C901, excludes excavation or backfill	Q1A	321	0.031	Ea.	$ 3.82	$ 2.34	$ -	$ 6.16	$ 7.64	$ 4.68	$ -	$ 12.32	$ 4.20	$ 3.48	$ -	$ 7.68	$ 8.40	$ 6.96	$ -	$ 15.36	$ 27.68
1.00	331413457171	Water supply distribution piping, copper, curb stops, no lead, 1" diameter, excludes excavation or backfill	1 Plum	16	0.5	Ea.	$ 198.00	$ 37.50	$ -	$ 235.50	$ 198.00	$ 37.50	$ -	$ 235.50	$ 218.00	$ 55.50	$ -	$ 273.50	$ 218.00	$ 55.50	$ -	$ 273.50	$ 509.00
0.02	329223100020	Sodding, bluegrass sod, on level ground, 1" deep, 8 M.S.F.	B63	22	1.818	M.S.F.	$ 450.00	$ 94.00	$ 12.20	$ 556.20	$ 8.10	$ 1.69	$ 0.22	$ 10.01	$ 495.00	$ 139.00	$ 13.40	$ 647.40	$ 8.91	$ 2.50	$ 0.24	$ 11.65	$ 21.66
Grand Total														***$ 1,263.13***								***$ 897.07***	***$ 2,160.20***

Customer Side, DD Cu

Quantity	LineNumber	Description	Crew	Daily Output	Labor Hours	Unit	Material	Labor	Equipment	Total	Ext. Mat.	Ext. Labor	Ext. Equip.	Ext. Total	Mat. O&P	Labor O&P	Equip. O&P	Total O&P	Ext. Mat. O&P	Ext. Labor O&P	Ext. Equip. O&P	Ext. Total O&P	Grand Total
0.10	013113200100	Field personnel, field engineer, junior engineer		0	0	Week	$ -	$ 1,700.00	$ -	$ 1,700.00	$ -	$ 170.00	$ -	$ 170.00	$ -	$ -	$ -	$ 2,549.00	$ -	$ -	$ -	$ 254.90	$ 424.90
0.05	013113200200	Field personnel, project manager, average		0	0	Week	$ -	$ 2,500.00	$ -	$ 2,500.00	$ -	$ 125.00	$ -	$ 125.00	$ -	$ -	$ -	$ 3,749.00	$ -	$ -	$ -	$ 187.45	$ 312.45
1.00	312316130110	Excavating, trench or continuous footing, common earth, 3/4 C.Y. excavator, 4' to 6' deep, excavator, excludes sheeting or dewatering	B12F	300	0.053	B.C.Y.	$ -	$ 3.14	$ 2.96	$ 6.10	$ -	$ 3.14	$ 2.96	$ 6.10	$ -	$ 4.65	$ 3.26	$ 7.91	$ -	$ 4.65	$ 3.26	$ 7.91	$ 14.01
30.00		Directional drilling, utility, <4" diameter				L.F.				$ 20.00				$ 600.00									$ 600.00
1.00	312323130100	Backfill, heavy soil, by hand, no compaction	1 Clab	11	0.727	L.C.Y.	$ -	$ 35.50	$ -	$ 35.50	$ -	$ 35.50	$ -	$ 35.50	$ -	$ 53.00	$ -	$ 53.00	$ -	$ 53.00	$ -	$ 53.00	$ 88.50
30.00	331413452200	Water supply distribution piping, copper tubing, 20' joints, 1" diameter, type K, excludes excavation or backfill	Q1	320	0.05	L.F.	$ 7.15	$ 3.36	$ -	$ 10.51	$ 214.50	$ 100.80	$ -	$ 315.30	$ 7.90	$ 5.00	$ -	$ 12.90	$ 237.00	$ 150.00	$ -	$ 387.00	$ 702.30
1.00	331413457171	Water supply distribution piping, copper, curb stops, no lead, 1" diameter, excludes excavation or backfill	1 Plum	16	0.5	Ea.	$ 198.00	$ 37.50	$ -	$ 235.50	$ 198.00	$ 37.50	$ -	$ 235.50	$ 218.00	$ 55.50	$ -	$ 273.50	$ 218.00	$ 55.50	$ -	$ 273.50	$ 509.00
2.00	221113250130	Elbow, 90 Deg., copper, wrought, copper x copper, 1"	1 Plum	16	0.5	Ea.	$ 13.45	$ 37.50	$ -	$ 50.95	$ 26.90	$ 75.00	$ -	$ 101.90	$ 14.80	$ 55.50	$ -	$ 70.30	$ 29.60	$ 111.00	$ -	$ 140.60	$ 242.50
0.02	329223100020	Sodding, bluegrass sod, on level ground, 1" deep, 8 M.S.F.	B63	22	1.818	M.S.F.	$ 450.00	$ 94.00	$ 12.20	$ 556.20	$ 8.10	$ 1.69	$ 0.22	$ 10.01	$ 495.00	$ 139.00	$ 13.40	$ 647.40	$ 8.91	$ 2.50	$ 0.24	$ 11.65	$ 21.66
Grand Total														***$ 1,599.31***								***$ 1,316.01***	***$ 2,915.32***

Customer Side, Open PE

Quantity	LineNumber	Description	Crew	Daily Output	Labor Hours	Unit	Material	Labor	Equipment	Total	Ext. Mat.	Ext. Labor	Ext. Equip.	Ext. Total	Mat. O&P	Labor O&P	Equip. O&P	Total O&P	Ext. Mat. O&P	Ext. Labor O&P	Ext. Equip. O&P	Ext. Total O&P	Grand Total
0.10	013113200100	Field personnel, field engineer, junior engineer		0	0	Week	$ -	$ 1,700.00	$ -	$ 1,700.00	$ -	$ 170.00	$ -	$ 170.00	$ -	$ -	$ -	$ 2,549.00	$ -	$ -	$ -	$ 254.90	$ 424.90
0.05	013113200200	Field personnel, project manager, average		0	0	Week	$ -	$ 2,500.00	$ -	$ 2,500.00	$ -	$ 125.00	$ -	$ 125.00	$ -	$ -	$ -	$ 3,749.00	$ -	$ -	$ -	$ 187.45	$ 312.45
10.00	312316130110	Excavating, trench or continuous footing, common earth, 3/4 C.Y. excavator, 4' to 6' deep, excavator, excludes sheeting or dewatering	B12F	300	0.053	B.C.Y.	$ -	$ 3.14	$ 2.96	$ 6.10	$ -	$ 31.40	$ 29.60	$ 61.00	$ -	$ 4.65	$ 3.26	$ 7.91	$ -	$ 46.50	$ 32.60	$ 79.10	$ 140.10
10.00	312316133020	Excavating, trench backfill, 1 C.Y. bucket, minimal haul, front end loader, wheel mounted, excludes dewatering	B10R	400	0.03	L.C.Y.	$ -	$ 1.79	$ 0.92	$ 2.71	$ -	$ 17.90	$ 9.20	$ 27.10	$ -	$ 2.65	$ 1.01	$ 3.66	$ -	$ 26.50	$ 10.10	$ 36.60	$ 63.70
30.00	331413201120	Water supply distribution piping, polyethylene pipe, 160 psi, 1" diameter, C901, excludes excavation or backfill	Q1A	485	0.021	L.F.	$ 0.74	$ 1.55	$ -	$ 2.29	$ 22.20	$ 46.50	$ -	$ 68.70	$ 0.81	$ 2.30	$ -	$ 3.11	$ 24.30	$ 69.00	$ -	$ 93.30	$ 162.00
2.00	331413202240	Water supply distribution piping, fittings polyethylene insert type, nylon, cold water, clamp ring, stainless steel, 160 & 250 psi, 1" diameter, C901, excludes excavation or backfill	Q1A	321	0.031	Ea.	$ 3.82	$ 2.34	$ -	$ 6.16	$ 7.64	$ 4.68	$ -	$ 12.32	$ 4.20	$ 3.48	$ -	$ 7.68	$ 8.40	$ 6.96	$ -	$ 15.36	$ 27.68
1.00	331413457171	Water supply distribution piping, copper, curb stops, no lead, 1" diameter, excludes excavation or backfill	1 Plum	16	0.5	Ea.	$ 198.00	$ 37.50	$ -	$ 235.50	$ 198.00	$ 37.50	$ -	$ 235.50	$ 218.00	$ 55.50	$ -	$ 273.50	$ 218.00	$ 55.50	$ -	$ 273.50	$ 509.00
0.09	329223100020	Sodding, bluegrass sod, on level ground, 1" deep, 8 M.S.F.	B63	22	1.818	M.S.F.	$ 450.00	$ 94.00	$ 12.20	$ 556.20	$ 40.50	$ 8.46	$ 1.10	$ 50.06	$ 495.00	$ 139.00	$ 13.40	$ 647.40	$ 44.55	$ 12.51	$ 1.21	$ 58.27	$ 108.33
Grand Total														***$ 749.68***								***$ 998.48***	***$ 1,748.16***

Customer Side, Open Cu

Quantity	LineNumber	Description	Crew	Daily Output	Labor Hours	Unit	Material	Labor	Equipment	Total	Ext. Mat.	Ext. Labor	Ext. Equip.	Ext. Total	Mat. O&P	Labor O&P	Equip. O&P	Total O&P	Ext. Mat. O&P	Ext. Labor O&P	Ext. Equip. O&P	Ext. Total O&P	Grand Total
0.10	013113200100	Field personnel, field engineer, junior engineer		0	0	Week	$ -	$ 1,700.00	$ -	$ 1,700.00	$ -	$ 170.00	$ -	$ 170.00	$ -	$ -	$ -	$ 2,549.00	$ -	$ -	$ -	$ 254.90	$ 424.90
0.05	013113200200	Field personnel, project manager, average		0	0	Week	$ -	$ 2,500.00	$ -	$ 2,500.00	$ -	$ 125.00	$ -	$ 125.00	$ -	$ -	$ -	$ 3,749.00	$ -	$ -	$ -	$ 187.45	$ 312.45
10.00	312316130110	Excavating, trench or continuous footing, common earth, 3/4 C.Y. excavator, 4' to 6' deep, excavator, excludes sheeting or dewatering	B12F	300	0.053	B.C.Y.	$ -	$ 3.14	$ 2.96	$ 6.10	$ -	$ 31.40	$ 29.60	$ 61.00	$ -	$ 4.65	$ 3.26	$ 7.91	$ -	$ 46.50	$ 32.60	$ 79.10	$ 140.10
10.00	312316133020	Excavating, trench backfill, 1 C.Y. bucket, minimal haul, front end loader, wheel mounted, excludes dewatering	B10R	400	0.03	L.C.Y.	$ -	$ 1.79	$ 0.92	$ 2.71	$ -	$ 17.90	$ 9.20	$ 27.10	$ -	$ 2.65	$ 1.01	$ 3.66	$ -	$ 26.50	$ 10.10	$ 36.60	$ 63.70
30.00	331413452200	Water supply distribution piping, copper tubing, 20' joints, 1" diameter, type K, excludes excavation or backfill	Q1	320	0.05	L.F.	$ 7.15	$ 3.36	$ -	$ 10.51	$ 214.50	$ 100.80	$ -	$ 315.30	$ 7.90	$ 5.00	$ -	$ 12.90	$ 237.00	$ 150.00	$ -	$ 387.00	$ 702.30
1.00	331413457171	Water supply distribution piping, copper, curb stops, no lead, 1" diameter, excludes excavation or backfill	1 Plum	16	0.5	Ea.	$ 198.00	$ 37.50	$ -	$ 235.50	$ 198.00	$ 37.50	$ -	$ 235.50	$ 218.00	$ 55.50	$ -	$ 273.50	$ 218.00	$ 55.50	$ -	$ 273.50	$ 509.00
2.00	221113250130	Elbow, 90 Deg., copper, wrought, copper x copper, 1"	1 Plum	16	0.5	Ea.	$ 13.45	$ 37.50	$ -	$ 50.95	$ 26.90	$ 75.00	$ -	$ 101.90	$ 14.80	$ 55.50	$ -	$ 70.30	$ 29.60	$ 111.00	$ -	$ 140.60	$ 242.50
0.09	329223100020	Sodding, bluegrass sod, on level ground, 1" deep, 8 M.S.F.	B63	22	1.818	M.S.F.	$ 450.00	$ 94.00	$ 12.20	$ 556.20	$ 40.50	$ 8.46	$ 1.10	$ 50.06	$ 495.00	$ 139.00	$ 13.40	$ 647.40	$ 44.55	$ 12.51	$ 1.21	$ 58.27	$ 108.33
Grand Total														***$ 1,085.86***								***$ 1,417.42***	***$ 2,503.28***

Appendix C: ENR Annual Construction Cost Indices

Sources:

- All annual index values shown below are published at: https://www.enr.com/economics/historical_indices/construction_cost_index_history
- All annual index values shown below, from 1999 through 2022, are also included in the LCRI docket in a spreadsheet supporting the LCRI Economic Analysis, which is titled "LSLR Unit Cost Analysis," https://www.regulations.gov/document/EPA-HQ-OW-2022-0801-0521.

Year	Cost Index
2023	13358.05
2022	13006.84
2021	12133
2020	11465.67
2019	11281
2018	11062
2017	10737
2016	10338
2015	10035
2014	9806
2013	9547
2012	9308
2011	9070
2010	8799
2009	8570
2008	8310
2007	7966
2006	7751
2005	7446
2004	7115
2003	6694
2002	6538
2001	6343
2000	6221
1999	6059