Life Cycle Cost Benefit Analysis of the Utilidor Method and Traditional Method for Worth Street (Focusing on Direct Cost)

Final Report

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1 Executive Summary

This report presents a life cycle cost-benefit analysis comparing the Utilidor method and the traditional trenching method for utility infrastructure along Worth Street in New York City, focusing specifically on direct costs. The project examines Worth Street, from Hudson Street to Park Row, as a case study to highlight the significant financial, operational, and long-term implications of utilizing these two approaches.

The traditional method of utility installation, characterized by direct subsurface burial and repeated street cuts, has led to inefficient and unsustainable conditions commonly referred to as the "spaghetti subsurface problem." This approach imposes high long-term costs due to frequent road resurfacing, utility trenching, and associated debt services, with the total estimated cost over 100 years being approximately $1.07 billion. These costs are further exacerbated by recurring disruptions to traffic, environmental impacts, and the inability to conduct routine maintenance without extensive excavation.

Figure 1: Photo Showing Traditional Method by Richard Levine/Corbis via Getty Images

In contrast, the Utilidor method, which involves placing utility lines within a dedicated underground tunnel, offers a comprehensive solution to the challenges posed by the traditional approach. While the initial capital investment for the Utilidor method is significantly higher—estimated at two to three times the cost of traditional trenching—

the long-term benefits, including reduced maintenance and operational expenses, demonstrate substantial cost savings over the infrastructure's life cycle. The total estimated direct cost for the Utilidor method ranges from $470 million to $705 million, depending on varying cost scenarios.

The analysis shows that the Utilidor method minimizes the need for future excavations, extends the roadway design life, and improves asset conditions. The break-even analysis indicates that even under conservative estimates, the Utilidor approach results in significantly lower direct costs over the long term compared to the traditional trenching method. Specifically, compared to the Utilidor approach, the traditional approach costs 2.27 times as much in the 2X initial cost scenario and 1.51 times as much in the 3X initial cost scenario.

This study concludes that despite the higher initial costs, the Utilidor method provides a more sustainable and financially sound solution for managing urban utility infrastructure. It offers direct cost savings, operational efficiencies, and enhanced long-term resilience, making it a compelling alternative to the traditional approach. For New York City, implementing the Utilidor system alongside regular roadway reconstruction could transform its utility management practices, reduce overall infrastructure costs, and contribute to the city's vision of becoming a smarter, more resilient urban environment.

2 Introduction

2.1 Background and Context

Worth Street, located in the heart of Lower Manhattan, is a critical corridor supporting various commercial, residential, and governmental activities. This street, stretching from Hudson Street to Park Row, faces challenges due to the frequent need for utility maintenance and upgrades beneath its surface. Historically, the traditional trenching method has been used to install and maintain utility lines, involving direct subsurface burial and repeated street cuts. This method has resulted in the so-called "spaghetti subsurface problem," characterized by a complex web of uncoordinated and overlapping utility lines, frequent excavations, and significant surface disruptions.

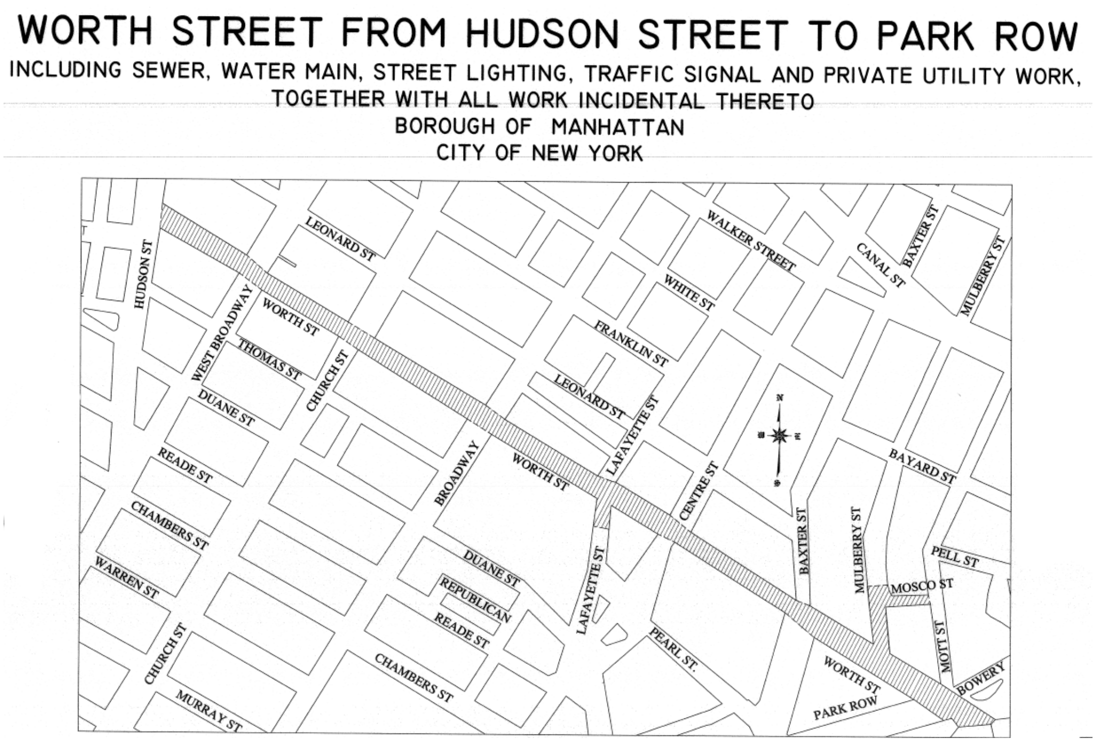

Figure 2: The road map of the project area

The traditional method's impact extends beyond the visible surface disturbances; it includes substantial direct costs related to repeated road resurfacing, trenching, and utility line maintenance. These issues are further compounded by the need for constant repairs, traffic disruptions, and the challenges associated with managing aging and corroding underground infrastructure.

In contrast, the Utilidor method, which involves the installation of utility lines within a dedicated underground tunnel, offers a transformative approach. This method addresses the inefficiencies of traditional subsurface utility management by organizing utilities within a protected environment that allows for easy access, routine maintenance, and technological integration, such as remote monitoring. Despite its higher initial capital investment, the Utilidor method has the potential to significantly reduce direct costs over the long term and improve urban infrastructure management.

2.2 Objectives of the Study

The primary objective of this study is to conduct a life cycle cost-benefit analysis focusing on the direct costs associated with the Utilidor and traditional trenching methods for Worth Street. The analysis aims to:

1. Compare the direct capital, maintenance, and operational costs of the Utilidor method against the traditional trenching method.
2. Evaluate the long-term financial impacts of both methods to determine which approach offers greater cost efficiency and sustainability.
3. Highlight the potential operational and maintenance advantages of the Utilidor method, such as reduced need for future excavations and enhanced asset management capabilities.

This study will focus on direct costs, excluding broader social and environmental costs, to provide a clear financial comparison between the two methods. The findings will inform recommendations for future utility infrastructure planning in New York City, emphasizing the importance of adopting innovative solutions like the Utilidor method to improve urban resilience and efficiency.

3 Methodology

3.1 Data Collection

The data for this study was collected from various sources, including historical records of utility street cuts, financial data from relevant city departments, and projections based on existing cost estimates. Specific data points were derived from:

- **Street Excavation Permits:** A comprehensive analysis of street excavation permits issued between 1991 and 2024 was conducted, focusing on the frequency and nature of cuts along Worth Street. This data provided a baseline for estimating the costs of the traditional trenching method.
- **Cost Estimates from Contracts and City Records:** Public and private capital costs, including road resurfacing and trenching expenses, were gathered from existing contracts and New York City Department of Transportation (NYC DOT) records. Future value projections were calculated to assess costs in 2024 dollars, allowing for an accurate comparison of long-term financial impacts.
- **Utilidor Cost Projections:** Utilidor cost data was estimated based on industry standards and past implementations of similar projects in urban settings. These estimates were adjusted to reflect two scenarios: 2X and 3X the initial cost compared to traditional methods, as suggested in related studies and practical implementations.

3.2 Cost Calculation Approaches

A detailed financial modeling approach was employed to compare the direct costs of the Utilidor with those of traditional methods. This approach focused on capital costs, debt service, maintenance, and operational costs over a projected 100-year period.

Present Value Calculations: Future value costs were discounted to present value (PV) using a standard discount rate of 4%, as commonly applied in infrastructure cost analysis. This approach allowed for a direct comparison of costs incurred at different times, ensuring a consistent basis for evaluation.

Capital and Debt Service Costs:

- For the traditional trenching method, public and private capital costs were calculated separately, including the cost of road resurfacing and ongoing utility trenching. Debt service calculations incorporated the interest rates and repayment schedules typical for municipal and private infrastructure projects.
- For the Utilidor method, costs were estimated based on initial capital investment, projected debt service, and post-construction operation and maintenance expenses. Scenarios were developed assuming that the initial cost would be either double or triple that of traditional trenching to account for variations in construction complexity.

Operational and Maintenance Costs:

- The maintenance costs for the traditional method included routine resurfacing and unplanned trenching, which were projected based on historical street cut data. The average cost per foot for utility cuts was adjusted for inflation, with an 8% increase every ten years, reflecting past trends.
- Based on industry standards and existing literature, post-construction operation and maintenance costs were assumed to be 10% of the original construction costs for the Utilidor method. These costs were projected over 100 years to capture long-term financial implications.

Sensitivity Analysis:

Sensitivity analyses were conducted to test how variations in key assumptions—such as the discount rate, trenching cost growth, and maintenance frequency—affected the overall cost comparison. These analyses were crucial in identifying the range of potential outcomes and validating the robustness of the results.

Break-Even Analysis:

A break-even analysis was performed to determine the cost multiplier at which the Utilidor method's total direct costs would equal those of the traditional trenching method. This analysis provided critical insights into the economic feasibility of the Utilidor approach under varying financial conditions.

3.3 Assumptions and Limitations

The study assumes that the Utilidor method will not encounter unforeseen technical challenges that could significantly increase costs beyond the 2X and 3X estimations. Social and environmental costs, such as traffic delays and carbon emissions, were not included in the financial analysis, focusing solely on direct cost implications. All projections are based on historical data and industry-standard growth rates; however, unexpected economic factors could alter future cost trajectories.

4 Traditional Method Analysis

4.1 Capital and Debt Service Costs

The traditional trenching method involves the direct burial of utility lines beneath the street surface, requiring repeated excavations for installation, maintenance, and repairs. This method incurs significant capital and debt service costs due to its fragmented and reactive approach to infrastructure management.

- **Public Capital Costs:** The public sector is responsible for a significant portion of the initial construction costs associated with trenching. The analysis indicates public capital costs amounting to approximately $31.5 million in future value terms by 2024.
- **Private Capital Costs:** Private utilities such as electricity, gas, and telecommunications companies bear a substantial share of the costs for installing and maintaining their respective utility lines. The total private capital costs are estimated at around $60 million in future value terms by 2024.
- **Total Capital Costs:** Combining public and private investments, the total capital expenditure for the traditional method is projected to reach approximately $91.5 million (future value by 2024).
- **Debt Service:** The debt service associated with the original construction costs is considerable. The total debt service payments, which include interest and principal repayment over time, amount to approximately $177.7 million. This figure reflects the long-term financial burden placed on both public and private entities due to ongoing infrastructure debt.

4.2 Ongoing Maintenance and Resurfacing Costs

Maintenance and resurfacing are continuous and costly aspects of the traditional trenching method. Due to the frequent need to access underground utilities, the roadway is often disrupted, leading to additional resurfacing costs.

- Resurfacing Costs: According to an estimation from John Speroni, the cost of resurfacing is approximately $160,000 per lane mile. Over 100 years, resurfacing due to utility cuts and general wear and tear is estimated to cost the city around $6.77 million.

4.3 Utility Trenching Costs

Trenching costs represent a significant and ongoing expense under the traditional method. As utilities age or require expansion, new trenches must be dug, which adds to the overall lifecycle costs of the method.

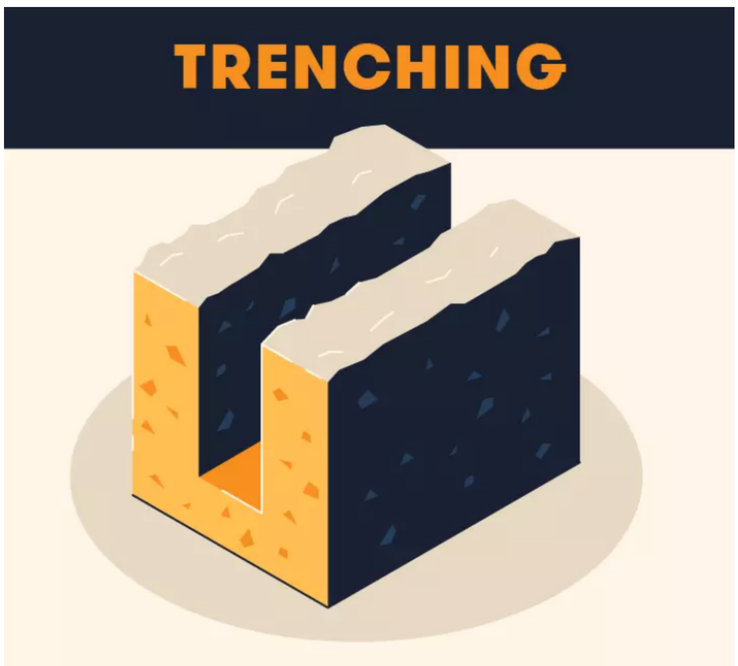

Figure 3: Schematic diagram of the trenching method

- **Frequency of Cuts:** Analysis of historical data shows an average of 18.3 utility cut permits per year along Worth Street, with approximately one-third resulting in actual street cuts. These cuts have a growth rate of 0.05% after the first 25 years, indicating a steady increase in maintenance frequency as the infrastructure ages.

- **Trenching Cost per Foot:** The average cost per foot for trenching is $378, adjusted for inflation with an 8% increase every ten years, reflecting the rising costs of labor and materials over time.
- **Total Trenching Costs:** Over a projected 100-year period, the cumulative costs of trenching along Worth Street amount to approximately $881.4 million. This figure underscores the financial impact of the traditional method's reliance on frequent maintenance.

4.4 Total Costs of the Traditional Method

The traditional trenching method's reliance on direct subsurface burial and repeated roadwork leads to high long-term costs. The total estimated direct costs, including capital, debt service, resurfacing, and trenching, are summarized as follows (see Table 1):

Traditional Trench Method	FV	PV
Total Debt Service for Original Construction Costs		
City	$ 61,805,050.30	
Utilities	$ 115,911,019.07	
	$ 177,716,069.38	
DOT Resurfacing Costs (100 years)	$6,771,424.98	
Private Utility Trenching Costs (100 years)	$ 881,405,412.91	
Traditional Trench Method Total	**$ 1,065,892,907.26**	$21,104,722.32

Table 1: Detailed Costs for the Traditional Trench Method

This analysis highlights the significant financial burden imposed by the traditional method over time. The frequent need for maintenance, resurfacing, and trenching, combined with substantial debt service costs, makes this approach both costly and inefficient. The data underscores the need for exploring alternative methods, such as the Utilidor system, to address these persistent challenges in urban utility management.

5 Utilidor Method Analysis

5.1 Capital and Debt Service Costs (2X and 3X Estimations)

The Utilidor method involves constructing a dedicated underground tunnel, or utilidor, to house multiple utility lines in a controlled and protected environment. This method significantly reduces the need for future excavations and provides streamlined access for maintenance and upgrades. However, the initial capital costs are notably higher than the traditional trenching approach.

- **Initial Capital Costs:** The construction of utilidors requires substantial upfront investment, which is estimated to be approximately two to three times higher than the traditional method. The future value of the capital costs in 2024 is projected at $182.97 million under the 2X cost scenario and $274.46 million under the 3X scenario. These estimates account for the complexity of constructing a tunnel that can accommodate various utility services safely and efficiently.
- **Debt Service Costs:** The debt service associated with the Utilidor method reflects the high initial capital investment but benefits from more predictable and lower maintenance costs over time. For the 2X scenario, the total debt service is estimated at $369.78 million; in the 3X scenario, it rises to $554.67 million. These costs include interest payments and principal repayment over the tunnel's useful life, which is 40 years, with an assumed interest rate of 4%.

5.2 Post-Construction Operation and Maintenance (O&M)

One of the most significant advantages of the Utilidor method is the reduced operational and maintenance costs after construction. The utilidor's design allows for easier access to utilities without the need for disruptive surface excavations, thereby minimizing routine maintenance expenses.

- **O&M Costs:** The post-construction operation and maintenance costs are assumed to be 10% of the original construction costs. This estimate aligns with industry standards for similar tunnel structures. Under the 2X scenario, the projected O&M cost over 100 years is approximately $100.02 million. For the 3X scenario, this figure increases to $150.03 million. These costs reflect the ongoing expenses required to keep the utilidor functional and safe, including routine inspections, minor repairs, and technological updates.

- **Total O&M Costs Over 100 Years:** The long-term O&M costs demonstrate a relatively stable and predictable expense, contrasting sharply with the escalating maintenance costs observed under the traditional trenching method.

5.3 Total Cost Analysis

The total direct costs of the Utilidor method include the initial capital investment, debt service, and ongoing operation and maintenance expenses. The analysis presents two cost scenarios to capture the range of potential financial impacts (see Table 2&3):

Utilidor (2X Cost Estimation)	FV	PV
Total Debt Service for Utilidor	$369,777,242.46	
O+M @10% construction costs	$100,017,859.92	
Utilidor Total	**$469,795,102.38**	$9,301,961.87

Table 2: Detailed Costs for the Utilidor Method (Under 3X Cost Estimation)

Utilidor (3X Cost Estimation)	FV	PV
Total Debt Service for Utilidor	$554,665,863.68	
O+M @10% construction costs	$150,026,789.88	
Utilidor Total	**$704,692,653.56**	$13,952,942.81

Table 3: Detailed Costs for the Utilidor Method (Under 3X Cost Estimation)

These cost projections highlight that, despite the higher initial investment, the Utilidor method's total direct costs are significantly lower than those of the traditional trenching method when analyzed over 100 years. The stability of the maintenance costs and the avoidance of repeated surface disruptions offer substantial long-term savings.

5.4 Summary of Utilidor Method Benefits

The Utilidor method provides a forward-looking solution to urban utility management by minimizing direct costs, enhancing operational efficiency, and reducing the need for future excavations. Substantial savings in maintenance and operation offset the method’s initial high capital expenditure, positioning it as a sustainable and financially sound alternative for managing critical infrastructure in populated urban areas like Worth Street.

Figure 4: Con Edison Harlem River Utilidor Tunnel
(https://mrce.com/project/con-edison-harlem-river-utilidor-tunnel/)

6 Comparison, Break-Even Analysis, and Sensitivity Analysis

6.1 Traditional vs. Utilidor Cost Comparison

The financial analysis of the traditional trenching method and the Utilidor method provides a detailed comparison of their direct costs over 100 years. The comparison highlights the significant cost disparities between the two approaches, emphasizing the long-term economic benefits of the Utilidor method.

Traditional Trench Method	FV	PV
Total Debt Service for Original Construction Costs		
City	$ 61,805,050.30	
Utilities	$ 115,911,019.07	
	$ 177,716,069.38	
DOT Resurfacing Costs (100 years)	$6,771,424.98	
Private Utility Trenching Costs (100 years)	$ 881,405,412.91	
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Utilidor Total	**$704,692,653.56**	$13,952,942.81

Traditional Trench Method / Utilidor Method (2X)	2.27	2.27
Traditional Trench Method / Utilidor Method (3X)	1.51	1.51

Table 4: Detailed Cost Comparison of Traditional and Utilidor Methods

The comparison shows that the traditional method incurs substantially higher costs over time, primarily due to the recurring expenses associated with resurfacing and trenching. In contrast, despite its higher initial capital investment, the Utilidor method results in lower overall costs thanks to its efficient maintenance and operational structure.

In the 2X Estimation scenario, the traditional method is approximately 2.27 times the Utilidor method, highlighting the substantial savings potential of utilizing Utilidor.

In the 3X Estimation scenario, even when the Utilidor costs are tripled, the traditional method still proves to be 1.51 times the Utilidor method, demonstrating the Utilidor's long-term cost advantage.

6.2 Break-Even Analysis

To determine the economic feasibility of the Utilidor method, a break-even analysis was conducted to identify the conditions under which the Utilidor costs would match those of the traditional trenching method. The break-even point helps assess the maximum allowable increase in Utilidor costs while still maintaining a cost advantage over the traditional method.

Break-Even Cost Multiplier: The analysis found that the Utilidor method would need approximately **4.54 times** the initial capital investment of the traditional trenching method for the total costs to equalize. This indicates that the Utilidor approach remains financially viable and competitive even with significant cost escalations.

6.3 Sensitivity Analysis

The sensitivity analysis was conducted to assess how variations in key factors impact the cost comparison between the traditional trenching method and the Utilidor method under the 2X cost estimation scenario. This analysis helps to validate the robustness of the findings by examining the effects of changes in discount rates, frequency of street cuts, construction costs, trenching costs, and maintenance costs.

1) Discount Rate

Setting: The analysis was conducted using a standard discount rate of 4%, which is typical for infrastructure project evaluations. The rate was varied between 1% and 10% to examine its impact on the total costs of each method.

Results: As the discount rate increases, the present value of long-term costs decreases, benefiting the Utilidor method more significantly. Both methods have higher present values at lower discount rates (1%-4%), but the traditional trenching method's costs remain substantially higher. The gap narrows as the rate approaches 10%, but the Utilidor still has a cost advantage (see Figure 5).

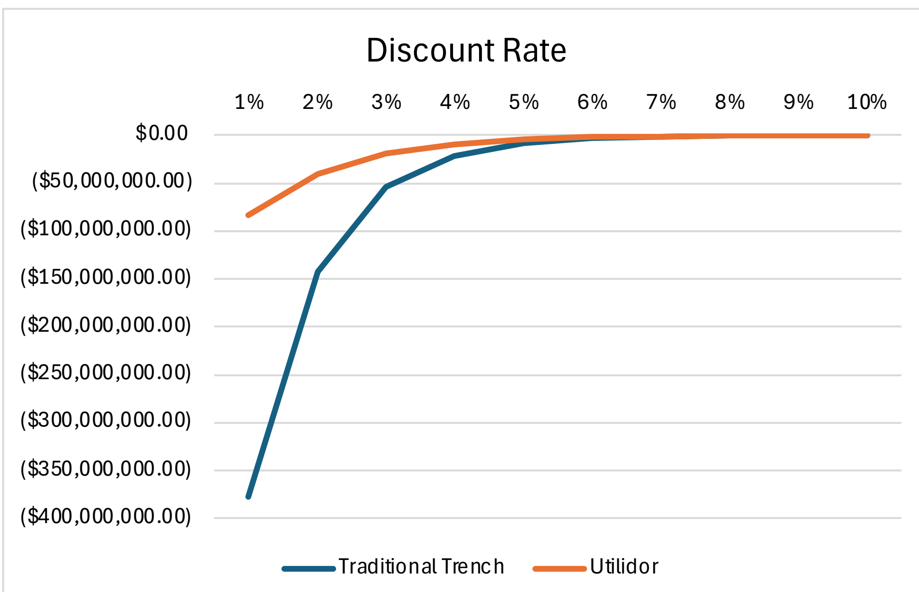

Figure 5: Sensitivity Analysis of Different Discount Rate

2) Number of Street Cuts (% of Total Number of Street Cut Permits)

Setting: Initially, 1 out of every 3 street cut permits results in actual street excavation, reflecting the current estimations on Worth Street. The analysis explored variations from 1 out of 5 cuts to 1 out of 1 to determine the sensitivity of costs to cut frequency.

Results: As the frequency of street cuts increases, the traditional trenching method's costs rise dramatically, driven by the need for frequent and expensive resurfacing. The Utilidor method remains relatively unaffected by this variable, as it eliminates most surface disruptions, solidifying its economic advantage in scenarios with high excavation rates (see Figure 6).

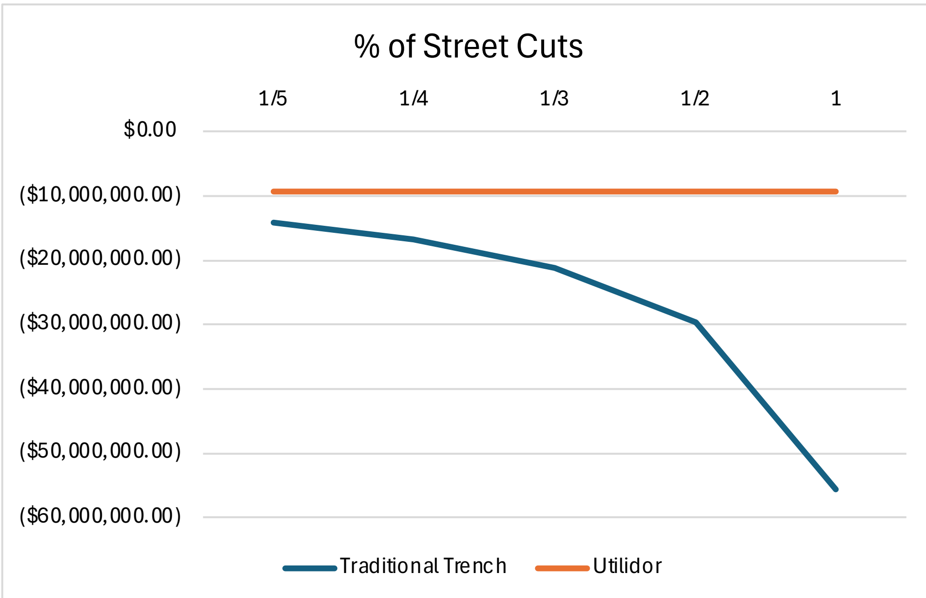

Figure 6: Sensitivity Analysis of Different Percentages of Street Cuts

3) Cost of Construction

Setting: The traditional method's construction cost was 100% of the current estimated costs under the 2X scenario. Sensitivity analysis tested cost variations from 50% to 150% to understand the impact of construction cost overruns or savings.

Results: The analysis shows that even if the construction costs were to increase by 50%, the total costs of the Utilidor method would still be lower than those of the traditional trenching method. This demonstrates the financial resilience of the Utilidor system, which maintains cost competitiveness despite potential increases in upfront investment (see Figure 7).

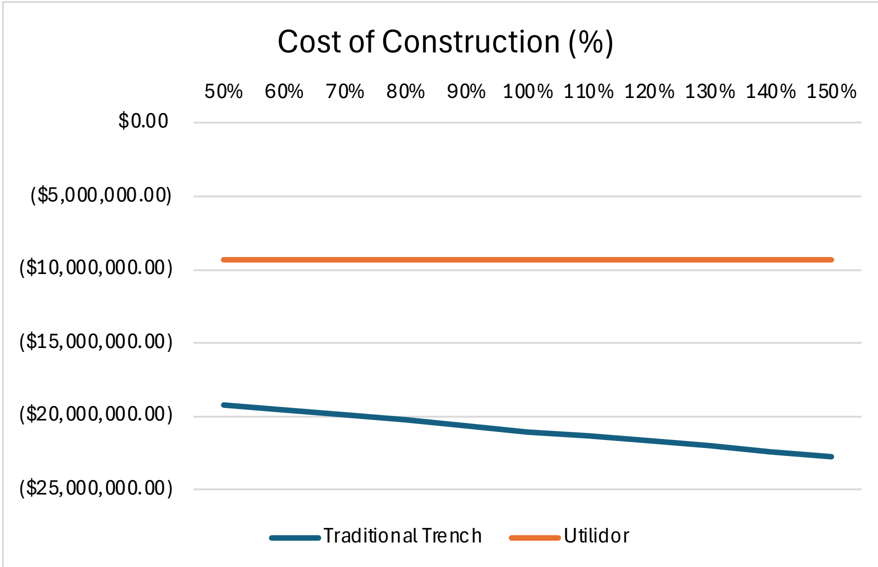

Figure 7: Sensitivity Analysis of Different Costs of Construction (%)

4) Trenching Cost per Foot

Setting: The average cost per foot for trenching is $378, with an 8% growth rate applied every 10 years to reflect inflation and increasing labor costs. The sensitivity analysis tested trenching costs from $278 to $478 per foot.

Results: As trenching costs increase, the overall expenses for the traditional method rise steeply, whereas the Utilidor method's costs remain (see Figure 8).

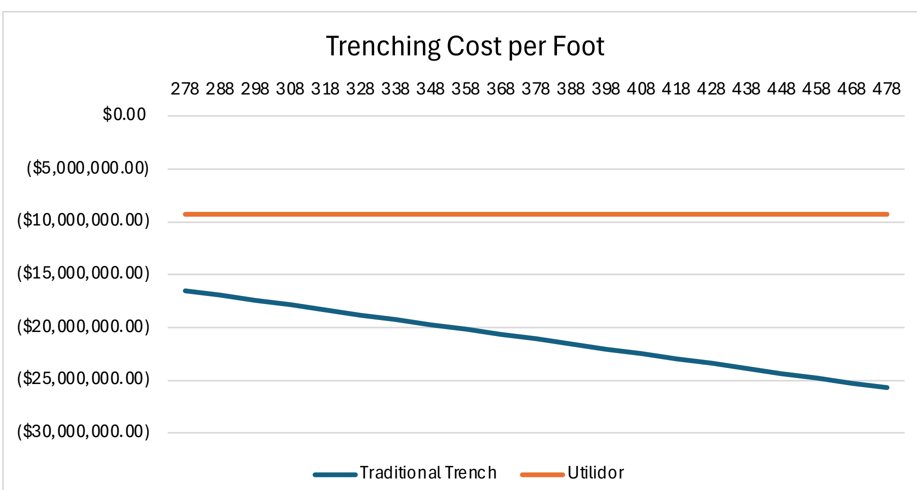

Figure 8: Sensitivity Analysis of Different Discount Rate

5) Debt Service for O&M After End of 40-Year Period

Setting: Debt service for the operation and maintenance costs was considered after the 40 years of the initial debt service, capturing long-term financial impacts.

Results: The debt service costs for O&M are relatively predictable and manageable in the Utilidor method compared to the traditional method, which faces compounded costs due to frequent resurfacing and repairs.

6.4 Conclusion of Cost Analysis

The comprehensive cost comparison and break-even analysis demonstrate that the Utilidor method provides a cost-effective alternative to the traditional trenching approach. Despite higher initial costs, the Utilidor's operational efficiencies, reduced maintenance needs, and minimized surface disruptions translate into substantial long-term savings. The break-even multiplier of 4.54 underscores the resilience of the Utilidor method under varying economic conditions, making it a financially sound choice for urban infrastructure management.

These findings support adopting the Utilidor method as a strategic investment in New York City's utility infrastructure, offering immediate operational benefits and significant cost savings over time.

7 Benefits Beyond Direct Costs

While this analysis primarily focuses on direct costs, the Utilidor method offers additional advantages beyond immediate financial savings, enhancing its overall appeal as a sustainable urban infrastructure solution.

Operational and Maintenance Efficiencies:

- Reduced Surface Disruption: The Utilidor method minimizes the need for street excavations, allowing for easier access to utilities without frequent road closures. This improves operational efficiency and reduces maintenance times compared to the traditional trenching approach.
- Extended Asset Lifespan: Utilities housed within a protected tunnel are less exposed to environmental factors that cause wear and tear, resulting in fewer repairs and replacements.

Environmental and Social Benefits:

- Lower Emissions and Reduced Congestion: By avoiding repetitive roadworks, the Utilidor method reduces traffic delays, noise, and pollution, creating a cleaner and more accessible urban environment.
- Improved Safety: With fewer open trenches, the risk of accidents for workers and the public is significantly reduced, enhancing overall safety in the area.

Urban Resilience and Flexibility:

- Adaptability to Future Needs: The Utilidor provides a flexible infrastructure platform that can easily accommodate new technologies and utilities, supporting the city's evolving needs without disruptive construction.

These broader benefits highlight the Utilidor method's potential to enhance urban infrastructure management beyond immediate cost considerations, contributing to a more efficient, sustainable, and resilient city landscape.

8 Conclusion and Recommendations

8.1 Summary of Findings

The life cycle cost-benefit analysis of the Utilidor method versus the traditional trenching method for utility infrastructure on Worth Street reveals significant long-term financial and operational advantages of the Utilidor approach. Despite higher initial capital costs, the Utilidor method offers substantial savings in maintenance, reduced surface disruptions, and enhanced asset longevity. Over 100 years, the total direct costs of the Utilidor method are markedly lower than those of the traditional method, demonstrating its economic resilience and suitability for sustainable urban utility management.

Key findings include:

- The total direct costs of the traditional trenching method are approximately $1.07 billion, driven mainly by recurring trenching, resurfacing, and high debt service expenses.
- The Utilidor method's total costs range from approximately $469.8 million under the 2X cost estimation to $704.7 million under the 3X scenario, reflecting significant savings over time.
- Sensitivity analyses confirm the Utilidor method's cost advantage under various financial scenarios, emphasizing its robustness and long-term viability.
- The break-even analysis indicates that the Utilidor method would need approximately 4.54 times the initial capital investment of the traditional method for the total costs to equalize. This break-even point highlights the significant cost-efficiency of the Utilidor system under varying conditions, reinforcing its economic attractiveness.

8.2 Recommendations for New York City

Based on the analysis, the Utilidor method is strongly recommended as a strategic investment for New York City's utility infrastructure. The following recommendations are proposed:

- Pilot Implementation: Initiate a pilot project to construct a Utilidor on Worth Street, allowing the city to evaluate real-world performance, operational efficiencies, and cost savings. This pilot would model future expansions across other critical urban corridors.
- Explore Financing Options: Given the high initial costs, the city should explore diverse financing mechanisms, including public-private partnerships (P3), municipal bonds, and federal infrastructure grants. These options can help mitigate upfront financial burdens and distribute the investment costs more sustainably.
- Stakeholder Engagement and Education: Conduct targeted outreach to inform and involve key stakeholders, including utility companies, local businesses, and residents. Highlight the long-term benefits of the Utilidor approach, such as reduced disruptions and improved service reliability, to build community support.
- Incorporate Utilidors into Future Urban Planning: Integrate the Utilidor approach into New York City's broader infrastructure planning and development strategies. Prioritize areas with frequent utility conflicts or high maintenance costs, aligning with the city's goals of enhancing urban resilience and sustainability.

8.3 Future Research Directions

Further research is recommended to expand upon the findings of this study, including:

- A comprehensive analysis of social and environmental benefits, such as reduced carbon emissions and improved urban mobility, to capture the full impact of the Utilidor method.
- Exploration of innovative technologies that can be integrated into the Utilidor system, such as smart sensors for real-time monitoring and data-driven maintenance optimization.
- Comparative studies on similar Utilidor implementations in other cities to gather best practices and refine the model for broader application in New York City.