Assessment of Smart Utility Technologies Costs & Benefits

June 2017

boston planning & development agency

AECOM

BOSTON SMART UTILITIES

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METHODOLOGY HIGHLIGHTS

- The *Assessment of Smart Utility Technologies Costs & Benefits* (Analysis) enables stakeholders to evaluate potential investments and to better set policy to catalyze regulations and financing mechanisms for infrastructure investments.
- Some benefits have been quantified and others have been monetized. Benefits included in the Analysis were chosen based on the following four criteria:
    1) Ease of access to data
    2) Accuracy and precision of data available
    3) Availability of dependable monetization methodologies
    4) Priority to Boston Smart Utilities Vision Goals
- Costs were estimated based on conceptual designs, AECOM's Infrastructure Model*, and Project Team discussions.
- The Project Team includes AECOM, NetZero Microgrid Solutions, LLC, Axis Engineering, and the Boston Smart Utilities Steering Committee.
- Cost and benefit estimates are the difference between the Base Case "Business-as-Usual" build-out and the integration of the smart technology.
- The Analysis provides an estimated impact of implementing each Smart Utility Technology.
- The estimated costs, benefits, and resulting analysis is not a complete financial analysis but rather an exploration into the justification for further development of the smart technology and public investment.
- This cost-benefit assessment measures the dollar value of the benefits and costs to all members of society, which includes the City, Bostonians, private organizations, and other public entities.
- Analyses identifying higher net benefits than costs indicate that society is willing to pay more than the project actually costs, and thus may justify public investment.
- The Analysis does not assign ownership of the costs or the benefits.

** The AECOM Infrastructure Model estimates the system costs and benefits based on specific design, use, placement, and construction assumptions.*

EXECUTIVE SUMMARY
ANALYSIS OUTPUT

- Based on the estimated costs and benefits, four indicators were calculated:
  - Net Present Value (NPV) is the total discounted net benefits over the analysis period and represents the value of the total benefits minus costs in 2017 dollars.
  - Benefit-Cost Ratio (BCR) compares the total discounted benefits to the total discounted costs. Higher ratios indicate better investments based on the assigned costs and benefits.
  - Economic Rate of Return, also referred to as an internal rate of return, represents the interest rate at which the NPV of all the cash flows (both positive and negative) from a project or investment equal zero.
  - Return on Investment represents the total discounted benefits divided by the total capital investment; it excludes operations and maintenance costs.
- Each technology is analyzed based on an estimated useful lifespan specific to that smart technology, therefore, analysis timeframes vary by technology.

EXECUTIVE SUMMARY
ANALYSIS OVERVIEW

- 8 Smart Technologies in 4 Asset Classes were analyzed. A Cost-Benefit Analysis was conducted for the technologies highlighted in Yellow.

Smart Energy Technologies
- District Energy Microgrid
- Solar PV & Battery Microgrid

Smart Water Technologies
- Green Infrastructure
- Water Re-use

Smart Transportation Technologies
- Smart Traffic Management
- Autonomous Vehicle Infrastructure

Smart Communications Technologies
- Telecom Utilidor & Resilient Fiber Loop
- Public Wi-Fi, Smart Sensors, & Smart Streetlights

EXECUTIVE SUMMARY

SMART UTILITY TECHNOLOGIES HIGHLIGHTS

District Energy Microgrid

A system for distributing hot and chilled water from a centralized location to meet connected space heating and water heating needs. For this analysis, the generation of electricity through a natural gas combined generation system is included.

Solar PV and Battery Microgrid

A localized arrangement of Solar Photovoltaic (PV) electricity sources, battery storage assets and loads that typically operate connected and synchronous with a traditional centralized grid, but also have the ability to disconnect and function autonomously as the need arises.

Green Infrastructure

Approach to water management that reduce effects of stormwater. Bioretention basins, planters, pavements, and disconnection downspouts are some examples of Green Infrastructure strategies.

Water Re-use

Techniques that reduce use of potable water for irrigation and/or reduce stormwater discharge into pipes and rivers, reducing flood risk.

Smart Traffic Management

Use of intelligent signals and traffic cameras to manage traffic flow in real-time and used to facilitate vehicle progression and reduce wait times and congestion.

Autonomous Vehicle Infrastructure

Infrastructure developed to support the use of autonomous vehicles including striping, communication devices, and extra signals.

Telecommunication Utilidor

A tunnel system with wall-mounted racks to carry fiber optics, cable, and/or telephone cables, reducing the amount of roadway disruptions.

Smart Sensors

Sensors that detect changes in air quality, noise pollution, gunshot detection, and other key factors for a healthy urban environment, leading to more leveraged deployment of community resources.

EXECUTIVE SUMMARY

KEY FINDINGS & NEXT STEPS

District Energy Microgrid

Favorable cost-benefit analysis under two design scenarios for a cluster of four parcels. Exploration into necessary agreements and financing structures to implement a district energy microgird in the Pilot Project Area is recommended.

Solar Photovoltaic & Battery Microgrid

Favorable cost-benefit analysis for a utility-owned microgrid with solar photovoltaic, battery storage, and electric vehicle charging infrastructure. Exploration into ideal location and necessary agreements and financing structures to implement a solar PV & battery storage microgird in the Pilot Project Area is recommended.

Green Infrastructure

Unfavorable benefit-cost ratio because of the narrow scope of benefits considered. To increase the benefit-cost ratio, value additional benefits for green infrastructure, such as energy and carbon emissions savings due to avoided treatment and aesthetic and property value benefits. Further analysis is recommended to fully capture these monetized benefits.

Water Re-use

Favorable cost-benefit analysis for onsite greywater re-use for non-residential buildings paired with rainwater harvesting for non-residential and residential buildings. Exploration into the potential to connect residential with non-residential buildings for a district water re-use system is recommended.

Telecommunication Utilidor

Favorable cost-benefit analysis under one of three design scenarios, but there is potential for favorable design under all scenarios if full benefits are monetized. Exploration into appropriate usage rates and structures for a telecommunications Utilidor in the Pilot Project Area is recommended.

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SMART ENERGY TECHNOLOGIES

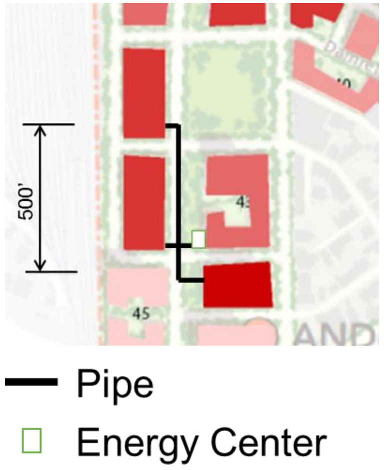
2A. DISTRICT ENERGY MICROGRID

DISTRICT ENERGY MICROGRID
DESIGN

- Case Study
  - A cluster of buildings was selected in the Pilot Project Area to test District Energy feasibility.
  - High-density 'clusters' of buildings, where distribution costs are estimated to be lower, were assessed.
  - Buildings were selected based on projected high heating and cooling demands.
  - All buildings are in the same development phase (year 2022).
  - Two district energy designs with a 2 MW Gas-Powered Combined Heat and Power Turbine (CHP) were analyzed:
    - **Design A**: Tri-generation Plant
    - **Design B**: Tri-generation Plant with Thermal Energy Storage (TES)

DISTRICT ENERGY MICROGRID
DESIGN

- Case Study:
  - Based on the criteria discussed, the four parcel area circled on the maps on the right was selected for study.
  - Approximately 1.9 million square feet of real estate.
- Potential distribution network:
  - 700 feet length (heating and cooling each); 1,400 feet total
  - Sized ~ 14” (heating) - 20” (cooling) diameter to meet demand
  - Energy center could be located adjacent to or within planned building.



DISTRICT ENERGY MICROGRID

COSTS (USD 2017)

	Design A: Trigeneration	Design B: Trigeneration + TES
Energy Center Building	$0.3 million	$0.3 million
CHP Plant	$5 million	$5 million
Heat Recovery	$0.9 million	$0.9 million
Absorption Chiller	$4.6 million	$4.6 million
Central Boilers	$1 million	$1 million
Central Centrifugal Chillers	$4.7 million	$4.7 million
DE Piping + Building Heat Exchangers	$5.2 million	$5.2 million
TES Tank	-	$3.5 million
Total Capital Costs	**$22 million**	**$25 million**
Total O&M Costs (20 Years)	**$3.5 million**	**$3.5 million**

Notes:
1. *Values may not total due to rounding*
2. *Non-inflated costs*

DISTRICT ENERGY MICROGRID

BENEFIT DEFINITIONS

Economic & Fiscal Benefits

O&M Savings*

Operation and Maintenance of District Energy Systems are lower than traditional building heating and cooling systems.

(Measured in dollars avoided)

Reduced Developer Construction Costs*

Developers no longer build individual heating and cooling systems saving on building construction costs.

(Measured in dollars avoided)

Resilience Benefits

Continuous Power

Co-generation and Tri-generation systems produce electricity locally allowing for continuous power in the event of a larger grid failure.

(not quantified)

End User Impacts

Reduced Energy Costs*

More efficient use of energy reduces overall energy demand thereby lowering consumer energy bills.

(Measured by reduced MWh multiplied by energy costs)

Environmental Benefits

Reduced CO_2 Emissions

Integration of combined heat and power systems reduces Greenhouse Gas emissions.

(Measured in metric tons of Carbon Dioxide multiplied by the Social Cost of Carbon)

Capacity Impacts

Efficient Space Use*

The space traditionally reserved for heating and cooling components can be used for more valuable uses.

(Measured in SF of saved space multiplied by the office rental rate)

Peak Electricity Demand Reduction+

Energy storage allows buildings to reduce electricity demand during peaks reducing strain on macrogrid.

(not quantified)

** Denotes a Benefit that could potentially be included in future financial analyses*

\+ Design B only

DISTRICT ENERGY MICROGRID

BENEFITS: DESIGN A (TRI-GEN)– 20 YEAR ANALYSIS

Economic & Fiscal Benefits

O&M Savings*
$2 million

Reduced Developer Construction Costs*
$6 million

Resilience Benefits

Continuous Power
(not quantified)

End User Impacts

Reduced Energy Costs*
$28 million

Environmental Benefits

Reduced CO_2 Emissions
$0.3 million

Capacity Impacts

Efficient Space Use*
$29 million

Peak Electricity Demand Reduction+
(none)

+ Design B only

Note: Inflated, non-discounted estimates
** Denotes a benefit that could potentially be included in future financial analyses*

DISTRICT ENERGY MICROGRID

BENEFITS: DESIGN B (TRI-GEN + TES) - 20 YEAR ANALYSIS

Economic & Fiscal Benefits

O&M Savings*
$2 million

Reduced Developer Construction Costs*
$6 million

Resilience Benefits

Continuous Power
(not quantified)

End User Impacts

Reduced Energy Costs*
$33 million

Environmental Benefits

Reduced CO_2 Emissions
$0.3 million

Capacity Impacts

Efficient Space Use
$29 million

Peak Electricity Demand Reduction+
(not quantified)

+ Design B only

Note: Inflated, non-discounted estimates
** Denotes a benefit that could potentially be included in future financial analyses*

DISTRICT ENERGY MICROGRID

RESULTS

DESIGN A: Tri-Gen

Total Capital Investment: **$24 Million**
(Inflated costs)

Net Present Value: **$11 Million to $22 Million**
(7% to 3% Discount Rate)

Benefit-Cost Ratio: **1.6 to 1.9**
(7% to 3% Discount Rate)

Economic Rate of Return: **15%**

Return on Investment: **125% to 191%**
(7% to 3% Discount Rate)

DESIGN B: Tri-Gen + TES

Total Capital Investment: **$28 Million**
(Inflated costs)

Net Present Value: **$6 Million to $17 Million**
(7% to 3% Discount Rate)

Benefit Cost Ratio: **1.3 to 1.6**
(7% to 3% Discount Rate)

Economic Rate of Return: **3%**

Return on Investment: **101% to 160%**
(7% to 3% Discount Rate)

BENEFIT AND COST REALIZATION

Stakeholder	Cost/Benefit	Relative Impact Increase/Decrease	Relative Impact Positive/Negative
District Operator	District Energy Microgrid O&M Costs	Increase	Negative
	Service Fee Revenue	Increase	Positive
District Operator/City/Developer	District Energy Microgrid Capital Costs	Increase	Negative
Developer	Building Capital Costs	Decrease	Positive
	Heating and Cooling O&M Costs	Decrease	Positive
	Real Estate Availability	Increase	Positive
Eversource	Peak Electricity Demand	Decrease	Positive
Microgrid-Connected Residents and Businesses	Continuous Energy Supply	Increase	Positive
	Utility Costs	Decrease	Positive
Bostonians	Greenhouse Gas Emissions	Decrease	Positive

Note: Not all benefits have been, or will be, quantified

DISTRICT ENERGY MICROGRID

CONSIDERATIONS

- Developers, residents, businesses, and Bostonians in general benefit from the District Energy system.
- The capital investment to build the District Energy System can be split between main beneficiaries and District Energy Operator.
- District Energy Operator can structure usage fee system to cover O&M costs and recoup capital investment.

2B. SOLAR PV & BATTERY MICROGRID

SOLAR PV & BATTERY MICROGRID

- Microgrids redefine how the traditional electric distribution system is managed by providing localized energy choice and control.
- Microgrids provide communities in Boston opportunities ranging from electric “islanding” for improved resiliency, to a system that can accommodate significant concentrations of alternative clean energy and the anticipated EV charging market.
- Benefits:
  - Distributed Generation integration
  - Lower Greenhouse Gas sources
  - Load management
  - Resilience and continuous power

- The analysis assumes a scaled utility-owned microgrid system buildout over a 20-year period covering the entire Pilot Project Area with **7.6 MW*** of distributed solar resources, **3.6 MWh** of battery storage, and a mix of **approximately 480** level 1, level 2, and level 3 electric vehicle charging stations.
- The analysis assumes a gradual expansion of the microgrid to cover the entire Pilot Project Area over the 20-year build-out, although no specific start location was selected. The microgrid components will be developed in the following sequence:
  - By 2022, a “foundational” base system will be designed and implemented for a total cost of $2 million, which will include all microgrid systems inclusive of the controller, communications packages package, and tie ends with this phase of real estate.
  - Additional components and expansion of the system will continue throughout the remaining development as buildings, DERs, and new technologies and apps are developed. Additional phase-ins will occur proportionately for a final investment of $5 million.
  - Solar PV, Battery Storage, and Electric Vehicle Charging Stations are added in proportion to the development growth.

** 7.6 MW of solar PV is a best-case-scenario estimate that assumes a 40% coverage of Pilot Project Area roof space with solar PV. The estimate of total area roof space is based on projected building footprints of the 47 project sites assumed to be developed by 2037, provided by BPDA.*

SOLAR PV & BATTERY MICROGRID
COSTS

	Microgrid + Distributed Resources
Microgrid Components	$5.5 million
Solar PV & Battery Storage	$28 million
Electric Vehicle Charging Infrastructure	$0.9 million
Total Capital Costs	**$34.4 million**
Total O&M Costs (20 years)	**$6.8 million**

Notes:
1. *Values may not total due to rounding*
2. *Non-inflated costs*

SOLAR PV & BATTERY MICROGRID

BENEFIT DEFINITIONS

Economic & Fiscal Benefits

Lower O&M Costs*

Electric Vehicle owners have lower O&M costs than combustion engine owners.

(Measured by miles driven multiplied by dollars saved per mile)

Capital Avoided*

Reduced electricity demand reduces needed investment in generation assets.

(Reduced demanded valued at $1.5 million per avoided MW)

Resilience Benefits

Continuous Power

Microgrid produces electricity locally allowing for continuous power in the event of a larger grid failure.

(not quantified)

Protection of Critical Infrastructure

Microgrids can allow critical infrastructure and service provides to maintain operations during emergency events.

(not quantified)

End User Impacts

Reduced Energy Costs*

Efficient onsite generation of electricity lowers consumer energy bills.

(Measured by reduced MWh multiplied by energy costs)

Environmental Benefits

Reduced CO_2 Emissions

Integration of low-carbon energy sources and improved energy efficiency through grid optimization reduce Greenhouse Gas emissions.

(Measured in metric tons of Carbon Dioxide multiplied by the Social Cost of Carbon)

Capacity Impacts

Peak Electricity Demand Reduction*

Energy storage allows buildings to reduce electricity demand during peaks, reducing strain on macrogrid.

(Quantified as the amount of electricity provided by battery storage during peak – high usage – times multiplied by the peak value of electricity)

** Denotes a benefit that could potentially be included in future financial analyses*

SOLAR PV & BATTERY MICROGRID

BENEFIT DEFINITIONS – 20 YEAR ANALYSIS

Economic & Fiscal Benefits

Lower O&M Costs*

$9 million

Capital Avoided*

$28 million

Resilience Benefits

Continuous Power

(not quantified)

Protection of Critical Infrastructure

(not quantified)

End User Impacts

Reduced Energy Costs*

$65 million

Environmental Benefits

Reduced CO_2 Emissions

$5 million

Capacity Impacts

Peak Electricity Demand Reduction*

$16 million

Note: Inflated, non-discounted estimates
** Denotes a benefit that could potentially be included in future financial analyses*

SOLAR PV & BATTERY MICROGRID
RESULTS

Total Capital Investment: **$41 Million**
(Inflated costs)

Net Present Value: **$23 Million to $45 Million**
(7% to 3% Discount Rate)

Benefit-Cost Ratio: **1.9 to 2.2**
(7% to 3% Discount Rate)

Economic Rate of Return: **21%**

Return on Investment: **118% to 196%**
(7% to 3% Discount Rate)

BENEFIT AND COST REALIZATION

Stakeholder	Cost/Benefit	Relative Impact	
		Increase/Decrease	Positive/Negative
Eversource*	Capital Cost - Microgrid	Increase	Negative
	Annual O&M - Microgrid	Increase	Negative
	Load Management Ability	Increase	Positive
	Power Quality & Reliability	Decrease	Positive
	Peak Demand & Import Reduction	Decrease	Positive
Solar PV & Storage Owner/Operator	Capital Cost – Solar PV & Storage	Increase	Negative
	Annual O&M - Solar PV & Battery Storage	Increase	Negative
	Renewable Energy Certificates (RECs) Sales	Increase	Positive
	Capacity Market Sales	Increase	Positive
	Ancillary Services Provision	Increase	Positive
Developer	Roof Rental for Solar PV	Increase	Positive
	Backup Power Requirements	Decrease	Positive
Microgrid-Connected Residents and Businesses	Resilient Electric Supply	Increase	Positive
	Power Quality & Reliability	Increase	Positive
	Electricity Costs	Decrease	Positive
Bostonians	Greenhouse Gas Emissions	Decrease	Positive

**Assumes this is a Utility Microgrid owned/operated by Eversource*
Note: Not all benefits have been or will be quantified

SOLAR PV & BATTERY MICROGRID
CONSIDERATIONS

- In order to capture benefits of islanding capabilities, there must be enough distributed generation assets to meet minimum critical loads.
- Utility service provider buy-in is required for interconnection.
- Certain building users, such as manufacturers or research laboratories, place a higher value on resilient power supply and improved power quality. These users may be willing to pay a premium for resilient, uninterrupted service.
- Community Microgrids may result in higher efficiencies and more benefits. The primary differentiator between a Utility Microgrid and a Community Microgrid regards the incentives for demand reduction for the aggregated loads of a given neighborhood. In the case of a public utility-owned microgrid, few incentives currently exist to cause the utility to reduce the aggregated demand, since its customers are the individual electric users, billed on the basis of individual meters. In the case of a 3rd party-owned microgrid (community), the owner does have incentive to reduce the aggregated demand load for the neighborhood since this reduces the 3rd party's overall electric costs.

03

SMART WATER TECHNOLOGIES

3A. GREEN INFRASTRUCTURE

GREEN INFRASTRUCTURE

Five Green Infrastructure (GI) strategies within the Pilot Project Area were analyzed:

- Bioretention Basin on Parcels: 1,200 square feet
- Permeable Pavement on Parcels: 4,900 square feet
- Downspout Disconnection: 396 square feet
- Detention Basins: 2,700 square feet
- Bioretention Planters on Right-of-Way: 7,342 square feet

These strategies were applied to specific street segments in the Pilot Project Area to calculate costs and impacts.

- All proposed new street segments were assumed to be built with Green Infrastructure. Additionally, *PLAN Dot Ave.* outlined two specific roadways for significant additions of Green Infrastructure:
  - A linear park is assumed to run parallel to the existing and proposed segments of **Ellery Street**
  - **D Street** will be made into a boulevard
- Streets were assumed to have specific Green Infrastructure strategies based on their street type

Street Type	Bioretention Basin (Parcel)	Permeable Pavement (Parcel)	Downspout Disconnection	Detention Basin	Bioretention Planter (ROW)
Downtown Mixed-Use					X
Neighborhood Main					X
Neighborhood Connector					X
Neighborhood Residential					X
Road + Linear Park		X	X	X	
Boulevard	X				X

LOCATION OF PROPOSED GREEN INFRASTRUCTURE

- The map to the right shows the proposed new streets in the Pilot Project Area.
- Green Infrastructure is assumed to be incorporated in all new streets.
- Green Infrastructure is assumed to be incorporated in two existing streets.

Map Source: AECOM analysis and Pilot Project Area planning documents.

GREEN INFRASTRUCTURE
COSTS (USD 2017)

	Green Infrastructure
Bioretention Basin (Parcel)	$65,000
Permeable Pavement (Parcel)	$370,000
Downspout Disconnection	$7,000
Detention Basin	$74,000
Bioretention Planter (ROW)	$590,000
Total Capital Costs	**$1.2 million**
Total O&M Costs (30 Years)	**$1 million**

Notes:
1. *Values may not total due to rounding*
2. *Non-inflated costs*

GREEN INFRASTRUCTURE

BENEFIT DEFINITIONS

Economic & Fiscal Benefits

Deferred Infrastructure Investment*

Green Infrastructure allows cities to defer capacity upgrades of traditional stormwater infrastructure. It can also reduce piping requirements for developers.

(not quantified)

Resilience Benefits

Reduced Flooding*

Green Infrastructure can slow and/or reduce stormwater discharge reducing flood risk.

(not quantified)

Vision Zero Realization

Green Infrastructure designs can slow traffic and reduce pedestrian and cyclists accidents.

(not quantified)

End User Impacts

Open Space Access

More open greenspace for community use

(not quantified)

Environmental Benefits

Reduced CO_2 Emissions

Reduced Greenhouse Gas emissions from increase of greenspace and trees

(not quantified)

Water Quality

Green Infrastructure can filter out pollutants and reduce the chance of combined sewer overflows.

(not quantified)

Capacity Impacts

Reduced Stormwater*

Green Infrastructure reduces the discharge into stormwater systems and can lower the cost of water treatment

(Estimated stormwater runoff reduction by Green Infrastructure strategy for a typical year multiplied by the sewer rates for the City of Boston)

* *Denotes a benefit that could potentially be included in future financial analyses*

GREEN INFRASTRUCTURE
BENEFIT – 30 YEAR ANALYSIS

Economic & Fiscal Benefits

Deferred Investment in grey infrastructure*

(not quantified)

Resilience Benefits

Reduced Flooding*

(not quantified)

Vision Zero Realization

(not quantified)

End User Impacts

Open Space Access

(not quantified)

Environmental Benefits

Reduced CO_2 Emissions

(not quantified)

Water Quality

(not quantified)

Capacity Impacts

Reduced Stormwater*

$0.4 million+

Note: Inflated, non-discounted estimates
** Denotes a benefit that could potentially be included in future financial analyses*
+ To remove the stormwater reduction benefits of Permeable Pavement (ROW), a reduction factor was applied to the benefits. Each of the GI technologies evaluated, including Permeable Pavement, is assumed to be equally effective in capturing stormwater. Stormwater reduction is assumed to reduce by the same ratio that the square footage of green infrastructure reduced. Thus, the original stormwater reduction estimate was multiplied by a factor of 0.26.

BENEFIT AND COST REALIZATION

Stakeholder	Cost/Benefit	Relative Impact	
		Increase/Decrease	Positive/Negative
City/Developer*	Capital Costs	Increase	Negative
	O&M Costs	Increase	Negative
City	Vision Zero Realization	Increase	Positive
	Grey Infrastructure Investment	Decrease	Positive
	Stormwater Infrastructure Capacity Use	Decrease	Positive
Developer	Grey Infrastructure Investment	Decrease	Positive
Project Area Residents and Businesses	Flooding Risk	Decrease	Positive
	Open Space Access	Increase	Positive
	Vehicle Accidents	Decrease	Positive
Bostonians	Greenhouse Gas Emissions	Decrease	Positive
	Water Quality	Increase	Positive

**Cost sharing between City and Developer to be agreed upon in MSA*
Note: Not all benefits have been, or will be, quantified

GREEN INFRASTRUCTURE
RESULTS

Total Capital Investment: **$1.5 Million**

(Inflated costs)

Net Present Value: **-$1 Million to -$2 Million**
(7% to 3% Discount Rate)

Benefit-Cost Ratio: **0.1 to 0.1**
(7% to 3% Discount Rate)

Economic Rate of Return: **--**

Return on Investment: **8% to 16%**
(7% to 3% Discount Rate)

GREEN INFRASTRUCTURE
CONSIDERATIONS

- Solely evaluating GI’s impact on sewer charges, GI has an unfavorable Benefit-Cost Ratio. It is recommended to evaluate the full benefits to Boston’s Combined Sewer System.
- GI usually produces a positive Benefit-Cost Ratio compared to traditional stormwater infrastructure when factoring in reduced traditional stormwater infrastructure capital costs, reduced pumping and treatment, reduced carbon emissions, and improved air quality.
- This analysis demonstrates that Annual Stormwater Reduction Benefits are greater than or equal to Annual Operations and Maintenance costs of the infrastructure.
- Approximately 85% of capital costs are from permeable pavement installations. A detailed analysis of Pilot Project Area stormwater runoff patterns and urban flooding incidences could be conducted to better target placement of permeable pavement and reduce capital expenses while capturing the greatest benefit.
- Pilot Project Area Residents and Businesses, Bostonians overall, and the City realize the majority of the benefits.

3B. WATER RE-USE

WATER RE-USE
RAINWATER HARVESTING AND GREYWATER

- Water Re-use systems can be in-building systems, on-site systems or connected to create district systems. For this analysis, only on-site systems were considered.
- These systems include the following:
  - Collection piping, “purple piping”, and treatment of greywater for uses in toilets and irrigation;
  - Rainwater harvesting cisterns for irrigation uses

- The cost and benefits of installing water re-use piping/treatment in non-residential laboratory and office buildings (approximately 5.3 million square feet) and 18 rainwater harvesting cisterns* in the Pilot Project Area on residential or non-residential buildings were analyzed.

** 18 cisterns were assumed based on assumptions around usable roof space, irrigation needs/demand, and collection ability*

WATER RE-USE
COSTS (USD 2017)

	Water Re-use & Rainwater Harvesting
Rainwater Cisterns	$0.7 million
Greywater Dual Plumbing	$1 million
Greywater Cisterns & Treatment	$0.6 million
Total Capital Costs	**$2.2 million**
Total O&M Costs (20 years)	**$0.6 million**

Notes:
1. *Values may not total due to rounding*
2. *Non-Inflated Costs*

WATER RE-USE
BENEFITS DEFINITIONS

Economic & Fiscal Benefits	Resilience Benefits	End User Impacts	Environmental Benefits	Capacity Impacts
Reduced Water Treatment Costs* On-site treatment of water for re-use reduces quantity of water being treated at city facilities *(not quantified)*	**Reduced Flooding** Rainwater Harvesting can slow and/or reduce stormwater discharge reducing flood risk *(not quantified)*	**Reduced Utility Costs*** More efficient use of water reduces overall demand and lowers consumer energy bills *(Measured by reduced water & sewer consumption multiplied by water and sewer rates)*	**Efficient Water Use*** Greywater systems reduce overall water consumption and rainwater harvesting allows reduce use of water for irrigation *(Measured as gallons saved multiplied by water utility rates)*	**Reduced Stormwater*** Rainwater Harvesting reduces the discharge into stormwater systems and can lower the cost of water treatment *(Estimated stormwater captured in cisterns multiplied by the sewer rates for the City of Boston)*

** Denotes a benefit that could potentially be included in future financial analyses*

WATER RE-USE

BENEFITS DEFINITIONS – 20 YEAR ANALYSIS

Economic & Fiscal Benefits	Resilience Benefits	End User Impacts	Environmental Benefits	Capacity Impacts
Reduced Water Treatment Costs* *(not quantified)*	**Reduced Flooding** *(not quantified)*	**Reduced Utility Costs*** *Captured through Environmental and Capacity Benefits, not included in CBA*	**Efficient Water Use*** **$3 million**	**Reduced Stormwater*** **$2 million**

Note: Inflated, non-discounted estimates
** Denotes a benefit that could potentially be included in future financial analyses*

WATER RE-USE
RESULTS

Total Capital Investment: **$2.8 Million**
(Inflated costs)

Net Present Value: **$0.3 Million to $0.8 Million**
(7% to 3% Discount Rate)

Benefit-Cost Ratio: **1.2 to 1.3**
(7% to 3% Discount Rate)

Economic Rate of Return: **3%**

Return on Investment: **74% to 121%**
(7% to 3% Discount Rate)

BENEFIT AND COST REALIZATION

Stakeholder	Cost/Benefit	Relative Impact	
		Increase/Decrease	Positive/Negative
Boston Water and Sewer Commission (BWSC)	Water Demand	Decrease	Negative
	Stormwater & Water Infrastructure Capacity Use	Decrease	Positive
Developer	Capital Costs	Increase	Negative
	O&M Costs*	Increase	Negative
Building Tenants	Water & Sewer Utility Bills**	Decrease	Positive
Bostonians	Water Conservation	Increase	Positive

** O&M costs may be passed on to tenants in the form of higher rents*
*** For buildings with water re-use only. Speculative, assumes BWSC will not increase building specific rates. As a larger share of the City incorporates this technology, BWSC would likely increase rates to maintain revenues.*
Note: Not all benefits have been, or will be, quantified

WATER RE-USE
CONSIDERATIONS

- Greater benefits can be realized by combining residential buildings, which have higher water demands, with non-residential buildings in a district-scale water re-use design.
- Exploration of district scale systems was not considered in accordance with project scope.
- Installation of water re-use systems in the Pilot Project Area will not have a great enough impact on Citywide water consumption to prompt a rate increase by BWSC. However, as more water re-use technologies are installed around the city, BWSC may increase rates to continue to recoup the revenues necessary to maintain the system.

04

SMART TRANSPORTATION TECHNOLOGIES

4A. SMART TRAFFIC MANAGEMENT

SMART TRAFFIC MANAGEMENT

- Smart traffic management uses intelligent signals and traffic cameras to manage traffic flow in real-time. It is used to facilitate vehicle progression and reduce wait times.
- The costing analysis assumes the use of adaptive traffic signals and smart pedestrian safety sensors at 12 new smart signalized intersections.

SMART TRAFFIC MANAGEMENT
BENEFIT DEFINITIONS

Economic & Fiscal Benefits

Reduced Travel Times and Delays

Improved traffic flow patterns reduces congestion and improves travel times.

(not quantified)

Resilience Benefits

Vision Zero Realization

Intelligent traffic management systems provide data to adjust traffic systems to reduce accidents.

(not quantified)

End User Impacts

Accident Reduction

(not quantified)

Accident Fatalities & Injuries

Reduction in injuries and fatalities to Bikers and Pedestrians through smarter pedestrian management systems

(not quantified)

Environmental Benefits

Reduced CO_2 Emissions

Reduced idling at traffic signals reduces emissions from vehicles.

(not quantified)

Capacity Impacts

Reduced Congestion

(not quantified)

SMART TRAFFIC MANAGEMENT
COSTS (USD 2017)

	Smart Traffic Management
Adaptive Traffic Signals	$0.5 million
Smart Pedestrian Safety Sensors	$0.2 million
Total Capital Costs	**$0.7 million**
Total O&M Costs (20 years)	**$0.6 million**

Assumes 12 signalized intersections

Notes:
1. *Values may not total due to rounding*
2. *Non-Inflated numbers*

BENEFIT AND COST REALIZATION

Stakeholder	Cost/Benefit	Relative Impact	
		Increase/Decrease	Positive/Negative
Boston Transportation Department	Capital Costs	Increase	Negative
Public Works Department	O&M Costs	Increase	Negative
City	Vision Zero Realization	Increase	Positive
Bostonians	Traffic Congestion	Decrease	Positive
	Vehicle Accidents	Decrease	Positive
	Vehicle, Bike, Pedestrian Accident Injuries	Decrease	Positive
	Vehicle, Bike, Pedestrian Accident Fatalities	Decrease	Positive

Note: Not all benefits have been or, will be, quantified

Considerations:

1. Dorchester Avenue is a high congestion corridor that will benefit from more effective traffic management.
2. While Smart Traffic Management in a small district alone, will not create major traffic benefits, it is part of a larger system that has citywide benefit.

4B. AUTONOMOUS VEHICLE INFRASTRUCTURE

AUTONOMOUS VEHICLE INFRASTRUCTURE

- Three options for supporting the use of autonomous vehicles were assessed for use in the Pilot Project Area:
  - **Striping:** Increased frequency of striping maintenance to facilitate easier detection of road lines by vehicle sensors
  - **Communication Devices:** Roadside devices to communicate with autonomous vehicles
  - **Extra Signals:** Extra traffic signals and poles to reduce glare that inhibits sensor reading of traffic lights

- Autonomous Vehicles are projected to constitute 40% of vehicles on the road in dense urban areas by 2035. This penetration rate was used to estimate potential benefits of providing supporting infrastructure.

AUTONOMOUS VEHICLE INFRASTRUCTURE
COSTS (USD 2017)

	Smart Traffic Management
Roadside Equipment Device*	$0.7 million
Extra Traffic Signal & Pole*	$0.07 million
Total Capital Costs	**$0.7 million**
Extra Annual Restriping	$0.7 million
Other O&M	$0.03 million
Total O&M Costs (20 years)	**$15 million**

** Assumes 12 roadside equipment devices and extra traffic signals.*

Values may not total due to rounding
Non-inflated numbers

AUTONOMOUS VEHICLE INFRASTRUCTURE

BENEFIT DEFINITIONS

Economic & Fiscal Benefits

Efficient Time Use

Time typically spent driving can now be spent on other activities while riding in the car

(not quantified)

Resilience Benefits

Vision Zero Realization

Autonomous Vehicles have a 24% lower crash rate than traditional vehicles

(not quantified)

End User Impacts

Accident Reduction

Autonomous Vehicles have a 24% lower crash rate than traditional vehicles

(Estimated reduction in accidents in study area based on average annual accidents)

Accident Fatalities & Injuries

Autonomous Vehicles get in less serious accidents on average than traditional vehicles

(Estimated reduction in fatalities & injuries in study area based on average annual incidences)

Environmental Benefits

N/A

Capacity Impacts

Efficient Space Use

Some space traditionally reserved for parking can be used for more valuable uses

(not quantified)

AUTONOMOUS VEHICLE INFRASTRUCTURE
BENEFIT DEFINITIONS

Economic & Fiscal Benefits

Efficient Time Use

Time typically spent driving can now be spent on other activities while riding in the car

(not quantified)

Resilience Benefits

Vision Zero Realization

Autonomous Vehicles have a 24% lower crash rate than traditional vehicles

(not quantified)

End User Impacts

Accident Reduction

2.2 Fewer Accidents Annually in Project Area

Accident Fatalities & Injuries

0.06 Fewer Incidences Annually in Project Area

Environmental Benefits

N/A

Capacity Impacts

Efficient Space Use

Some space traditionally reserved for parking can be used for more valuable uses

(not quantified)

BENEFIT AND COST REALIZATION

Stakeholder	Cost/Benefit	Relative Impact		% Change
		Increase/Decrease	Positive/Negative	
Boston Transportation Department	Capital Costs	Increase	Negative	--
Boston Public Works Department	O&M Costs	Increase	Negative	--
Developer	Real Estate Availability	Increase	Positive	--
Bostonians	Vehicle Accidents	Decrease	Positive	-10%
	Vehicle Accident Injuries	Decrease	Positive	-15%
	Vehicle Accident Fatalities	Decrease	Positive	-4%

Note: Not all benefits have been, or will be, quantified

Considerations:

1. Dorchester Avenue is a high congestion corridor that will benefit from more effective traffic management.
2. While Smart Traffic Management in a small district alone will not create major traffic benefits, it is part of a larger system that has citywide benefits.

05
SMART COMMUNICATIONS TECHNOLOGIES

5A. TELECOMMUNICATIONS UTILIDOR

DESIGN GUIDELINES
TELECOMMUNICATIONS UTILIDOR

OVERVIEW
The Telecommunications Utilidor (Utilidor) is an underground passageway that will contain all telecommunication utility assets. By unifying all the telecom assets in one Utilidor, surface street disruptions will be decreased when telecom utility upgrades/changes are required, as well as when subsequent providers want to add assets. Additionally, by providing opportunity for utility coordination, initial construction costs, as well as future operation and maintenance costs will be reduced.

USE
The Utildior is designed to provide easy access for operation and maintenance and service expansions with minimal disruption to public right of ways. Additionally, the design of the Utilidor, at a minimum, should:
- Coordinate highly collinear routing to reduce the overall encumbrance on surrounding development
- Use a prefabricated utility corridor with racks on the side to hold wire runs and easy-to-remove covers for access at vaults. (The corridor can also be built on-site.)
- Be sized to match the capacity needs. For conceptual purposes, the Utilidor herein is sized at 48 inches wide and 60 inches tall. The Utilidor can be made smaller to fit in congested areas, however, some capacity for additional telecom assets may be lost.

CONSIDERATIONS
The Utilidor can allow rapid access to conduits/fiber without requiring the digging of trenches. Therefore, it is important to account for utility access needs during design and map out the corresponding utility access points accordingly. Access is provided through a series of manholes or removable pavers depending upon Utilidor placement and final design. Although a walkable or crawable Utilidor is ideal, if space conditions do not allow, a smaller tunnel/culvert-type passageway with fiber placed in inner-ducts can be utilized. Additional considerations include:
- Housing specifications of the telecom utilities within Utilidor
- Development of policies regarding access to and security of each telephone providers' assets
- Analysis of drainage issues due to potential water infiltration of Utilidor (possible resolutions include construction of an underdrain system that links to the storm sewer).
- Inspection and maintenance procedures and frequency
- Coordination of connections to customer sites at vaults

DESIGN GUIDELINES

40’ ROW

Legend

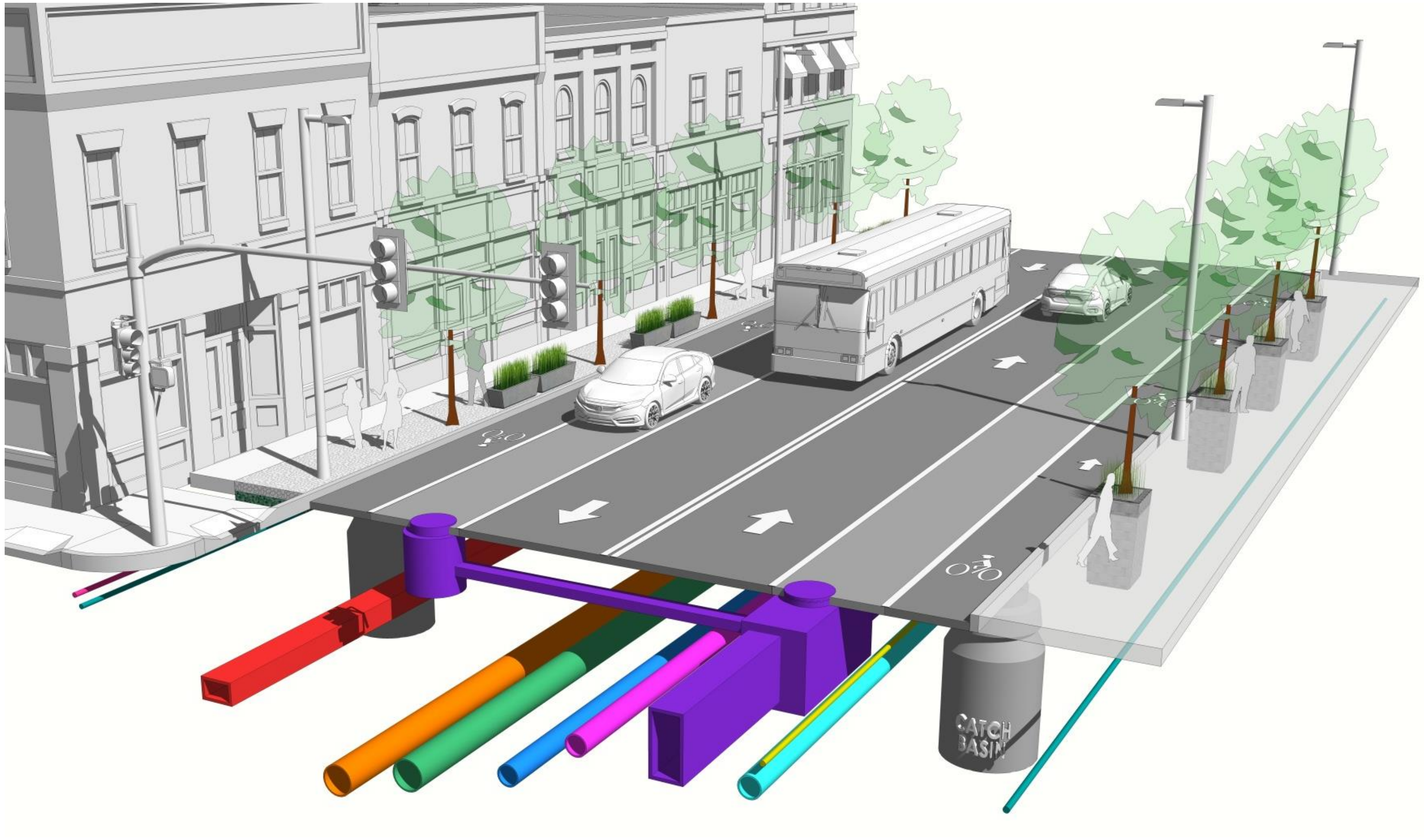
- Electrical Duct Bank
- Sewer
- Storm Drainage
- Water
- Street Lighting
- Traffic Signal
- Gas
- Telecom Utilidor
- Smart Sensors
- District Chilled Water Distribution Line
- District Hot Water Distribution Line
- Biorentention Planter

Notes

1. The information included herein is for conceptual purposes only and does not override the requirements of *Boston Complete Streets Guide 2013* which provides specific location criteria for each of the street assets. For example, the locations of street assets (streetlights, sidewalks, trees, etc.) shown herein are conceptual only.
2. The information included herein is for conceptual purposes only and does not override the requirements of the various City departments ((Public Works Department, Transportation Department, etc.) and other utility stakeholders, including Boston Water and Sewer Commission, MBTA, Eversource Energy, National Grid and the various telecommunication providers. For example, the size, location and clearance information of each utility shown is conceptual only.
3. The size of utilities depicted are at the distribution level. Larger pipework for transmission level services will require special accommodation.

DESIGN GUIDELINES

60' ROW



Legend

- Electrical Duct Bank
- Sewer
- Storm Drainage
- Water
- Street Lighting
- Traffic Signal
- Gas
- Telecom Utilidor
- Smart Sensors
- District Chilled Water Distribution Line
- District Hot Water
- Biorentention Planter
- Permeable Pavement
- Infiltration Bed
- Bioretention Basin

Notes

1. The information included herein is for conceptual purposes only and does not override the requirements of *Boston Complete Streets Guide 2013* which provides specific location criteria for each of the street assets. For example, the locations of street assets (streetlights, sidewalks, trees, etc.) shown herein are conceptual only.
2. The information included herein is for conceptual purposes only and does not override the requirements of the various City departments ((Public Works Department, Transportation Department, etc.) and other utility stakeholders, including Boston Water and Sewer Commission, MBTA, Eversource Energy, National Grid and the various telecommunication providers. For example, the size, location and clearance information of each utility shown is conceptual only.
3. The size of utilities depicted are at the distribution level. Larger pipework for transmission level services will require special accommodation.

DESIGN GUIDELINES
UTILIDOR DESIGN & EQUIPMENT

Distribution Option 1

Streets within new development or major reconstruction area,
high congestion of underground utilities

High-capacity conduits will be used when tunnel systems are deemed infeasible.

Manholes and/or pull covers allow access to underground vaults and/or waist-high vaults for service and construction.

Point of entry to building or curbside allows access to multiple retail service providers.

Distribution Option 2

Streets within new development or major reconstruction area,
minimum congestion of underground utilities

Walkable and/or crawlable tunnel system with wall-mounted racks for wire line.

Photo:www.udevices.com/wunpeece-spacer.html

Photo: www.advanceconcreteproducts.com/1/acp/precast_concrete_manholes.asp

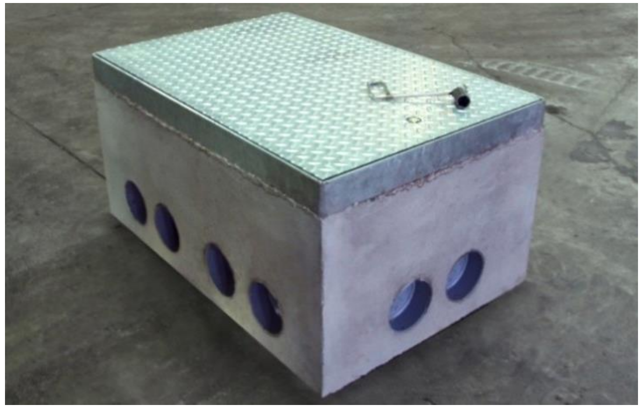


Photo: http://concastinc.com/images/hi-res/FHR_Shop_foto.jpg

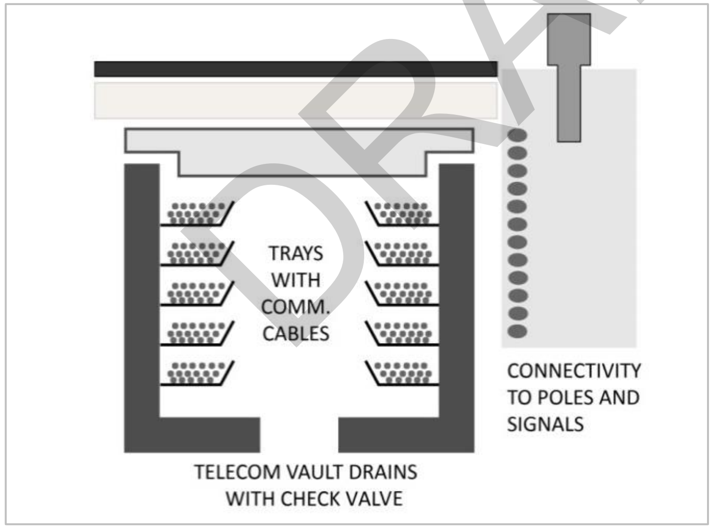


Photo: AECOM

CONCEPTUAL LAYOUT DESIGNS

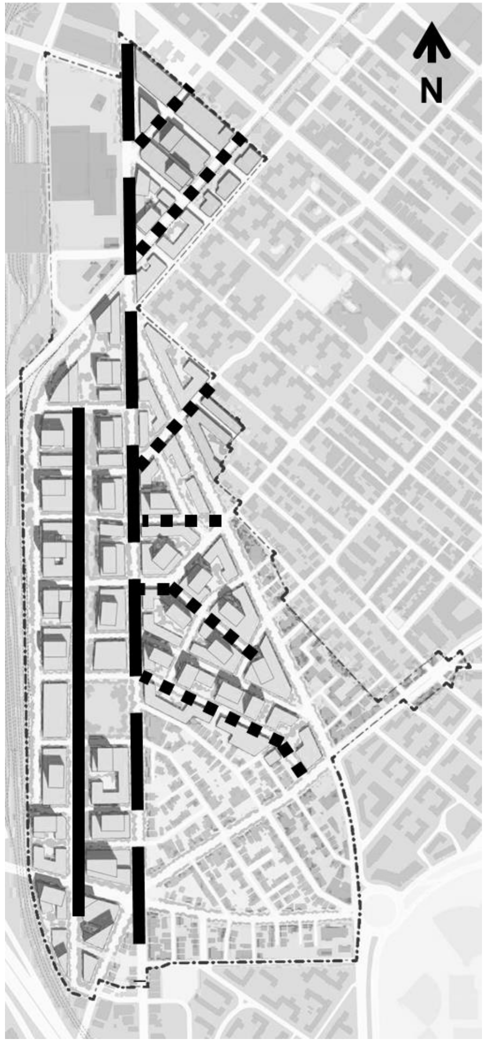
- Based on a simulated, sporadic build-out of the Pilot Project Area* (see appendix) three conceptual design layouts were analyzed and costed.
- The conceptual infrastructure layouts are shown in the three maps to the right.
- Utilidors are assumed to be built in the year 2022 with distribution build as sites develop (see Appendix for site development phasing)

Construction Component

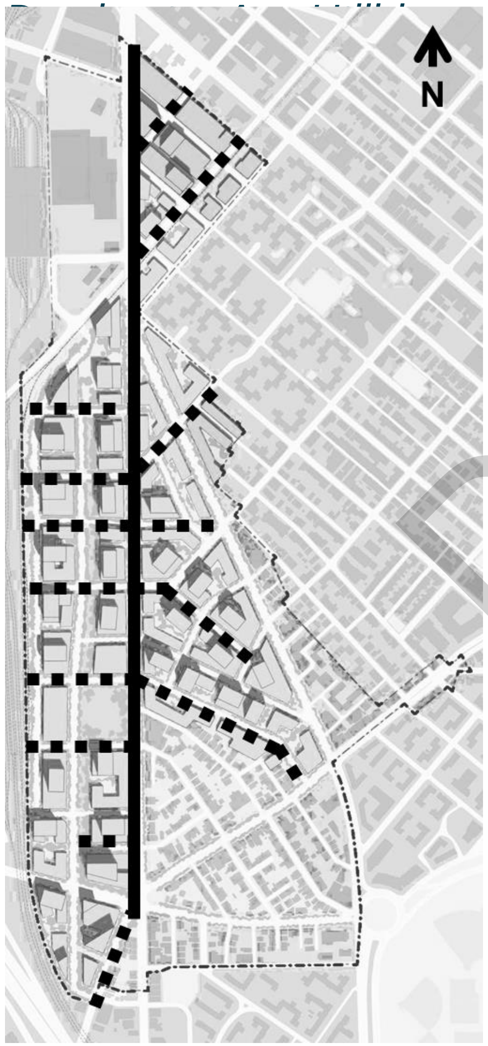
Existing Fiber Trunk	▬ ▬
Distribution	·········
Utilidor	━━━

** Pilot Project Area definition found in the **Smart Utility Standards** document.*

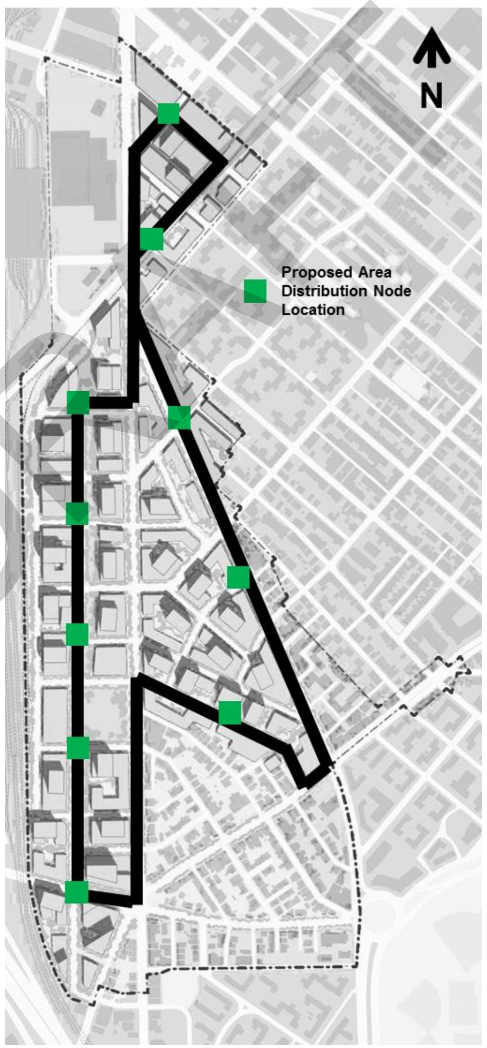
Design A:
Pilot Concept in New Ellery
New Ellery Utilidor



Design B:
Replace Existing Fiber Trunk



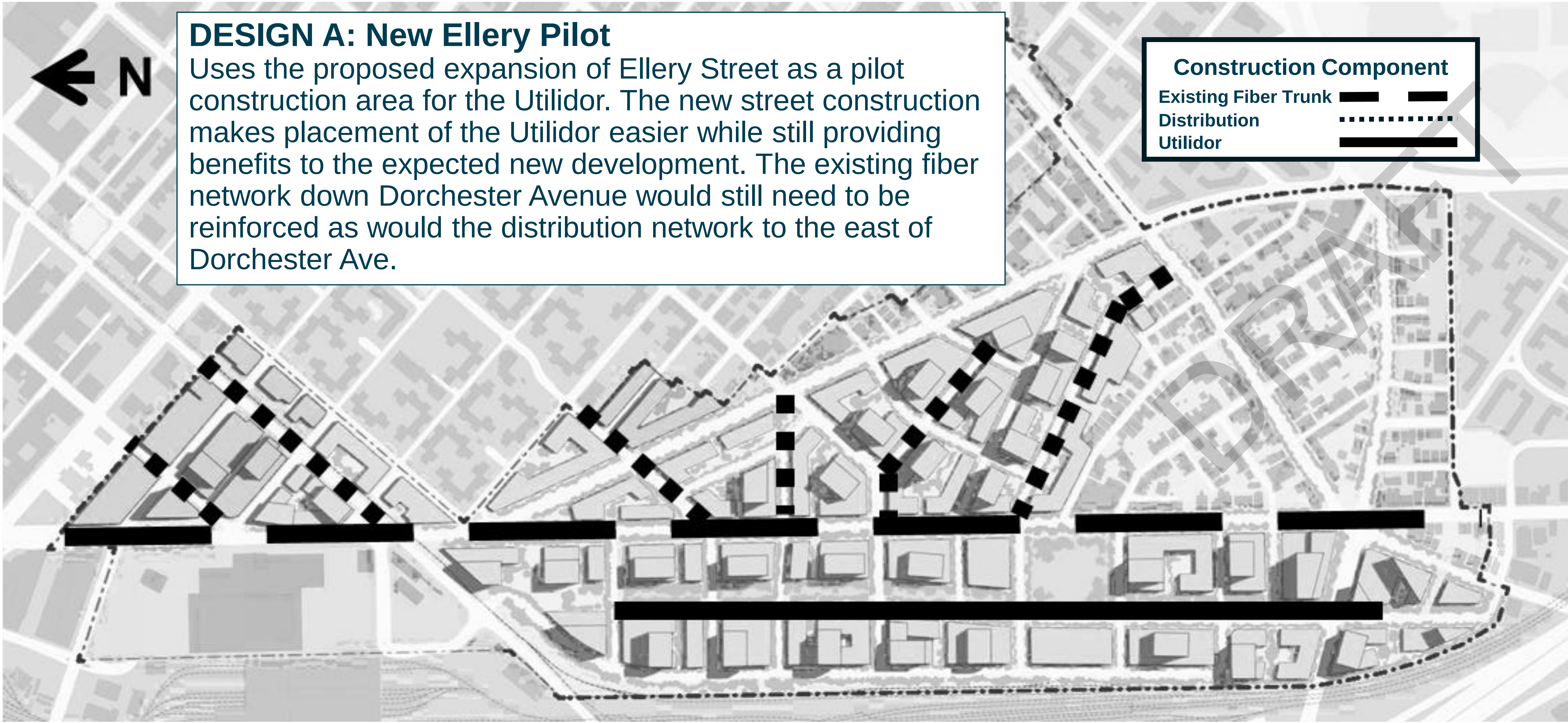
Design C:
Resilient Utilidor
Looped Utilidor System



CONCEPTUAL LAYOUT DESIGNS

DESIGN A: New Ellery Pilot

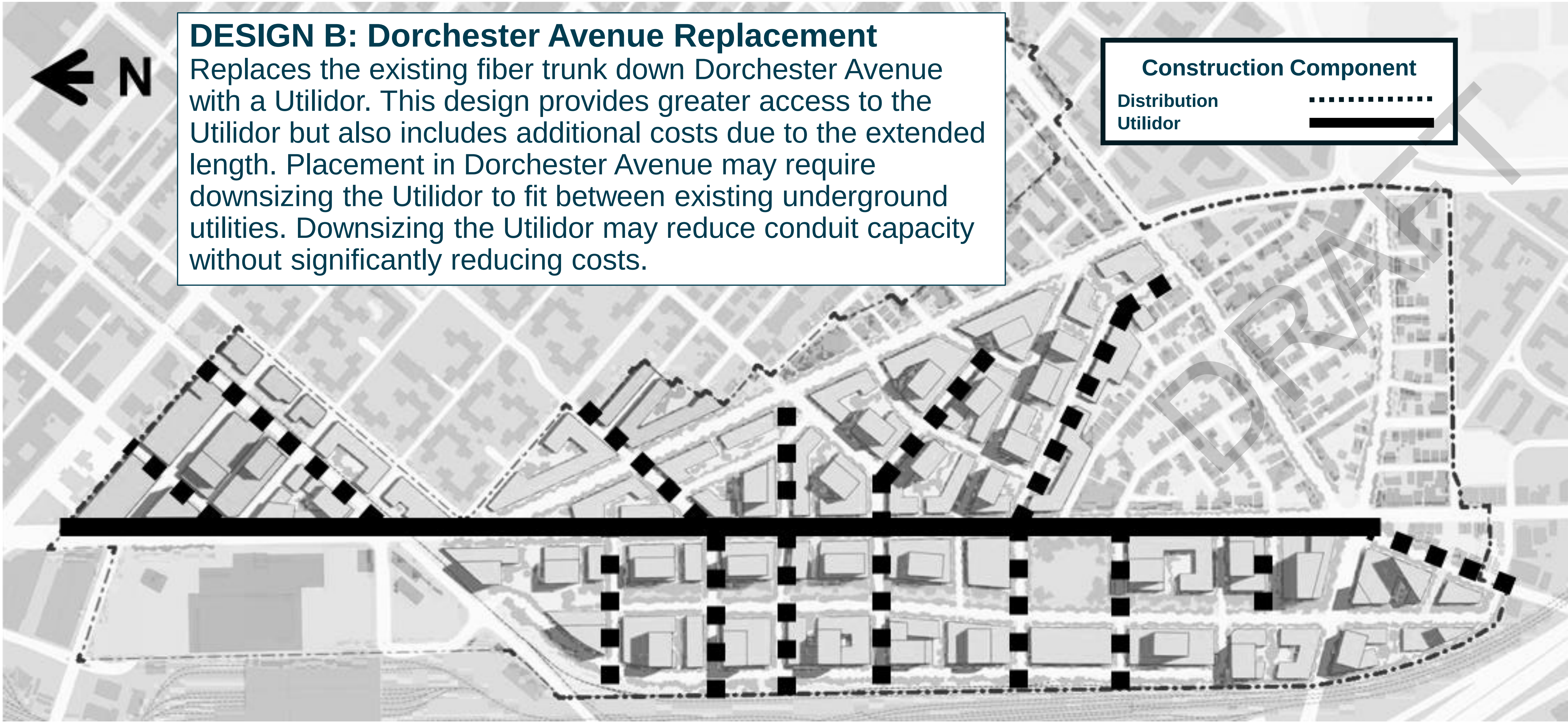
Uses the proposed expansion of Ellery Street as a pilot construction area for the Utilidor. The new street construction makes placement of the Utilidor easier while still providing benefits to the expected new development. The existing fiber network down Dorchester Avenue would still need to be reinforced as would the distribution network to the east of Dorchester Ave.



CONCEPTUAL LAYOUT DESIGNS

DESIGN B: Dorchester Avenue Replacement

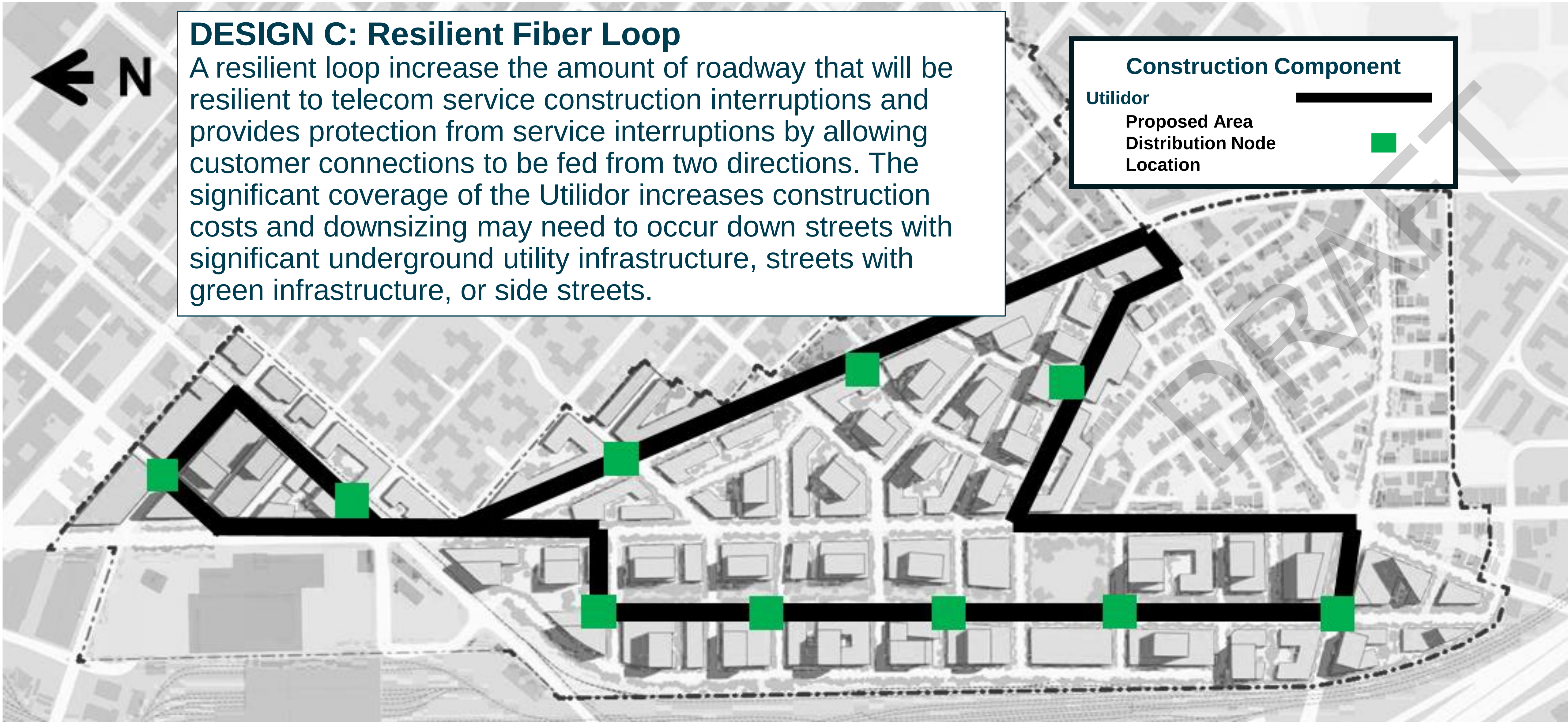
Replaces the existing fiber trunk down Dorchester Avenue with a Utilidor. This design provides greater access to the Utilidor but also includes additional costs due to the extended length. Placement in Dorchester Avenue may require downsizing the Utilidor to fit between existing underground utilities. Downsizing the Utilidor may reduce conduit capacity without significantly reducing costs.



CONCEPTUAL LAYOUT DESIGNS

DESIGN C: Resilient Fiber Loop

A resilient loop increase the amount of roadway that will be resilient to telecom service construction interruptions and provides protection from service interruptions by allowing customer connections to be fed from two directions. The significant coverage of the Utilidor increases construction costs and downsizing may need to occur down streets with significant underground utility infrastructure, streets with green infrastructure, or side streets.



TELECOMMUNICATIONS UTILIDOR & RESILIENT FIBER LOOP

COSTS (USD 2017)

	New Ellery Pilot	Dot Ave Replacement	Resilient Loop
Utilidor	$3 million	$10 million	$15 million
Other Distribution & Laterals	$4 million	$2 million	$2 million
Total Capital Costs	**$6 million**	**$12 million**	**$17 million**
Total O&M Costs (25 years)	**$2 million**	**$2 million**	**$2 million**

New Ellery Pilot: Assumes approximately 2,100 square feet of utilidor
Dorchester Avenue Replacement: Assumes approximately 6,600 square feet of utilidor
Resilient Loop: Assumes approximately 10,100 square feet of utilidor

Values may not total due to rounding
Non-Inflated values

TELECOMMUNICATIONS UTILIDOR

BENEFIT DEFINITIONS

Economic & Fiscal Benefits

Lower Retrenching & Repair Costs*
Utilidor reduces street cuts for service additions and operations & maintenance.
(Estimated utility costs with Utilidor minus baseline costs)

Reduced Road Depreciation*
Reducing street cuts improves the lifespan of the road reducing yearly depreciation.
(estimated as improved lifespan less current lifespan annual depreciation value)

Resilience Benefits

Continuous Service
Design C only –
Resilient Loop design provides protection from service interruptions by allowing customer connections to be fed from two directions.
(not quantified)

End User Impacts

Avoided Business Disruption (Construction)
Utilidor avoids losses to businesses from road construction in front of their properties.
(not quantified)

Traffic Disruptions
Utilidor reduces traffic disruptions for all Bostonians traveling through Pilot Project Area.
(not quantified)

Reduced Barriers to Entry
Equal-access Utilidor reduces barriers to entry for small telcos, increasing competition. Increased competition can lead to reduced utility costs.
(not quantified)

Environmental Benefits

Reduced CO_2 Emissions
Reduced traffic detours and disruptions reduces emissions from vehicles.
(not quantified)

Efficient Materials Consumption
Efficient use of construction materials reduces the total materials used.
(not quantified)

Capacity Impacts

Underground Space Planning
Utilidor organizes telecommunications infrastructure in one area improving space use and capacity for placement of other underground utilities.
(not quantified)

** Denotes a benefit that could potentially be included in future financial analyses*

TELECOMMUNICATIONS UTILIDOR

BENEFITS: DESIGN A - NEW ELLERY PILOT – 25-YEAR ANALYSIS

Economic & Fiscal Benefits

Lower Retrenching & Repair Costs*
$2.1 million

Reduced Road Depreciation*
$2.8 million

Resilience Benefits

Continuous Service
(not quantified)

End User Impacts

Avoided Business Disruption (Construction)
(not quantified)

Traffic Disruptions
(not quantified)

Reduced Barriers to Entry
(not quantified)

Environmental Benefits

Reduced CO_2 Emissions
(not quantified)

Efficient Materials Consumption
(not quantified)

Capacity Impacts

Underground Space Planning
(not quantified)

Note: Inflated, non-discounted estimates
** Denotes a benefit that could potentially be included in future financial analyses*

TELECOMMUNICATIONS UTILIDOR

BENEFITS: DESIGN B - DORCHESTER AVENUE REPLACEMENT– 25-YEAR ANALYSIS

Economic & Fiscal Benefits

Lower Retrenching & Repair Costs*

$2.3 million

Reduced Road Depreciation*

$3.4 million

Resilience Benefits

Continuous Service

(not quantified)

End User Impacts

Avoided Business Disruption (Construction)

(not quantified)

Traffic Disruptions

(not quantified)

Reduced Barriers to Entry

(not quantified)

Environmental Benefits

Reduced CO_2 Emissions

(not quantified)

Efficient Materials Consumption

(not quantified)

Capacity Impacts

Underground Space Planning

(not quantified)

Note: Inflated, non-discounted estimates

** Denotes a benefit that could potentially be included in future financial analyses*

TELECOMMUNICATIONS UTILIDOR

BENEFITS: DESIGN C - RESILIENT FIBER LOOP– 25-YEAR ANALYSIS

Economic & Fiscal Benefits

Lower Retrenching & Repair Costs*

$2.6 million

Reduced Road Depreciation*

$5.2 million

Resilience Benefits

Continuous Service

(not quantified)

End User Impacts

Avoided Business Disruption (Construction)

(not quantified)

Traffic Disruptions

(not quantified)

Reduced Barriers to Entry

(not quantified)

Environmental Benefits

Reduced CO_2 Emissions

(not quantified)

Efficient Materials Consumption

(not quantified)

Capacity Impacts

Underground Space Planning

(not quantified)

Note: Inflated, non-discounted estimates

** Denotes a benefit that could potentially be included in future financial analyses*

TELECOMMUNICATIONS UTILIDOR

RESULTS

7 % Discount Rate Analysis

	Design A New Ellery Pilot	Design B Dorchester Avenue Replacement	Design C Resilient Loop
Net Present Value	$500,000	-$3,400,000	-$6,400,000
Benefit-Cost Ratio	1.1	0.7	0.5
Economic Rate of Return	45%	40%	53%
Return on Investment	100%	52%	42%

3 % Discount Rate Analysis

	Design A New Ellery Pilot	Design B Dorchester Avenue Replacement	Design C Resilient Loop
Net Present Value	$1,500,000	-$3,600,000	-$6,700,000
Benefit-Cost Ratio	1.2	0.7	0.6
Economic Rate of Return	45%	40%	53%
Return on Investment	137%	71%	59%

Note: Figures rounded to the nearest 100,000

Based on the Cost-Benefit Analysis:

- The Design A - New Ellery Pilot is the most attractive pilot program.
- The results for the New Ellery Pilot show that there are enough cumulative benefits from the Utilidor to justify the extra capital investment.
- As not all benefits have been monetized, the Dorchester Avenue Replacement and Resilient Loop designs may still be viable upon further analysis.

UTILIDOR FINANCING AND GOVERNANCE
BENEFICIARIES

Stakeholder	Cost/Benefit	Relative Impact	
		Increase/Decrease	Positive/Negative
Public Works Department/ Developers / Residents / Businesses / Telecom Service Providers	Capital Costs	Increase *(If structured correctly, costs will be allocated according to who benefits, with no net increases)*	Negative
	O&M Costs	Increase	Negative
Public Works Department	Annual Road Depreciation	Decrease	Positive
	Management of Telco Permitting Process	Decrease	Positive
Utilidor-Connected Residents and Businesses	Business Disruptions	Decrease	Positive
Bostonians	Traffic Interruptions	Decrease	Positive
	Utility Costs*	Decrease	Positive

**Assumes that the Utilidor lowers barriers to entry for telecos and increases telecommunications competition, thus lowering utility costs.*
Note: Not all benefits have been, or will be, quantified

TELECOMMUNICATIONS UTILIDOR

CONSIDERATIONS

- Positive Cost-Benefit Analysis: The Cost-Benefit Analysis shows that there are sufficient benefits globally to compensate for the increased cost of the Utilidor.

- Mechanisms for recovering money from benefiting parties need to be identified (e.g., MSA, Fees, Taxes). To do so, costs and benefits can be allocated to relevant beneficiaries to see who has the highest willingness to pay.

- Magnitude of fee* should be such that all costs are recuperated:
    - Construction
    - Management
    - Societal costs (e.g., construction disruption)
- See the **Telecommunications Utilidor Business Plan** for more details.

*In order to estimate fees, more detailed data on existing management costs (e.g., permitting) and societal costs (e.g., traffic disruption costs) are need.

5B. SMART SENSORS

SMART SENSORS

- Smart sensors, enabled through Public Wi-Fi, robust telecommunications infrastructure, or smart streetlights, improve community livability, safety, and health while providing more efficient city services.
- With a robust telecommunications network in place, these technologies can be installed and can provide benefits and services to the community.
- Benefits of Public Wifi, Smart Sensors and Smart Streetlights were not estimated due to scope and ease of implementation

- Potential Smart Sensors:
  - Smart Traffic Management *(discussed In Smart Traffic Management Section)*
  - Disaster Management
  - Flood Sensors
  - Dumpster-Level Detection
  - Air Quality Monitoring & Health Risk Notifications
  - Gunshot Detection
  - Automated light outage detection
  - Water Quality Monitoring
  - Green Infrastructure Sensors

SMART SENSORS
COSTS (2017 USD)

- Approximate costs & project area coverage for sample of sensors
- Recommended geospatial analysis to identify the most effective placement of sensors within the Pilot Project Area

	Unit Costs	Recommended Units	Total Costs
Smart Parking Management	$750	350	$263,000
Disaster Management	$700	5	$3,500
LED Smart Signs	$10,000	5	$50,000
Water Quality Monitoring	$7,500	1	$7,500
Green Infrastructure Sensors	$5,000	6	$30,000
		Total Smart Sensor Budget	**$350,000**

Notes:
1. *Values may not total due to rounding*
2. *Non-inflated values*
3. *O&M Costs not estimated*

BENEFIT AND COST REALIZATION

Stakeholder	Cost/Benefit	Relative Impact	
		Increase/Decrease	Positive/Negative
Smart City Service Company / City / Developers / Residents / Businesses	Capital Costs	Increase	Negative
	O&M Costs	Increase	Negative
Smart City Service Company	Smart City Service Revenues	Increase	Positive
City	Access to Data for Process Improvement	Increase	Positive
	Data Mining Revenue *(if applicable)*	Increase	Positive
Bostonians	Free Wi-Fi Access	Increase	Positive
	Access to Public Data	Increase	Positive
	Community Livability	Increase	Positive
	Community Safety	Increase	Positive
	Public Health	Increase	Positive

Note: Not all benefits have been, or will be, quantified, Capital/O&M costs can be split among a variety of stakeholders

06

APPENDIX

SIMULATED SPORADIC BUILDOUT