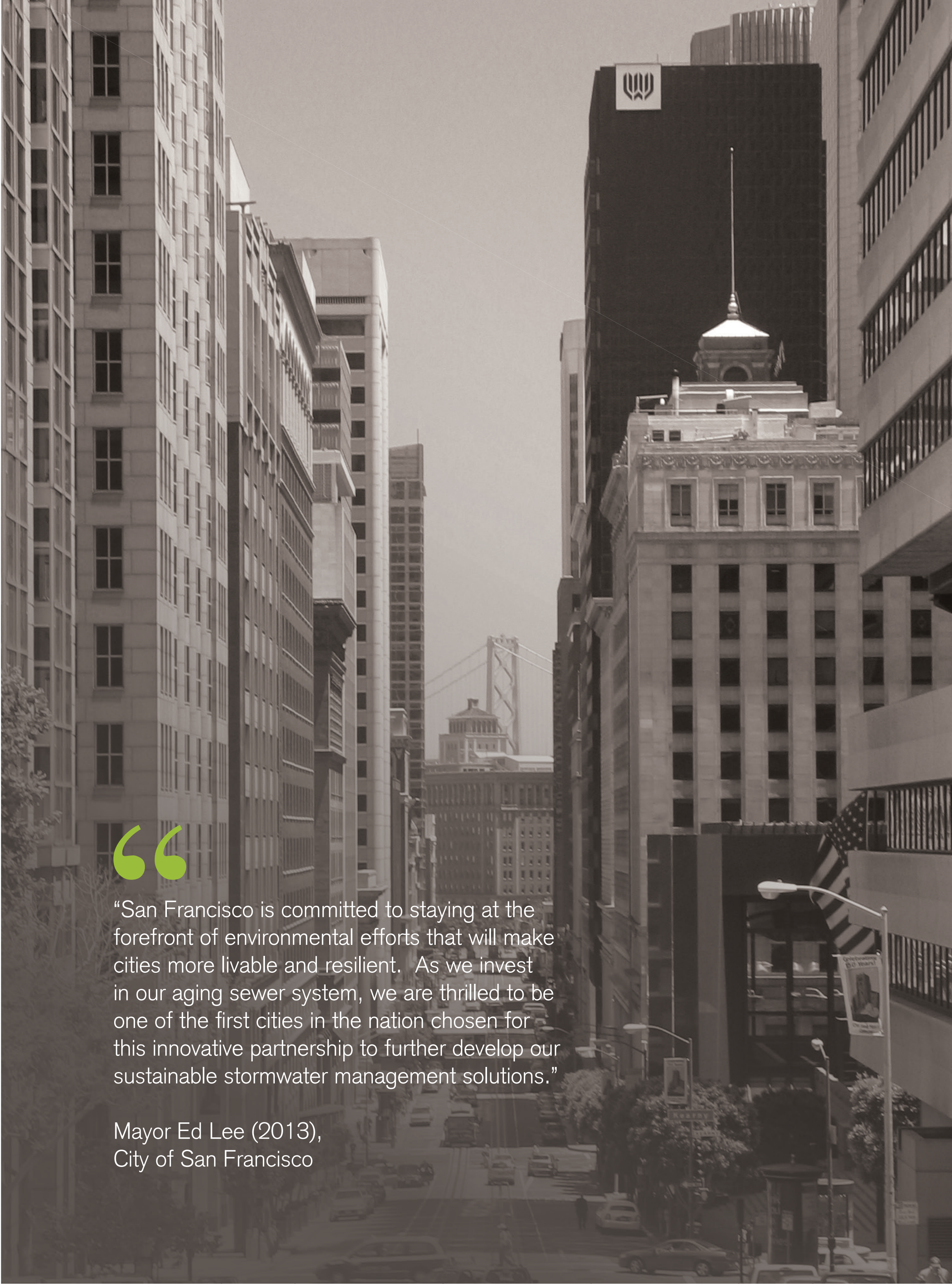
REinvest

CITY REPORT 2015

SAN FRANCISCO



“San Francisco is committed to staying at the forefront of environmental efforts that will make cities more livable and resilient. As we invest in our aging sewer system, we are thrilled to be one of the first cities in the nation chosen for this innovative partnership to further develop our sustainable stormwater management solutions.”

Mayor Ed Lee (2013),
City of San Francisco

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CONTENTS

SAN FRANCISCO REPORT | 2015

FIGURES

TABLES

RE.invest Introduction

There has been significant coverage in the global media about chronic underinvestment in urban infrastructure. It is clear that governments alone cannot be expected to meet all future infrastructure needs with increasingly constrained public budgets. This is especially true in the face of emerging climate impacts, like more severe storms, that mean future infrastructure systems will need to look and function differently than our current systems.

In the face of these challenges, the RE.invest initiative was designed to reimagine city infrastructure systems—including water, energy, and telecommunications among others to enhance community resilience and bridge the gap between planning and large-scale project delivery. Designing new types of projects, not just building more of the same, is essential. To this end, RE.invest was launched based on three core ideas. First, resilience is about systems, not just projects. Careful integration, coordination, and sequencing are essential to make sure that when one domino falls it doesn't take down a whole system. In practice that means that green, resilient, and sustainable infrastructure systems are not made up of a few large projects, but many small pieces and parts. Second, cities need to plan for large networks of small projects to align public and private interests and invest at scale. Costs and benefits associated with resilient infrastructure systems are often spread across sectors; therefore, coordination between sectors during project design is critical, not just for government agencies, but also for investors. Third, when it comes to green and resilient systems, success is often something that doesn't happen. The city didn't flood, the power didn't turn off, even though the storm hit. Capturing these benefits over time requires thoughtful design and advance planning.

Over the last decade, the field of sustainable infrastructure investment has focused largely on developing the financial instruments to deliver resources more effectively. This is essential; however, it is only one part of the solution. Cities and communities must also put forward viable, large-scale projects. To bridge this gap, the RE.invest team provided technical support to translate city needs and priorities into financeable projects using a rapid, structured, and replicable project preparation and delivery process designed to generate innovative integrated resilient infrastructure investment opportunities.

In San Francisco, the RE.invest Team focused on providing analysis, recommendations and funding strategies to help the City of San Francisco promote privately owned non-potable water systems, in coordination with broader publicly owned recycled water treatment and distribution systems, in the Central SoMa eco-district and beyond through both new construction and the retrofit of existing building stock.

Overview

San Francisco is the only consolidated city-county in California, encompassing a land area of 46.9 square miles on the northern end of the San Francisco Peninsula at a density of approximately 17,179 people per square mile.

Broadly, San Francisco has been recognized for its innovation in city sustainability. A 2011 survey by Siemens and the Economist Intelligence Unit (EIU) found San Francisco to be the greenest major city in the U.S. and Canada. This is due in large part to San Francisco's progressive environmental policies related to climate change, zero waste, green building and energy and water efficiency.

Over the last decade, the City's Planning Department has designed for significant growth in the city and anticipated continued densification of the urban center. State and local environmental goals and requirements aim to drive future growth to be more sustainable, particularly in the areas of water and energy conservation and waste reduction. The San Francisco Public Utilities Commission (SFPUC) has also pursued a series of policy tools to support greater water efficiency. Each of those efforts is described here.

- COMMERCIAL WATER CONSERVATION ORDINANCE
  This ordinance requires properties to repair plumbing leaks and replace inefficient plumbing fixtures including toilets, urinals, faucets, and showerheads with high-efficiency models. Retrofits for commercial properties are required by 2017 or upon major improvements.

- RESIDENTIAL ENERGY AND WATER CONSERVATION ORDINANCE
  This ordinance requires properties to repair plumbing leaks and replace inefficient plumbing fixtures including toilets, faucets, and shower- heads with high-efficiency models. Residential retrofits are required upon sale of the property or at the time of major improvements.

- NON-POTABLE WATER ORDINANCE
  The Non-potable Water Program creates a streamlined process for new commercial, multi-family, and mixed-use developments in San Francisco that choose to collect, treat, and reuse alternate water sources for toilet flushing, irrigation and other non-potable uses. Alternate water sources include: rainwater, stormwater, graywater, foundation drainage, and blackwater.

- RECYCLED WATER ORDINANCE
  Projects located in the City's designated recycled water use areas are required to install recycled water systems for irrigation, cooling, and/or toilet and urinal flushing. New construction, subdivisions, or major alterations with a total cumulative area of 40,000 square feet or more, and any new, modified, or existing irrigated areas of 10,000 square feet or more are required to comply with this ordinance. In a mixed-used residential building where a recycled water system is installed, any restaurant or other retail food-handling establishment must be supplied by a separate potable water system to ensure public health and safety.

- WATER EFFICIENT IRRIGATION ORDINANCE
  To ensure the efficient use of water for the City's landscapes, all projects with 1,000 square feet or more of new or modified landscape area are required to comply with this ordinance. Projects must design, install, and maintain efficient irrigation systems, utilize low water- use plantings, and calculate a water budget.

- STORMWATER MANAGEMENT ORDINANCE
  To protect the water quality of San Francisco Bay and the Pacific Ocean, and to enhance the function of the City's sewer systems, the Stormwater Management Ordinance requires all new and redevelopment projects that disturb 5,000 square feet or more of ground surface, or surface over water, to comply with the Stormwater Design Guidelines and manage a portion of their stormwater on-site. Ground surface disturbance is measured cumulatively across the development project.

Central SoMa

The City's plan for Central SoMa intends to build off the neighborhood's strengths, while addressing many of its challenges, with a comprehensive strategy to address land use, building size and heights, transportation, the public realm (including sidewalks and open space), preservation of historic buildings and environmental sustainability.

The Central SoMa Plan intends to accomplish the following goals:

- Support transit-oriented growth, particularly workplace growth, in the Central SoMa Area.
- Shape the area's urban form recognizing both city and neighborhood contexts.
- Maintain the area's vibrant economic and physical diversity.
- Support growth with improved streets, additional open space, and other elements of "complete communities".
- Create a model of sustainable growth.

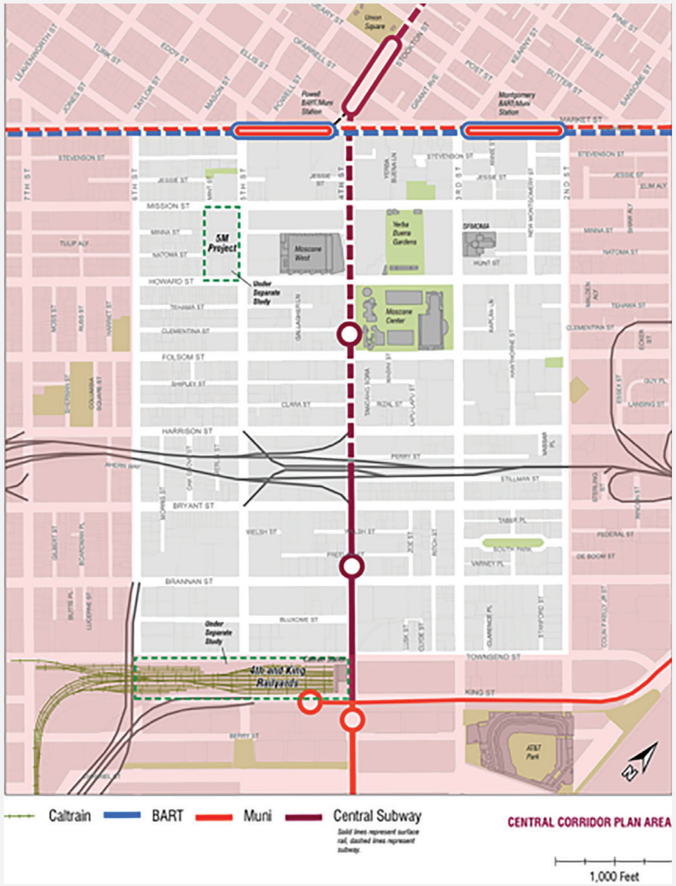

Figure 1. Central SoMa Plan Area (source: Central SoMa Plan)

The Central SoMa Plan Area covers a 24 square block area south of Market Street, from Market Street to Townsend, and from 2nd Street to 6th Street that notably includes the CalTrain station, a freeway and the Moscone Convention Center. This once-industrial area is now positioned to become a growing center of the City and region's high-tech industry.

GROWTH POTENTIAL - RESIDENTIAL	RESIDENTIAL AREA sq. ft.	RESIDENTIAL UNITS	COMMERCIAL AREA sq. ft.
Under Existing Zoning	9,872,355	8,225	3,827,445
Growth Potential under Central SoMa Plan	4,185,900	3,490	5,563,700
Total Growth	14,058,255 (approx. 11, 715 units)	11,715	9,391,145

Table 1 - Growth Potential in Central SoMa lists the residential and commercial growth potential estimated in the Central SoMa Plan

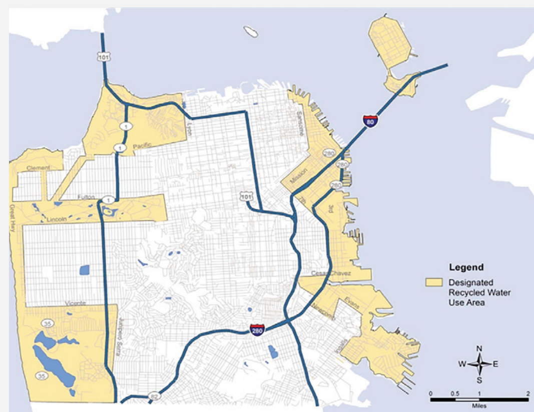

Figure 2. Designated Recycled Water Use Areas (Source SFPUC)

The development plans, in combination with the fact that the Central SoMa plan area is inside the City's recycled water use area, as seen in Figure 2, provides a real opportunity to support the development of privately owned water reuse systems.

Because the Recycled Water Ordinance requires that all new development above the proscribed thresholds must install dual plumbing, implementing building-level reuse projects near high-density wastewater supply and areas of high demand for non-potable water can reduce the need for long recycled water distribution mains and create new opportunities for local developers.

The Central SoMa Eco-District Task Force Recommendations Report proposed a strategy for leveraging redevelopment investments to make Central SoMa a model for sustainability. As seen in Figure 3, the report issued a conceptual rendering of how district-scale energy or water systems could serve the Central SoMa area.

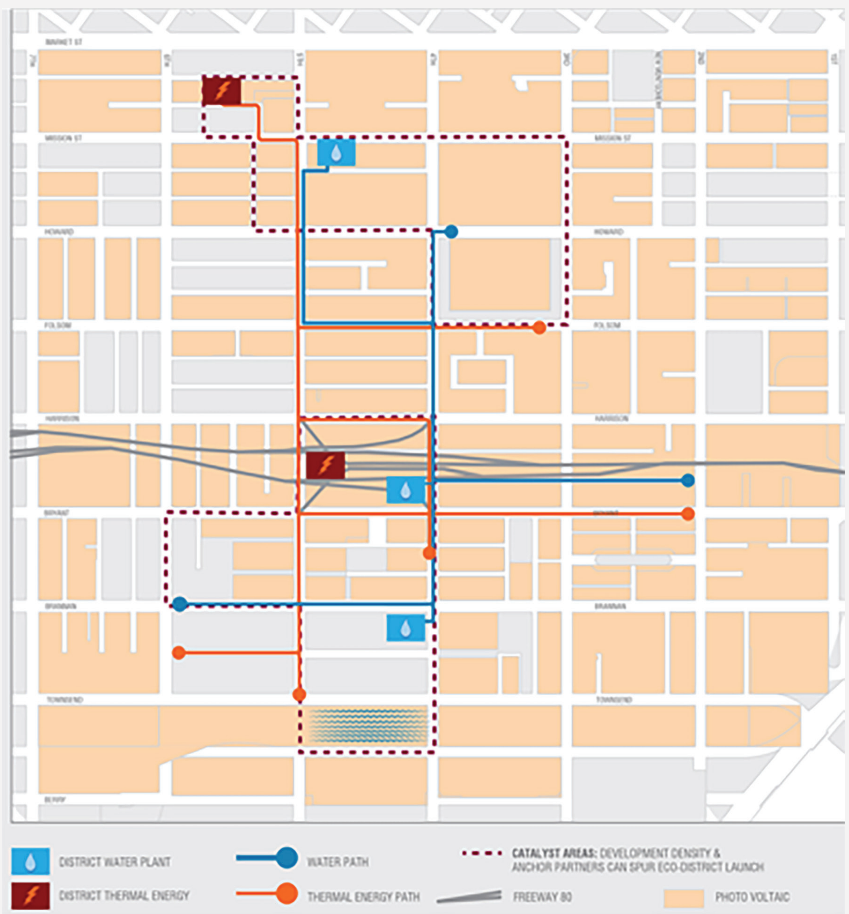

Figure 3. Conceptual Eco-District Utility Systems
(Source: Central SoMa Eco-District Task Force Recommendations Report 2013)

The reality is retrofitting a developed urban area like Central SoMa with a recycled water distribution system can be expensive.
That is both because of the cost related to installing dual-plumbing in existing and new buildings and for updating the broader municipal infrastructure for carrying recycled water within the area. But cost effectiveness is not the only factor in determining the feasibility of these systems as water re-use systems provide many environmental and economic benefits as well. In some cases, the benefits of conserving potable water may justify the cost.
For example, in some cities, a water reuse system may be cost-effective if the reclaimed water system reduces the need to obtain additional water supplies from considerable distances, treat a raw water supply source of poor quality, or treat wastewater to stricter surface water discharge requirements.

In developing urban areas like Central SoMa, substantial cost savings may be realized for both the municipality and individual building owners by installing a dual distribution system as developments are constructed.

Non-Potable Water Demand

In Central Soma

The SFPUC's non-potable water calculator uses building information (gross area, number of occupants and nature of occupancy) to estimate the non-potable water demand of proposed developments. The calculator was used by the San Francisco Planning Department to estimate with the potential demand for non-potable water within the Central SoMa development area for an Environmental Impact Report. Those estimates are included to describe the potential recycled water market in the area.

Based on projected growth within existing and new buildings in the plan area, the total water demand is 585,255,287 gallons per year, non-potable demand as of December 2014, including all domestic fixtures, cooling and irrigation is 221,461,080 gallons per year. Total supply of alternative water sources including stormwater and treated greywater from blackwater, rainwater and even foundation drainage, is 217,675,891 - which means that 37% of Central SoMa's total water demand can be off-set by using on-site supplies for non-potable uses and almost 100% of the district's non-potable water demand can be off-set from on-site supplies.

POTENTIAL DEVELOPMENT	RESIDENTIAL	COMMERCIAL	
Occupancy	Multi-family	General office, 250 days/year	
Gross Area	14,058,255 sq. ft.	9,391,145 sq. ft.	
POTENTIAL DEVELOPMENT	RESIDENTIAL	COMMERCIAL	
POTENTIAL DEVELOPMENT	RESIDENTIAL (gpy)	COMMERCIAL (gpy)	TOTAL (gpy)
Irrigation	51,497,535	56,310,756	107,808,291
Toilets/Urinals	-	1,098,542	1,098,542
TOTAL	51,497,535	57,409,298	108,906,833

Table 2. Projected Non-potable Water Demands in Central SoMa Development Area

The analysis assumes that urban irrigation demands are limited to small-scale landscaping incidental to commercial developments, and does not include the additional irrigation demands that would arise from parks and other municipally owned open space as this report focuses on privately owned systems and users.

Non-Potable Water Solutions
In Central Soma

The Central SoMa Area Plan provides a functional opportunity for the City to test and model strategies for addressing growing water demands reliably and sustainably by treating greywater and stormwater on-site for re-use in buildings to meet non-potable water demand.

According to their website, the SFPUC, through its commitment to develop sustainable local supplies, anticipates reducing demand by 14mgd – 5mgd from active conservation measures and 9 mgd from passive plumbing code and ordinance requirements. The SFPUC's conservation program currently provides incentives, services, and education to retail customers to reduce water use and achieve compliance with existing legislation. To further expand its conservation efforts, the SFPUC is also looking to nontraditional sources of water through its Non-Potable Water Program to encourage the use or reuse of rainwater, graywater, and other sources for non-potable uses.

Currently, San Francisco's centralized wastewater treatment system managed by SFPUC collects and treats stormwater and wastewater from the entire City. Recently the SFPUC completed construction of two smaller recycled water projects, the first in collaboration with Daly City to produce and deliver recycled water to irrigate Harding Park and Fleming Golf Course and the second in collaboration with North Coast County Water District to meet the irrigation needs of Sharp Park Golf Course. In addition, the SFPUC's Westside Recycled Water Project, which is currently under design, will produce and supply up to 2 million gallons per day of recycled water for non-drinking purposes such as irrigation and toilet flushing. In contrast to these more centralized systems, distributed treatment is designed to work at the scale of a large high rise apartment building, a cluster of residential homes, or a commercial or industrial park - reusing the treated effluent onsite or at adjacent properties to offset potable water use. The treated water can be used for a variety of non-potable uses, including toilet flushing, irrigation, and heating and cooling systems.

Within Central SoMa, the projected demands are assumed to increase incrementally as development that exceeds the square footage threshold limits set by the Recycled Water Ordinance occurs. For this report, the RE.invest team focused on the viability of privately owned distributed recycled water treatment facilities for fulfilling anticipated increasing non-potable demand within the Central SoMa plan area as development occurs.

Private non-potable water systems can be implemented at a variety of different scales.
The RE.invest team identified three ways to achieve economic scale in Central SoMa: (1) an individual building owner could install a non-potable water treatment system and sell any treated water not used onsite to nearby customers, (2) individual property owners can join together in a cooperative program, or (3) the City could support the installation of a publicly owned non-potable treatment system designed to support the entire plan area. The SFPUC defines "district-scale" as a group of buildings selling and/or sharing water resources, however for the purposes of this report the RE.invest team differentiated between these three scales in order to understand incentives and economic feasibility.

BUILDING LEVEL
At this level, an individual property owner can install a non-potable water system onsite to treat their own alternate water sources, similar to the SFPUC's Living Machine installation at their own headquarters. As an extension of traditional building-scale implementation approaches, individual property owners could sell excess treated water not used onsite to other nearby non-potable consumers by leveraging existing or installing new distribution systems and structuring purchase contracts with those consumers by leveraging existing or installing new distribution systems and structuring purchase contracts with those customers.

BLOCK LEVEL
At this level, a non-potable water system consisting of an underground cistern with an integrated treatment system could be designed to hold alternate water sources for a set of buildings, creating a closed-loop non-potable water reuse system for anywhere from one city block to multiple city blocks. The implementation strategy at this scale is similar to a savings-sharing model used on college and business campuses to aggregate savings from energy efficiency investments in multiple-buildings.

DISTRICT LEVEL
At the district-level, the City and/or SFPUC have the option to create a publicly owned recycled water distribution system for the entire Central SoMa area. This option was evaluated for its technical feasibility, but subsequently not prioritized for further analysis under this Initiative based on the longstanding position of the San Francisco Public Utilities Commission to avoid ownership of distributed non-potable water within sub-districts of the City.

The following section describes treatment scenarios that could be applied or scaled at the individual building or cooperative block level as described.

Treatment Scenarios

There are a variety of treatment technologies and systems that could be utilized by private property owners to produce reusable non-potable water. In order to analyze capital along with operations and maintenance costs, this report evaluated the following options[1].

Membrane Bioreactor

Membrane bioreactor technologies are known for providing high quality effluent with smaller space requirements than conventional biological systems. By combining a suspended growth biological reactor with solids removal via a microfiltration membrane the MBR system replaces the secondary clarifier and sand filtration often used in conventional activated sludge wastewater treatment. Often MBR treatment trains include additional processes such as reverse osmosis and disinfection. The treatment train is shown in Figure 4.

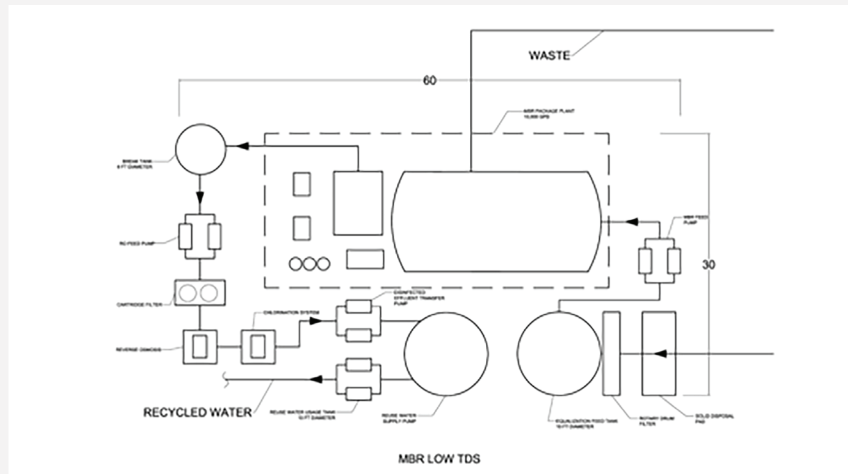

Figure 4. Membrane Bioreactor with Low Total Dissolved Solids

1 These wastewater treatment technologies are described in depth in EPA (2002), EPA (2007) and EPA (2012)

The primary disadvantage of MBR systems is the typically higher operating costs than conventional systems for the same output. This is based mostly on the need for additional maintenance including membrane cleaning, fouling control, and relatively high energy demands. However, in certain situations - including retrofits - MBR systems can realize lower or at least competitive capital costs when compared with alternatives. This is because minimal space requirements and smaller tanks can reduce capital costs associated with construction in addition to limiting any opportunity costs from losing revenue-generating space.

Engineered Wetland

Constructed wetlands are artificial wastewater treatment systems consisting of shallow ponds or channels which have been planted with aquatic plants, and rely on natural microbial, biological, physical and chemical processes to treat wastewater. Typically, engineered wetlands have a series of impervious clay and/or synthetic liners along with man-made structures to control the flow direction, detention time and level. Constructed wetlands have been used to treat a variety of wastewaters including urban runoff, municipal, industrial, agricultural and acid mine drainage.

The RE.invest team looked specifically at the Living Machine system used in SFPUC's headquarters as an example engineered wetland. This trademarked process uses the same basic processes (e.g. sedimentation, filtration, clarification, anaerobic and aerobic decomposition) as are applied in conventional biological treatment within a medium of wetland cells filled with special gravel. The cells are alternately filled and emptied as the wastewater flows in, and the process is completed by disinfection prior to reuse.

Figure 5 shows a site schematic diagram of a Living Machine. Because of the living plant features, the Living Machine system provides a unique and aesthetically pleasing environment while treating and recycling wastewater, which is ideal in a high-density area like Central SoMa. However, because of the living elements, the system requires a consistent and temperate climate and can be constructed either outdoors or within a greenhouse.

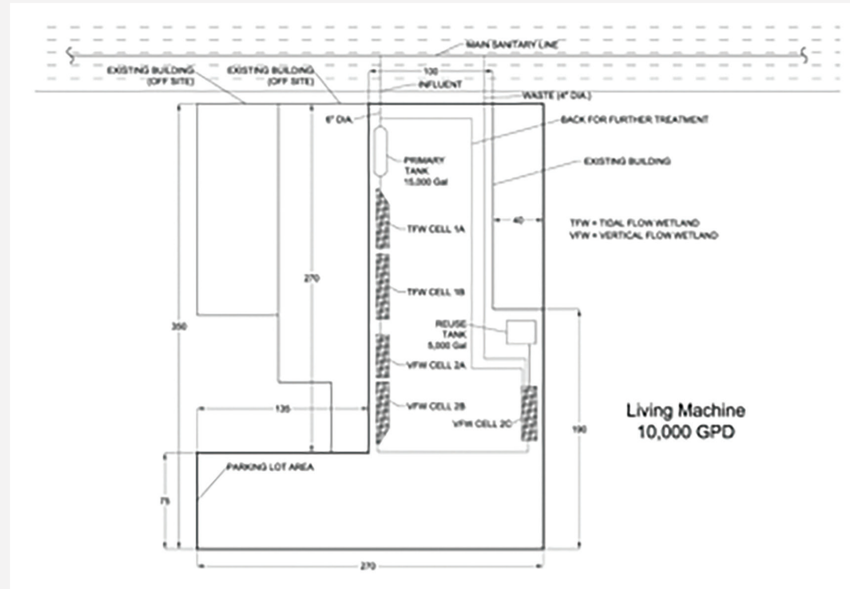

Figure 5. Living Machine

Recovered Foundation Drainage

Given the potential for a high-groundwater table in the Central SOMA area, the RE.invest team also reviewed a simpler treatment process should a building or co-op choose to store and treat only recovered foundation drainage. Depending on the quality of groundwater, the treatment level may vary. For this report, the team looked at treatment consisting of filtration and disinfection for water with low total dissolved solids, and in the case of groundwater with high total dissolved solids an electrodialysis reversal process was added to the described treatment train. Electrodialysis reversal is a process whereby dissolved ions are migrated by an electric current through a series of ion exchange membranes which provides an additional layer of treatment. A typical site schematic for groundwater recovery is shown in Figure 6.

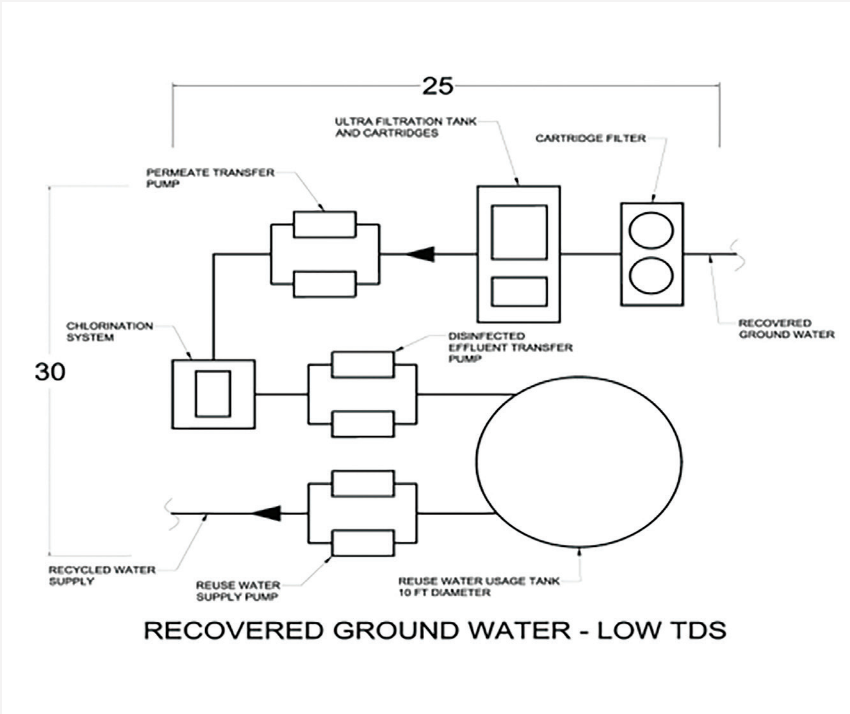

Figure 6. Recovered Groundwater with Low Total Dissolved Solids

TREATMENT TRAIN	INFLUENT			EFFLUENT		FLOW gpd	AREA sq. ft.
	High/Low TDS	TDS mg/l	TURBIDITY NTU	TDS mg/l	TURBIDITY NTU		
MBR	Low	<450	5-10	<450	<0.5, 0.2 average	10,000	2,000
MBR	High	>450	5-10	<450	<0.5, 0.2 average	10,000	2,000
Engineered Wetland (Living Machine)	Low	<450	5-10	<450	<10, 2 average	10,000	5,000
Engineered Wetland (Living Machine)	Not able to process wastewater with high TDS as defined	N/A	N/A	N/A	N/A	N/A	N/A
Groundwater (w/only filtration and disinfection)	Low	<450	5-10	<450	<10, 2 average	10,000	2,000
Groundwater (w/ filtration, electrodialysis reversal, and disinfection)	High	>450	5-10	<450	<10, 2 average	10,000	2,000

Table 3. Comparison of Identified Treatment Trains

Regardless of the chosen system, the treatment process would need to meet effluent requirements as determined by Article 12C of the San Francisco Health Code. Because the principal uses for recycled water in Central SoMa are likely to include toilet flushing, irrigation, heating and cooling, the RE.invest team considered two scenarios of source water quality to assess relative costs. Based on the maximum allowable total dissolved solids in water used for irrigation based on Article 12C of the health code, the first scenario considered was for wastewater with low total dissolved solids (TDS, less than 450 mg/l) and the second was for wastewater with high total dissolved solids (greater than 450 mg/l).

Table 3 lists the treatment trains, influent and effluent water quality, treatment processes, and estimates the area required for each facility based on a 10,000 gallons per day (11 afy) capacity, which if deployed could feasibly serve the needs of two commercial buildings sized similarly to SFPUC Headquarters.

For retrofitting an existing building, of which there are many in Central SoMa, each treatment system would need to be connected to an expanded piping system. The retrofit process includes the installation of an alternate water source collection and non-potable distribution system. An alternate water source collection system includes infrastructure such as rainwater gutters, foundation drainage sump pumps, or graywater piping systems. This would also include equalization storage to help level flow prior to treatment as supplies vary throughout the day. Dual plumbing is also necessary to distribute the treated non-potable water to users. Also referred to as “purple pipe”, this separate distribution system must be colored or marked purple to distinguish it from the potable water system to protect against cross connection with the potable water supply.

Siting Options

All of the treatment scenarios reviewed by the RE.invest team can be designed for deployment in a dense urban area like Central SoMa and can be scaled based on both demand and siting availability.

Generally, distributed recycled water treatment facilitates are most cost effective when sited near both a steady supply of wastewater and a demand. For example, when comparing a high-rise apartment building with a high-rise office building, the apartment building is likely to both supply more wastewater and demand more non-potable water. This is because apartment buildings often have at least one full bathroom and one full kitchen per unit in addition to laundry services, which means showers, toilets, washing machines and sinks that serve as sources for capturing wastewater, along with toilets and perhaps community green spaces that could use non-potable water. That being said, areas of dense development with high water demand and available space of at least 2000 square feet within a building or open outdoor space for installation can serve as an effective site for recycled water treatment.

BUILDING LEVEL

If a private property owner intended to develop an onsite water system, they could use any area within the property lines. For example, a building could construct an MBR system in a basement, or site a Living Machine throughout the property as done at SFPUC's headquarters. In this case, all projects would be required to obtain a plumbing permit from the San Francisco Department of Buildings and Inspection (SFDBI) and approval of the Engineering Report from SF Department of Public Health (SFDPH).

BLOCK LEVEL

If a set of private property owners intended to develop a co-op recycled water treatment facility, the siting could be more complicated. Like the building level facility, the co-op could site within a single building or an outdoor space owned by a member of the co-op. Like a building level system, the co-op would be required to obtain the same plumbing permit and approval of the Engineering Report. In addition, any projects that require infrastructure located within the public right-of-way (e.g. sidewalk or roadway) would need to obtain a Minor and/or Major Encroachment Permit from the Department of Public Works. While not overly burdensome, this additional complication could be a dis-incentive for property owners. For this reason, the RE.invest team suggests that a co-op structure would likely to be most cost-effective when buildings are located within a city block and/or do not have to cross a municipal right-of-way.

A number of locations have been identified by the Planning Department (September 2014) as potential development sites that could be evaluated with developer interest for distributed recycled water systems based on the previously described criteria. Some of these include those listed below.

- SKS (flower mart) Development (610-620 Brannan Street)
- KILROY (flower mart) Development site (Brannan and 6th Street)
- Bank of America development site (501- 505 Brannan Street)
- Bay Tennis Club (645 5th Street)
- CIM Group 330 Townsand Street
- 85 Bluxome Street
- Bluxome Street (btw 4th & 5th Streets)

DISTRICT LEVEL

A larger district scale recycled water treatment facility to support the entire plan area could be pursued if a set of buildings are interested in pursuing recycled water projects but are physically dispersed – meaning collection and distribution would need to cross multiple public right of ways - throughout the Central SoMa area. In that case, siting would need to be coordinated with the City as both placement and distribution may impact other development potential. Because of the complication related to coordination, a single property owner or even a collective of property owners are unlikely to pursue this option, making it feasible only for City development and ownership.

Relative Costs

The RE.invest team used a modular plan with 10,000 gallons per day (11 afy) capacity - twice the flow at the SFPUC's Living Machine at its headquarters - to establish overall costs and benefits. Analysis at this scale allowed the RE.invest team to cost out a variety of treatment scenarios that could be scaled as demand increased. The estimates provided outline the costs required for construction and annual operation of the various systems.

TREATMENT SYSTEM	FLOW gpd	CONSTRUCTION COST	ANNUAL OPERATING COST
Membrane Bioreactor	10,000	$1.6M	$140,000
Living Machine	10,000	$1.0M	$8,500
Recover Groundwater	10,000	$.10M - $0.15M	$11,000

Table 4. Relative Costs of Identified Recycled Water Treatment Systems

The capital costs of installation described here include design and ramp-up costs, including mobilization and demobilization, for the treatment system only. The costs do not include estimates for the capital cost to retrofit existing buildings with the plumbing required to utilize recycled water which can be hard to quantify across a diverse building stock as it depends on existing materials and design.

The RE.invest team ran a basic financial analysis, using simply the savings from reduced potable water charges as the payback, for the installation of a 10,000 gpd MBR treatment train and using the actuals from the existing 5,000 gpd Living Machine at San Francisco PUC Headquarters. Both show the systems operating at a los based on current municipal water rates.

What this analysis shows is that reduced potable water charges to an individual property owner alone is unlikely to cover the relatively expensive direct financial cost of installing and operating the treatment process and related infrastructure for water reuse, especially in a situation where retrofitting buildings and systems is required. New developments where a system may serve multiple buildings could result in cost-sharing which could make systems more feasible by distributing costs among different properties or developments. These systems, however, may also include an increased cost of designing systems to serve more than one building.

While financial analyses are important, they typically provide too limited a context to evaluate the real value of a water reuse project. Financial analyses focus only on cash stream and revenue, and neglect indirect financial benefits along with broader environmental and social benefits. A broader economic analysis can capture additional benefits to both individual property owners and the municipality including reducing stress on potable water resources, reducing nutrient loading to waterways, putting less strain on failing septic tanks or treatment plants, and using less energy - all of these benefits add up to savings in both water and energy from the centralized water and wastewater systems. For example, an economic analysis for a recycled water project in Central SoMa should capture (1) avoided and deferred wastewater costs, (2) avoided and deferred water supply costs, (3) increased water supply reliability, and (4) decreased energy usage for normal building operations. Significant additional analysis would be needed to begin quantifying these factors.

Translating these benefits into real sources of revenue requires adequate data to define cost allocations between parties and projected current and future savings, and also structures that make those cash flows more secure.

TREATMENT SYSTEM	FLOW gpd	FLOW gpd	FLOW gpd	CAPITAL COST ($)	ANNUAL OPERATING COST ($)	ANNUALIZED ($)	$/af	COST OF SUPPLY & TREATMENT $/yr	SAVINGS (loss)
Membrane Bioreactor	10k	3.65M	11.2	$1.6M	$140k	$244k	$21,790	$67k	($177k)
Living Machine(as deployed in SFPUC Headquarters)	5k	1.825M	5.6	$1.0M	$17k	$82k	$14,650	$34k	($48k)

Table 5. Estimated Potential Annual Savings

Implementation Strategies

Characterizing Beneficiaries

There are a wide range of potential direct and indirect beneficiaries among San Francisco's property owners and system operators. Monetizing the value of non-potable water and willingness-to-pay of beneficiaries is a prerequisite for project developers and investors looking to finance and install recycled water systems. In the case of San Francisco, both private property owners and the municipal government will accrue economic benefits as described below:

Private Property Owners

The costs associated with pumping and treating stormwater and wastewater fall directly onto private property owners through utility rates. Transitioning to onsite or more localized wastewater treatment and use can produce not only reduced wastewater bills for large residential properties but can also help to reduce system operating costs more broadly. Quantifying these financial benefits for private property owners is an important piece of increasing the adoption of more localized recycled water treatment solutions.

City Government

The San Francisco Public Utilities Commission is responsible for building and maintaining stormwater and wastewater infrastructure in San Francisco. Given the environmental and economic benefits of transitioning to reusable water systems including reducing potable water consumption and providing some decentralized wastewater treatment capacity - both of which increase resilience and reduce risk to natural disasters including drought - the City could bolster incentives like the Non-potable Water Grant and develop additional strategies to provide private property owners with the up-front capital to invest in building and block-level recycled water systems.

Capturing Value

In San Francisco there are multiple potential benefits that could be monetized, captured as revenue, and used for repayment based on the benefits accrued to private property owners (e.g. reduced wastewater rates).

Based on the estimated that the total potential recycled water demand within Central SoMa is about 221,461,080 gallons per year and current water and wastewater rates charged by the SFPUC, the area-wide costs to these anticipated building owners for utilizing potable water and treating the resulting wastewater is about $3-4 million annually. Therefore transitioning from using potable water to non-potable water as a district is likely to save building owners across Central SoMa at least $3 million annually. While reduced costs associated with transitioning from potable water to non-potable water use will not be sufficient to cover costs, in buildings that also require significant foundation drainage, additional savings on wastewater and energy bills are also possible. For income properties (commercial properties not individual homes) these reduced utility costs translate into increased Net Operating Income (NOI)[2], which in turn improves the various operating ratios and profitability indicators – this is because many major cost components in real estate ownership (e.g. property taxes, insurance, and management) are not directly controllable.

The scale of savings for a single building can be significant. For example, a Living Machine installed at SFPUC Headquarters is expected to reduce water consumption by some 60% compared to similarly sized office buildings. Aggregating those collective savings can make privately owned systems viable at the building or block scale in areas with high demand.

While the savings are real for private buildings, the challenge to financing privately owned non-potable water systems is capturing those savings and turning them into viable revenue streams. The following sections describe structures and mechanisms that could be presented to private property owners as strategies for making project financing easier.

[2] Net Operating Income (NOI) = Realized Income - Expenses (incl. utilities)

While the engineering solutions identified by the RE.invest Team vary, all of the options are based on the following core assumptions:

1. Private property owners are required to comply with regulations for dual-plumbing and increased on-site retention and reuse of water.

2. Technology exists that allows for greater retention and treatment of stormwater and wastewater onsite.

3. Owners lack up-front capital to invest in retrofits but are able to finance retrofits through savings on their water bills, or avoidance/reduction of fees that might be levied on them for non-compliance with regulations.

4. Owners typically do not want to be in the business of doing the retrofits on their own, but would prefer a third party handle all development, operations and maintenance of the water retention and treatment, as well as the measurement of water savings/efficiency.

5. Increased water reuse provides an economic and environmental benefit to the City.

What Private Property Owners Can Do

New Construction

Assuming owners lack the capital and motivation to pay for the retrofits upfront, the easiest way to finance them is as a component of a larger development. If the property is new construction, the new water systems could be designed, developed and absorbed into the total project financing via the senior debt, whether loan or bond.

Existing Buildings

If the project is a major renovation or a refinancing, the same could hold true. There would have to be enough value in the property to exceed the total loan amount, i.e. the loan-to-value ratio (LTV), would have to be acceptable to the financier. This method allows the owner to take advantage of the real estate asset as collateral for the retrofits. Essentially, this means that the additional capital required to dual-plumb an existing building could be financed as a part of reconstruction through a traditional loan or refinanced loan if the increased overall value of the property exceeds the cost to retrofit – this is because the lender will hold title to the property until the loan is paid off in full.

Credit Enhancement

If the loan-to-value ratio is too high, meaning the value of the building once retrofitted is not greater than the cost to retrofit, another option is to find a lender who is willing to make subordinate debt available to the owner. Examples of second mortgages abound in the affordable housing and community development field. Usually, the lender is a government entity or a nonprofit CDFI. In this scenario, the lender could take a second lien on the property. Another option for a high LTV is for another entity, like a public entity or foundation, to provide credit enhancement. These instruments can take many forms, from loan guarantees to letters of credit, or first loss reserves. These credit enhancements can be extended to senior lenders or subordinate lenders to reduce the risk of absorbing the cost to retrofit a building.

Savings-based Financing

Theoretically, a third option is to fund water retrofits separately, with all repayment coming from savings. In this scenario the property owner would continue to pay the same monthly rate as before, thus creating the tangible cash flow to repay the financing. Much like an energy efficiency upgrade or solar energy financing, this option requires that a third party do the structural design and construction, while signing a performance contract to capture the additional savings accrued to the property owners over time. This is occasionally a risky proposition because if the savings don’t materialize, there is no collateral for the lender to fall back on. An agreement would have to be reached upfront regarding who assumes the risk if the savings do not materialize and each project would need to be addressed on a case-by-case basis. In this option, it is critical to have a sound methodology for establishing a baseline water usage number so that the monthly payment made by owner can be established. Equally important is a reliable, trusted way to measure changes over time so that all parties know if the program is working. If the data collection methodology, or the data itself, is not high quality, the project is unlikely to attract investors. The fact that there is little to no data currently available on water efficiency savings associated with new technologies will make the case to investors harder to build.

Within the three financing options described, there are numerous variations and financing models for savings based programs that could be restructured to support investment in building or block-level recycled water systems in Central SoMa.

What Public Institutions Can Do

While capital costs for installation and retrofitting are significant, they are not the only hurdle to implementation of distributed wastewater treatment systems. To date, many cities, including San Francisco, have looked for ways to reduce capital cost expenditures with grant programs and other incentive structures like the SFPUC offered grant program that will provide up to $500,000 to building or district scale projects that replace a defined minimum (1,000,000 gpy for a building and 3,000,000 gpy for a district) of the project's potable water use for 10 years. That said, similar to energy efficiency programs, reducing transaction costs - or all the costs associated with aligning stakeholders - is another way to reduce the overall cost of retrofitting and motivate action by private property owners.

Value Capture Instruments

The City of San Francisco's ability to create a special assessment authority or district that can levy taxes and/or fees as described, offers a unique opportunity for financing comprehensive resilience upgrades. Across the country, local governments have used these value capture mechanisms and borrowing against future tax revenues (i.e. tax-increment financing, TIF) or Development Impact Fees to incentivize, if not directly finance, investments in areas with high private investment risk. These value capture mechanisms use special district-level taxes and community improvement fees to capture a portion of the value created for private property owners and developers as a result of public investments.

The same mechanisms used to capture value created for private entities by public investment in transport or drainage systems could, in principle, be applied to public or private investments that reduce disaster or insurance risks to private property-owners. Tax-increment financing is a form of value capture based on borrowing against future increases in market based land values and associated increases in tax revenues in order to finance investments in higher-risk areas. In San Francisco, by establishing that climate and/or disaster risks are directly impacting property values TIF or similar types of value capture mechanisms should be available to finance public or private recycled water solutions that would reduce those risks.

More generally, other value capture and savings based financial instruments such as PACE bonds for energy efficiency retrofits and upgrades have been deployed with great success to support large-scale investments in private property, such as rooftop solar energy systems, to support capital investments. In contrast to TIF mechanisms, PACE and similar instruments do not require the designation of any specific geographic area or district for funding eligibility, giving a city more flexibility to administer a broad program of upgrades.

As the Central SoMa plan area will be subject to development impact fees, the City could dedicate some portion of the fees collected to bolster the existing SFPUC non-potable grant program to support sustainable infrastructure systems like private recycled water projects or to provide incentives for implementation of water recycling and re-use facilities. Most likely, those funds would be best suited to support block-level or co-op structures that would have a greater impact. Typically TIF and development impact fees are only allowed to be used to finance publicly-owned infrastructure, however further analysis should consider whether these types of financing could be used to support privately owned systems that provide a public benefit.

Pooled Funds

As noted, the challenge with investing in any structural retrofit is that working within existing properties and building stocks is complicated and often more costly. Beyond that, financial savings are frequently distributed across multiple beneficiaries (e.g. owners, occupants and tenants) and can only be accrued over a long period of time. Traditionally, public financing has leveraged taxing authority, through TIF and other structures, to capture distributed benefits. However, since the 1970s, the private sector has created other mechanisms to capture sector-specific savings effectively – particularly through the energy efficiency and renewable energy sectors via ESCOs (Energy Savings Companies) and the PACE program (Property Assessed Clean Energy). Now that the practice is well understood it is starting to be applied more broadly to support infrastructure investments that generate significant longer-term financial value, and the City of San Francisco could leverage this market interest to support recycled water retrofit investments that similarly produce broader benefits.

In fact, the City of San Francisco has already leveraged this expanding market interest to structure a pooled fund to support seismic retrofitting of private buildings to implement their Community Action Plan for Seismic Safety – a $1 million study to understand regional earthquake risk.

One of the first steps the City took under the Earthquake Safety Implementation Program was to sign into law the Mandatory Soft Story Retrofit Ordinance, which requires evaluation and retrofit for multi-unit soft story buildings. To support both mandatory and voluntary retrofits, the City created a grant fund to support earthquake retrofit upgrades, but learned quickly that funding, even when coupled with an ordinance was not enough to compel action. Because any retrofit project comes with high up-front analytical and transaction costs, the grant funds to support construction were seen as too little too late for many private property owners. Interested in motivating both mandatory and voluntary retrofits, the City of San Francisco approached Alliance NRG, an energy service company, and Deutsche Bank to restructure their grant funds into a public financing option.

Launched in the Fall of 2014, the program has a simple structure – Deutsche Bank provides the upfront capital guarantee to Alliance NRG, who then accepts applications from individual property owners and manages the upgrade process from design through construction. Alliance NRG has a contractual relationship with the City to recoup their investment plus interest via an additional line item on each participating property owners' regular property tax invoice from the city.

In order to pursue this financing model to support dual-plumbing retrofits, the City of San Francisco would need to first define project types and restructure the mandate to cover retrofits and coordinate relevant contractors who could provide the retrofit services.
In addition, the City must be able to credit recycled water producers/consumers for energy and water efficiency savings via property tax assessments. Such a credit system may appear at first glance difficult to accomplish administratively as most wastewater charges are calculated as multipliers on the quantity of water sold to a homeowner or business. However, the permitting process represents an opportunity to calculate the quantity or percentage of wastewater diverted into the non-potable water system. In this case, the utility would need to work with the City to quantify the individual property's wastewater multiplier and calculate the scale of the cost savings that the property provides the wastewater utility. Unlike on-bill savings, which accrue to property owners directly in the form of reductions to water or electricity bills, the savings created in this model accrue to the wastewater utility and the system more broadly. While any single property may not make a large impact, the collective impact has the potential to be significant for the City.

The City could follow a similarly simple structure to leverage existing SF PUC grant funds for financing non-potable water system retrofits. Transferring management of existing grant funds to a private bank would enable the infusion of additional cash, and provide the necessary upfront capital guarantee to a private contractor. Like the soft-story pooled fund, the selected wastewater treatment contractor would then accept applications from property owners, and manage the upgrade process from design through construction. This contractor would require a series of contractual relationships to recoup their investment plus interest. The first would obligate property owners to pass-through energy and water savings, and a second agreement with the City and/or SF PUC would ensure the contractor receive an annual or semi-annual payment that scales based on system-wide savings accruing to the City.

This pooled fund would go beyond providing financing to help streamline the retrofit process and reduce transaction costs in a way that can also increase project uptake.

Local Policy Changes

The most immediate actions that any city can take to motivate private activity are to create mandates and reduce burdens. Because the City has already taken proactive steps, like the Recycled Water Ordinance and other policy tools to mandate action, the RE.invest team focused on ways the City can continue to reduce the revenue and cost uncertainties associated with private sector project development.

On the cost side, non-potable water and reuse policies can influence the type, and therefore cost, of technology needed for adequate treatment. It may also determine the quantity of non-potable available onsite, thereby influencing the minimum scale of production for an onsite system, which will determine the unit cost of treatment. Over the past two years, the City of San Francisco has worked hard to clarify this for private property owners and the broader retrofit market to make uptake easier. Beyond those recent policy changes, the City should continue to support block-level or co-op structures by providing technical guidance where possible and streamlining permitting processes, including minor and major encroachment permitting, to facilitate broader distribution.

In order to clarify the revenue generation potential of a privately owned recycled water system it must be clear to private property owners that any recycled water produced can be sold to adjacent properties and/or that the City will credit recycled water producers/consumers for reducing the quantity of wastewater that must be treated by the sewerage system. Currently in San Francisco, a building can enter into a defined district agreement where they identify the users of the water, however property owners cannot turn into a utility by marketing their non-potable water resource to additional consumer in a way that competes with the Public Utilities Commission. The City has already leveraged State policy to make these revenue streams a reality and should continue to promote the opportunity for private property owners.

Data Collection & Public Participation

In order to pursue any of the described financial strategies, data collection and public participation will be key to motivate action. Providing baseline data, projecting savings and identifying partners or customers for individual property owners interested in designing onsite recycled water facilities reduces some of the upfront capital costs. Engaging the hundreds of private property owners and managers in Central SoMa in the planning, implementation, and financing of new resilient infrastructure projects, including onsite recycled water facilities will be essential.

Because there are few property-level sources of data, the RE.invest team encourages the City to explore ways to make existing water data more available to the public and property owners. Potential partnerships with technology firms that can help crowdsource data on building level water and energy related costs and lossesc ould also be beneficial. The City could also consider establishing a water benchmarking and reporting program in Central SoMa to collect self-reported building-level water use data. Building-specific data and engaged property owners are key to helping the City build a data-backed representation of the potential recycled water market localized in Central SoMa. By constructing a detailed profile, the City can systematically support the development of private owned recycled water systems while also packaging the benefits to property owners clearly enough to pursue savings based financing through a pooled fund more effectively.

While none of the proposed strategies will produce wholly private financing options for non-potable water system construction and retrofit in the short term, when combined they can offer a menu of options for the City to support long-term investment.

RE invest

Conclusions

For purposes of this report, the RE.invest team focused on the viability of privately owned distributed recycled water treatment facilities for fulfilling anticipated increasing non-potable demand within the Central SoMa plan area as development occurs. The RE.invest team identified two ways individual property owners could feasibly achieve economic scale in Central SoMa: (1) an individual building owner could install a non-potable water treatment system and sell any treated water not used onsite to nearby customers, or (2) individual property owners can join together in a cooperative program for collective reuse and/or sale.

There are a variety of treatment technologies and systems that could be utilized by private property owners at either scale to produce reusable non-potable water, but the RE.invest team focused on (1) membrane bioreactor, (2) engineered wetland and (3) recovered groundwater. Generally, distributed recycled water treatment facilitates are most cost effective when sited near both a steady supply of wastewater and a demanding population. Areas of dense development with high water demand and available space of at least 2000 square feet in total can serve as an effective site for recycled water treatment.

Retrofitting an urban area like Central SoMa for broad non-potable water reuse will require significant investment. Costs include that the installation of expensive. That dual-plumbing both in existing and new buildings as well as updating the broader municipal infrastructure for carrying recycled water within the area. The many benefits of conserving potable water provide a strong argument for justifying increased costs.
In contrast to existing centralized wastewater treatment systems, distributed treatment is designed to work at the scale of a large high-rise residential or commercial building, a cluster of residential homes, or a commercial or industrial park - reusing the treated effluent onsite or at adjacent properties to offset potable water use. The treated wastewater and/or rainwater can be used for toilet flushing, irrigation of parks or landscaping, and heating and cooling

systems, which are projected to be in high demand in a developing area such as Central SoMa.

Incentives such as the SFPUC Non-Potable Water Program's Grant Assistance for Large Alternate Water Source Projects exist to help decrease the cost of installing non-potable water systems. This report recommends increasing these incentive programs to expand installation of non-potable systems in Central SoMa. Even with incentives, however, these systems require additional investment by property owners and developers. . The RE.invest team analyzed the potential of using savings from reduced potable water charges as the payback for the installation of an MBR treatment train, an engineered wetland and recovered groundwater processes. The analysis revealed that under current municipal water rates, these water savings alone are unable to cover the full cost of system installation and operation. However, the analysis does not take into account broader economic value including (1) avoided and deferred wastewater costs, (2) avoided and deferred water supply costs, (3) increased water supply reliability, and (4) decreased energy usage for normal building operations.

Capturing and aggregating those broader economic savings can make privately owned systems viable at the building or block scale in areas with high demand. Example structures the RE.invest team identified as viable for the City of San Francisco to explore, individually or as a package of mechanisms, to help capture those distributed benefits include:

VALUE CAPTURE INSTRUMENTS

As the Central SoMa plan area will be subject to development impact fees, the City could consider revising TIF and/or development impact fees structures to support privately owned infrastructure that provides a public benefit. This could be achieved by dedicating some portion of the fees collected to bolster the existing SFPUC non-potable grant program for the implementation of private water recycling facilities. Most likely, those funds would be best suited to support block-level systems that would have a greater impact.

POOLED FUND

Transitioning any single property from potable to non-potable water use may not make a large impact, the collective impact to the system of many buildings transitioning has the potential to be significant for the City. Building on the availability of on-bill financing, the City could structure a non-potable water retrofit fund that leverages existing grant funds, streamlines the retrofit process and captures not only property-specific but system-wide savings.

The presented financing structures are all based on good property-level data, which is why the RE.invest team recommends that the City continue and expand where possible data collection efforts aimed at collecting data on building level water and energy usage, costs and losses. This data can then be used on building level water and energy related costs and losses to demonstrate the opportunity and help motivate third party financiers to act in support of projects.

When combined, these proposed strategies can help the City more systematically engage private property owners and motivate the planning, implementation, and financing of privately owned resilient infrastructure projects.

References

01. Central SoMa Eco-District Formation Task Force (2013). Task Force Recommendations, November 2013.
02. Environmental Protection Agency (2002). The Living Machine, Wastewater Technology Fact Sheet, October 2002
03. Environmental Protection Agency (2007). Membrane Bioreactors, Wastewater Management Fact Sheet, September 2007
04. Environmental Protection Agency (2012). Guidelines for Water Reuse, EPA/600/R-12/618 September 2012
05. Living Machine Systems San Francisco Public Utilities Commission Case Study website http://www.livingmachines.com/Services/Case-Studies/SF-PUC-Case-Study-080913.aspx accessed April 24, 2014
06. Lohan, E., Muñoz, P.A., Salthouse, G., Fisher C., and K. Reid Black, (2011). "Performance of decentralized wastewater systems for green building projects in North America and Australia", Greenbuild International Conference and Expo Research Track Conference Proceedings, 2011, Toronto, Canada, Oct. 4-7.
07. National Research Council (2012). Water Reuse: Potential for Expanding the Nation's Water Supply Through Reuse of Municipal Wastewater. The National Academies Press: Washington, D.C. (2012).
08. San Francisco Planning Department (2012). Central Corridor Eco-District, Program Framework, October 2012
09. San Francisco Planning Department (2013). Central Corridor Plan, draft for public review, April 2013
10. San Francisco Public Utilities Commission (2009). Technical Memorandum No. 802 Green Treatment Plant Technologies, 2030 Sewer System Master Plan. August 2009
11. San Francisco Public Utilities Commission (2009). Technical Memorandum No. 803 Distributed Treatment and Local Reuse: Feasibility and Regulatory Considerations, 2030 Sewer System Master Plan. August 2009
12. San Francisco Public Utilities Commission (2009). Technical Memorandum No. 805 Recycled Water Regulations and Reuse Opportunities, 2030 Sewer System Master Plan. August 2009
13. San Francisco Public Utilities Commission (2011). Study of Existing Groundwater Supplies: Opportunities and Constraints Analysis. June 2011
14. San Francisco Public Utilities Commission (2011). 2010 Urban Water Management Plan. June 2011
15. San Francisco Public Utilities Commission (2012). Eastside Recycled Water Project, Needs Assessment Report. Draft March 2012
16. San Francisco Public Utilities Commission (2012) Potable Offset Investigation Summary. April 2012
17. San Francisco Public Utilities Commission (2014). San Francisco's Non-potable Water Program. January 2014
18. San Francisco Public Utilities Commission (2014). CS-199 Planning Support Services for Auxiliary Water Supply System (AWSS), Project Report. February 2014.
19. San Francisco Public Utilities Commission (2014). Single Site Nonpotable Water Calculator Version 2.0 04/16/14.