Green City, Clean Waters:

How can a city enhance delivery of co-benefits from a green infrastructure program?

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# Table of Contents

Acknowledgements ................................................................................................................................. 2  
Executive Summary ................................................................................................................................. 4  
Introduction ........................................................................................................................................ 5  
   The Rising Popularity of Green Infrastructure as a Nature-Based Solution .................................... 5  
Theoretical Underpinnings ..................................................................................................................... 7  
   Exploring the Green Infrastructure Concept ..................................................................................... 7  
   Can co-benefits be realized regardless of explicit intention? .............................................................. 9  
   Are there risks to trying to leverage an investment to achieve multiple benefits? ....................... 11  
Case Study Background ....................................................................................................................... 13  
   The City of Philadelphia Green City, Clean Waters Program .............................................................. 13  
      Program design ............................................................................................................................. 13  
      Outcomes sought, committed to and monitored ........................................................................... 14  
Methodology ..................................................................................................................................... 17  
Results ................................................................................................................................................. 20  
   Conceptualizing GI and its benefits ................................................................................................. 20  
   Program Ownership and Commitment ............................................................................................ 22  
      Types and quality of partners ....................................................................................................... 23  
   Coordination-Related Issues ............................................................................................................ 24  
Legal Mandate .................................................................................................................................... 25  
   Contracting and Financing Procedures/Rules .................................................................................. 25  
Leadership and Organizational Culture .............................................................................................. 26  
The Right Skill Sets ............................................................................................................................... 27  
Discussion and Recommendations ........................................................................................................ 27  
   Internally-oriented Actions .............................................................................................................. 29  
   Externally-oriented Actions ............................................................................................................... 30  
References ............................................................................................................................................ 33
Executive Summary

As city water departments responsible for Combined Sewer Overflow (CSO) management programs grapple with numerous concurrent challenges, experimenting with nature-based green infrastructure (GI) solutions is becoming an increasingly attractive proposition (Zidar et. al., 2017). The case is being made that GI is a more cost-effective solution than investment in traditional grey stormwater infrastructure, plus can simultaneously be leveraged to contribute to a range of additional social, economic and environmental outcomes (American Rivers et.al., 2012). But while the concept of leveraging is theoretically compelling, this MP explores how GI investments that are designed and implemented to deliver specific water-related outcomes can more effectively deliver sizable co-benefits.

The research project takes a normative/evaluative approach to answer the core questions presented above. Three inter-linked methodological approaches are employed: A review of scholarly literature with thematic analysis; in-depth review of a case study - City of Philadelphia Green City, Clean Water - programmatic documentation; and semi-structured informant interviewing.

The conclusion of this research is that issues including an absence of co-benefit indicators in the M&E framework, government processes that increase the transaction costs of collaboration, and the water-focused ambition of the legal contract with the EPA have meant that the water investment has not yet been sufficiently leveraged to maximize co-benefit outcomes. Nevertheless, many good practices have been identified, and the MP presents them to illustrate where and why co-benefits were able to be achieved. This research concludes that there are a number of very actionable ways that cities can enhance delivery of co-benefits even when legislatively obliged to meet stormwater objectives.
Introduction

The Rising Popularity of Green Infrastructure as a Nature-Based Solution

As city water departments responsible for designing, implementing and monitoring Combined Sewer Overflow (CSO) management programs grapple with the concurrent challenges of increasing populations, insufficient capital improvement budgets for expanding and upgrading aging stormwater infrastructure, and the increasing number of severe weather events overwhelming existing systems, experimenting with nature-based green infrastructure (GI) solutions is becoming an increasingly attractive proposition (American Water Works Association, 2017; Zidar et. al., 2017). US cities including New York, Seattle, Philadelphia, Washington DC and Detroit have embarked on pilot or scaled GI stormwater management programs, with the US Environmental Protection Agency (EPA) lauding this approach as being both more sustainable and more comprehensive than traditional grey stormwater infrastructure approaches (US EPA, 2018).

The case being made by some city water officials is that GI is a more cost-effective solution than investment in traditional grey stormwater infrastructure if considering the investment’s potential contribution to a range of additional social, economic and environmental outcomes is considered (American Rivers et. al., 2012). Such often cited co-benefits include carbon sequestration, reduction of heat island effects, improved air quality, expanded green recreational spaces and reduced building energy use (Ranjha, 2016). Given that over a trillion dollars will be needed over the next 25 years to restore and expand aging US water infrastructure for a growing population, an increasing number of cities are seeking ways to leverage these expenditures to simultaneously deliver the heterogenous range of public and social goods desired by the community (American Water Works Association, 2013). Forest Trend’s Alliances for Green Infrastructure: State of Watershed Investment 2016 report showed that while mitigating risks to water supplies was a major driver of the $25b invested globally in GI in 2015, governments, utilities, companies and communities were also motivated by the environmental and social co-benefits these projects delivered.

On the ground evidence of this motivation is easy to find. Mayor Nutter of Philadelphia, upon the signing of the City’s 25-year Consent agreement with the EPA, indicated “we have worked
with the state and the EPA to take this greener, more fiscally prudent approach that will realize multiple benefits” (Stormwater Solutions, 2012). Chicago’s climate action plan includes the creation of 500 new green roofs each year between 2017-2020 as way of managing stormwater and addressing the urban heat island (USGBC, 2017). The City of Portland, Oregon likewise includes GI in their climate action plan, emphasizing their use of the urban forestry infrastructure to support equity, resilience and biodiversity goals (USGBC, 2017). Likewise, in 2018, Mayor Barret of Milwaukee launched the city’s green infrastructure plan framework highlighting the city partnership with the Milwaukee Public Schools to redevelop blacktop schoolyards into functional green space and learning environments - “Not only does this directly benefit the environment, it directly benefits our students” (Kilmer, 2018)

But while the concept of leveraging is theoretically compelling, this research explores the limitations to and possibilities for designing and implementing GI investments to more effectively deliver sizable co-benefits. As the pressure to meet federally mandated water targets looms, what are the strategies and approaches that could be employed to support the simultaneous achievement of other social, economic and environmental co-benefits?

This MP begins with a literature review exploring the diversity of GI conceptualizations including looking at how the primary outcomes sought by the infrastructure investment strongly influence the physical form of said infrastructure. The paper then analyzes whether there is need to be explicit about the co-benefits for such co-benefits to be maximized. The theoretical risks and opportunities faced by water departments grappling with questions of how all-encompassing their stormwater management program should be are subsequently presented.

This background is a foundation for exploring the MP’s primary question of **how can a city enhance delivery of co-benefits for a green infrastructure program**, when its primary motivation is complying with combined sewer overflow regulations? The MP hopes to present a range of key considerations and recommendations for cities looking to better leverage such legislatively mandated programs.

This MP will contribute to the green infrastructure research literature by using the City of Philadelphia’s Green City, Clean Waters (GCCW) stormwater infrastructure program as a case study.
With implementation of this 25-year, $3b program having started in 20011, GCCW is Philadelphia's plan to reduce stormwater pollution currently entering its combined sewer system through the use of GI (City of Philadelphia, 2011). Being the first US water utility to take a comprehensive GI approach to managing urban water, it is an important case to study (Travaline et.al., 2015).

Theoretical Underpinnings

Exploring the Green Infrastructure Concept

Credited with coining the term at the onset of the US Greenway movement, Benedict and McMahon saw GI as “an interconnected network of protected land and water that supports native species, maintains natural ecological processes, sustains air and water resources, and contributes to the health and quality of life...for communities and people” (Williamson, 2003, p.4). This expansive definition touched upon both what GI could physically look like as well as what outcomes or types of benefits it could seek to achieve. But alternative perspectives on how GI is envisaged have emerged, influenced by factors including geography, academic discipline and worldview regarding the relationship between nature and people. According to Mell in his comprehensive 2016 book *Global green infrastructure: lessons for successful policy-making, investment and management*, one clear influence on how GI has been understood has been along geographical lines. The author suggests that “in the USA there is a predominant process of water-centric green infrastructure investment, framed within US governmental and Environmental Protection Agency (EPA) guidelines, which influences the focus of delivery” (Mell, 2016). In fact, the EPA defines GI as “a cost-effective, resilient approach to managing wet weather impacts that provides many community benefits” (EPA, 2018). Such water-centric conceptualizations are thus seen in the design of green infrastructure investments in places including New York, Philadelphia, Seattle and Milwaukee (Mell, 2016). This entails a focus on infrastructure such as bioretention planters on sidewalks, bioswales, rain gardens, green roofs and impervious surface transformation (Figure 1).
Explicit outcomes sought have focused on stormwater management and related water pollution control.

But a more nuanced story reveals increasingly integrated approaches to landscape planning have been emerging in the US. Institutions like The Trust for Public Land agree that GI is a key approach to providing stormwater solutions, but they expand on the possible multifunctional outcomes or co-benefits by explicitly acknowledging the role it can play in air quality improvements, in reducing city temperatures and in creating green urban spaces that provide important recreational, aesthetic and mental and physical wellbeing contributions to the lives of city dwellers (Trust for Public Land, 2018). Under this viewpoint, GI physical infrastructure includes such things gardens, trails, natural areas and recreation centers.
Consistent with the contention that geography has influenced both the nature of GI and the outcomes sought, European institutions such as the European Commission have taken the most expansive views, seeing GI as key to “supporting a green economy, improving quality of life, protecting biodiversity and enhancing the ability of ecosystems to delivery services such as disaster risk reduction, water purification, air quality, space for recreation and climate change mitigation and adaptation” (European Commission, 2016; Roe et. al., 2013). Countries including France and Italy have intentionally focused their greening activities on those with the ability to deliver a wide range of ecosystem services (Mell, 2016). Under such a conceptualization, physical forms including cycling paths, a wide range of green spaces, community gardens, green walls and even beehives are considered to be components of GI.

Can co-benefits be realized regardless of explicit intention?

A relevant question to explore early on is whether realization of co-benefits will inevitably occur regardless of whether such benefits were intentionally considered as part of the GI design process. Evidence to suggest that this indeed is the case would render the posed MP question redundant.

One recent comprehensive report concludes with the contrary finding. The Willamette Partnership argues that GI can make significant contributions to improved health, but stresses that achieving health outcomes from it is difficult and ‘means being intentional about engaging community, locating green infrastructure, and selecting designs that improve physical activity, mental health, social cohesion, air quality, and other health factors’ (Oregon Health and Outdoors Initiative, 2018). Yet the recommended Green Infrastructure Implementation guides featured on the EPA Green Infrastructure Design and Implementation website reveal limited practical guidance related to non-water considerations (US EPA, 2017).

Unfortunately, despite an in-depth search, scant research evidence was found directly addressing the relationship between co-benefit outcomes and the requirement or otherwise for intentional co-benefit GI design considerations. Given this, this following section takes a sample of GI co-benefits and explores the evidence regarding design related aspects that improve effectiveness of the particular intervention in terms of the key co-benefit sought.
<table>
<thead>
<tr>
<th>Type of co-benefit</th>
<th>Examples of additional elements to consider for maximizing co-benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban heat island effect reduction</td>
<td>Jaganmohan et al 2017 show that the cooling benefits of trees tend to be significantly greater if managed more as an urban forest than as an urban park with greater open spaces. Therefore, determining the level of tree density that maximizes both water retention as well as urban heat island reduction is important. Ballinas and Barradas have shown that evapotranspiration is also an important way that trees reduce the heat island effect, but that the tree species is a very important determinant of effectiveness (2016). Therefore, species selection is a key consideration.</td>
</tr>
<tr>
<td>Community cohesion building</td>
<td>Kondo’s 2015 study showed that in Philadelphia, over a four-year period, neighborhood sites where GI had been installed experienced a significant reduction in crimes such as narcotics possession, compared to sites marked for future GI interventions. Reduced crime provides opportunities for increased social gatherings in outdoor spaces, and the chance to strengthen community cohesion. Site selection can therefore impact greatly on the degree to which a GI investment delivers community building/cohesion benefits.</td>
</tr>
<tr>
<td>Workforce development</td>
<td>The Sustainable Business Network 2016 report indicates that intentional efforts to link up workforce development opportunities with the city’s programs around youth violence reduction, truancy reduction and ex-offender re-entry has had great success, with 50% of Water Department Corps members reporting to have leveraged their PowerCorpsPHL experience towards new professional opportunities. If workforce development initiatives, particularly those targeting historically marginalized members of the community, are not considered upfront, the establishment of formal GI-focused training programs are unlikely to happen.</td>
</tr>
</tbody>
</table>
| Climate Change Adaptation and Mitigation | Demuzere’s 2014 study explore some of the tradeoffs to be considered in seeking climate change benefits from GI. Key areas identified include:  

- Maintenance: GI may require fertilizers that emit carbon via fossil-fuel combustion processes  
- Tree shade: Can reduce the penetration of solar radiation, which in cold |
climates, can mean increased heating energy use. Additionally, for long term viability of individual GI investments, consideration should be given to selecting green infrastructure plant and tree species that will thrive in predicted future climatic conditions in particular sites. Bioversity International research demonstrates the importance of genetically diverse and site-matched germplasm for avoiding expensive failures in forest restoration efforts (Thomas et.al, 2015).

Table 1

This relatively superficial analysis points to the likely relationship between being intentional about co-benefits sought in the GI design upfront, and the extent to which co-benefits are realized.

Are there risks to trying to leverage an investment to achieve multiple benefits?

For a city choosing to utilize a GI approach to meet federally legislated CSO requirements, how broadly or narrowly GI is envisaged becomes important. A question that decision makers must answer is whether designing the GI investment to intentionally harness the multifunctional potential of GI impacts positively or negatively on the city’s ability to deliver upon ambitious CSO targets. Cities increasingly need to understand such tradeoffs so as to ensure they only make commitments for benefits they are confident they will eventually be able to deliver.

Unfortunately, an extensive literature review revealed no empirical studies related to this fundamental question regarding the existence of tradeoffs in seeking to achieve stormwater performance and achieve co-benefits. As such, the following section is limited to an examination of the theoretical benefits of designing and implementing GI with the goal of achieving a broad range of outcomes.

Many academics and practitioners promote the economic efficiencies gained from greater leveraging of scarce financial and human resources, as well as reduction in fragmentation of infrastructure, land use and governance (GIZ & ICLEI, 2014). Mell argues that “green infrastructure planning is a fluid process that explicitly requires trans-disciplinary working in order to explore the most cost-effective and positive socio-ecological outcomes of development” (2016, p.18).
A somewhat similar approach, focusing on the nexus of historically separated sectors, involves identifying synergies across such sectors. It highlights the potential for the generation of more innovative solutions thanks to the co-generation of ideas by people from different disciplines and experiences (Weitz et al., 2014). Building on Denzau’s work on systems thinking for interorganizational collaboration, it is argued that GI, by its very nature, relies on the interconnectedness of different natural and man-made systems to achieve outcomes (Denzau et al., 2016).

The above work focuses on the intersections between sectors, and while Matthews et al., 2015, recognize that “definitional ambiguity is leading to issues around how planners conceptualize green infrastructure” (p.157). The research nevertheless sees this ambiguity as bringing together environmental and economic interests under a more comprehensive framework. This framework reduces conflict by claiming that GI can support the achievement of both economic growth as well as the expansion and protection of nature. Shifting to a more ecological perspective, James et al. make a strong argument that multiple use landscapes tend to be more robust than those with single uses, therefore urging collaboration in design and use (2009).

But a number of researchers also pay attention to the risks of attempting to maximize multifunctional GI outcomes. Many of these risks relate to efficient and effective use of scarce public funds as well as public perceptions around the ability of an agency to deliver against its core mission.

Starting with advocates of the core mission model, they argue that agencies with more narrowly defined agenda as more likely to succeed in developing coherent plans of operation, develop specialized expertise and become effective regulators (Lee, 2016). Their argument is one based on efficiency and core competency grounds. Others, including Boas et al. appear in agreement, contending that focused, sectoral goals are both easier to monitor as well as easier to communicate about to crucial audiences such as citizens and elected representatives (2016). As such they are often more politically palatable and more likely to be supported by core constituents.

For others, the costs incurred in taking a multi-sectoral approach, particularly the collaboration-related transaction costs, are the major impediment to cost effectiveness.
example, Feiock’s work on the institutional collection action (ICA) framework explicitly recognizes the costs of cooperation. He sees the ICA framework as being relevant in situations where local governing units, such as city agencies, recognize they can achieve better outcomes through collective action, but need to find ways to ensure the transaction costs of such collaboration are managed right down (2013). Feiock, Krause and Hawkin's 2017 research tackles what they call “functional collective action problems”. They argue that “absent an administrative mechanism to coordinate across functions and integrate policy, individual decisions may lead to inefficient outcomes and stymie larger goals” (p.615). The research also points to the fact that sustainability related efforts that require coordinated efforts across multiple departments also suffer from a moral hazard problem. This is because although the efforts of the sustainability initiative team as a whole are visible, the efforts of the different individual departments that form part of this team are less obvious. This leaves open the possibility for departments to free ride, resulting in an overall sustainability outcome that is less than that which is desired.

Case Study Background

The City of Philadelphia Green City, Clean Waters Program

Program design

The Green City, Clean Water (GCCW) 25-year program was developed as a response to both the state of Pennsylvania and the US Environmental Protection Agencies legislative requirements that Philadelphia find ways to reduce sewer overflows and sewage entering waterways (Zidar et. al., 2017). At a federal level, this requirement was mandated by the federal Clean Water Act and to meet the 1994 National Combined Sewer Overflow Policy requirements (City of Philadelphia, 2011).

The approach proposed by GCCW was considered courageous and innovative, with faith placed in the ability of green infrastructure to manage the first inch of stormwater at the

What are Combined Sewer Overflows?
Combined sewer systems comprise of piping systems that combine and transport household sewage, stormwater run-off and wastewaters from industrial processes through to wastewater treatment plants. After treatment, treated water is discharged into waterways. But times of heavy rainfall or snow melt result in the capacity of the sewer or wastewater treatment plant being exceeded. The sewer system are therefore designed to allow for occasional Combined Sewer Overflows (CSO) of untreated sewage directly into waterways. Given the often-toxic nature of such untreated wastewaters, CSOs have been a major target for environmental regulation and management attention.
exact location the water met city surfaces, rather than through creation of more grey-pipe infrastructure which would transport water to treatment sites (Fitzgerald and Lauger, 2017). It was the first of its kind to be submitted to the EPA in response to federal regulations, and despite the lengthy 3-year period of back and forth between the EPA and the PWD, it was considered a collaborative effort with EPA putting resources and energy behind the co-development of GSI approaches and technologies that would support the success of the program.

That the program was primarily focused on tackling a water-related issue is apparent in the more regular use of the term Green Stormwater Infrastructure (GSI) throughout GCCW program documentation compared to the broader Green Infrastructure (GI) term. The PWD defines GSI as;

“a range of soil-water-plant systems that intercept stormwater, infiltrate a fraction of it into the ground, evaporate a portion of it into the air, and in some cases release a portion of it slowly back into the sewer system where it can ultimately be treated at a wastewater treatment plant... PWD’s definition of green infrastructure also includes restoration of physical habitats in stream channels, along stream corridors, and on riverfronts.” (City of Philadelphia, 2009a, p.1)

Nevertheless, the business case for this program drew heavily on a triple bottom line report produced as supplemental documentation for the Philadelphia CSO Long term control plan for the EPA. This report, widely promoted by PWD, indicated that GI or GSI could simultaneously address a number of other urban environmental problems (Zidar et. al., 2017; City of Philadelphia, 2009a).

“By investing in green stormwater infrastructure... we are not only ensuring the rebirth of our ecological resources but are also striving to provide a host of other environmental, social and economic benefits that will catalyze our success in achieving the sought-after reality of the ‘Greenest City in America’” (City of Philadelphia, 2011, p.15).

Outcomes sought, committed to and monitored

Under GCCW, the Consent Order and Agreement (CO&A) issued by the EPA required the City to “construct and place into operation the controls necessary to achieve the elimination of the
mass of pollutants that would otherwise be removed by the capture of 85% by volume of the combined sewage collected in the Combined Sewer System during precipitation events on a system-wide annual average basis” (City of Philadelphia, 2014, p.1.1).

To assess the effectiveness of GSI in reducing combined sewer overflows, a comprehensive monitoring plan was put into place (City of Philadelphia, 2014). The City agreed to a number of progress indicators, including:

- Water pollution control plant upgrades
- Miles rehabilitated of a number of receptor creeks
- Reduction in the volume of water overflow
- Equivalent Mass Capture (EMC) of Total Suspended Solids (TSS), Biological Oxygen Demand (BOD), and fecal coliform bacteria; and
- Total Greened Acres (TGA), one of the most publicly used indicators, one of equaled one inch of managed stormwater from one acre of drainage area.

This list of indicators, included in the legal contract between the city and the EPA, demonstrates that EPA was to judge successful implementation of GCCW predominantly through a water-related lens.

But regardless of a lack of direct reference to co-benefits in this contract, this MP argues that the city entered into an implicit social contract with its citizens regarding the delivery of co-benefits. The city explicitly made a co-benefit commitment, through the language used within the approved monitoring plan that stated that the goals and strategies of the program “go well beyond nominal achievement of water quality standards and look to achieve a broad array of environmental and societal goals that the community values and respects” (City of Philadelphia, 2014, p1.4). Program documentation promoted the fact that GCCW utilized the environmental regulatory obligation as a means for long-term strategic investments in community and economic development (City of Philadelphia, 2011). Additionally, the triple bottom line report, which showed the many social, economic and environmental benefits to be obtained from the program, was publicly and widely released, promoted by Water Department Officials directly and via partners indirectly (Goodyear, 2014; McRandle, 2012). Taken directly from this report, the GCCW program
documentation presented the co-benefits envisaged to be delivered over the 25-year program (City of Philadelphia, 2011). These are presented here below in table 2.

<table>
<thead>
<tr>
<th>Sector</th>
<th>Co-Benefit</th>
<th>Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic</td>
<td>Poverty reduction</td>
<td>Annually, about 250 people employed in green jobs</td>
</tr>
<tr>
<td>Social</td>
<td>Greater recreational opportunities</td>
<td>Increase of up to 10% recreational and stream related visits to Fairmont Park</td>
</tr>
<tr>
<td></td>
<td>Enhanced community quality of life</td>
<td>Increase of up to $390million in property value of homes near parks and green areas over next 45 years</td>
</tr>
<tr>
<td></td>
<td>Heat island reduction</td>
<td>Reduction of up to 140 fatalities caused by excessive heat over next 45 years</td>
</tr>
<tr>
<td>Environmental</td>
<td>Improved air quality</td>
<td>Air quality benefits from full-grown trees will annually lead to:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Up to 1-2 avoided premature deaths</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Up to 20 avoided asthma attacks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Up to 250 fewer missed days of work or school</td>
</tr>
<tr>
<td></td>
<td>Energy savings and climate change offsets</td>
<td>Up to 1.5 billion lbs. of carbon dioxide emissions avoided or absorbed</td>
</tr>
<tr>
<td>Restored ecosystems</td>
<td>Up to $8.5m in water quality and habitat improvements over the next 40 years including:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Up to 45 acres of wetlands restored</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Up to 148 acres of wetlands created</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o 7.7 mi of stream restored in Cobbs Creek watershed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o 3.4 mi of stream restored in Tookany/Tacony-Frankford watershed</td>
</tr>
</tbody>
</table>

Table 2 – City of Philadelphia 2014

Zidar et. al.’s interviews with stakeholders revealed that such triple bottom line expectations were embraced by Philadelphian communities, with a hope that investment would also address jobs, tackle heat island effects and green up neighborhoods, thereby increasing property values (2017). A
community GI project site visit conducted as part of this MP revealed that communities in 2018 continued to hold on to expectations about how GCCW could support neighborhood revitalization.

It is therefore noteworthy that no economic, social or non-water environmental indicators appear in the EPA approved monitoring and evaluation framework, nor are they being monitored as part of any formal or informal program reporting exercises. Co-benefit indicators are absent from the five-year GCCW official monitoring reported released in 2016 and interview communications with Philadelphia Water Department Staff confirm co-benefits are not formally being captured by the department. This makes impossible a qualitative analysis of whether achievement of non-water-related targets has come at the expense of the CSO targets.

One final aspect of the monitoring framework is worthy of attention. There is an explicit program intention that GSI investments be distributed equally across neighborhoods. “The uniform investment of green stormwater infrastructure will ensure equal access for all to the expected environmental, social and economic benefits derived from green infrastructure” (City of Philadelphia, 2014, p.3.3). Philadelphia Water Department committed and does in fact gather data to verify that the spatial distribution of infrastructure is occurring.

Methodology

The project took a normative/evaluative approach to answer the core MP question around how a city can enhance co-benefits from a GI program. The MP employs three inter-linked methodological approaches: A review of scholarly literature with thematic analysis; in-depth review of the selected case study programmatic documentation; and semi-structured informant interviewing.

Having completed the literature review, the research project used a case study methodology focusing on the City of Philadelphia’s GCCW program, and was mainly qualitative in nature (SAGE, 2004). This was followed by an in-depth review of relevant GCCW program documentation including the Green City, Clean Waters feasibility study and its appendices which included a cost benefit analysis, a triple bottom line analysis and an in-depth monitoring and evaluation framework. The 2016 5-Year monitoring and evaluation status report and a number of
external program reviews were also studied to gauge implementation progress. This allowed me to better understand both the expressed design intent of the program including its scope and ambition, as well as how implementation was subsequently occurring. This review was complemented by review of reports and articles produced both other stakeholders involved or interested in the GCCW program.

This desk work helped shape the design of a qualitative survey that I used to undertake semi-structured interviews with seven key stakeholders (SAGE, 2004). Each interviewee was selected purposefully to represent an important sector or group of stakeholders. Of the seven interviews conducted, five were conducted face-to-face, with just two conducted over the telephone due to logistical impediments. Each interview was recorded to facilitate subsequent interview analysis, with an average length of around 45 minutes.

To encourage interviewee candidness, I committed to ensuring their anonymity. As such, each participant was given an interview respondent number (IR) which provided anonymity but allowed for the attribution of quotes or perspectives to the respective sectors (Matthews; 2015). The below Table 3 lists each of the interviewee’s IR alongside information on their sector, current place of work and years of relevant experience. Former relevant work experience is also indicated after the semi-colon.

<table>
<thead>
<tr>
<th>IR Number</th>
<th>Sector/s</th>
<th>Organizational Affiliations</th>
<th>Years of GI-related work experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Municipal government</td>
<td>Philadelphia Water Department</td>
<td>1-5 years</td>
</tr>
<tr>
<td>2</td>
<td>Municipal government</td>
<td>Philadelphia Water Department</td>
<td>5-10 years</td>
</tr>
<tr>
<td>3</td>
<td>Academia; Previous municipal government</td>
<td>University of Pennsylvania</td>
<td>Over 20 years</td>
</tr>
<tr>
<td>4</td>
<td>Municipal government; Previous civil society</td>
<td>Office of Sustainability</td>
<td>10-20 years</td>
</tr>
<tr>
<td>5</td>
<td>Municipal government</td>
<td>Parks and Recreation Leadership</td>
<td>10-20 years</td>
</tr>
<tr>
<td>6</td>
<td>Private sector; Previous civil society</td>
<td>Sustainable Business Network</td>
<td>10-20 years</td>
</tr>
</tbody>
</table>
Interview questions centered around the primary MP question but were refined based on the preliminary findings from the desk-based documentary research phase. Questions were open-natured and tailored for each interviewee with the aim of eliciting detailed open responses relevant to their particular area of expertise. The aim was not to statistically aggregate responses to draw a definitive conclusion, but rather to be able to tell a story and identify the common themes emerging from the interviews.

To assist in analysis of the interview data, I used NVivo software. Interview transcripts were imported into the software, with each response coded by the themes or subject matter. This allowed me to extract themes that were common across all interviews, as well as more easily identify differences in perspectives. The results section below is based upon an exploration of each of these main themes.

To complement the interviews, I also participated in a publicly announced joint GreenPhilly and PWD field visit to Heston Lot, a historically abandoned lot in West Philadelphia. This was the site of a joint PWD, Pennsylvania Horticultural Society, Mural Arts and Baker community GI project. This particular project was designed with multiple aims and benefits in mind, namely the management of flooding; aesthetic and community-building benefits from transforming an abandoned and unsightly lot into a beautiful green space with benches; and the creation of employment for youth-at-risk through several community members becoming involved in a green infrastructure maintenance apprentice program (Philadelphia Water Department, 2015). A range of observations arising out of the public conversations that took place during the site visit have been incorporated into the results section.

The qualitative nature of the interviews and site visit undertaken for this MP limits the ability to develop generalizations applicable to all US or global GI stormwater programs. That said, the MP should at a minimum draw out a range of considerations that other projects may wish to have front of mind in making design and implementation choices.

| 7 | Civil society; Previous municipal government | Pennsylvania Horticultural Society | 10-20 years |

*Table 3*
Results

Using the City of Philadelphia as a case study, I aimed to better understand how the GCCW program could enhance the delivery of co-benefits without trading off achievement of its ambitious stormwater management targets. I aimed to identify factors that enabled or inhibited multifunctional outcomes and out of that, raise important considerations that might aid other cities that were designing their GI programs to also deliver a range of benefits.

Drawing from in-depth interviews with a range of key GCCW program stakeholders, the GCCW site visit, as well as from GCCW program-related reports and studies, a number of reoccurring themes emerged. These have been broadly categorized and explored in depth below.

Conceptualizing GI and its benefits

All interviewees recognized that the rationale for GCCW was stormwater management, and that legally, that is how success or failure would be judged. And in that regard, the 5-year program monitoring report released in 2016 indicated that the program had met or exceeded all of its water related targets and was well on track to meeting the 10-year targets (City of Philadelphia, 2016).

But all interviewees, including those whose professional experiences with GI were stormwater focused, also spoke about the importance of this large investment delivering on a range of co-benefits (IR1, IR2). The ‘triple bottom line’ concept was raised in the majority of interviews, and all expressed the opinion that there was some community expectation that co-benefits would materialize out of this water focused program. Most were realistic in their assessments of the degree to which the program was achieving its full potential, with the academic interviewee (IR3) believing that there was room for many more co-benefits to be realized. That said, having been the former GCCW program design leader, he saw the program as being an evolution of a land management system and a water utility system that would take time to arrive at its final destination. He expressed his confidence that there was no turning back.

An important issue raised by a number of interviewees, at the site visit presentations, and contained within the Sustainable Business Network’s (SBN) 2016 Economic Impact Report was that
of the economic development/green jobs/workforce development potential of GCCW. Although not part of the GCCW monitoring and evaluation framework, SBN was tracking economic progress, with their report indicating that approximately 430 green jobs had been created to date, along with a conservative $60m positive impact on the local economy (2016). The report concluded that deliberate attention did need to be paid to ensuring that these opportunities reached lower socio-economic communities and Philadelphia’s returning citizens, a term used in Philadelphia for formerly incarcerated citizens that have completed their sentences and are now returning back into community (IR6, site visit). Site visit presenters lauded the linking up of workforce development opportunities arising out of GCCW with established programs like Philadelphia’s PowerCorpsPHL.

Community building and improving general quality of living was another co-benefit that several interviewees indicated they expected GCCW to deliver. This too was an important theme emerging from the site visit. The GI investment in this neighborhood demonstrated that GCCW could improve community life when the time was invested in building community leadership around and ownership of project sites such as vacant land transformed into GI community parks.

Interviewees also discussed the extent to which GCCW investment was expected to contribute to climate change adaptation and mitigation goals. Many interviewees felt that achieving climate related goals deserved more explicit attention by GCCW. IR3 from the University strongly voiced this opinion, and a PWD staff member (IR2) backed this up. Despite a sense that the program could and should be doing more in this regard, IR2 reported that very few conversations had taken place to date between the climate adaptation team and the GCCW implementation team despite sitting within the same government agency. This lack of communication was attributed to the current senior management focus on developing adaptation strategies for grey infrastructure, which they perceived as facing much greater risks.

Interviewees were asked their perspectives on whether the program needed to design GI interventions with co-benefit outcomes in mind, in order for co-benefits to be realized. The sustainable business sector representative (IR6) felt that site selection was an important factor in thinking through who would benefit and in what ways. This was particularly important when thinking about equitable development in the city. The Parks and Recreation leader (IR5) articulated that without being intentional, it would be easy to miss a range of positive outcomes, especially
those related to such things as building community cohesion through this infrastructure development. Consistent with this, one of the PWD staffers (IR2) expressed concern that there were many missed opportunities at present because of a lack of mindful or purposeful consideration of climate adaptation. Nevertheless, all interviewees accepted that some co-benefits would naturally occur even if little intentional effort was made.

Program Ownership and Commitment

There was consensus among interviewees that the PWD alone was not responsible for delivering non-water related benefits through GCCW. A sense of ownership of and commitment to the program by different actors both inside and outside of government was necessary. Interviewees did perceive some commitment existed. Several people attributed this to the highly collaborative process undertaken at the time of program conceptualization and design (IR4,5,7). IR3 argued that the program could be even more successful at delivering broader co-benefits if it sat outside of the water department, as a cross-cutting city government program. He felt PWD could only broaden its mandate so much and that it needed to also be careful to not forget its primary mandate. Sitting inside a department opened the possibility for other departments to feel ‘all care, no responsibility’ for delivery of results. That said, IR7 indicated that the city’s General Manager (now retired at time of writing this report) was fully onboard with the ambitious nature of the program and its desire to leverage the investment to deliver multiple outcomes. IR7 saw him sending the message to all departments to play their parts, seeing this as a city issue, not a water issue. IR4 concurred, indicating that the legal obligation the city had towards the EPA may have sat primarily with PWD, but the broader benefits envisaged required the efforts of all City of Philadelphia departments. In her words “everybody was on the hook for contributing to the program’s implementation”.

The private sector interviewee felt that the GCCW plan represented a recognition of the need for inter-agency cooperation, which he felt was occurring (IR6). That said, the greatest barrier to really enhancing ownership was lack of financial and human resources in a number of partner-agencies such as Parks and Recreation, Streets and the School District. IR5, representing a sister-agency fully on board with the program goals, indicated that her department was already severely stretched, budget-wise. She indicated that there were many colleagues who felt that given PWD
was a revenue-generating department, they should have the capacity to bear the bulk of the implementation costs.

Types and quality of partners

Regardless of where interviewees felt ownership for GCCW did or should have sat, all agreed that PWD held primary accountability for delivering upon the results promised in the GCCW program document – both water and non-water related. Most felt that PWD themselves did not always have to directly implement the non-water related components of projects, but they did need to coordinate and bring in the right partners to make sure those results were delivered. The theme of partnerships – touching on quality, breadth, diversity and effectiveness – and partners’ abilities to help deliver the co-benefits envisaged in the triple bottom line report was therefore a common discussion point.

Interviewees reflected on the kinds of partners that PWD was engaging with. A review of program documentation revealed that the majority of knowledge partners engaged in GCCW came from the world of hydrology and engineering. Their strengths were in researching and designing GI that delivered most effectively on water indicators. And there was success in that area, with the cost of GI investments coming down over the first five years as the city and its contractors gained more experience in how to undertake GI, applying new techniques emerging out of program-funded research (City of Philadelphia, 2016).

What appeared lacking in program implementation documentation was engagement of social scientists who, for example, might look at economic co-benefits, or ecosystem scientists who might bring in perspectives related to multifunctionality. Interviewees confirmed this observation, again pointing out that the water-targets remained front of mind of PWD staff. IR7, representing the voice of civil society, emphasized the need to find ways to bring more multisectoral partners to the table. Similarly, IR6, who coordinated the private sector engagement with the program also saw the value in bringing non-water focused private sector partners into its coordination mechanism, specifically because of the value they could bring to delivery of the co-benefits. But this was sometimes easier said than done. IR1 spoke of the difficulty in mobilizing certain partnerships that would be important for the realization of co-benefits. An example of the Philadelphia schools district was given.
Coordination-Related Issues

The majority of interviewees raised the issue of coordination costs during the partnership conversations. Such costs were the most commonly cited impediment to delivering both water outcomes and co-benefits. IR1 voiced a strong opinion that “the transaction costs of collaboration outweigh the savings from leveraging costs at scale”. Examples of costs were given. For example, there was currently no city-wide mechanism for pooling departmental funds together for joint projects, something that the contractors and communities had indicated would greatly facilitate coordination and program effectiveness when effectiveness was being viewed more broadly than just stormwater management outcomes (IR6, IR7). A not insignificant transaction-related issue raised by both PWD staff members (IR1, IR2) was related to operational departments having primary responsibility for ensuring operability of the infrastructure, whether it be water or road infrastructure. A collaborative process that, for example, attempted to take advantage of street repair schedules to install underground water capture systems was generally much slower and therefore did not meet operational expectations from a timeliness perspective. Joint up infrastructure processes involving multiple departments would often take up to two years to design, have approved and implement. IR7, presenting civil societal perspectives, echoed such views.

All interviewees inside and out of government indicated that the will to coordinate existed and that intentions across government were to find solutions to reduce coordination costs. Procurement was a focal area in this regard (IR6, IR5). There were also a number of coordination mechanisms designed to support cross-government and cross-partner program delivery. IR4 spoke of an inter-agency working group made up of different city departments identified by PWD as crucial partners in helping them to meet their goals. Meeting quarterly, it is comprised of commissioners and agency heads, with the seniority of the representatives seen as an indication of the importance of this work.

IR6 spoke of the regular meetings of the GCCW advisory committee, comprised of a broad range of stakeholders including community representatives, city department representatives and non-profits. Finally, IR7 spoke of the smaller advisory committee primarily made up of environment
stakeholders including the Pennsylvanian Environmental Council, the Natural Resources Defense Fund, Sustainable Business Network, the Pennsylvania Horticultural Society.

**Legal Mandate**

What became clear in early literature and programmatic documentation review is that although there appeared to be a sincere desire for GCCW to achieve a range of economic, social and non-water environmental co-benefits, the first five years of implementation has been focused on the achievement of CSO targets. This could arguably have been predicted given that both the monitoring and evaluation framework as well as in the cost modelling developed prior to program implementation were silent on the monitoring or expending of funds on non-water related activities (City of Philadelphia 2014; City of Philadelphia, 2009b). A number of the stakeholder interviews confirmed this documentary observation. IR1, sitting within PWD, felt that had the agreement with the EPA made it a legal requirement for PWD to also partially fund non-water activities focused on achievement of co-benefits, it would have resulted in significantly more leveraging of city financial assets. IR3, a key designer of the program, recalls EPA being intentional in removing legal requirements for GCCW to deliver co-benefits. IR7, who worked at PWD at the time of program approval, succinctly stated “The primary driver bottom line is regulatory compliance, and so what EPA and DEP really care about is very water specific”. The siloed nature of the regulator’s internal structure reinforced the water staffs’ focus on water outcomes rather than broader environmental benefits.

**Contracting and Financing Procedures/Rules**

Several interviewees pointed to a number of administrative barriers that made effective collaboration difficult. A PWD staff member (IR1) spoke of how different interpretations of what was considered allowable spending by the department’s chief finance officer impacted on what funds were or weren’t spent on. A former chief financial officer had interpreted financial rules to mean that up to 10% of a GCCW project budget could be dedicated to non-water related expenses. For example, playground equipment could be procured with a GCCW budget as part of a project involving installation of a stormwater infiltration unit in a park playground. IR1’s opinion was that the more conservative interpretation of the current chief financial officer arose out of his concern
that the bond market would react negatively to expenditures seen by the market as being outside the direct responsibility of the water department. IR1 felt this resulted in a restriction in the unit’s ability to fully leverage expenditure for co-benefit delivery.

Differences in procurement rules across departments was also cited as an obstacle by several interviewees. The sustainable business sector representative (IR6) spoke of the difficulties contractors had in trying to leverage contracts from different departments for the same project site. The Parks and Recreation interviewee (IR5) also noted that the different contractual criteria of different departments related to project completion and quality assessments made it difficult to develop joint department service procurement agreements.

**Leadership and Organizational Culture**

The topic of leadership was one of the most commonly reoccurring themes across all interviews. All interviewees spoke of the change in PWD leadership since the program’s design and approval, and that the current commissioner was much more operations-focused than the former commissioner. This was not necessarily a criticism, but it did impact on the degree to which staff were being encouraged to consider co-benefits in design and delivery of their programs, versus focusing on what was considered core business. IR1, working within PWD, referenced the organizational chart and the fact that the GCCW implementation unit under the current commissioner had become a standalone unit, sitting outside the operations unit. IR1 did feel that broader City of Philadelphia leadership was very supportive of GCCW and heads of many departments saw a clear role for their departments in supporting delivery of the program and the co-benefits, but he felt that the impediment from sister-departments sat more often with middle level management. Generally, at this level, people were much more focused on their respective core department business and what they were legally and operationally obliged to deliver.

IR7 mentioned his organization was watching closely who might succeed the current commissioner at the end of her 2019 term. Speaking on behalf of the private sector members that formed part of the sustainable business network, he indicated that his network was hoping to see the appointment of a new commissioner that shared the broader GCCW vision of using GI to deliver stormwater and other co-benefits. That would set the tone for the entire department.
Organizational culture was raised by several interviewees. IR2, imbedded within PWD, spoke about the fact that many staff members had been in the department for a very long time and were used to doing things the same way they had always done them. She also referred to the fact that in the absence of sufficient investment funds all these years, the culture was a somewhat reactive one, rushing to fix broken pipes when they occurred. Many PWD frontline workers could not envisage having the ‘luxury’ of planning a coordinated project for two years into the future. That said, IR6, IR7 and IR3 all felt that some mind shifting was slowly occurring, especially with some younger, more systems-thinking oriented recruits entering the department.

The Right Skill Sets

Interviewees discussed their perspectives on the required skills sets for successful delivery of water and co-benefit outcomes. IR1 felt there was significant work to be done on PWD workforce development in this regard. He believed that understanding hydrological systems was no longer sufficient for broader program delivery. The civil society focused interviewee, IR7, echoed this view, expanding to suggest that PWD had not ever really constructed infrastructure within a true partnership model, which is what GCCW required. He believed that existing PWD staff were less knowledgeable about how to do this and needed to draw more on partners like the Pennsylvania Horticultural Society and the Sustainable Business Network to assist. IR5, speaking from within the bureaucracy indicated that leaders needed to undertake conscious recruitment not just for the diverse hard skills needed for GCCW to be successful, but also for the soft skills, including the demonstrated personal commitment to delivery of co-benefits. IR2, sitting within PWD, also spoke of the need to be developing the workforce in such a way that PWD would become a learning organization given the very steep learning curve being faced by everyone working on the program.

Discussion and Recommendations

Drawing on GCCW related documentation, informant interviews and a site visit, the above section explored a number of themes related to both the opportunities for, as well as barriers to realizing greater co-benefits out of Philadelphia’s GI investments. This section takes a step back. Having analyzed the above information, some conclusions are now presented regarding the degree to which the case study city of Philadelphia appears to have achieved delivery of co-benefits. As the
MP question is focused on approaches that might enhance benefit co-delivery, this analysis provides a range of concrete recommendations on actions that cities may wish to consider taking when embarking on the GI design and implementation process.

Interviews and program documentation revealed that during the design phase, GCCW did indeed pursue a broad conceptualization of GI that promoted the wide range of co-benefits that would be simultaneously achieved as the program was rolled out. Extolling the multifunctionality of GI increased the number of stakeholders that benefited from the program, which arguably increased support for the program concept, encouraging increased political buy-in and eventual EPA and State Legislative approval.

But in this case study, the implementation phase saw the intensity of focus shifting squarely on to the achievement of stormwater outcomes. Interviews with core implementers of the program including the PWD and the GSI Partners confirmed that stormwater management was the guiding objective, with those actors involved in direct implementation possessing skill sets reflective of the objective. The saying ‘if you measure it, you manage it’ aptly applied to this case, with achievement indicators focused on water-related activities. While a range of co-benefits were certainly realized as a kind of externality to the GI approach, issues including PWD leadership buy-in, government processes that increased the transaction costs of collaboration, and the water-focused ambition of the legal contract with the EPA meant that limited deliberate or targeted investment appeared to have been put into maximizing the co-benefits.

While the term *wicked problem* was not directly used by any interviewee, the substance of many of their comments pointed directly to the intractable problems associated with trying to manage an ecosystem for multiple outcomes. The case for ecosystem management falling into the wicked problem basket was made by DeFries and Nagendra who argued that land and seascapes are capable of providing multiple ecosystem services simultaneously, but that the complexity of ecosystem interactions is such that we are still far from clear as to what synergies or tradeoffs will result from decisions we make (2017). Using their words, “sector-wise administrative structures limit abilities to weigh outcomes of management decisions that affect sectors outside a given sector’s mandate” (2017, p.267). This observation is highly consistent with those made by all those interviewed, with sectoral silos appearing to limit the full potential of GI.
Despite this, the process of undertaking interviews and visiting a site allowed for the mining of a range of good practice examples that showed where co-benefits were being realized. A broad commitment to a sustainable, livable Philadelphia, a genuine desire to partner across government and across sectors, and an appreciation for leveraging scarce funding were key motivations expressed by interviewees in pursuing co-benefits despite institutional and incentive barriers.

Through the process of undertaking this MP a number of very actionable ways that a city can enhance delivery of co-benefits, even when being legislatively obliged to meet stormwater objectives, can be identified. Below, these have been classified loosely as internally-oriented actions and externally oriented actions.

**Internally-oriented Actions**

The Philadelphia Water Department, and water departments throughout the US may wish to consider undertaking the following actions:

1) Reviewing the legal and financial regulations related to the GI program under development, with the aim of ensuring language and legal obligations support a culture of cross-sectoral collaborations required for co-benefits to be maximized. Examples of actions could include:
   a. Putting co-benefit language into legal agreement to give it the attention that all stakeholders (communities, private sector and public sector) feel it deserves.
   b. Explicitly allowing for some GI-related expenditure to be spent on co-benefit related investments
   c. Including a number of key co-benefit targets within program monitoring and evaluation – If you measure it, you manage it.

2) Reviewing procurement barriers that complicate joint collaboration across departments and with external partners. Actions could include:
   a. Looking for opportunities to standardize procurement rules across government departments
      i. It is recommended that private sector be involved in this review given their first-hand experience with often contradictory procurement rules, and also their experience to propose alternatives
3) Ensuring existing coordination mechanisms both within government and with external stakeholders are fit for purpose, are accountable in terms of deliverables and are meeting with sufficient regularity. This involves:
   a. Looking for opportunities to build this GI work into other cross governmental working groups such as the climate change working group
4) Undertaking a range of human resources related actions including:
   a. A workforce skills audit of city departments but also of key implementation partners from private and civil society sectors
   b. Looking at ways to incentive mid-level manager involvement. This includes finding ways for them to make delivering multiple objectives easier.
   c. Succession planning within PWD. Ensuring recruitment practices target the kinds of skill sets required for delivering upon more cross-sectoral and multi-faceted water system initiatives.
5) Securing senior political and bureaucratic leadership commitment for some level of experimentation and innovation. Ways to do this include:
   a. Establishing an innovation bucket of funding that can be applied for and used for cross departmental collaborations that attempt to develop new ways of working
6) More radical considerations such as exploring whether a program like GCCW should remain sitting within a thematic department or instead should become its own standalone program sitting horizontally alongside a number of key departments.
   a. If it is to remain within a department, such as the water department, a strong message regarding multi departmental responsibility must come from the top
   b. Also look to ways to encourage contribution/ownership of other departments. For example, introducing an annual indicator that captures departmental spending on GCCW related activities.

**Externally-oriented Actions**

Not all responsibility sits with the water departments. The following list present some ideas for water departments to undertake alongside external partners, or actions that can be entirely led by players external to municipal government.
7) Establish broader representation on coordination mechanisms. These mechanisms should increasingly include partners that also represent the social and ecological sciences.

8) Undertake greater outreach to multi-disciplinary knowledge partners.
   a. Such partners can participate in the development of tools to assist both water departments as well as implementation partners in designing GI interventions that maximize co-benefits. Obviously, importance of site physical characteristics mean that scalability tools are not always useful. But tools can capture more general principles.

9) Identification of alternate sources of co-funding. Attempts should be made to look outside of the usual sources of GI co-funding such as Parks and Recreation, Schools and Streets Departments. Many actors and organizations benefit from GI co-benefits and so the argument can be made that they should pay for them. Some example alternatives include:
   a. Insurance companies – Water departments and partners should develop business cases for insurance companies regarding the ability of GI to reduce localized flooding events, thereby reducing insurance claims.
   b. Energy utilities - For example, in Philadelphia, customers are now receiving rebates from utilities for using energy efficient appliances. This is because the current energy infrastructure is hitting its maximum production thresholds and the investment in new infrastructure to supply more energy is sizable. Utilities prefer right now to reward efficiency and defer new investments. Making the business case that neighborhood trees have been shown to reduce energy needs in both summer and winter, thereby reducing home energy heating demands, may be well received by utilities.
   c. Health insurers – Many studies show that green spaces and trees provide important health benefits to city residents (Oregon Health and Outdoors Initiative, 2018). One of the main pathways is through trees ability to address particulate matter pollution (TNC, 2016). Health insurers may be open to co-funding GI as a way of reducing health claim liabilities.
The potential for GI investment to support sustainable, livable, equitable cities is immense. This MP has attempted to highlight some of the barriers to and opportunities for maximizing city investment in water-focused GI to deliver on this potential.
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