Incentivizing Private Property Green Infrastructure:

Recommendations for Los Angeles County

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Cover Image: Kitsap County YMCA Rain Garden, Courtesy of STORM Outreach

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Throughout history as cities have developed, challenges have arisen in managing stormwater in highly modified urban environments. Stormwater is rain and snowmelt which in the natural environmental infiltrates into the ground or follows through its natural drainage path (U.S. EPA 2018a; Copeland 2014). As developers in the urban environment transform ground surfaces into buildings and pavement, this natural hydrology is altered. Stormwater runoff becomes an increasing flood risk to communities and runoff is polluted, picking up major pollutants from impervious surfaces, posing health and environmental risks (Copeland 2014).

As a highly developed urban area, Los Angeles County faces pressing stormwater challenges along both water quality and water quantity dimensions. Due to its unique regional, political, and climatic context, Los Angeles County must address water pollution and flooding issues while also facing water scarcity. Historically, Los Angeles' population boomed thanks to water imported from Northern California, the Eastern Sierra Nevada mountains, and the Colorado River (Hughes et al 2013). Much of the water in the City of Los Angeles is still imported and local water supplies only account for 12% of the Los Angeles Department of Water and Power's total supply (LADWP 2019). Growing concerns about drought and climate change put these imported water supplies at risk, and stormwater currently represents a missed opportunity to improve local water reliance. Throughout the county, where local groundwater makes up a larger portion of water supplies (35%), stormwater can still serve as valuable aquifer recharge that could bolster water supplies in the event of future droughts (Pincetl et al 2015).

Additionally, despite its reputation for endless sunshine, Los Angeles still experiences rainfall and subsequent flooding and water pollution risks. Nearly 100 million gallons of contaminated water flows through Los Angeles County storm drains each day, swelling to 10 billion gallons per day during rain events ("Frequently Asked Questions" n.d.). The network of 5,000 miles of storm drains in the county directly drains to rivers and beaches which suffer from this polluted runoff ("Pollution Fast Facts" n.d.).

In November 2018, Los Angeles County voters approved Measure W, an annual parcel tax that will charge private properties 2.5 cents per impervious square foot to provide around $300 million annually for stormwater projects in the county ("Safe Clean Water: FAQs" n.d.). Along with the tax, the county also committed to implementing grant, tax reduction, and trading programs ("Program Elements" 2018). As the county develops these incentive programs, now is the ideal time to research how other municipalities encourage green infrastructure on private property to improve stormwater management. Based on other case study municipalities and a literature review, this report suggests ways that Los Angeles County can structure Measure W to encourage green infrastructure development on private property[1] and address the county's water pollution, flooding, and water resilience concerns.

Background

Cities are increasingly adopting 'green infrastructure' which uses vegetation, soils, and natural elements to treat, infiltrate, and store stormwater (U.S. EPA 2018b). Green infrastructure provides low cost, effective stormwater management and additional co-benefits such as green space, local job opportunities and economic development, increased property values, and public health benefits (Hammer & Valderrama 2018; Copeland 2014). Smaller scale green infrastructure distributed across the urban landscape holds the potential to effectively reduce stormwater pollution and flooding (Porse 2013). Many different property owners generate urban stormwater runoff in a given city, making it difficult to regulate and reach citywide compliance with federal regulations (Subramanian 2017). Thus, policies which encourage green infrastructure installation on private properties can provide important benefits.

It is important to note that decentralized green infrastructure can provide environmental benefits but it is not meant to replace other necessary measures of stormwater management such as existing gray infrastructure or even larger regional green infrastructure projects. Indeed, current street drainage patterns and existing infrastructure often engineer untreated stormwater to quickly rush off private properties into storm drains—and in Los Angeles, the Los Angeles River—and directly into waterways and beaches. This still necessitates larger regional strategies and municipal action to manage these flows and pollutants. Costs also widely vary based on many factors so green infrastructure programs may not be the best fit for stormwater management in all locations. However, the case study municipalities in this report all found private property green infrastructure to be a valuable component to their overall municipal stormwater management strategies. Given that Los Angeles County committed to adding this approach (via Measure W) alongside other stormwater management efforts, this report assumes that the county evaluated all its options and already determined that undertaking private property green infrastructure would be

[1] For the remainder of this report green infrastructure located on private property will be referred to as "private property green infrastructure" for brevity.

beneficial. Once pursued, policies to increase private property green infrastructure can fall into three categories: the regulatory, financial, and market-based approaches.

Regulatory Approach (LID Ordinances)

The regulatory approach involves low impact development (LID) ordinances. LID ordinances require new and redevelopment projects of certain sizes and types to meet stormwater management requirements, often requiring specific green infrastructure installations (known as "best management practices" or BMPs) to reduce the impact of development on urban runoff quantity and quality (Johnson & Staeheli 2006; Chang et al 2018). These LID ordinances are sometimes explicitly required by, or mentioned in, municipal stormwater permits (Metres 2013).

Financial Approach (Stormwater Charge with Incentives Programs)

A more advanced policy option, which provides a financial incentive for property owners, is a stormwater fee or tax ('charge') with incentives program. This option requires levying a charge for stormwater services on property owners, with the option for them to reduce or eliminate the cost by implementing green infrastructure. A related option is for the money from the charge to be used to provide grants or rebates directly to owners to implement these projects (Valderrama & Hammer 2018; Doll et al 1998, Debo & Reese 2003).

Market-Based Approach (Trading Scheme)

The most complex policy option is a trading scheme. This is a market-based system in which property owners implementing green infrastructure can sell credits to other property owners who are required to meet stormwater management requirements (e.g. from an LID ordinance or industrial stormwater permit) (Dougherty et al 2016; Thurston et a, 2004; Ellis et al 2017).

Methods

The primary research question of this project is: *How can Los Angeles County update its existing policies, and implement new policies, to expand green infrastructure for stormwater management on private properties?*

This report utilizes two main research methods: a literature review and case studies (with interviews). A general literature review on stormwater management and green infrastructure followed by a targeted literature review on each of the three policy approaches resulted in the development of a set of guiding considerations for each policy approach. These guiding considerations represent some of the major factors that municipalities must consider during program design and implementation. The case studies then provided detailed examples of how municipalities addressed these considerations given their unique contexts. Figure 0-1 shows the location of the five selected case studies (Seattle, WA; Washington, DC; Philadelphia, PA; Montgomery County, MD; Chattanooga, TN). The case studies were selected to represent a range of municipalities based on geographic location, stormwater regulation, and policy approaches employed. A review of policy ordinances and city websites, in addition to phone interviews with municipal staff, provided the evidence to evaluate these case studies and discern lessons learned to apply to Los Angeles.

Figure 0-1 Map of case study municipalities and Los Angeles County

The next step for each policy approach involved the creation of principles of success, which bring together lessons learned from the literature review and case studies to highlight necessary aspects for policy success. The principles of success provided the framework for analyzing the Los Angeles County context in order to make recommendations. The county's existing LID ordinance was analyzed in the regulatory section and recommendations were devised to improve the ordinance to encourage more private property green infrastructure. The proposed Measure W financial incentives and trading scheme were analyzed in the financial and market-based sections respectively, with associated recommendations proposed for each. The project utilized a content analysis approach to review multiple lines of evidence for commonalities. These common categories of evidence and findings across sources helped devise the guiding considerations and principles of success for each policy type.

Findings

In addition to specific findings for each policy approach, two overall high-level findings were found to be relevant across case studies. First, municipal stormwater regulation serves as an important driver for policy implementation and design. Most case studies cited their municipal National Pollutant Discharge Elimination System (NPDES) permit (the form of stormwater regulation authorized by the Clean Water Act) as an impetus for their green infrastructure policy and structured their policies to assist in permit compliance. Second, all case studies highlighted the importance of layering incentives since tax or fee reductions alone were insufficient to motivate property owners to install green infrastructure. Layered incentives can provide stronger motivation for property owner involvement: Measure W already calls for the creation of tax reduction, grant, and trading programs in Los Angeles County. These two findings appeared across case studies and helped to inform some of the principles of success for each policy type. Both the case study lessons and principles of success for each policy approach are summarized in Figure 0-2 and result from analysis of the literature review and case study cities.

Careful program design which follows these principles can potentially assist with, although does not guarantee, policy success. Each municipality must consider its own unique context and stormwater management goals when designing these types of policies. These broad suggestions are meant to highlight some of the general aspects which proved successful in existing programs while the example of Los Angeles County in this report can show the diversity of questions and considerations which municipalities must consider when undertaking policy designs of their own. The Los Angeles County recommendations thus apply the principles of success to the current structure of proposed Measure W programs to suggest several general aspects of future policy direction.

	LID Ordinance	**Financial Incentives**	**Trading Scheme**
Principles of Success	● Regular pace of development and long-term adoption goals ● Clearly defined goals based on watershed needs ● Opportunity for flexible alternative compliance ● Defined	● Legal feasibility and political willpower ● Adequate incentive amounts ● Defined goals to tailor incentive structures ● Program focus tailored to land use patterns ● Combining	● Sufficient market for buyers and sellers ● Strong regulatory basis for program goals and design ● Administrative capacity to implement ● Low transaction costs and credit liquidity ● Comprehensive

	implementation guidelines ● Enforcement, monitoring, and maintenance	approaches (carrots and sticks)	policy package for adequate incentives
Case Study Lessons Learned	**Washington, DC** ● Set a permanent percentage of allowed off-site compliance to create a market **Seattle, WA** ● Created an LID ordinance with multiple goals and standards ● Piloted stricter standards in High Point Public Housing Development before city-wide expansion	**Philadelphia, PA** ● Layered grants with fee reductions to motivate property owners ● Separated residential and commercial programs with different goals and structures **Montgomery County, MD** ● Used outreach to target priority areas ● Invested in residential programs for education benefits	**Washington, DC** ● Created 1-year, 1-gallon credits for continual market use and shorter maintenance obligations ● Created a Price Lock Program to set price floor and target priority areas **Chattanooga, TN** ● Reduced eligibility for credit coupon use, permanent credit life, and no trade facilitation hinders market use

Figure 0-2 Principles of success and case study lessons learned by policy approach

Conclusion and Recommendations

In conclusion, Los Angeles County and its voters signaled a commitment to more innovative stormwater management with the passage of Measure W, which will provide new tools and consistent funding. By committing to a private property green infrastructure program, Los Angeles County has confirmed that leveraging private property will be a complementary strategy to existing stormwater management. The next step will be to make decisions on the numerous aspects of program design. Based on the experiences of the five case study municipalities analyzed, along with information from existing literature, this report identified nine recommended actions which the county can take when creating new private property green infrastructure policies. These recommendations do not reflect the entirety of program design decisions or considerations which Los Angeles County must address, but can provide a useful starting point based on lessons learned from existing policies in other locations. These recommendations are summarized in Figure 0-3 and span all three policy approaches. The first and central component of policy development should be updating the county's current LID ordinance, since it will serve as the basis for both the tax reduction and trading programs in Measure W.

LID Ordinance	Financial Incentives	Trading Scheme
● Increase opportunities for off-site and alternative compliance ● Prioritize compliance strategies to achieve specific goals ● Use LID ordinance as the foundation of a trading program	● Separate residential and commercial grants or rebate programs ● Provide education and outreach, technical, and design assistance ● Coordinate with municipalities for funding	● Update LID ordinance to create market ● Create credits with limited lifetime and maintenance obligations ● Establish county level market support tools

Figure 0-3 Recommendations for Los Angeles County

Private property comprises a significant portion of Los Angeles County and generates a significant amount of urban runoff and pollution, making it an ideal target of future stormwater policies. With its existing LID ordinance and the commitment to implement financial incentive and trading programs, the county has the potential to join the case studies in this project as an innovative leader in stormwater management through green infrastructure implementation. This report serves as an initial first step by providing background information, analysis, and general recommendations which could be a useful guide for other municipalities considering the adoption of these policies. Green infrastructure continues to expand in cities across the country as a promising flexible, cost-effective solution to stormwater management with multi-benefits.

Introduction

When it rains it pours. Throughout history as cities have developed, challenges have also arisen with stormwater management in highly modified urban environments. Stormwater is rain and snowmelt which naturally infiltrates into the ground or follows a natural drainage path (U.S. EPA 2018a; Copeland 2014). This natural hydrology is altered when the development of the urban environment transforms pervious ground surfaces into buildings and pavement. In addition to creating flood risk, stormwater runoff picks up major pollutants from these impervious surfaces, posing health and environmental risks (Copeland 2014). Historically, cities have relied on 'gray infrastructure,' such as pipes and storm drain systems to manage these issues (U.S. EPA 2018b).

Cities are increasingly adopting 'green infrastructure' which uses vegetation, soils, and natural elements to treat, infiltrate, and store stormwater (U.S. EPA 2018b). Types of green infrastructure include bioswales[2], rain barrels or cisterns, permeable pavement, and downspout disconnections (U.S. EPA 2018b). Green infrastructure provides low-cost, effective stormwater management and additional co-benefits such as local job opportunities and economic development, increased property values, and public health benefits (Hammer & Valderrama 2018; Copeland 2014). Projects can be large and located in public areas such as green streets and parks as well as be smaller and located on private properties. Smaller scale green infrastructure distributed across the urban landscape holds the potential to effectively reduce stormwater pollution and flooding when combined with larger, public green infrastructure and other existing stormwater management approaches (Porse 2013). Many different property owners generate urban stormwater runoff in a given city, making it difficult to regulate and reach city compliance with federal regulations (Subramanian 2017). Thus, policies which encourage green infrastructure installation on private properties can provide important benefits if used as a supplement to existing gray infrastructure and regional stormwater management activities. This report studied the different policy options for municipalities seeking to incentivize green infrastructure on private properties for improved stormwater management and ultimately make recommendations for Los Angeles County, a municipality facing pressing stormwater concerns.

[2] Bioswales are channels with vegetation and mulch that slow, infiltrate, and filter collected stormwater (EPA, July 2018).

Background

Numerous factors affect stormwater management and the types of policies a municipality will implement, including geophysical factors affecting stormwater flow and quality, existing laws and socio-political contexts that enable (or hinder) new strategies, and financial constraints for municipalities to implement certain solutions (Barbosa et al 2012). Most municipalities in the United States make stormwater management decisions within the framework of national stormwater regulation administered by the U.S. Environmental Protection Agency (EPA)[3] (Galavotti et al 2012). The Municipal Separate Storm Sewer (MS4) process requires National Pollutant Discharge Elimination System (NPDES) permits under the Clean Water Act (Subramanian 2017), which set certain compliance standards for municipalities. Older cities with combined sewer and stormwater systems[4] must also have NPDES permits to prevent combined sewer overflows (CSOs): these permits are known as CSO Control Policies (Spitzig & Vassar 2017). These municipalities may be under Consent Decrees or Consent Orders with the EPA to undertake particular stormwater management actions if they failed to meet CSO standards in the past (Spitzig & Vassar 2017).

Municipalities often struggle to comply with NPDES permits (both MS4 and CSO) when so much of the runoff stems from private property, limiting potential policy responses (Johns 2019). Green infrastructure is one option to manage stormwater and thereby meet NPDES permit requirements. Yet Johns (2019) studied the City of Toronto in Canada and found that private property was a major barrier to implementing green infrastructure. Municipalities can, however, enact certain policies to expand green infrastructure onto private properties and thereby improve stormwater management. Policies can fall into three categories: regulatory, financial, and market-based approaches. Each approach differs in its potential efficacy and applicability for a given municipality based on a range of unique factors, some of which will be discussed in the findings of this project. Below is a brief description of what the approaches entail.

Regulatory Approach (LID Ordinances)

The regulatory approach involves low impact development (LID) ordinances. LID ordinances require new and redevelopment projects of certain sizes and types to meet stormwater management requirements, often requiring specific green infrastructure installations (known as “best management practices” or BMPs) to reduce the impact of development on urban runoff quantity and quality (Johnson & Staeheli 2006; Chang et

[3] See Appendix A: Glossary, for a summary of common terms and acronyms used in this project.
[4] Combined sewer systems mix stormwater and sewer waste in a single pipe system as opposed to separate storm sewers which only collect stormwater.

al 2018). These LID ordinances are sometimes explicitly required by, or mentioned in, municipal MS4 permits (Metres 2013).

Financial Approach (Stormwater Charge with Incentives Programs)

A more advanced policy option, which provides a financial incentive for property owners, is a stormwater fee or tax ('charge') with incentives program. This option requires levying a charge for stormwater services on property owners, with the option for them to reduce or eliminate the cost by implementing green infrastructure. A related option is for the money from the charge to be used to provide grants or rebates directly to owners to implement these projects (Valderrama & Hammer 2018; Doll et al 1998, Debo & Reese 2003).

Market-Based Approach (Trading Scheme)

The most complex policy option is a trading scheme. This is a market-based system in which property owners voluntarily implementing green infrastructure (i.e. not subject to requirements) can sell credits to other property owners who are required to meet stormwater management requirements (e.g. through an LID ordinance or industrial NPDES permit) (Dougherty et al 2016; Thurston et a, 2004; Ellis et al 2017).

This report reviews these three types of policy options and ultimately makes recommendations on each policy type for Los Angeles County. The county currently has an existing LID ordinance and, with the November 2018 passage of Measure W, it will soon be implementing the financial and market-based approaches ("Program Elements" 2018). Measure W creates a stormwater parcel tax for all property owners in the county and also commits the Board of Supervisors to develop guidelines for tax credit, grant, and market trading programs by August 1, 2019 ("Program Elements" 2018). The next section of this introduction provides more information on the county's unique stormwater context.

Los Angeles Context

Due to its unique regional, climatic, and political context, Los Angeles County faces pressing stormwater challenges along both water quality and water quantity dimensions. In particular, Los Angeles must address water pollution and flooding issues while also facing concerns about water scarcity.

Water Scarcity Challenges

Located in arid Southern California, Los Angeles only receives about 15.5 inches of rain per year and imports a significant portion of its water supply (Hughes et al 2013). Historically, Los Angeles' population boomed thanks to water imported from Northern California, the Eastern Sierra Nevada Mountains, and the Colorado River (Hughes et al

2013). Figure 1-1 shows the 2016-2017 water supply makeup for the Los Angeles Department of Water and Power (LADWP), which provides a significant amount of water to the City of Los Angeles. Much of the water is still imported and local water supplies only account for 12% of total supply (LADWP 2019). Los Angeles County relies more on local groundwater supplies than the City (35% of 2010 supply) but still faces equally pressing concerns about water supplies in the event of droughts and unpredictable precipitation, which climate change will exacerbate (Pincetl et al 2015).

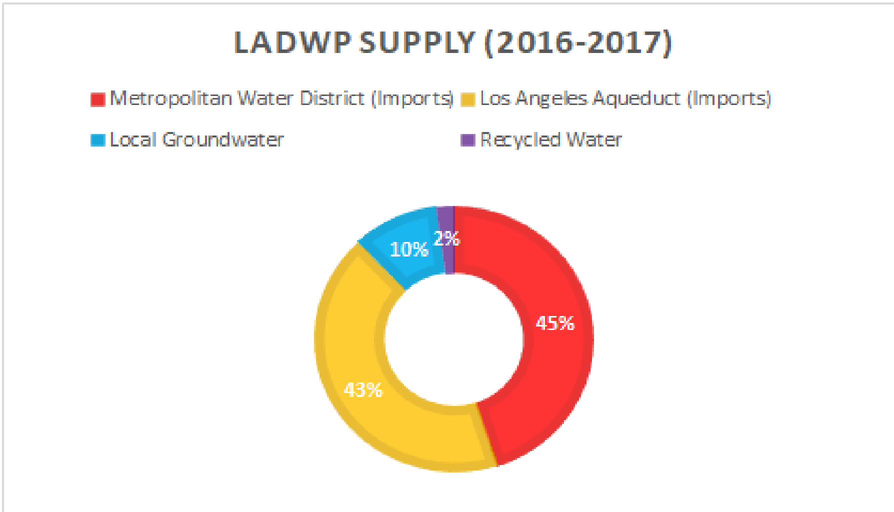

Figure 1-1. 2016 Los Angeles Department of Water and Power water supply (Data: LADWP 2019)

Growing concerns about drought and climate change put both imported and local water supplies at risk, and many suggest that Los Angeles County should expand water sources such as recycled water and captured stormwater (Hughes et al 2013). Stormwater currently represents a missed opportunity to improve local water reliance. Just last year, 100 billion gallons of stormwater in the county flowed directly to the ocean. This water could have been used to augment Los Angeles' supply ("Safe Clean Water: FAQs" n.d.). Green infrastructure can not only reduce flooding and improve water quality, but also capture stormwater for aquifer recharge and on-site reuse for landscaping or other needs ("Safe Clean Water: FAQs" n.d.). Although it is still important to note that the nature of seasonal rains, existing impermeability, and difficulty of recharging groundwater basins are all challenges to this strategy which should be considered when designing and siting green infrastructure.

Water Pollution and Flooding

Despite its reputation for endless sunshine, Los Angeles still experiences rainfall, subsequent flooding, and water pollution risks. Historic floods during rain events led to the channelization of the Los Angeles River, which now acts as a giant storm drain to quickly rush rain water (and trash and pollutants) out to the ocean to avoid flooding

("History of the Los Angeles River" n.d.). The Los Angeles River drains most of the stormwater in Los Angeles County but many of the storm drains leading to the river are filled with trash, algae, and other pollutants (Ackerman et al). Nearly 100 million gallons of contaminated water flows through the county's storm drains each day, swelling to 10 billion gallons per day during rain events ("Frequently Asked Questions" n.d.). The network of 5,000 miles worth of storm drains in the county directly drains to rivers and beaches which suffer from this polluted runoff ("Pollution Fast Facts" n.d.). Many of the water bodies in Los Angeles are considered 'impaired' on the Clean Water Act's 303(d) list. The EPA issues surface waters on this list total maximum daily load (TMDL) standards prescribing acceptable levels of pollution (U.S. EPA 2018c). The Los Angeles Regional Water Quality Control Board (L.A. RWQCB) regulates Los Angeles and Ventura County waters under the Clean Water Act. Based on 2010 data, the L.A. RWQCB listed over 800 impaired water bodies in the region (CASWRCB 2018). Figure 1-2 shows impaired water bodies in the county in red[5].

Heal the Bay, a nonprofit focused on beach and water quality, annually rates beaches in its Beach Report Card with grades from A to F based on bacteria and pollution levels (Heal the Bay 2018). In 2018, 91% of Los Angeles County beaches achieved 'A' grades during dry summer conditions but this dropped to 54% during wet weather, with 26% of beaches receiving 'F' grades (Heal the Bay 2018). This is largely due to polluted urban runoff bringing contaminants to beaches where the network drains to the ocean.

[5] Map created in ArcMap with State Water Resources Control Board data, to see interactive map visit https://www.waterboards.ca.gov/water_issues/programs/tmdl/integrated2014_2016.shtml .

Figure 1-2. Impaired water bodies (on the 303(d) list) in Los Angeles County based on 2010 Data (Data: California State Water Resources Control Board 2018)

In November 2018, Los Angeles County voters approved Measure W, an annual parcel tax that will charge private properties 2.5 cents per impervious square foot to provide around $300 million annually for stormwater projects in the county ("Safe Clean Water: FAQs" n.d.). Along with the tax, the county committed to implementing grant, credit, and trading programs ("Program Elements" 2018). Measure W also enables larger regional projects, green streets, and other important stormwater measures. With over 10 million people across 4,000 square miles (U.S. Census Bureau 2017), Los Angeles County can make a huge impact on regional stormwater issues with a combination of new policies and funding. A county-wide private property green infrastructure program can be a valuable complement to new and existing stormwater management in the county. As the county develops these incentive programs, now is the ideal time to research how other municipalities encourage private property green infrastructure to influence Los Angeles County's ultimate policy decisions.

Research Question and Methodology

The primary research question of this project is as follows:

How can Los Angeles County update its existing policies, and implement new policies, to expand green infrastructure for stormwater management on private properties?

To answer this question, this report analyzes the defining aspects of the three types of local government policies for private property green infrastructure (the aforementioned regulatory, financial, and market-based approaches). This research will result in the formulation of guiding considerations for policy design and principles of success recommended for each policy type. Ultimately, a review of the current Los Angeles context in terms of these principles of success will result in suggestions for designing future policies in Los Angeles County.

The report utilizes several sources of data including secondary source literature (e.g. peer reviewed academic articles, white papers, and conference proceedings) along with detailed case studies of five municipalities with existing private property green infrastructure policies (Seattle, WA; Washington, DC; Philadelphia, PA; Montgomery County, MD; and Chattanooga, TN). These case studies include a mix of primary and secondary sources including review of ordinances, official websites, and interviews with staff. A qualitative content analysis found commonalities across these sources to determine the guiding considerations and principles of success for each policy type.

Findings

The bulk of this report consists of the three findings sections which provide detail on each policy type along with recommendations for Los Angeles County. Two overarching findings are detailed here, along with the main recommendations for Los Angeles County. First, across all policy types and case studies, regulation was found to be an important driver of, and guide for structuring, policies. The need to comply with NPDES regulation proved a strong impetus for case study municipalities to increase green infrastructure on private properties. Thus, Los Angeles County should use its MS4 Permit to help design its policies. Second, combining incentive programs is necessary to adequately incentivize property owners. All case study interviews used a combination of requirements (e.g. LID ordinance) and different incentive types (e.g. discounts, grants, and/or rebates). Measure W proposes implementing both financial and market-based programs to supplement the county's existing LID ordinance—providing an ideal opportunity to layer incentives.

Outline of Project

This project is organized as follow:

Section 1: Introduction provides background and context for this report, as well as a brief description of findings and project organization.

Section 2: **Literature Review** presents the current state of research and debates on this topic, along with where this report fits within and contributes to the field.

Section 3: **Data and Methodology** describes the data sources and methodology used to arrive at the findings and recommendations.

Section 4: **Findings and Analysis** contains three separate parts, one for each policy approach: regulatory (LID ordinances), financial (fee or tax discounts, grants, and rebates), and market-based (trading schemes). Each of the sections contains an overview of the policy type and program design considerations followed by case studies, resulting in principles of success for each policy type. Each section ends with recommendations for Los Angeles County to implement or update its policies using each approach.

Section 5: **Conclusion** reiterates the major findings and recommendations for Los Angeles County consolidated across each of the three policy types. This section concludes with suggestions for further research on this topic.

Literature Review

Introduction

While traditionally the purview of engineers, stormwater management now features in environmental policy, planning, and geography literature seeking to evaluate new and more sustainable solutions to urban stormwater challenges. Numerous academic articles describe the challenges of urban stormwater and suggest policy and planning frameworks—with various degrees of detail and specificity—for how to improve stormwater management (for example see Dhakal & Chevalier, 2017; Parikh et al, 2005). Since much of the runoff-producing impervious developed land in cities is private property, cities have attempted to design policies to encourage green infrastructure on private property to manage stormwater runoff quality and quantity. A body of professional and academic literature now details case studies, provides policy recommendations, and evaluates barriers and opportunities. This literature review largely focuses on the research emerging around private property green infrastructure and policies for its implementation. The review categorizes and describes significant studies while highlighting the current state of research, gaps in literature, and the potential contributions of this report.

This research project uses current literature and case study analysis of local government private property green infrastructure policies to create recommendations for Los Angeles County. Thus, this literature review provides an overview of some of the sources serving as evidence in this project, in addition to highlighting where the project fits amongst existing scholarship. In particular, most literature thus far provides general overviews of policy designs with a lack of context specific applied research or comparison studies between the three policy types (LID ordinances, tax/fee reductions and rebates/grants, and trading schemes). This research project provides comparative policy research and creates a framework for applying questions of policy design to a specific municipal context. The project creates specific recommendations for Los Angeles County while contributing to the debate surrounding policy design options and how these policies interact.

Review of Significant Studies

At present, the majority of literature in this field (i.e. studies of local government policies for private property green infrastructure) can be categorized into two types of research: descriptive and analytical. “Descriptive studies” refers to case study and overview literature which describes the different policy types and examples of existing policies. “Analytical literature” refers to studies which, beyond simply detailing best practices or general overviews, provide additional evaluative analysis of policies, programs, or governance. Spanning both these categories of literature are the various types of sources in this field: grey literature, white papers, issue briefs, and peer-reviewed academic publications. As an emerging field that derives from an engineering discipline (green infrastructure and stormwater management), a large portion of this literature consists of grey and white papers as opposed to academic journal articles. While an emphasis on peer-reviewed sources is desired and attempted, given the novelty of this applied policy field, significant and relevant grey and white literature is also included. A review of some significant studies in each of the two areas follows.

Descriptive Studies

A large amount of literature in this field can be categorized as descriptive; many studies detail the different policy options, separately or in combination, and also describe specific case studies with existing policies.

Several significant studies focus on describing a single policy type. Dolowitz et al (2012) and Gearhart (2007) both provide an overview of LID techniques and policies while identifying best practice examples in cities such as Seattle. Fisher and Frey (2008) provide a more detailed analysis of LID ordinances, including specific policy design options and the potential for LID ordinances to include alternative compliance, which sets the stage for trading schemes or fee credits (the other policy options). This study describes the myriad of ways LID ordinances can be designed, such as with specific numerical infiltration standards, required amounts of open space, hydrology-based flow standards, or holistic site-level standards: in addition to the different standards, ordinances can be designed to be voluntary, incentive-based, or legally binding (Fisher & Frey, 2008). Doll et al (1998) describes the tax/fee reductions policy type and its many variants (e.g. based on peak runoff, water quality, or maintenance) and highlights the need to consider other influencing geophysical factors in policy design (such as slope and soil).

Other studies describe multiple types of policies at once. Dhakal and Chevalier (2015), Cappiella et al (2008), and Fortin et al (2018) all provide descriptive overviews of the multiple policy options with case study examples and recommendations. Most overview literature highlights the importance of context specific policies which provide sufficient incentives to private property owners (Dhakal & Chevalier, 2015). Other descriptive literature focuses on specific case studies or places. Valderrama & Levine (2013) and Valderrama & Davis (2015) describe Philadelphia's credit and grant programs, from initial inception and design to implementation and evaluation. Brears (2017) discusses Washington, DC's multiple policies and programs while Johnson and Staeheli (2006) describe Seattle's LID ordinances. As this report makes recommendations for Los Angeles County, it is helpful to list a few studies which have specifically focused on Los Angeles. Cousins (2017) describes the current stormwater governance challenges of Los Angeles from a stakeholder perspective while Mika et al (2017) and Mika et al (2018) study the existing LID ordinance for the City of Los Angeles and model potential results across watersheds. While one study does briefly review the potential for a trading scheme policy in Los Angeles (Jones et al, 2015), no studies explicitly review the three policy types in the context of Los Angeles. This study will contribute to the Los Angeles stormwater policy literature by reviewing all three policy types and making recommendations on each for Los Angeles County.

Analytical Studies

The analytical literature provides a more critical review of the policy types, extending beyond description and case study examples to evaluate or analyze these policies. There are four general types of existing analytical research in this field: studies about effective program design and lessons learned, studies about governance and the role of the government in green infrastructure adoption, studies which identify barriers and policy solutions, and comparison studies reviewing the different policy types.

Effective Program Design and Lessons Learned

Crisostomo et al (2014) provide a comprehensive overview of policy solutions for private property stormwater intervention which results in the identification of six key elements of program design: targeting of property types, selection of intervention types, guidelines for project selection, maintenance, data collection/monitoring/project tracking, and program evaluation and adaptation. The authors also note the distinction between financial and non-financial incentive programs, list various lessons learned (such as the importance of dedicated funding, technical assistance, third parties, and regulatory mandates), and identify primary goals and participation barriers in most programs. Clements et al (2017) perform a more descriptive overview of current programs but also identify key barriers and considerations from interviews with existing program administrators (which include maintenance, uncertain costs and benefits, and low incentive levels). Ahiablame et al (2012) meanwhile, take a more technical approach and focus on the effectiveness of LID practices, emphasizing how implementation represents a shift toward volume-based hydrology (VBH) with a focus on stormwater volume reduction to achieve associated benefits in flow rates, pollutants, erosion control etc.

Governance and the Role of Government in Green Infrastructure

Several studies focus on the role of governments and the overall governance structure at play in these stormwater policies. Jeong et al (2015) evaluates local governments based on low, moderate, and high levels of LID adoption and identifies some of the key factors that influence adoption levels. In particular, high level adopters tended to be characterized by certain ‘champions’ within communities or local government who pushed for LID adoption while moderate and low-level adopters were often driven by regulation or other external requirements (Jeong et al, 2015). The study also discusses organizational contexts (horizontal versus vertical influence, human resources/culture) and different driving motivations such as frustration with conventional stormwater responses, recognition of severe stormwater problems, and a desire to project an innovative reputation (Jeong et al, 2015). Meanwhile, Harrington and Hsu (2018) identify the government's central role in driving, coordinating, and building capacity for green infrastructure in the U.S., while recognizing nonprofits can serve collaborative, information sharing roles. Hopkins et al (2018) identify 'green leader' cities which invest more than 20% of their stormwater budgets in green infrastructure and finds their commonalities; all leading cities used impervious cover or stormwater runoff volume as the basis for their goals, the main driver of investment was regulatory requirements, and existing gray infrastructure provided flexibility to experiment with green infrastructure. The study examined these cities along the lines of management system scale and complexity, regulatory drivers, types of water streams managed, and overall budgets but found that green infrastructure investment occurs across all different types of scales and complexity, suggesting many different types of cities can pursue green infrastructure (Hopkins et al, 2018).

Barrier and Policy Solution Identification

A popular focus for analytic literature in this field centers on identifying barriers and policy solutions to green infrastructure implementation and adoption. Each study evaluates existing cities and policies to suggest broad lists of barriers and related strategies. Keeley et al (2013) groups these barriers into financial, administrative, political, and technical areas while Dhakal and Chevalier (2017) focus on cognitive limitations and socio-institutional arrangements as the main factors causing challenges. Dhakal and Chevalier (2017) go on to group barriers into four areas which they recommend for future policy intervention: city policy, governance, resource, and cognitive barriers. As part of their study, Earles et al (2009) created a checklist of factors which influence failure or success of LID approaches that developers and municipal staff should consider. They created their own list of potential barriers which included lack of education and economic incentives, fear of liability, and conflicts with existing codes or water rights (Earles et al 2009). More recently, Johns (2019) defines specific barriers to green infrastructure implementation in the case study of Toronto, Canada. Each of these studies lists their unique barriers and categories but all generally agree on the fact that challenges tend to arise both internally (e.g. lack of dedicated municipal funding or city staff commitment) and externally (e.g. lack of property owner interest or community support).

Comparison Studies

A final type of analytical literature is comparison studies which explicitly compare policy scenarios and approaches. Only one identified study did this; Parikh et al (2005) which analyzed four approaches and compared the pros and cons of each. The study ranked stormwater user fees, stormwater runoff charges, allowance markets, and voluntary offset programs in terms of each policy's economic, hydrologic, and legal concerns. Ultimately, each policy option had its own tradeoffs but the stormwater runoff charge ranked highest overall followed by the allowance market (largely for cost effectiveness and informational reasons) (Parikh et al 2005). Two other studies with comparative approaches are Lieberherr and Green (2018) and William et al (2017). Lieberherr and Green (2018) compared green infrastructure policy instruments along the dimension of citizen influence and engagement; the study concluded that policy types can be categorized as carrots, sticks, or sermons which differ in their level of citizen input and government intervention (but they note that approaches can use a combination of these three). Particularly unique in the literature, William et al (2017) review simplified hypothetical green infrastructure policy scenarios using game theory to evaluate likely downstream property owner responses and ultimate policy success for pollutant reduction. They evaluated four scenarios (business as usual, direct grants, municipal regulation, and stormwater fee credits) and found that municipal regulation leads to the lowest environmental impact, with direct grants as the second-best option but less financially sustainable for local governments in the long term (William et al, 2017).

Conclusion

This literature review provides an overview of the significant research on local government policies for private property green infrastructure. The remainder of this chapter provides a critical review of the current literature in this field and how this research fits with existing scholarship.

Current State of Research

While a rather nascent field in the planning and policy literature, the issue of local government policymaking around green infrastructure and stormwater management is well established. Building off extensive literature in the fields of engineering and environmental management around green infrastructure and stormwater, researchers are beginning to critically assess how local government policies can transform private properties into tools for citywide stormwater management. Due to a focus on practical policy applications for U.S. cities (and to a lesser extent, internationally), much of the research to date consists of grey literature, white papers, and conference proceedings providing overviews of policy options or detailed case studies (for example see Fortin, 2018; Dougherty et al, 2016; Doll et al, 1998). More recently, the topic moved into peer-reviewed academic literature, particularly with a more analytical focus on identifying barriers and policy solutions (Dhakal & Chevalier, 2017), and, in one instance, comparing the different policy types (Parikh et al, 2005). Much of the research to date, however, focuses on policy overviews and guides to municipalities considering these kinds of policies (Fortin et al, 2018; Dougherty et al, 2016; Gearhart, 2007).

Gaps in the Literature

As mentioned above, a lack of literature exists that explicitly compares each of the policy types. Additionally, none of the literature reviewed here specifically considers the ways these policy types might interact and layer on top of each other. While case studies are extensive, most of the analytical literature focuses on general or hypothetical scenarios and does not provide context-specific recommendations. Thus, there appears to be a gap in the literature of studies that compare all policy types together and evaluate how different municipal characteristics impact policy effectiveness.

Key Areas of Debate

Several studies on this topic pose questions which reflect current debates in the field. Perhaps most central is the question of whether LID and green infrastructure practices are, in fact, effective for stormwater management (Strecker, 2001) or for providing other purported multi-benefits (Teeffelen et al 2015; Hostetler et al, 2011) and how to value these myriad benefits (Netusil et al, 2014; Schaffler & Swilling, 2013). Overall, the literature looks favorably on green infrastructure as a cost-effective and successful solution for stormwater management (Jaffe, 2010; Ahiablame et al, 2012; Parikh et al, 2005). More specific to private property policies are debates around the financing of these programs (Aquije, 2016) and if the structure should be modeled on other sustainability efforts like energy efficiency (Starkman, 2016). With so many options for policy design, debate also centers on what properties to include. Case studies show that cities diverge on this question; Philadelphia does not include residential properties in its main grant programs (Valderrama & Davis, 2015) while Montgomery County, MD does (Hammer & Valderrama, 2018). Kertesz et al (2014), Crisostomo et al (2014), and Keeley (2007) all discuss the question of extending program coverage to single-family residences, although none reach definitive answers, and instead acknowledge the context-specific nature of this decision for each municipality.

Where This Project Fits

This report reviews existing literature and case studies for each policy type in order to make recommendations for Los Angeles County. To facilitate these recommendations, this report first analyzes broad literature and case study examples (using primary source ordinances and city staff interviews) to define guiding considerations for policy design and principles of success for each policy type. In this respect, the work will be descriptive in nature. However, the application of these principles to the Los Angeles context serves as the analytical portion. This research contributes to the literature by providing context-specific recommendations and a new comparative policy study. The project's recommendations also consider the interactions between policy types and the ways they may be implemented together in Los Angeles County for improved outcomes. Ideally, by moving beyond hypothetical scenarios, this project's specific recommendations detail the types of questions and analysis other municipalities can ask or perform to decide the right policy design for their stormwater management goals.

Data and Methods

This section describes the data gathered and methods employed to conduct this study. Overall, the project aims to answer the following research question:

How can Los Angeles County update its existing policies, and implement new policies, to expand green infrastructure for stormwater management on private properties?

This research focuses on the three types of policy approaches: regulatory (LID ordinances), financial (tax/fee reductions, grants, and rebates), and market (trading schemes). The literature review and case studies of municipalities analyze each policy type in detail. Ultimately the project identifies guiding considerations for program design and principles of success for each of the three policy types and applies these to the Los Angeles County context to create policy recommendations. This section further details how collection and analysis of information determined the policy considerations, principles, and final recommendations.

Overview

Due to the nature of the research question, which seeks to comparatively study green infrastructure policies to create recommendations for Los Angeles County, this project relies on a combination of qualitative data sources. Three main methods were used to study each of the three policy types: a literature review, case study analyses, and interviews. Each method is described below in further detail.

Literature Review

The first main source of data for this project was a literature review conducted from August 2018 to January 2019. This review utilized Google and Google Scholar to collect a combination of peer-reviewed academic literature, conference proceedings, white papers, and reports funded by nonprofit foundations. The review consisted of four main phases: general literature review (with a focus on stormwater management, regulation, and green infrastructure) and three targeted literature reviews (focusing on each of the three policy types). A review and summary of sources occurred after each data collection phase and included a search for commonalities and themes across the sources. The salient points of these sources were then grouped into several categories which ultimately formed the guiding considerations described in each policy type section. While the search expanded beyond academic journals to be as comprehensive as possible, a certain level of bias is inherent in the process. The selection (or absence) of certain search terms may have missed some articles, while the use of citations from reviewed articles to identify new sources may have led to a review of sources with similar approaches and conclusions (thereby missing alternate or opposing viewpoints or approaches).

Case Studies

The bulk of evidence for this project consists of case studies of five municipalities, each of which enact a combination of the aforementioned policy approaches. Case studies provide the best opportunity to examine policy implementation in a real-world context to generate informed suggestions for policy design within Los Angeles County.

The literature review helped to identify these five municipalities as commonly cited examples of innovative and long-standing private property green infrastructure programs. The case studies were selected to ensure an adequate spread of different policy approaches, stormwater challenges, and political contexts. Case studies were limited to the U.S. to reflect the specific influence of U.S. stormwater regulation (i.e. the NPDES permit program) on policy design and implementation. Ultimately, the case studies aimed to identify how particular policy design and implementation successfully addressed the given stormwater challenges of each municipality. These findings, along with commonalities found in the literature review, suggested the principles of success for each policy type which were then applied to Los Angeles County to generate recommendations.

Due to the small number of selected cases, inherent bias in the sample may influence results. Additionally, due to a lack of comparable U.S. municipalities which sufficiently match Los Angeles County across the variety of dimensions (size, climate, governance structure, etc.), the findings from each case study may not be directly applicable to Los Angeles County. Instead, the project combines case study findings with a literature review to create more generalized principles of success for each policy type which could then be tailored to the Los Angeles County context. A description of each of the selected case studies below provides reasoning for their selection; Figure 3-1 shows the location of these case studies.

Figure 3-1 Five case study municipalities and Los Angeles County, Data Source: US Census Bureau, 2010

Seattle, WA

Located in the rainy Pacific Northwest, Seattle is a large developed city with a population of around 725,000 residents (U.S. Census Bureau 2017) which faces a combination of stormwater challenges including flooding, pollution, and stream erosion (Seattle Public Utilities 2018). The city also contains a mix of combined and separate storm sewers. Seattle's LID ordinance within the Stormwater Code demonstrates how policy design can target different stormwater challenges, while providing a unique example of how stricter LID regulations can be piloted within a particular area (the High Point Development) prior to city wide implementation (Johnson & Staeheli 2006).

Washington, DC

Another city with overlapping separate and combined storm sewers, Washington, DC (DC) is another heavily developed urban area with a population of around 694,000 residents (U.S. Census Bureau 2017). DC's LID ordinance is unique because it provides the basis for the city's trading program. As the only active stormwater trading market (the Stormwater Retention Credit market) in the country, DC serves as a prime case study for evaluating LID ordinances and market design success (DC DOEE 2018).

Philadelphia, PA

Philadelphia has one of the most robust and frequently cited private property green infrastructure grant programs in the country and is thus an ideal choice to examine the financial approach. With a population of 1.58 million, the city is the most populous municipality of the case studies and more closely mirrors Los Angeles County in terms of size and extent of development than the others (U.S. Census Bureau 2017). Additionally, Philadelphia demonstrates how program design interacts with strong regulation, as the city's combined sewer has a consent order with the EPA which provides very specific requirements that motivated the city's private property green infrastructure policy (Philadelphia Water Department 2018).

Montgomery County, MD

Located in Maryland, Montgomery County faces similar stormwater challenges to nearby Washington, DC but covers a larger geographic area with a larger population (around 1.06 million residents) (U.S. Census Bureau 2017). As a county coordinating a program amongst multiple cities, Montgomery County was selected to identify how county level governance impacts program design (an aspect directly applicable to Los Angeles County). The county also has a very active and often cited rebate program—a useful contrast with Philadelphia's grant program to study the two financial approaches (Montgomery County Environmental Protection 2018).

Chattanooga, TN

Chattanooga is the only other city besides Washington, DC with a stormwater trading scheme in place (the Credit Coupon market), making it the obvious choice for a second case study of the market approach. As of December 2018, however, the Credit Coupon market had not generated any trades, making it a useful contrast to the active DC market to generate lessons learned for a potential Los Angeles County market (Chattanooga Public Works 2018). Chattanooga is also the only case study in the Southern region of the U.S. Further, it is the smallest of the case study municipalities, with a population of around 179,000 residents (U.S. Census Bureau 2017).

Each case study review focused on three main sources of information: primary text sources (municipal ordinances, policy documents, and city websites), primary source interviews with local government officials responsible for these policies, and secondary sources such as journal articles. More detail on the interviews follows in the next subsection. Each case study focused on identifying the main stormwater challenges of the municipality, the overall design and implementation of the policies, indicators of policy success, and any unique aspects of policy design specific to the municipality's context. This case study analysis aimed to study different policy design options currently employed across the U.S. to discern lessons for Los Angeles County's forthcoming policies.

The description and findings from each case study analysis can be found in the section which most closely reflects the policy approach utilized: the regulatory section features

Seattle and Washington, DC to discuss their LID ordinances, the financial section details Philadelphia's fee reduction and grant programs and Montgomery County's tax reduction and rebate programs, the market section describes the trading schemes of Washington, DC and Chattanooga. Each municipality uses a combination of all the approaches but they are separated between the sections based on which of their policies provides the most findings applicable to Los Angeles County (Washington, DC appears twice to reflect that its trading scheme is built from its LID ordinance and both provide equally important lessons for Los Angeles County). Each case study organizes findings into background and context, policy overview, unique features of the policy, and lessons learned for Los Angeles County. The principles of success detailed in each policy type section also reference and incorporate the case study findings.

Interviews

Phone interviews[6] conducted with staff members responsible for implementation of the policies formed a central part of the case studies. These phone interviews served as essential evidence of each municipality's policy design considerations and motivations. Semi-structured 30-minute phone interviews occurred with 1 to 2 staff members from each municipality in late November and early December 2018. The sample of staff members was identified from local government webpages on the private property green infrastructure programs. The lead staff member listed on the website for each municipality (often titled some variation of Program Director/Manager or Water Quality Manager/Specialist) was contacted via email to schedule a phone interview. In the case of Montgomery County and Chattanooga, the phone interview also included an additional support staff member. As the municipal staff members most directly involved in policy design, implementation, and evaluation, interviewees were the best people to provide insight into these aspects of each case study. Although, the limited sample (only lead staff members from the municipal programs) may contain bias, as it does not include other individuals who may have different opinions on outcomes and design (e.g. participating or non-participating property owners or elected local officials).

Each phone interview asked a set of identical questions, with additional follow-up as needed particular to each municipality. The standard interview questions listed in Appendix B highlight the main motivation for the phone interviews; interviews focused on local government stormwater challenges, motivations for policy design decisions, and current evaluations of policy success for each municipality. Notes were taken during the interviews and later reviewed to determine the most salient points to incorporate into case study findings and principles of success for each policy type.

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[6] Phone interviews received an Institutional Review Board exemption from UCLA's Office of the Human Research Protection Program (IRB #18-001987).

Evidence Gathering and Management

The bulk of data collection occurred during the latter half of 2018. The general literature review occurred in August 2018, and targeted literature reviews occurred for each policy type in September 2018 (regulatory approach), October 2018 (financial approach), and November 2018 (market approach). Interviews with case study staff members took place during the last week of November and first week of December 2018. November and December 2018 also coincided with other case study data collection, particularly review of municipal ordinances, local government websites, and other secondary sources discussing the case study municipalities. All non-interview evidence was collected via web searches using Google and Google Scholar. Final additional data collection on the Los Angeles County context and its current policies occurred in January 2019. This involved a review of the county's current LID ordinance and the program elements of Measure W (which provide the most current information on planned stormwater policies and programs). Additional secondary source literature review on Los Angeles County's stormwater challenges, climate, politics, and geography also contributed to the final policy recommendations found at the end of each section.

Summaries of all data sources, including evidence from phone interviews, were initially organized by policy type. Content analysis of all sources further organized this evidence into general categories within each policy type. These categories resulted in the development of the guiding considerations and principles of success detailed for each policy type.

Analysis Overview

As described earlier in this section, the main analysis of this project occurred as qualitative content analysis. With a broad range of sources, content analysis enabled the identification of commonalities and recurring themes across sources. Certain recurring categories of information for each policy type from literature and interviews were synthesized into guiding considerations and principles of success. An element of narrative analysis also occurred when reviewing the semi-structured phone interviews, which provided further evidence on case study policy designs, motivations, and lessons learned.

This research methodology focuses on gathering multiple lines of evidence and seeking commonalities across them to draw conclusions. Thus, the methodology most closely aligns with the established methodologies of meta-synthesis and triangulation. Walsh and Downe (2005) define meta-synthesis as a method that "attempts to integrate results from a number of different but interrelated qualitative studies. The technique has an interpretive, rather than aggregating, intent, in contrast to meta-analysis of quantitative studies" (p.204). Additionally, triangulation uses multiple methods or data sources in qualitative research to develop a comprehensive understanding of a phenomena (Carter et al 2014). Both methods fit well with how this research assessed various qualitative sources (from literature review and case studies) to establish underlying principles and considerations that cut across sources. Through a combination of actual policies, secondary literature, and first-person perspectives from staff interviews, a stronger conclusion emerged that informed recommendations for Los Angeles County.

Findings and Analysis

The next three sections comprise the findings and analysis of this report. Each chapter is dedicated to one of the three policy approaches for incentivizing private property green infrastructure (regulatory, financial, and market). Each section first provides an overview of the given policy approach and its tools with additional background information. Next, guiding considerations for the given policy approach provide a list of policy design and implementation aspects which, according to the literature, municipalities must determine when implementing such an approach. These guiding considerations frame the analysis of the two case studies for each policy approach which follow. These in turn help establish the principles of success for each policy approach, which are aspects of policy design and implementation which past examples prove important for success. Each chapter ends with a study of the Los Angeles County context and recommendations for structuring its policies. Los Angeles County already has an existing LID ordinance, thus Section 4 reviews this ordinance and provides suggestions for updates. Sections 5 and 6 look at financial incentives and trading schemes, respectively. Los Angeles County committed to implementing these two approaches with the passage of Measure W so these sections review what has already been presented by the county as details of the forthcoming programs as well as makes suggestions for other aspects of policy design.

Ultimately these sections can provide an overview and analysis of the three policy approaches to any municipality considering implementation. The guiding considerations and principles of success can be applicable across municipal contexts. The Los Angeles County example, in turn, demonstrates how these considerations and principles should be adapted to a given context to result in better policy design for a given municipality.

Regulatory Approach: LID Ordinances

Introduction

The first of the three main policy approaches for encouraging private property green infrastructure is the regulatory approach. This approach uses local government regulations to require the construction of green infrastructure features and stormwater management on private properties. Due to the otherwise limited legal jurisdiction for municipalities to require green infrastructure on private property, this approach focuses only on new development or redevelopment, for which municipalities already impose other requirements via building codes and conditions on permit approvals. This approach uses the LID ordinance policy type which involves the municipality imposing certain requirements for stormwater management on developers. This also means that the developer pays for these projects as part of the cost of meeting all development requirements. Thus, the LID ordinance is an option for municipalities lacking funding to provide incentives for property owners, although it is more limited in scope than the other policy approaches. The LID ordinance can also be used as a foundation on which to build the other policy options (incentives and trading) which are discussed later.

Overview

LID and Green Infrastructure

Low impact development (LID) is an approach to site and building design that attempts to maintain hydrological function through the design of conveyance, storage, infiltration, evaporation, detention, and landscaping features (Hager 2003). Essentially, LID aims to design sites to minimize the stormwater impacts of new impervious development and mimic the natural hydrology of the site, often relying on green infrastructure to achieve these objectives. LID's early roots as a design strategy came from studies into green infrastructure bioretention technology in the 1980s and 1990s, including installation of pilot landscape projects with this technology in Prince George's County, Maryland (Hager 2003). Several examples of green infrastructure which represents LID design, are featured in Figure 3-1. LID is also known as sustainable drainage systems (SuDS) in the UK, decentralized stormwater management in Germany, and water sensitive urban design (WSUD) in Australia (Chang et al 2018). For the remainder of this report, LID is used in the context of LID ordinances, which require LID practices via local government regulation and thus result in green infrastructure implementation.

Figure 4-1. Clockwise top left to bottom right: rain gardens, bioswales, and permeable pavement are all green infrastructure solutions that are often incorporated into LID site and building design. Courtesy of U.S. EPA, City of Kirkland, NACTO

LID Ordinances

LID ordinances, which are sometimes called stormwater codes or regulations when incorporated into existing municipal codes and regulations, require developers undertaking new or redevelopment projects of certain sizes to include LID and green infrastructure features to manage stormwater on their property. These ordinances add additional requirements on developers who must already meet other design standards in building codes or as conditions for permit approval. It is common practice for local governments to impose many requirements on developers, including materials, building design, and construction standards along with the collection of developer fees (an increasingly major source of local government revenue) (Fulton & Shigley 2012). LID ordinances expand this idea to require new and redevelopment projects to mitigate hydrologic impacts by installing green infrastructure and managing certain amounts of stormwater on-site. Ordinances can be structured in different ways (e.g. as a standalone ordinance or within existing city code), cover different development types and sizes (e.g. by use designation, square footage, etc.), and require different standards (e.g. specifying installation of certain best management practices (BMPs) or the meeting of certain volume or flow standards) (Gearhart 2007).

Guiding Considerations of LID Ordinance Design

This section describes several categories of considerations which influence the design of an LID ordinance. The case studies provide more detailed descriptions of how two specific municipalities, Washington, DC and Seattle, structured their ordinances along the dimensions of these guiding considerations.

Physical Considerations

The physical context of a municipality influences the design of an LID ordinance through climate, topography, geology, and more. Factors such as soil, rainfall patterns, and height of the groundwater table can influence which BMPs will be most effective at addressing a location's unique stormwater challenges (Montalto 2007). Flexible alternative compliance methods can account for the variety of physical conditions at development sites. Meanwhile, more prescriptive standards can vary based on site conditions. For example, numerical retention or treatment standards can differ based on the drainage locations of a site to account for more sensitive water bodies (Seattle PU 2018). Municipalities must carefully consider both the overall physical context of their location and the potential variations among development sites when designing ordinance requirements.

Ordinance Design Considerations

Ordinance Goals

Municipalities must first establish the goals of an ordinance in order to set appropriate requirements for developers and performance metrics for evaluation. Stormwater management can have a variety of goals including flood control, water quality, social or aesthetic benefits, and water supply (Chang et al 2018; Chen et al 2017). Many existing LID ordinances often only focus on two defined storms (e.g. the 85th percentile 2- and 10-year storm events) and set peak flow requirements for these events; this can provide no control for small frequent storms or miss out on more frequent water capture (Gearhart 2007). Ultimately, after goals have been established, the ordinance must balance the need for specific and clear standards to achieve these goals with flexibility for developers to accomplish goals despite unique site characteristics (Fisher & Frey 2008).

Ordinance Structure

Municipalities must also decide how to structure the ordinance from a variety of options. First is the legal structure; an ordinance can be standalone, located within a stormwater code, included within the building code or zoning overlay, or within a regional stormwater management plan (Fisher & Frey 2008). Next, the above determined goals impact which specific requirements to include in the ordinance. Infiltration or retention requirements can achieve local water capture goals, open space buffers can meet conservation goals, effective impervious area limits can assist in flood control, and treatment requirements can address water quality concerns (Fisher & Frey 2008). These requirements can then be numeric, such as specific percentages of impervious area or inches of stormwater retained on-site, or more holistic. The structure of the ordinance can include accommodation for alternative compliance options such as in-lieu fees, off-site compliance, or a credits market (Fisher & Frey 2008).

Conflict or Harmony with Existing Regulations

Municipalities must also consider how ordinance requirements will fit within existing regulations such as building codes and zoning. Existing regulations may conflict with proposed LID standards, such as when building codes provide restrictive curb heights, setbacks, or other design standards which preclude BMP installation (Jeong 2015). Municipalities should review existing regulations to amend or change codes to accommodate green infrastructure (Fisher & Frey 2008). LID ordinances can also harmonize with existing certifications or smart growth policies.

Implementation Considerations

Public versus Private Benefits and Costs

Municipalities must recognize the difference between the private and public costs and benefits of such an ordinance. LID ordinances require developers to install BMPs to comply, and thus implement green infrastructure at a lower cost to the local government. While private developers pay the costs, many public benefits such as water quality improvement and flood control result. However, private benefits can also occur which should be stressed during outreach to improve political support for the ordinance. Studies find that green infrastructure can lead to higher land values, flood control benefits, and water reuse that lowers water bills (Clements & St. Juliana 2013). Despite benefits, the costs can still be inefficiently allocated among developers if standards do not provide adequate flexibility. The trading section of this study discusses how a market for off-site compliance, which can build off of an LID ordinance, can ensure the most efficient allocation of green infrastructure costs by installing capacity where it is least expensive (Thurston et al 2004). Early outreach to developers is important to ensure developers are aware of the requirements and compliance options, and can incorporate BMPs early into their design process to reduce costs (Montalto 2007).

Adoption and Pace of Development

The results of an LID ordinance can vary based on the nature of development within the implementing municipality. Since the LID ordinance will only apply to certain types and sizes of development, the resultant green infrastructure implementation will depend on the rate and type of development occurring in the municipality (Mika et al 2018). The BMPs and green infrastructure investment may also be geographically concentrated if development is mostly occurring in specific areas of the city. Off-site alternative compliance options can ensure investments are spread throughout the city to areas which see less development but would benefit from green infrastructure ("2013 DC Stormwater Rule").

Maintenance/Education/Monitoring and Enforcement

LID ordinances result in decentralized stormwater infrastructure that may be more challenging to maintain than municipal projects in the public right of way. Property owners or volunteers will likely perform maintenance which requires additional education, monitoring, and enforcement (Macmullen & Reich 2007). LID ordinances need maintenance and enforcement requirements so that BMPs installed by developers remain effective over time. Many cities require written maintenance agreements in which developers commit to maintenance of BMPs and give cities the right to conduct random inspections (EPA 2009). These agreements are essential since cities are otherwise restricted in their ability to access BMPs on private property.

No Incentive for Going Above and Beyond

One concern with LID ordinances and the regulatory approach, as opposed to financial or trading approaches, is that they do not encourage property owners to exceed requirements. LID ordinances can be combined with incentive programs to provide other benefits to property owners who install additional capacity or otherwise exceed standards (Clements et al 2018). For developers this could include density bonuses and expedited permitting, or stormwater fee reductions (Clements et al 2018). Incentives will, however, increase program complexity and require additional resources (Clements et al 2018).

Case Studies

Washington, DC

With the first stormwater trading scheme in the country, Washington, DC (DC) is often presented as an ideal example of innovative stormwater management. The following case study reviews DC's equivalent of an LID ordinance, the 2013 Stormwater Management Rule, which requires developments to retain the first 1.2 inches of rain that falls on their property ("2013 DC Stormwater Rule"). This requirement serves as the basis for DC's Stormwater Retention Credit (SRC) Trading Program which is discussed in the trading section.

Background and Context

A historic East Coast city, DC is built out with large percentages of impervious surface area and minimal vacant space for new buildings. With extensive developed land that drains to several larger rivers and small stream tributaries, DC faces challenges with both the quantity and quality of urban runoff (DC DOEE 2018). Figure 4-2 shows a map of DC with the main rivers and tributaries to which stormwater drains: the Anacostia and Potomac Rivers, Rock Creek, and its tributaries ("2013 DC Stormwater Rule").

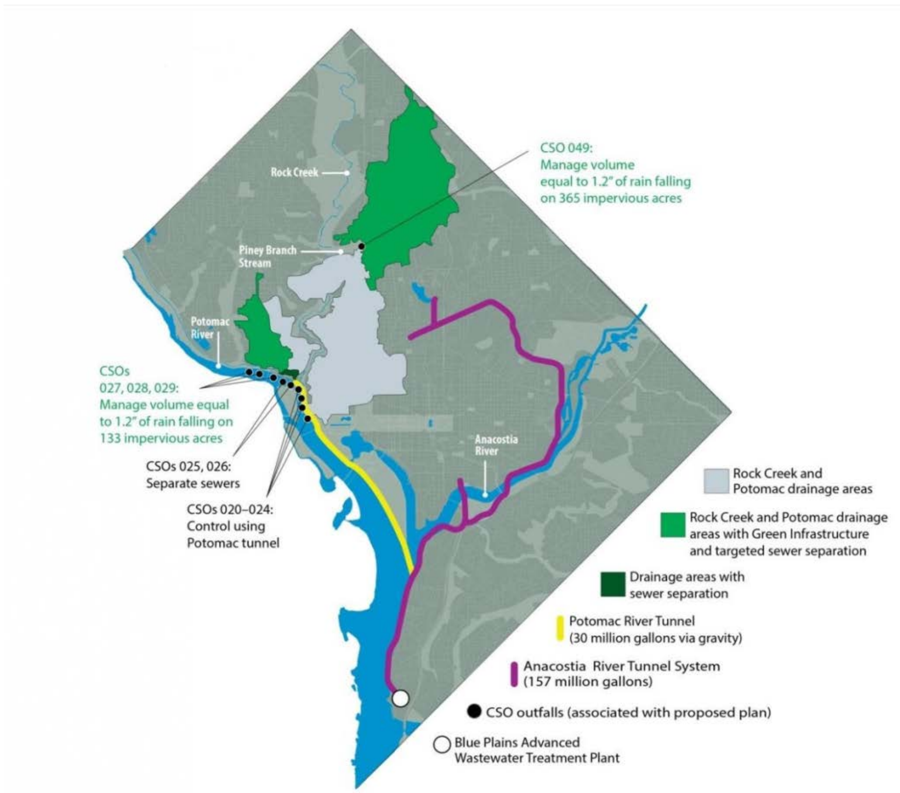

Figure 4-2: Washington, DC stormwater infrastructure and drainage areas. Courtesy of DC Water

Adding to challenges of stormwater management in the city, DC contains two different storm sewer systems which cover different parts of city but drain to the same waterways. Roughly ⅔ of the city is covered by a separate storm sewer (MS4 area) for which DC's Department of Energy and the Environment (DOEE) manages the area's MS4 Phase I Permit. The other ⅓ is a combined sewer system (CSS area) managed by DC Water. DC Water, under consent decree with the EPA for the CSS area, is building underground tunnels to manage the majority of stormwater in this area (see Figure 3-1). By contrast, in the MS4 area, where untreated runoff drains directly to waterways, green infrastructure practices that capture stormwater runoff are the primary water quality solution (DC DOEE 2018). In response to these challenges, and the need to meet MS4 permit requirements, DOEE updated their stormwater regulations in 2013 (Stormwater Management, and Soil Erosion and Sediment Control). DOEE's existing regulation aimed to slow down the flow of stormwater by focusing on detention (to hold and slowly release runoff to prevent erosion in small streams) but the updated rule focuses on retention (preventing runoff from leaving development sites) (DC DOEE 2018). While the most pressing concerns are in the MS4 area, the regulation covers all areas of the city, including both the MS4 and CSS areas, which benefit from green infrastructure (DC DOEE 2018). The later trading section of this study discusses how DOEE also implemented trading and incentive programs to further target and encourage green infrastructure in the MS4 area (DC DOEE 2018).

As noted earlier, the regulatory approach enables a municipality to require the installation of green infrastructure, and thus makes the developer cover costs. In DC, DOEE acknowledges that regulation is the biggest tool for DOEE to retrofit impervious surface at a lower cost (DC DOEE, 2018). Estimates suggest the regulation manages 10 times more impervious area via green infrastructure than equivalent direct spending would (DC DOEE 2018).

Overview of Ordinance

The actual provision of the ordinance requires new and redevelopment to contain the first 1.2 inches of rain falling on their property. One point two inches roughly corresponds to the amount of water from a 90th percentile storm event, a requirement within DC's MS4 permit ("2013 DC Stormwater Rule"). Property owners and developers subject to this requirement must retain 50% of that 1.2-inch volume (known as the stormwater water retention volume, SWRv) on-site using their choice of techniques ("2013 DC Stormwater Rule"). However, the remaining 50% of the SWRv can be retained off-site, particularly through the purchase of stormwater retention credits (SRC) in the DOEE's trading program (DC DOEE 2018). If technical infeasibility means that the developer cannot retain 50% of stormwater on-site, the obligation can be met with more off-site retention ("2013 DC Stormwater Rule"). In addition to this volume requirement, the ordinance contains a flow requirement where the post development discharge rate for 24 hours after the 2- and 15-year frequency storm events must be equal to or less than the pre-development rate ("2013 DC Stormwater Rule"). Thus, the ordinance ensures the flow of urban runoff is not altered by new development while also reducing the volume of runoff discharged from the sites.

Unique Features of Ordinance Design

One of the main features of the DC Stormwater Rule is its flexible developer compliance. After meeting the 50% on-site stormwater retention requirement developers can meet the other 50% (or more, if technically infeasible) with a combination of payment of an in-lieu fee (which DOEE uses to implement its own projects), credits from the trading program (generated from other private property green infrastructure), or BMPs shared with other development sites (“2013 DC Stormwater Rule”). In addition to enabling developers to reduce compliance cost by pursuing cheaper alternative options, this policy realizes other benefits for the city. One such benefit is the opportunity for BMPs to be installed away from areas where development is occurring, potentially spreading out investment for environmental justice outcomes. The 2013 Stormwater Rule explicitly states:

> “DOEE sees the off-site provisions in these amendments as having the potential to result in a relatively large amount of retention BMPs being installed in less affluent parts of the District, meaning that these amendments also have the potential to improve environmental justice outcomes in the District.”

The regulation also considered flexibility in implementation to improve outcomes. The new rule provided two transition periods to ease into implementation of the new requirements (“2013 DC Stormwater Rule”). Period 1 exempts projects from certain requirements while Period 2 allows the entire SWRv to be achieved off-site (“2013 DC Stormwater Rule”). The phase in periods allow projects in the design or permitting process to move forward under the previous regulatory framework. These periods also help increase political palatability, lower costs for developers, and could build up support and knowledge of the trading program by offering the ability to increase use of stormwater retention credits (SRCs) during Period 2. A balance must be struck, however, between increased flexibility for developers and ensuring standards are specific enough to prove effective. DOEE designed the requirements to target areas of particular concern for runoff challenges. For example, projects receiving district funding that are located in the Anacostia Waterfront Development Zone (AWDZ) have an additional requirement to treat all runoff generated from 1.7 inches of rainfall (the 95th percentile rain event) (“2013 DC Stormwater Rule”). This additional requirement shows one way DOEE targeted the regulations to address water quality concerns in a particularly polluted area of the city that drains to the Anacostia River (see Figure 4-3).

Figure 4-3. The Anacostia River suffers from sewage discharge, trash, and polluted runoff, leading DOEE to target projects in the AWDZ for additional runoff treatment in its Stormwater Rule. Courtesy of WTOP and Urban Scrawl.

Lessons Learned for Los Angeles

Washington, DC's experience with its updated 2013 Stormwater Rule provides lessons applicable to Los Angeles County's own LID ordinance. This case study highlights the importance of clear and easy to understand requirements (the 1.2" SWRv) that still target requirements to areas with special circumstances (e.g. the 1.7" treatment standards in the AWDZ). Some of the standards directly result from MS4 requirements and highlight how LID ordinances can help municipalities toward regulatory compliance with limited local government funds. Meanwhile, flexible off-site mitigation options lower costs to developers while spreading out green infrastructure across the city. Finally, well designed LID ordinances can serve as the basis for trading markets or other unique programs to incentivize private property green infrastructure.

Seattle, Washington

Overview of Ordinance and Context

Located in the Pacific Northwest of the U.S., Seattle experiences much more consistent rainfall than Southern California. With this, the city faces a mix of both stormwater quantity and quality challenges, including pollution, creek and river health, and pipe capacity (Seattle PU 2018). Seattle's LID ordinance, located in the Seattle Stormwater Code, addresses all of these different goals. Like DC, about ⅓ of the city experiences CSO concerns from its CSS, while the rest contains an MS4 system (Seattle PU 2018). The complex nature of stormwater in Seattle resulted in the General Stormwater, Grading, and Drainage Control Code, which has multiple standards and requirements depending on a variety of project factors ("2016 Seattle Stormwater Code"). Standards become increasingly prescriptive depending on the receiving water body and impervious surface amounts of development projects (Seattle PU 2018). Some of these standards include a specified list of BMPs by land use type (e.g. single-family, etc.), flow control minimums (e.g. no higher or lower than pre-project flows by a given percent), minimum water quality treatment standards, and runoff volume control (for the 91st percentile storm) ("2016 Seattle Stormwater Code"). Seattle also updated this general stormwater code to align with its Leadership in Energy and Environmental Design (LEED) building program (Gearhart 2007; Johnson & Staheli 2006).

Unique Features of Ordinance Design

Washington State has strict NPDES MS4 requirements, which include flow control requirements. Seattle uses the stormwater code structure required for the MS4 system to address system needs in all the city's drainage basin types, including CSO basins. Since 1992 the city has focused on ensuring new development does not add to the city's existing stormwater burden (Seattle PU 2018). Seattle has an ambitious city-wide goal to capture 700 million gallons of stormwater. Since Seattle is so rainy, the city uses average annual volume managed as a metric instead of the inches from a hypothetical modeled storm event common in other cities (Seattle PU 2018).

Seattle also designed the requirements of the Stormwater Code and fee reduction program to match, so developers who comply with the ordinance are automatically eligible for a discount on the property's stormwater fees (Seattle PU 2018). This also means inspections can be done once to both assess code compliance and award credits (Seattle PU 2018). This example of streamlining management across policy types is discussed in the next section on financial incentives. Although, Seattle found that the fee reduction is not high enough to incentivize additional green infrastructure and instead serves as an equity adjustment for new developers who must spend more to comply with the regulations (Seattle PU 2018).

Figure 4-4: LID features in Seattle's High Point development, Courtesy of SvR Design

Another unique aspect of the Seattle case study is the piloting of stricter stormwater regulations for the High Point housing development, shown in Figure 4-4. Seattle's High Point neighborhood is the result of an extensive redevelopment project that created a mixed-use development with both subsidized affordable and market rate housing (Burgess et al 2017). The project was designed to use a natural drainage system with LID design principles, and thus incorporated higher standards than were in place at the time city-wide (Johnson & Staheli 2006). A 2003 city ordinance allowed the Seattle Housing Authority to implement stricter standards that require LID features throughout the development (Burgess et al 2017). A memorandum of understanding between the city and the Seattle Housing Authority established funding and maintenance of the drainage system (Johnson & Staheli 2006). While the city-wide stormwater code was updated in 2012, so the High Point development standards are no longer stricter than the code, the project demonstrates how Seattle implemented an innovative pilot project to test stronger LID requirements in a specific area. Seattle Public Utilities notes that the High Point project allowed the city to see if higher performance standards were feasible in a high-density urban area. Thanks to its success, stricter stormwater regulations now exist statewide (Seattle PU 2018).

Lessons Learned for Los Angeles

Seattle demonstrates how the design of the ordinance and its standards is integral to meeting the multiple needs of a watershed. Ordinances can achieve water quality, flow, and volume goals through multiple standards but must be simple enough to ensure developers understand the requirements. In addition, clear performance metrics and goals, like Seattle's 700-million-gallon city wide goal, can be valuable in program design. Seattle also uses this gallons managed metric in performance tracking and compliance reporting for their NPDES CSO Control Policy. The High Point development standards demonstrate the value of piloting stricter requirements before city-wide implementation.

Principles of Success

Analysis of case study interviews, ordinances, and websites along with secondary source literature resulted in the development of five 'principles of success' which appear important to the success of an LID ordinance.

Principle 1: Regular Pace of Development and Long-term Adoption Goals

Since LID ordinances rely on new and redevelopment projects to implement green infrastructure, they can only be effective if sufficient development occurs in the municipality. Municipalities without regular development activity may instead focus on incentives such as rebate and grant programs to encourage retrofits on existing properties.

Principle 2: Clearly Defined Goals Based on Watershed Needs

LID ordinance requirements must reflect the needs of the municipality and its watershed. For example, standards should focus on treatment where there are water quality concerns or retention and infiltration in places with water scarcity.

Principle 3: Opportunity for Flexible Alternative Compliance

Flexible alternative compliance options, and especially off-site or market trading options, can both reduce costs for developers and provide environmental justice benefits by targeting investments to areas most in need of green infrastructure.

Principle 5: Defined Implementation Guidelines

Developers must be able to clearly understand when a LID ordinance applies to them and what is required for compliance. A balance must be struck between simplicity and specific requirements tailored to water body and development needs. Providing technical assistance to developers can ensure compliance and overall policy success.

Principle 6: Enforcement, Monitoring, and Maintenance

LID ordinances must have strong and clear enforcement, monitoring, and maintenance in order to ensure compliance and continued operation of installed BMPs. Maintenance agreements with property owners are common, but inspections vary based on administrative capacity for enforcement.

Los Angeles Example and Recommendations

Existing LID Ordinance Overview

Both the City of Los Angeles and Los Angeles County have LID ordinances which contain similar requirements. While recommendations are made based on the County ordinance, the City ordinance will also be reviewed here to provide context. Both ordinances clearly outline which developments are subject to the ordinance based on size and type (e.g. 1 acre or more impervious surface area for industrial and commercial projects, restaurants, and parking lots of greater than 5,000 square feet) (City of Los Angeles 2015; Los Angeles County 2014). Both ordinances also require 100% on-site retention of 0.75 inches (corresponding to the 85th percentile 24-hour storm event), known as the stormwater quality design volume (SWQDv). Both ordinances only allow off-site and alternative compliance options when on-site retention is proven to be technically infeasible (City of Los Angeles 2015; Los Angeles County 2014). While the city allows an equal amount of off-site retention in the same sub-watershed in these cases, the county requires off-site retention of 1.5 times the SWQDv not retained on-site. The city also requires water quality treatment of 80% of the SWQDv and states a priority order for strategies: infiltration, evapotranspiration, capture and use, high removal efficiency biofiltration or biotreatment on-site (City of Los Angeles 2015). The city prioritizes infiltration first because its main concern is water quality and infiltration removes more pollutants than the other strategies (Gold 2018, email correspondence).

Analysis of Los Angeles County LID Ordinance

Los Angeles County's LID ordinance can be evaluated along the five principles of success outlined above to identify ways to improve its success.

Regular Pace of Development and Long-term Adoption Goals

Even with a range of real estate markets and development pressures across Los Angeles County, the region experiences a consistent rate of growth and development which makes it the ideal candidate for an effective LID ordinance. The Los Angeles County economic development forecast predicts the construction industry will grow 6.4% in 2019 and add an additional 14,600 jobs (Mitra et al 2018). However, all this development will not be spread evenly across the county—the current limited nature of off-site compliance in the existing ordinance means most green infrastructure will be limited to areas with new development. Mika et al (2018) modeled predicted outcomes from the City of Los Angeles LID ordinance and found that each watershed in the city has different redevelopment rates and land uses that result in a wide variety of outcomes across the city. Los Angeles County's ordinance will likely result in similar disparities of green infrastructure due to limited off-site compliance options.

Clearly Defined Goals Based on Watershed Needs

At present, the Los Angeles County ordinance creates a clear standard for retention through the SWQDv of 0.75 inches. This standard exists across both the county and city ordinances and aligns with the Standard Urban Stormwater Mitigation Plan (SUSMP) adopted in 2000 by the Regional Water Quality Control Board (Gold 2018, email correspondence). However, the county does not prioritize different strategies like the city does. More emphasis could be placed on infiltration or capture and reuse within the LID ordinance to encourage these strategies and help the county improve local water reliance.

Opportunity for Flexible Alternative Compliance/Off-Site Mitigation

The county LID ordinance currently only allows for off-site compliance when a developer can prove that meeting the requirements on-site is technically infeasible (Los Angeles County 2014). This misses the opportunity for more flexible compliance options which can both lower costs to developers and spread green infrastructure across the county to areas in need of investment. Increasing off-site compliance options regardless of technical infeasibility, like in Washington, DC, can also create opportunities for trading markets.

Defined Implementation Boundaries and Guidelines

The Los Angeles County LID ordinance has an LID Standards Manual with clear information and guidelines, including instructions on calculating SWQDv, various control measures, and a sample maintenance agreement (Los Angeles County 2014). If the LID ordinance were updated to increase opportunities for off-site compliance, additional education and outreach to developers or clarified guidelines could help guide site selection to ensure maximum benefits.

Enforcement, Monitoring, and Maintenance

The LID ordinance currently requires a maintenance agreement and operations and maintenance plan from property owners (Los Angeles County 2014). Once the Measure W-funded tax reduction and trading programs are established, sites receiving incentives will need additional monitoring and enforcement. Streamlining monitoring across these policies will reduce the inspection burden for the county. For example, inspections could be done once and development projects in compliance would be automatically approved for tax reductions. Seattle and Washington, DC both have LID ordinance requirements which match fee reduction programs so projects in compliance are automatically eligible for discounts (Seattle PU 2018; DC DOEE 2018).

Recommendations for Future Policy

After analyzing the Los Angeles County LID ordinance using the principles of success, we recommend the following to help to improve the policy.

Increase opportunities for off-site and alternative compliance

Off-site compliance options can be mutually beneficial for both municipalities and developers by lowering costs and spreading green infrastructure investments geographically. The county should update the existing LID ordinance to allow more off-site compliance, even for projects for which on-site compliance would be technically feasible. Washington, DC allows a set 50% of retention to be met with alternative compliance options; the county could consider a similar percentage to balance the need for on-site retention with the benefits of off-site compliance.

Prioritize compliance strategies to achieve specific goals, such as local water reliance

The City of Los Angeles' LID ordinance states a priority for infiltration techniques over other strategies to meet its main concern of water quality. The Los Angeles County LID ordinance could similarly prioritize certain strategies to meet its goals. With increasing concern over water scarcity, a clear preference in the regulations for infiltration into groundwater aquifers or direct capture and reuse could lead to increased local water reliance.

Use the LID Ordinance as the foundation of a trading program

Since Measure W already commits Los Angeles County to develop a trading program, an update of the LID ordinance's off-site compliance options can provide the basis for the trading program. Washington, DC uses its LID ordinance as the basis for its stormwater retention credit trading program, which is described later in this study.

Financial Approach: Fee/Tax Reductions, Grants, and Rebates

Introduction

While the regulatory approach detailed in the previous section focuses on requiring new and redevelopment to install green infrastructure for stormwater management, a financial approach instead encourages installation by offering financial incentives to property owners. The financial approach requires municipalities to fund rebate or grant programs instead of relying on developers to cover costs. While more expensive for municipalities, this non-mandatory approach also reaches more properties by encouraging behavior change on existing properties as well as new development. These incentives can be funded by, and include a reduction from, a stormwater tax or fee: this reduces the commitment of other municipal funds for the incentives while sending an additional signal to property owners to voluntarily install green infrastructure. This section describes the different options for a financial approach (fee or tax reductions, grants, and rebates) along with studies of two municipalities (Philadelphia, PA and Montgomery County, MD) adopting different combinations of these policy tools.

Overview

The case studies conducted for this study found that municipalities with incentive programs first implemented a stormwater fee or tax (charge) which collects revenue from property owners for stormwater programs. This subsection details these stormwater charges as well as different incentive program options.

Stormwater Fees and Taxes

Purpose and Prevalence

Stormwater fees or taxes (charges) collect revenue monthly or annually from property owners which is earmarked for stormwater management programs. This funding can provide a range of services including operation and maintenance, capital improvement, flood mitigation, water quality treatment, and program administration (Chalfant 2018).

A stormwater charge provides a stable source of funding for stormwater management rather than relying on fluctuating general funds, bonds, or competitive grants (Chalfant 2018). Stormwater charges have become increasingly common in municipalities across the U.S. The first stormwater fee passed in 1964 in Billings, Montana—as of 2017 over 1500 local stormwater utilities in the U.S. and Canada levied stormwater fees (Clements et al 2017).

Structure and Design Options

Stormwater charges can be designed in several ways based on their structure and collection. Most fundamentally, the charge can be a fee or a tax. Water or stormwater utilities can assess monthly fees for stormwater management on water bills while counties can collect annual stormwater taxes as a parcel tax (NACWA 2016). The distinction between a fee or tax can have major legal or political ramifications. For example, the Northeast Ohio Regional Sewer District faced a lawsuit over the constitutionality of imposing a stormwater fee (which they ultimately won) (NACWA 2016). Meanwhile in California, Proposition 218 was passed in 1996 and requires a 2/3 majority vote of property owners to pass any fees or assessments for flood or stormwater (Shimabuku et al 2018). Figure 5-1 shows the location of all stormwater fees in the U.S., which are assessed by a stormwater or water utility as opposed to a parcel tax administered by a county.

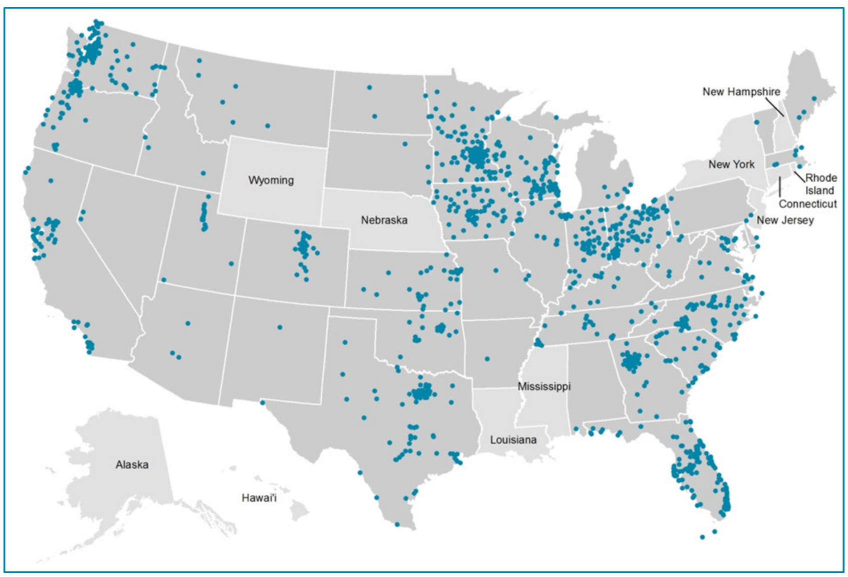

Figure 5-1. Locations of stormwater fees in the U.S. Courtesy of WEF.

The actual structure of the stormwater charge can also differ. Flat rates charge all properties the same rate while tiered rates charge rates based on property type or size (Valderrama & Hammer 2018). Variable rates based on impervious area use the 'polluter pays' principle of economics; properties with higher impervious area contribute more stormwater runoff and thus pay a higher rate (Valderrama & Hammer 2018). Flat or tiered rates may be easiest to administer but lack an incentive for property owners to minimize runoff to reduce their rate (Keeley 2007). A common way to structure variable rates is the equivalent residential unit (ERU) which serves as a basis for calculating the charge. One ERU corresponds to a certain square footage of impervious area and parcels can be charged a certain amount per ERU (Valderrama & Hammer 2018). Some municipalities consider all single-family residential parcels one ERU and calculate the number of ERUs only for commercial parcels to reduce the administrative burden (Valderrama & Hammer 2018). The structure of the charge can differ in complexity; Philadelphia assesses its fee with three different fixed and variable components (gross area, impervious area, and billing and collection charges) (Valderrama & Levine 2013).

Incentive Program Options

Often stormwater charge revenue help to pay for various financial incentive programs. Grants, rebates, coupons, uniform auctions, loans, and tax credits or fee reductions are all examples of financial incentives (Crisostomo 2014). The idea is to provide monetary benefits to property owners who voluntarily install green infrastructure which meets the stormwater goals of the municipality. In addition to the type of incentive (e.g. grant, rebate), program design must also determine the monetary value of the incentives and for what outcomes the incentives will be awarded (e.g. standards or requirements). The most common goals achieved with incentives are reductions in water quantity (peak runoff controls or runoff retention) and improvements in water quality (Scodari & Lindsey 1998). Even though incentive programs require municipal funding, the cost of retrofitting an acre of private property is often cheaper than equivalent retrofits on public land, making incentives a fiscally effective policy choice (Valderrama et al 2013).

Guiding Considerations of Incentive Program Design

The following considerations should guide the design of a financial approach to private property green infrastructure. The case studies which follow, of Philadelphia and Montgomery County, demonstrate how the two municipal contexts resulted in different program design based on these guiding considerations.

Program Design

Two central parts of implementing a financial approach to private property green infrastructure are the design of the stormwater charge and the design of the incentives program (which can be a combination of tax/fee reductions, grants, and/or rebates).

Design of Tax or Fee

Enacting a stormwater charge, like the collection of any tax or fee, requires a significant administrative burden. The charge must be designed to ensure that the municipality can accurately assess and collect the charge; user fees can be improperly priced, not include all parcels, or inaccurately calculate impervious area (Parikh et al 2005). Municipalities must design the charge carefully and ensure enough parcel level information is available (such as remote sensing or aerial photography) to calculate the charge. This charge can be based on impervious area, gross area, parcel type or some combination thereof. The design of the charge, including if it will be a tax or a fee, affects the different political requirements. For example, California's Proposition 218 requires majority approval of property owners before implementing any stormwater tax or fee. The design of the charge influences how incentives are offered, including the options for offering tax or fee reductions.

Design of Incentives

The first step of incentive program design requires determining what incentives will be offered (fee or tax reductions, grants, rebates). Next, the goals of the program should help determine the requirements for incentives. Program design will differ if a municipality wants funded projects to assist with regulatory compliance as opposed to achieve a public education goal. Choices in incentive program design may also affect the administrative requirements of the program. There may be legal restrictions to disbursing grant funding to private property owners. Fee or tax reductions simply involve the municipality foregoing revenue collection and do not face this issue.

Use of Revenue

With the collection of revenue through a stormwater charge, decisions must be made regarding how revenue will be spent and on what projects (e.g. rebates, grants, projects in the public right of way, maintenance of existing infrastructure). Even with dedicated revenue from a stormwater charge, there may still be competition for funding of different aspects of a municipality’s stormwater program if the charge does not generate sufficient revenue for the whole program. However, the cost effectiveness of private property retrofits means the dedication of additional funding for incentive programs may still be cheaper for a municipality than equivalent public projects.

Property Type Focus: Residential and/or Commercial

One major consideration in program design is what property types are eligible for which incentives. The land use and property types within the jurisdiction, municipal agency capacity, legal issues, and funding all influence which choice will be most appropriate (Crisostomo 2014). Ellard (2010) notes that the financial impact of incentives may be more noticeable on larger non-residential parcels with higher percentages of impervious area. Tasca et al (2017) similarly points out that most fees are already small for single-family homes so fee reductions alone would not drive residential BMP adoption. While residential properties comprise a significant portion of stormwater charge revenue collection due to sheer numbers, residential BMPs may be less cost effective due to more difficult monitoring and enforcement, increased need for design guidance and education, more property owner turnover, and smaller property sizes (Crisostomo 2014). However, residential development is often the largest share of land use in a municipality and thus should still be considered in a municipality's strategy (Keeley 2007). This can result in the creation of separate programs or differing incentive amounts based on property type.

Incentive Amounts

Municipal programs likely need to bundle several incentive programs together to adequately incentivize property owners; a fee or tax reduction alone creates too long of a payback period to encourage property owners to risk investment in green infrastructure (Valderrama et al 2013). Programs can be modeled on the energy efficiency sector, which uses on-bill financing, low interest loans, and rebates for energy efficiency retrofits (Valderrama & Levine 2012). Research finds that setting incentives correctly is very difficult, with more monetary benefit either accruing to the agency or the resident (Kertesz et al 2014). However, given that private retrofits are much less expensive than public property retrofits, incentives can still be cost effective for the agency (Valderrama et al 2013). Setting incentive amounts must consider all the costs of a project, including ongoing maintenance by the property owner. The Philadelphia, Montgomery County, Washington, DC, and Seattle case studies all found that tax or fee reductions alone were not sufficient to motivate property owners: bundles of reductions with grants or rebates were necessary.

Legal Challenges and Political Opposition

One reason for bundling incentives is that setting a stormwater charge high enough to encourage green infrastructure adoption through tax/fee reductions alone is politically infeasible (Keeley 2007). While acceptance of stormwater charges is growing, these charges can still be legally challenged based on the authority to enact them or the legality of the financial mechanism and charge calculation methodology (NACWA 2016). While tax or fee reductions may not provide much incentive for adopting green infrastructure alone, they can help reduce political opposition to charges (Debo and Reese 2002). Twenty-five percent of stormwater utility fees were challenged in 1998 but only 5.4% of fees faced legal challenges in 2013 (Tasca et al 2017). Of these challenges, 95% were from non-residential customers (NACWA 2016). Some municipalities even exempt certain property types from stormwater charges for political or socioeconomic reasons (Ellard 2010). Political and stakeholder input can play a major role in policy design.

Case Studies

Philadelphia, PA

Overview of Fee Reduction and Grant Programs

The Philadelphia Water Department (PWD) has had a stormwater fee for decades, although it was originally a flat rate based on water meter size (PWD 2018). Beginning in the late 1990s, ratepayers expressed equity concerns about the flat rate which spurred a decades long process of rate study and reform, culminating in a new impervious area-based stormwater fee beginning in July 2010 (PWD 2018). The current fee structure remains a uniform monthly charge for residential properties but the non-residential fee contains three separate charges: a billing and collection fee, a gross area charge (based on total parcel square footage), and an impervious area charge (Valderrama et al 2013). Philadelphia faces significant stormwater challenges due to its CSS (shown in Figure 5-2), and the timing of the new fee also coincided with increased stormwater regulation for the city. Stricter permit requirements for the MS4 portion of the city (shown in Figure 5-2) went into effect in 2005 and in 2011 the city signed a consent order with the EPA to reduce CSOs (PWD 2018). While the city faces both water quantity and quality issues, the main focus is on water quantity goals since volume reduction requirements are a major part of the city's consent order (PWD 2018). A need for green infrastructure to meet the stricter regulatory requirements, along with the move toward a more equitable fee structure, encouraged the PWD to design a financial incentive program alongside the new fee (PWD 2018).

Figure 5-2: CSO and MS4 areas of the city, courtesy of PWD

The PWD's current incentive program includes a fee reduction (credit) program, two separate grant programs for commercial property owners, and the Rain Check program for residential properties. The credit program allows commercial property owners who manage at least the 1st inch of runoff from their property through infiltration, detention, or volume reduction to receive a reduction (credit) of up to 80% off their stormwater fee (PWD n.d). These reductions are taken from the impervious area and gross area portions of the stormwater fee (PWD n.d). Additional reductions are awarded for property owners subject to, and in compliance with, NPDES industrial permits (the NPDES industrial permit credit) (PWD n.d). Each credit is awarded for four years, with the opportunity for property owners to reapply (PWD 2018).

The two grant programs are called the Stormwater Management Incentives Program (SMIP) and the Greened Acre Retrofit Program (GARP) (PWD 2018). SMIP was launched first in 2012, two years after the initial rollout of the new fee structure. This program offers non-residential property owners grants to defray upfront capital costs of green infrastructure installation (Valderrama & Davis 2015). The GARP launched in 2014 to allow developers to aggregate projects; the grants are awarded competitively to design and construction firms or contractors who propose multiple retrofit projects in a single application package (Valderrama & Davis 2015). GARP differs from SMIP by competitively awarding the most cost-effective projects (Valderrama & Davis 2015).

Unique Features of Program

PWD notes that the grant programs are a central part of its green infrastructure program. The fee credits are too low to incentivize adoption of green infrastructure on their own; the payback period for which a green infrastructure BMP would 'pay itself back' with reductions in stormwater fees is too long for most commercial property owners to consider investing (PWD 2018). Instead, the credit program serves to further improve the equity of the stormwater fee (which was initially re-structured due to equity concerns) and reward new development already required to comply with Philadelphia's equivalent of an LID ordinance. The credits also provide some monetary savings for the ongoing maintenance of BMPs (PWD 2018). Property owners are responsible for the operation and maintenance of their projects; grant funded projects require a signed operations and management agreement from the property owner, and a dedicated enforcement team of PWD staff inspect each project on a four year cycle (PWD 2018). A series of escalating repercussions for failure to maintain—starting with a notice and potentially ending with PWD performing maintenance and billing the property owner—ensures funded projects remain effective over time (PWD 2018).

The grant program, while the strongest motivator for green infrastructure installation, is only available to commercial property owners. Residential property owners instead participate in Rain Check, a program which provides free rain barrels and discounts on downspout planters, rain gardens, and permeable paving (PWD 2018). One major reason for this distinction is the administrative burden of the grant program. By focusing on the fewer, larger commercial properties which produce the most runoff, resources can be targeted to reduce program administration challenges (PWD 2018). The grants also require a third-party administrator for fund disbursement due to rules about private entities directly receiving city funds. Property owners enter into an agreement with Philadelphia Industrial Development Corporation (PIDC), the city's main nonprofit economic development corporation, which then disburses grant funds for project implementation (PWD 2018).

Another reason for the separation of commercial and residential programs is the differing goals of each. Rain Check focuses on educational outreach and community engagement; the rain barrels, gardens, and other residential installations are not actually reported for Philadelphia's required green infrastructure implementation under its EPA consent order. However, all larger projects funded via SMIP and GARP are tracked and reported for consent order compliance. The EPA consent order calls for 10,000 greened acres (impervious acres managed in green stormwater infrastructure) in the city, which simply cannot be met on publicly-owned land alone (PWD 2018). Even with major grant funding, projects on private land typically cost the city less to implement than projects on public land (Valderrama et al 2013). The grant funded private property projects are an essential part of Philadelphia's compliance strategy. The use of the 'greened acre' performance metric in the grant program allows these projects to be seamlessly integrated with other city green infrastructure projects on public land for reporting to the EPA (PWD 2018). Each residential project through Rain Check PWD is typically too small to meaningfully contribute to the number of 'greened acres' but can still provide an important educational role that builds community support for other larger green infrastructure projects that PWD implements for compliance.

Lessons Learned for Los Angeles

Philadelphia's programs are frequently cited as successful and innovative examples; 455 acres have already been 'greened' with another 885 acres in progress and over $100 million in grant funding awarded over the program's six years (The Water Research Foundation 2018). This example highlights the importance of combining different incentives to adequately motivate property owners, as fee or tax reductions alone are unlikely to provide enough motivation for investment. Before the launch of SMIP, Philadelphia offered a 1% interest rate loan in 2011 which did not generate much interest, ultimately grants were necessary to motivate retrofits (PWD 2018).

Philadelphia also designed its incentive programs with clear goals in mind: regulatory compliance, education, and outreach. SMIP and GARP help the city achieve consent order requirements and use a 'greened acre' metric to track progress and report to the

EPA. Meanwhile, the separate residential Rain Check program used fewer resources and administrative complexity to meet the goal of public education and outreach.

Montgomery County, MD

Overview of Tax Reduction and Rebate Programs

Located near DC, Montgomery County faces similar challenges in terms of stormwater quantity and quality. The county is particularly concerned with water pollution but focuses on runoff volume reduction because it is the easiest way to reduce pollution (Montgomery County DEP 2018). The county does not have any combined sewer areas but is subject to a Phase I MS4 permit which requires treatment of a certain amount of uncontrolled runoff. Since the early 2000s the county has assessed a stormwater tax on property taxes known as the Water Quality Protection Charge (WQPC) which helps fund stormwater management. Incentives were introduced later, with the rebate program in 2007 and the WQPC credits program in 2012. A grant program for nonprofit and watershed group projects has since been added (Montgomery County DEP 2018). Environmental advocates appealed to elected officials which helped encourage the development of the incentives program (Montgomery County DEP 2018).

The WQPC applies to all properties but the charges differ based on property type. Residences pay one of seven tiered rates based on categories of impervious square footage. The lowest annual tax of $34.40 applies to single-family residences with less than 1,000 square feet of impervious area while the properties with more than 6,215 square feet of impervious area pay the maximum $312.75 (Montgomery County 2019a). Non-residential properties pay $104.25 per ERU of impervious area, with an ERU defined as 2,406 square feet of impervious area (Montgomery County 2019a). Up to 80% of this tax can be reduced with complete on-site treatment of stormwater (Montgomery County 2019b; 2019c). Credit are good for three years, after it must be renewed through an online inspection form with photo documentation (Montgomery County DEP 2018). The county also commits in its MS4 permit to performing field verification of maintenance for at least 10% of installed projects. The applications for the credit program creates a database of projects from which 10% of projects are field verified. All projects must submit online inspection forms, which is one way the county addresses strained staff resources for enforcement (Montgomery County DEP 2018).

Much like Philadelphia's grant program, however, the largest incentive for green infrastructure installation comes from the RainScapes rebate program rather than the tax reduction. The rebate program provides up to $20,000 to commercial, Home Owners Association (HOA), multifamily, and institutional property owners and up to $7,500 to single-family homes (Montgomery County 2019d). Funding is awarded on a first come first serve basis to applicants beginning on July 1 each year. An inspection is required prior to award of the rebate and the actual rebate amount varies depending on the project type (e.g. $9/sf for green roofs, $1/gal for rain barrels, $14/sf for residential permeable paving and $14/sf for commercial permeable paving) (Montgomery County 2019d).

Unique Features of Program

Unlike Philadelphia, the RainScapes program is open to all property owners including residences, although rebate amounts differ by property and project type. Like Philadelphia, however, Montgomery County finds that providing direct monetary incentives to private property owners is still cheaper than retrofitting in the public right of way. The cost to the city of a private project is about $38,000-50,000 per impervious acre as opposed to around $200,000 per acre in the public right of way (Montgomery County DEP 2018). One unique aspect of Montgomery County's program results from its role as a county entity, coordinating across multiple municipalities and eight watersheds, shown in Figure 5-3. Three cities within the county (Rockville, Takoma Park, Gaithersburg) each have their own separate stormwater fees which are not connected to the WQPC and thus properties in these cities do not pay the WQPC and are ineligible for RainScapes rebates (Montgomery County DEP 2018).

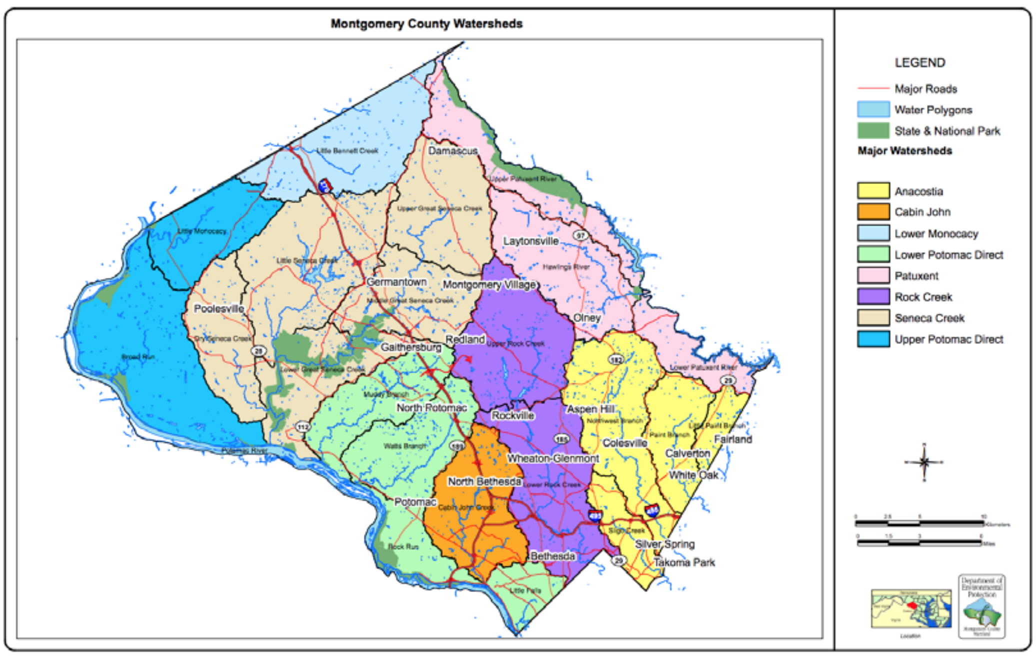

Figure 5-3: Montgomery County watersheds, courtesy of Montgomery County Department of Environmental Protection

For the areas within its jurisdiction, the county targeted those watersheds with higher water quality concerns. The county did presentations and outreach to congregations in target areas to encourage use of the nonprofit grant program (congregations often have large parking lot areas which can be retrofitted) and bonus points were awarded during the grant consideration process to projects in priority watersheds (Montgomery County DEP 2018). The county made the decision not to limit the rebate program to certain watersheds partly due to environmental justice concerns. Many of the areas in Montgomery County with the worst water quality are actually areas of the highest real estate value, and thus restricting rebates to those areas would limit opportunities for lower income property owners to obtain rebates and install green infrastructure in lower income areas (Montgomery County DEP 2018). One of the greatest benefits from the RainScapes program is increased public education and awareness, which results directly from the broad reach of the program. The program has built strong support within the community for green infrastructure and the stormwater tax. Staff at the county even report finding community members using RainScape as a generic term for green infrastructure that treats rainwater, demonstrating the educational impact of the program (Montgomery County DEP 2018). The county explicitly desired this public education and outreach goal, as it builds support for the overall stormwater program and makes future public projects more viable (Montgomery County DEP 2018).

Lessons Learned for Los Angeles

The Montgomery County case study shows how a county can implement a program across multiple municipalities, which Measure W will do for Los Angeles in the near future. The county's combination of a tax reduction with rebates applied to both residential and commercial properties. They found that extending the program provided valuable public outreach benefits while equitably allowing everyone who pays the WQPC to benefit from the incentive program. However, Montgomery County notes that the collection of the WQPC alone does not pay for all of the county's stormwater management activities. Additional bonds and other funding must supplement the tax to implement the incentive programs, capital improvement projects, street sweeping, and other projects. Thus, building public support for stormwater is important to ensure adequate funding for all of the county's projects. Like Philadelphia, the green infrastructure resulting from the incentive program counts toward regulatory compliance. Montgomery County's MS4 permit required 3778 impervious acres to be converted within five years; the county was able to achieve 50 of those acres through the rebate approach (Montgomery County DEP 2018). This case study highlights the importance of dedicated funding and public outreach with the financial approach.

Principles of Success

Based on the case studies and guiding considerations above, the following five principles of success highlight some of the necessary conditions for a financial approach.

Principle 1: Legal Feasibility and Political Willpower

As detailed in the guiding considerations, initial legal feasibility and political support must be in place for stormwater charges and incentive programs to succeed. Additional laws may be necessary to create authority for stormwater charges and avoid legal challenges. Pennsylvania passed several laws in 2016 to authorize local governments to enact stormwater fees because the legal authority was unclear (Chalfant 2018). Academic research into municipal green infrastructure adoption identifies the need for 'champions' or local policy advocates within municipal staff or decision-making bodies to ensure municipal program success (Jeong et al 2015; Hopkins et al 2018). Political willpower in the form of municipal government committed to overcoming institutional and cognitive barriers to new program design is as essential as public political approval and legal feasibility (Dhakal & Chevalier 2017).

Principle 2: Adequate Incentive Amounts

Since financial approaches rely on voluntary green infrastructure retrofits motivated by monetary incentives; the ultimate results of these policies can be difficult to predict. Different property types may react differently to incentive amounts and structures. The learning process during implementation showed Philadelphia it needed to add and alter incentives to encourage more participation. Many property owners may exhibit initial reluctance to retrofit due to high upfront costs, long term maintenance requirements, and low return on investment (Fortin et al 2018). Sometimes, due to limited space and capital, smaller properties cannot install green infrastructure regardless of the incentive amount (Proft 2015). Careful consideration of the total costs to property owners and the bundling of different incentive programs can ensure monetary benefits are adequate to encourage adoption.

Principle 3: Defined Goals to Tailor Incentive Structure

Just like LID ordinances in the regulatory approach, municipalities must have clear goals for stormwater management to influence incentive program design. Often regulatory requirements can be a guiding force for incentive structure, as with Philadelphia's greened acre metric for consent order compliance or the 500-acre goal in Montgomery County's MS4 permit. Incentive programs can be designed to encourage certain project types or locations based on the needs of the municipality and its watersheds. Municipal stormwater management goals can influence the overall type of programs enacted (such as Philadelphia's separation of residential and commercial programs for outreach and compliance, respectively) or specific standards within the program (such as the 1.5" runoff capture requirement for SMIP and GARP funding).

Principle 4: Program Focus Tailored to Land Use Pattern

The decision on what property or land use types to include in the incentives program can strongly influence program design and success. Municipalities must balance the administrative burden of including more property types against the extent of certain property types within the municipality. Residential incentives require more monitoring and education across many smaller projects as opposed to the larger commercial or aggregated development projects. Which land use types are included in the incentives program affects the extent of green infrastructure adoption as well as political palatability. The extent of residential properties, and their voting power to approve stormwater taxes, may necessitate their inclusion in an incentive program. Different incentives based on land use or property type can balance competing concerns.

Principle 5: Combining Approaches (Carrots and Sticks)

A central finding of this research is the importance of a layering approach to private property green infrastructure programs. In addition to combining incentive types, programs can combine the three approaches. Philadelphia's fee credit requirements allow development, which must already comply with a 1.5" runoff standard in its LID ordinance, to be automatically eligible for credits (PWD 2018). Lieberherr and Green (2018) identify three main types of policies which can be combined in stormwater management: carrots (financial incentives), sticks (government regulation), and sermons (educational outreach). Each type differs in the resulting amount of citizen participation and government involvement, encouraging the use of a combination of tools (Lieberherr & Green 2018). Since 'carrots' are voluntary, incentives may not cover all parcels and may not result in adequate adoption. An additional LID ordinance 'stick' can ensure a minimum of green infrastructure adoption on new development (Parikh et al 2005).

Los Angeles Example and Recommendations

Measure W and Safe Clean Water Program

With the passage of Measure W in November 2018, Los Angeles County committed to implementing an incentive program with grant and tax reduction programs. Measure W establishes a parcel tax of 2.5 cents per square foot of impervious area (Agrawal 2018). Details of the tax and incentive programs, collectively known as the Safe Clean Water Program, are not yet finalized. However, the program elements released in July 2018 provide a rough description of program design. The estimated $300 million annual revenue from the tax will be split into three separate funding pools: 10% for implementation and administration, 40% given back to municipalities, and 50% for funding regional projects at the watershed level ("Program Elements" 2018).

A tax reduction called the "credit program" is also detailed in the program elements. A maximum of 100% of the tax will be credited to parcels which provide water quality benefits (up to 75% of the tax), water supply benefits (up to 20%), and community investment benefits (up to 10%) ("Program Elements" 2018). Parcels achieve the water quality benefit when they comply with or exceed their applicable LID ordinance, Standard Urban Stormwater Mitigation Plan (SUSMP), or industrial NPDES permit ("Program Elements" 2018). For properties not subject to any of these, the county's LID ordinance provides the standards for awarding water quality credits ("Program Elements" 2018). Credits must be recertified every two years with photo documentation, a management plan, and proof of inspection by a licensed civil engineer ("Program Elements" 2018).

Another central part of the Safe Clean Water Program is the grant program. Of the 50% regional funding pool, a minimum of 85% must be spent on infrastructure with a maximum of 10% allocated for a technical resources program and a maximum of 5% for scientific studies ("Program Elements" 2018). The money will fund regional projects provided on a watershed level basis and will prioritize nature-based solutions. Funding for regional projects will be assigned by nine watershed area steering committees which consist of 17 members each. These members shall include seven members from municipalities within the watershed, five agency stakeholder representatives (from the largest municipal water, groundwater, sanitation, and park systems in the area) and five community stakeholder representatives (including one each from business, environmental justice, and environmental groups, and two at large members) ("Program Elements" 2018). Watershed area steering committees will select desired projects, which will then be sent to a scoring committee comprised of six technical experts. Projects meeting the 60-point threshold score will be forwarded back to the watershed area steering committees for final selection. The scoring is awarded based on the following benefits: water quality (50 points), water supply (25 points), community investment (10 points), nature-based solutions (15 points), and leveraging funds (i.e. the ability to provide matching funds) (10 points). Finally, funding for projects must provide benefits to disadvantaged communities (as identified by CalEnviroScreen[7]) based on the ratio of the disadvantaged population to total watershed population ("Program Elements" 2018). Municipalities have discretion to decide how their allocated share of the 40% municipal funding pool will be spent, provided the money is used for

[7] CalEnviroScreen is an online mapping tool and screening methodology that identifies pollution burden of different California communities. Run by the Office of Environmental Health Hazard Assessment, CalEnviroScreen identifies disadvantaged communities by census tract and measures exposure to air, water, and soil contaminants along with socioeconomic and health data. (OEHHA 2019).

implementation, operation and maintenance, or administration of stormwater projects and programs (“Program Elements 2018”).

Analysis of the Safe Clean Water Program

Legal Feasibility and Political Willpower

Even without an officially defined structure, the Safe Clean Water Program already successfully addressed legal and political challenges. Measure W passed with more than a ⅔ majority of voters, obtained significant public approval from county residents, and met Proposition 218’s required supermajority for new parcel taxes. This suggests that Los Angeles County already possesses strong political willpower and support for stormwater management.

Adequate Incentive Amounts

Beyond the general structure of the credit program, the county has not yet identified exact incentive amounts. The county committed to tax reduction (credit), grant, and market trading programs which signals multiple incentives will be combined to generate sufficient motivation. The credit alone, even for 100% of the tax, is unlikely to motivate property owners. For reference, the county estimates the average single-family home will pay $83 annually in the new tax, far too low to incentivize installation of rain gardens or permeable paving (“Safe Clean Water FAQ” n.d.). At present the grant program only outlines how regional watershed level projects will be scored and selected without reference to dollar amounts or minimum project size. Lessons from Philadelphia's GARP and SMIP grants could assist in setting the correct amounts and project requirements. The regional grant selection process appears too long and complex for a residential property owner, suggesting it might be for larger projects like Philadelphia's GARP. It is unclear if there would be an additional residential program with different goals, like Philadelphia’s RainCheck program.

Defined Goals to Tailor Incentive Structure

The program elements demonstrate how the county prioritizes certain goals via the setting of credit program percentages and the regional project scoring system. Water quality appears to be the county’s main focus as it accounts for the majority (75%) of the tax reductions, followed by a water supply (20%), and community investment focus (10%). Water quality and supply also provide the most points for grant project scoring. Given the pollution issues and water scarcity concerns facing Los Angeles, this appears to be a wise choice for the county.

Program Focus Tailored to Land Use Pattern

The program elements do not clearly delineate which types of properties will be eligible for which aspects of the incentive program. All properties will pay the stormwater tax while credits will be based on compliance with other stormwater regulations which only apply to new development (LID ordinance) or industrial properties (NPDES industrial permits). However, the program elements do state that any properties not subject to these regulations will simply use the standards from the county's LID ordinance to qualify for credits ("Program Elements" 2018). While this suggests that the credit program will apply to all property types, there is no indication of what property types will receive regional grant funding. The county must decide this before finalization of the program in August 2019. Ultimately, residential properties should be accommodated in some way, given the extent of single-family homes across the county. The City of Los Angeles alone has 585,738 single-family properties and about 60% of the urban areas of the Los Angeles region are residential (Water LA 2018). According to 2016 Los Angeles County Assessor's parcel data, 62.5% of all parcels in the county are single-family residential (Los Angeles County Assessor 2016). The current scoring process for regional grant projects appears too complex for the smaller scale projects of a typical residential homeowner, suggesting the need for development of a separate residential rebate or grant program.

Combining Approaches (Carrots and Sticks)

The Safe Clean Water Program commits the county to implementing a combination of a stormwater tax, tax reductions (credits), regional grants, and a trading market ("Program Elements" 2018). Thus, county representatives already understand the need to combine multiple incentives to motivate property owners. Additionally, the combination of 'sticks' and 'carrots' is apparent from requiring 2-year recertification for credits ("Program Elements" 2018). Requiring inspections by licensed civil engineers will likely reduce the monitoring burden of the county, although staff will still need to process credit applications. Given the annual tax rate of 2.5 cents per impervious acre, the credit alone will be unlikely to motivate green infrastructure projects, so more work must focus on developing the grant program as an easy and financially attractive process.

Recommendations for Future Policy

Measure W already overcame one significant challenge to the financial approach: gaining voter approval. The county committed to passing an ordinance with final program structure by August 1, 2019 ("Program Elements" 2018). Before then, the county must develop a clear credit and grant program to adequately motivate different types of property owners. Los Angeles County should consider the three recommendations below when finalizing the Safe Clean Water Program.

Separate Residential and Commercial Grant or Rebate Programs

The county should consider creating a separate grant or rebate program for residential property owners, much like Philadelphia's system. The complex scoring process for regional grant money suggests the process will only apply to aggregated development projects or large commercial properties. Grants or rebates will also be necessary for residential properties to supplement tax reductions, which are too low to incentivize behavior change alone.

Education and Outreach, Technical, and Design Assistance

A significant education and outreach campaign aimed at property owners will be important to raise awareness of the opportunities available and to explain the application process. Technical and design assistance may help overcome property owner knowledge gaps and start more projects (Crisostomo et al 2014).

Coordination with Municipalities Regarding Municipal Funding Use

Finally, there must be discussion of how the municipalities will use the 40% municipal funding pool. The county should work closely with municipalities to ensure municipal programs align with county programs and do not duplicate or contradict these efforts. Municipalities may be the best choice for implementing the simpler residential grant or rebate program recommended here, to allow for more targeted local outreach to homeowners while maintaining adequate funding for larger project grants in the 50% regional funding pool.

Market Approach: Trading Schemes

Introduction

The third and final policy approach to implement private property green infrastructure builds on both the regulatory and financial approach to create a market mechanism. While the most complex to administer, this option creates a market for private property owners who install green infrastructure BMPs to generate credits which can be sold to property owners under a regulatory requirement (like a LID ordinance) for off-site compliance. Trading markets are already common for other environmental issues, beginning with the success of the EPA's Sulphur Dioxide trading scheme to reduce acid rain which began in the 1990s (Schmalensee & Stavins 2017). Since then, carbon markets to reduce greenhouse gas emissions have become common internationally (Schmalensee & Stavins 2017). Markets also exist for water quality within the U.S. and can be extended to stormwater runoff.

Overview

(A Brief) Background on Market Theory

Environmental economists often point to markets as the most efficient and cost-effective way to allocate environmental goods or burdens. Environmental markets set a regulatory 'cap' or limit on pollution or emissions which is then allocated amongst polluters as tradable permits or credits (Schmalensee & Stavins 2017). Central to the market's operations is the different costs each polluting firm faces to reduce the same amount of pollution. Markets allow firms for whom abatement is cheaper to reduce more and sell their extra credits to firms for whom abatement is more expensive. Thus, the total amount of emissions or pollution remains under the 'cap' but at a lower overall abatement cost than if each firm was required to reduce an equal amount of pollution and could not trade (Schmalensee & Stavins 2017). The Coase Theorem in economics states that with property rights assigned to pollution and zero transaction costs, firms can reach the most efficient pollution reduction regardless of the initial allocation of the property rights. The firms will trade up until the point where the marginal cost of pollution reduction (i.e. the cost of one additional unit of abatement) is equal across all sources. This is the optimal equilibrium because no firms can further reduce costs from either buying or selling an additional credit (Schmalensee & Stavins 2017). Following this logic, a market for stormwater can allow property owners for whom green infrastructure is cheapest to reduce more runoff quantity or pollution to achieve management goals at the lowest cost.

Regulatory Basis for Market Structure

Central to a market structure is the need for a regulation that forms the basis for credit trading. In most existing water quality trading schemes, required Clean Water Act total maximum daily loads (TMDLs) for different pollutants imposed upon impaired water bodies form the 'cap' under which rights to release pollution can be traded (Corrales et al 2013). Without regulation that can be enforced, the 'cap' will not be binding so allowances will not be traded (Greenhalgh & Salman 2012). The Lake Tahoe Nutrient Clarity Trading Program provides an example of an existing water quality trading market which involves multiple pollutants, jurisdictions, and covered actions. The Lake Tahoe program uses "Lake Clarity Credits" as the traded currency; Clarity Credits use a formula to track and report reductions in multiple different pollutants for a single BMP or activity undertaken by a regulated agency or municipality in the Lake Tahoe area (Lahontan WQCB 2015). This allows all of the different entities responsible for reducing polluted runoff in Lake Tahoe to track their reductions of multiple pollutants with a single, easily tradable metric. Projects which reduce pollutants use the formula to calculate how many Clarity Credits are generated (see Figure 6-1). These credits can then be used by entities for regulatory compliance or traded to other entities requiring additional credits for their own compliance.

$$\text{Lake Clarity Credit} = FSP_{LR} \times FSP_{multiplier} + TN_{LR} \times N_{multiplier} + TP_{LR} \times P_{multiplier}$$

WHERE

FSP_{LR}	Fine sediment particle load reduction is expressed in $1.0\text{x}10^{16}$ fine sediment particles with diameter smaller than 16 μm
TN_{LR}	Total nitrogen load reduction is expressed in lb
TP_{LR}	Total phosphorus load reduction is expressed in lb
$FSP_{multiplier}$	Fine sediment particle multiplier is a number between 0 and 1 credit / $1.0\text{x}10^{16}$ fine sediment particles with a diameter smaller than 16 μm
$N_{multiplier}$	Nitrogen multiplier is a number between 0 and 1 credit / 1 lb of TN
$P_{multiplier}$	Phosphorus multiplier is a number between 0 and 1 credit / 1 lb of TP

Figure 6-1. Formula for calculating Clarity Credits for the Lake Tahoe Nutrient Clarity Trading Program. Courtesy of Lake Tahoe Info Stormwater Tools.

The entities within the Lake Tahoe program are all local governments or agencies, which are easier to regulate than private property owners. A central challenge to stormwater regulation more broadly is the non-point source nature of runoff. While point source pollution can be easily tracked to its source, much urban runoff is non-point source and comes from development throughout the urban environment. Some water quality trading programs only cover point source entities, meaning only point sources like factories buy and sell permits amongst each other (Stephenson & Shabman 2017). In other instances, while only regulated point sources buy credits, non-point sources can sell credits earned from voluntary reductions (Stephenson & Shabman 2017). Beyond NPDES permits, which apply to municipalities and certain industrial facilities, stormwater runoff is not a legally regulated pollutant which makes imposing a legally binding 'cap' on all properties generating runoff difficult (Thurston 2012). In an ideal hypothetical market, a limit of runoff volume would be imposed on each property with the option to trade excess runoff reductions to other property owners for whom meeting the runoff requirement is more difficult or expensive (Thurston 2012).

However, instead of imposing runoff restrictions on all private properties in a watershed (which can be difficult or constitutionally impossible), markets can be built from LID ordinances. In these markets, new or redevelopment required to retain a certain amount of runoff on-site can instead comply by purchasing credits from existing properties with voluntary BMPs (Ellis et al 2017). The market would thus complement existing regulation with an alternative compliance option for lower cost and higher efficiency (Metcalf Foundation 2016). Washington, DC currently has the only active market for stormwater built off an LID ordinance, while Chattanooga, Tennessee has an option for credit trading in place. These two examples serve as the case studies for this section. Similar markets are currently proposed or under study in Cook County, Illinois (Illinois State Water Survey 2017), San Diego County (Walsh 2017), and the City of Los Angeles (Jones et al 2015).

Compliance Properties

A central aspect of a stormwater market is what exactly is traded and how. The definition of a credit along with additional properties for compliance and trading will be referred to as 'compliance properties' in this report. For example, in Washington, DC one credit reflects one gallon of retained stormwater runoff for one year and compliance (i.e. if an entity has enough credits) is assessed in multi-year compliance periods (DC DOEE 2018). Compliance properties are a major part, but not necessarily all, of program design.

Guiding Considerations of Market Design

The following considerations describe some of the different choices and decisions which municipalities must make when creating a stormwater market. The Washington, DC and Chattanooga case studies provide two examples of municipalities which made different decisions along several of these considerations.

Defined Program Goals, Compliance Properties, and Market Structure

As with the regulatory and financial approaches, a trading approach must begin with clearly defined stormwater management goals which inform market structure and design. In particular, the compliance properties of the market should reflect municipal goals. Credits can be based on runoff water quality (e.g. pollution levels) or quantity (e.g. gallons captured). For example, if the goal is retention, credits can be based on gallons or cubic feet retained on-site. Municipal goals to address runoff problems in priority watersheds may also impact program design by targeting new green infrastructure in certain areas of the city. If serving as the basis for trading, an LID ordinance must have standards designed to reflect the municipal stormwater goals.

Other aspects of market structure include who is eligible to generate or purchase credits as well as design guidelines and maintenance obligations for eligible projects (Valderrama et al 2016). The market structure must describe where and to whom credits can be sold, such as within the same watershed or throughout the jurisdiction (Valderrama et al 2016). In terms of market operation, options include a municipal clearinghouse, simple bilateral negotiations between property owners, and a third-party administered clearinghouse (Thurston 2012; Metcalf Foundation 2016). Another major consideration involves the timeline for credit use. While the central debate of expiring credits versus credits in perpetuity must be considered, other factors include whether credits can be 'banked' (i.e. purchased in advance for later use) or if they must be used within a certain timeframe to ensure liquidity in the market (Valderrama et al 2016).

Credit Liquidity and Market Size

Market size is a major determinant of a trading program's success—more participants make prices less volatile and lower transaction costs (Rostek & Wenetka 2008). The larger the reach of the market the more opportunities exist for cost differences between credit generators and purchasers, which drive trades (Greenhalgh et al 2012). If built on an LID ordinance, the pace of development and amount of applicable projects influence this. Municipalities can take several steps to increase market liquidity such as building public projects to generate credits for sale, buying credits to establish a price floor, allowing multi-year credit banking, and providing purchase guarantees so purchasers are protected from noncompliance in the event that a project fails to be maintained (Valderrama et al 2016). Washington, DC uses some variation of most of these options.

Cost Considerations

A major reason to pursue trading as opposed to traditional regulatory methods is overall cost effectiveness (Metcalf Foundation 2016). This is made possible by cost differences in stormwater management and BMPs across different properties (Thurston et al 2004). Trades occur when it is cheaper for developers to purchase credits than to install on-site BMPs. Significant variations in such costs on non-residential properties make them particularly suitable to trading schemes and some markets remain limited to such properties (Keeley 2007). However, with residential properties accounting for such a large share of land use in many cities, it may be worthwhile to consider including them in a program. Regardless, the financial return from selling credits and any other layered incentives (e.g. fee reductions or grants) must be large enough to incentivize eligible property owners to install BMPs and participate in the market (Thurston 2006).

Property owners face conflicting considerations: while larger BMPs result in economies of scale and thus decreasing costs, they also have increasing opportunity costs from other uses of that land (Thurston 2006). A market program must prove financially attractive to property owners compared to other property uses to encourage credit-generating projects. Municipalities can educate property owners about other benefits of retrofits that can be positively weighed against costs. Commercial properties can see increased property values and retail sales, reduced energy and water use, lower crime rates, and increased employee satisfaction from green infrastructure (Clements et al 2013). Most studies also find 2-5% property value increases in residential homes that install green infrastructure (Clements et al 2013). Finally, transaction costs must be low enough not to outweigh potential monetary gains, otherwise trades will not occur (Thurston et al 2004). Third-party aggregators and clearinghouses can lower transaction costs (Metcalf Foundation 2016).

Maximizing Multi-benefits and Equity

Trading programs monetize three major benefits of green infrastructure—water quality, flood risk reduction, and savings in avoided stormwater conveyance infrastructure—but market values could be even higher considering other direct and ancillary benefits of green infrastructure (Thurston 2012). A market structure distributes BMPs throughout the watershed which can distribute the ecological, social, and health benefits more evenly while capturing more stormwater (Valderrama et al 2016). The flexibility of credits may also facilitate infill development which might otherwise be dismissed as infeasible due to costly on-site stormwater management requirements that lack alternative compliance options (Ellis et al 2017). One study of potential sites that could be developed under an LID ordinance based trading scheme in Chicago found that 67% of the potential projects which would purchase credits were less than 10 acres in size (Illinois Water Survey 2017).

A trading program can more equitably distribute new green space, climate and environmental benefits, recreation, and natural habitat (Ellis et al 2017). BMPs will be built where land is cheapest with the potential to bring money to underinvested neighborhoods and benefits to disadvantaged communities (Jones et al 2015; Montalto 2017). Often disadvantaged neighborhoods are most vulnerable to urban flooding and the impacts of climate change but least likely to experience the new development subject to an LID ordinance (Illinois Water Survey 2017). These areas may have vacant or underutilized land on which green infrastructure would improve use and ecosystem services (Ellis et al 2017). Vacant land is often privately owned and thus best tapped for retrofit via a private property green infrastructure trading scheme (Montalto 2017). Finally, markets incentivize cheaper BMPs (which generate more profit) and thus create the benefit of innovation in BMP technology and construction (Corrales et al 2013).

Monitoring, and Maintenance

As with the two other approaches, monitoring and maintenance is an essential part of a market program. A market also has the additional administrative burden of brokering trades and verifying credits (Thurston 2012; CVC 2018). Municipalities should have a set inspection cycle and protect credit purchasers from noncompliance if a credit-generating project fails.

Case Studies

Washington, DC

Market Overview

Washington, DC (DC) contains two stormwater systems: the older combined system run by DC Water and the newer MS4 for which the U.S. Department of the Energy and Environment (DOEE) manages the MS4 Phase I Permit. Property owners pay two separate stormwater charges with different incentive programs including DC Clean Rivers (DC Water) and RiverSmart Rewards (DOEE) (Brears 2017). DOEE administers the trading program, known as the Stormwater Retention Credit (SRC) trading program. The SRC program uses the 2013 Stormwater Rule (DC's LID ordinance) as the regulatory basis for the market. All new or redevelopment disturbing 5,000 square feet or more of land must retain 1.2" of runoff (the 90th percentile storm event) while 'substantial improvement projects' of 5,000 square feet must retain 0.8 inches (the 80th percentile storm event) (Brears 2017). As part of the ordinance, 50% of the requirement must be met on-site while the other 50% can be met through the purchase of credits (SRCs) or through payment of an in-lieu fee of $3.61 per gallon which DOEE uses to implement its own projects (DC DOEE 2018).

One SRC represents one gallon of retained stormwater runoff for one year; projects are certified for SRCs for up to three years at a time and can be recertified upon each 3-year inspection cycle (Brears 2017). Property owners generating SRCs for installed BMPs must commit to maintaining projects for the up to three years for which they receive credits. Credit purchasers must demonstrate they possess enough credits at the end of their compliance period, which can be a single- or multi-year period depending on how many credits the purchaser buys in advance (DC DOEE 2018). While trades can be negotiated independently between property owners, they must be approved by DOEE. Trades must occur through DOEE's online stormwater database (see Figure 6-2) which displays SRCs for sale, people seeking to purchase credits, sale prices, and market data ("SRC Trading Program" n.d.). The first trades in Fall 2014 resulted in the sale of 11,013 SRCs at a total of $25,000 (Metcalf Foundation 2016). The credit program successfully distributes stormwater projects throughout the city. Research shows decentralized solutions capture more of the initial (and more polluted) 'first flush' stormwater volume than centralized solutions (Van Wye 2012).

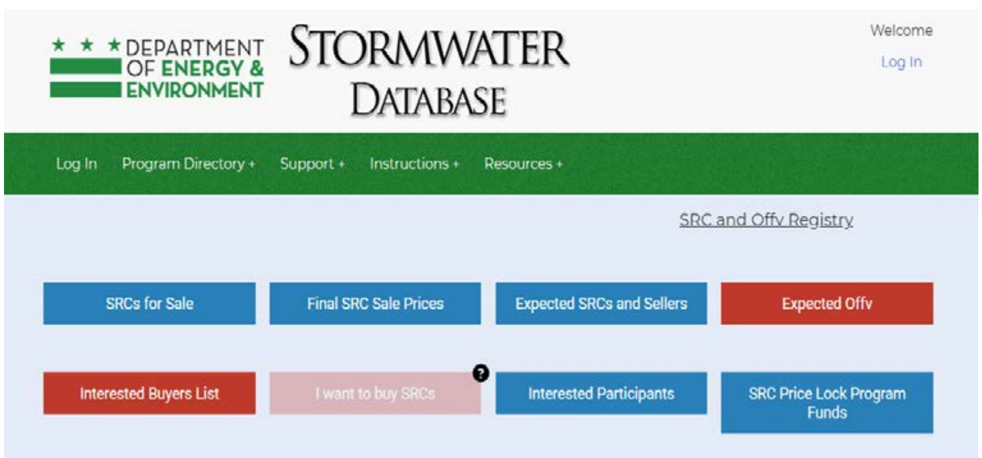

Figure 6-2: DOEE's online database for tracking and facilitating SRC trades

Unique Aspects of Market Design

DOEE staff confirm that the SRC program generates stormwater runoff reduction at a lower cost per gallon than would projects directly implemented by DOEE. The market's compliance properties (credits representing one year of retention and single or multi-year compliance periods) ensure an ongoing obligation to buy credits which keeps the market in operation (DC DOEE 2018). The gallon-per-year SRC refers to gallons captured in a designed storm rather than referencing actual capture in a given year (e.g. in a rainy year when BMPs capture more they do not generate more credits) which makes it a convenient metric for both comparing projects and tracking implementation (DC DOEE 2018). DOEE carefully considered program design to ensure a successful market, with particular emphasis on five main aspects: the compliance period, the way credit sellers receive revenue, the required maintenance contracts, the party responsible for correcting inadequate maintenance or faulty BMPs, and the commitment required to keep projects in place (DC DOEE 2018). Many of these considerations relate to the decision to give SRCs an annual, as opposed to permanent, lifetime. Since DOEE designed SRCs to require the credit-generating property owner to shoulder the maintenance responsibility, a permanent credit life could pose a barrier to program entry because of a high commitment to maintain BMPs in perpetuity. By awarding three years of SRCs at a time, with the option to renew, credit-generating property owners only need to commit to maintenance for three years at a time. DOEE finds this makes agreements easier for property owners who may be uncertain about future decisions and commitments (DC DOEE 2018).

DOEE also created the SRC Price Lock Program to ensure adequate trading activity and credits. Under this program, DOEE agrees to purchase SRCs at a fixed rate and retire them from the market. Credit-generating property owners can choose to either sell their SRCs on the open market or utilize this option to sell to DOEE (DC DOEE 2018). This sets a minimum price which property owners can expect for credits, creating stability for property owner decision-making while still allowing for higher prices on the open market. The Price Lock Program also enables DOEE to target or to encourage projects in certain high priority areas. While there are no restrictions on trading in the three watersheds (Anacostia, Rock Creek, and Potomac), DOEE does prefer green infrastructure installation in areas draining to streams and tributaries due to high pollution and erosion challenges (DC DOEE 2018). The Price Lock Program uses offered prices to encourage projects in the more polluted areas. Projects in areas draining to smaller streams and tributaries receive higher purchase prices from DOEE (see Figure 6-3). As another example of targeting via program design, only projects in the MS4 area—which faces more severe runoff challenges than the CSS area because it lacks the CSS's tunnel network—can partake in the SRC Price Lock Program (DC DOEE 2018). As of December 2018 the Price Lock Program alone resulted in the retrofit of 7.5 acres, with an additional 12.5 acres underway (DC DOEE 2018).

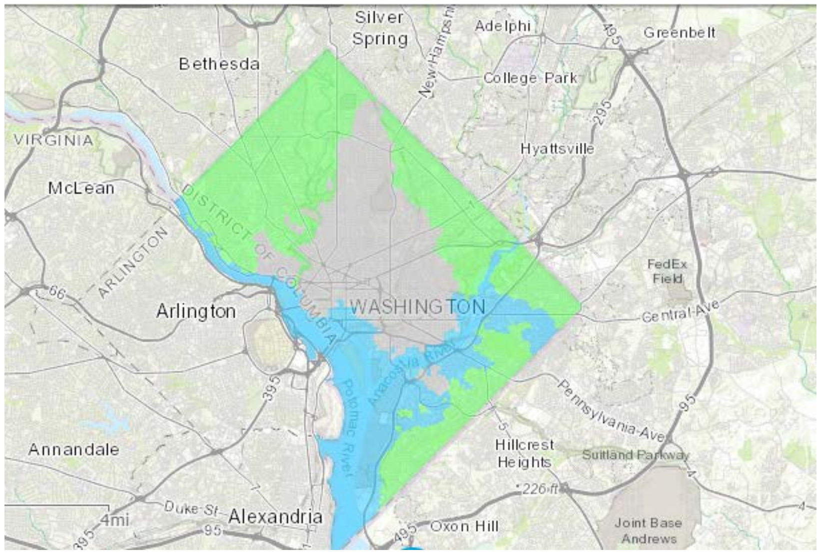

Figure 6-3. Map showing DOEE Price Lock Program Prices: Areas in the tidal MS4 (blue) receive higher credit purchase prices than the non-tidal MS4 areas (green) while projects in the combined sewer area (grey) are ineligible for the Price Lock Program. Courtesy of DC DOEE.

DOEE also encourages aggregators as a unique strategy to build up the market. Aggregators are contracting and construction businesses which complete retrofits on multiple properties. They often work with property owners to retrofit land and then take part of the SRC purchase price as payment. DOEE offers grants to help SRC aggregators start up, with competitive grants given to fund initial work (DC DOEE 2018). The competitive grant process includes scoring criteria for providing ecological and environmental justice benefits to areas of need, including criteria to prioritize the Anacostia Watershed (DC DOEE 2018). DOEE builds close relationships with these aggregators who are in turn very familiar with DC's water issues and pursue projects in those high priority areas (DC DOEE 2018). Aggregators serve an important role in DOEE's strategy to expand green infrastructure at a faster rate while targeting high priority areas. Prudential Financial invested $1.7 million in an SRC aggregator to spur new projects, an innovative example of how relationships with private companies can grow the market (Spector 2016).

DOEE recently proposed changes to the stormwater regulations which, as of March 2019, are currently out for public comment. These changes to the Stormwater Rule increase incentives and also change the eligibility of projects. Projects in the MS4 using SRCs for compliance would only be able to purchase SRCs from the MS4 area while projects draining to the combined sewer area tunnels could comply with 100% of the retention standard off-site by using SRCs from the MS4 area (DC DOEE 2019).

Lessons Learned to Apply to Los Angeles

Perhaps most importantly, the SRC Trading Program illustrates how careful thought in program design and compliance property structure can ensure success. Additional program features like the Price Lock Program and start up grants for aggregators support the market and target installations to areas DOEE deems high priority. Like the other case studies in this project, DOEE finds that the fee reduction it also offers is not a sufficient motivator for green infrastructure implementation. Instead, the opportunity to sell SRCs has been the most powerful motivator for property owners (DC DOEE 2018). SRCs are a more powerful incentive and the Price Lock Program sets prices to achieve a 6-year payback period for the average cost-effective project. While not guaranteed, this payback period aligns better with property owners shorter decision-making time frames than the longer payback periods from fee reductions (DC DOEE 2018). Instead, DOEE recognizes the fee reduction as a bonus or layered incentive; projects which generate SRCs also automatically receive the fee reduction (DC DOEE 2018).

This case study also highlights how a stormwater market can create new business opportunities. Aggregators now fund operations in DC by selling credits which perpetuates the market. Meanwhile, the aggregators' business model focuses on identifying projects in the more polluted MS4 and Anacostia Watershed areas, aligning with DOEE's goals. DOEE also ensures low transaction costs for market involvement through both its Price Lock program and online database for trades. Finally, the one gallon for one year SRC value serves as a clear and trackable performance metric which also makes regulatory compliance simpler. DOEE reports the projects generated from the SRC program for MS4 compliance (DC DOEE 2018).

Chattanooga, TN

Market Overview

The City of Chattanooga, Tennessee has a Phase I MS4 permit and faces flood control and drainage issues. With the most demanding MS4 permit requirements in the state of Tennessee, the city has collected a stormwater quality fee for 20 years (Chattanooga Public Works 2018). The city created a market through its 'Credit Coupon' program which is based on an LID ordinance similar to DC's 2013 Stormwater Rule. Figure 6-4 shows Chattanooga and its watersheds.

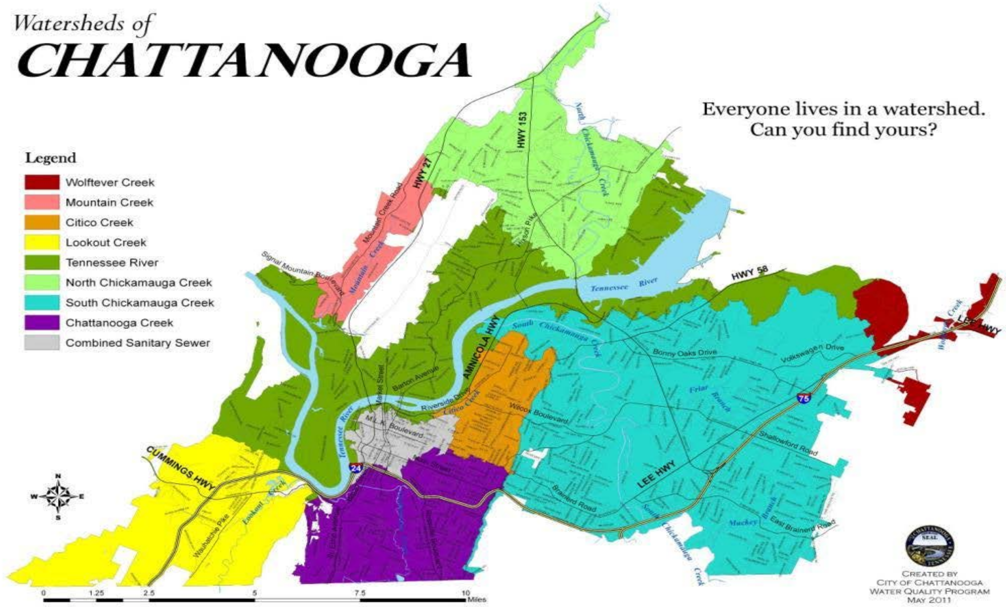

Figure 6-4: Watersheds in Chattanooga, TN Courtesy of City of Chattanooga

In 2014, new stormwater rules (Ordinance 12881) created the obligation for new and redevelopment to maintain a stay on volume (SOV) of urban runoff (City of Chattanooga 2014). Ordinance 12881 requires retention of 100% of a 1" rainfall event on-site, although 'Credit Coupons' (like SRCs in DC) can be purchased to meet some of this obligation. Initially, the ordinance required 1.6" rather than 1" in the more sensitive South Chickamauga Watershed due to the presence of endangered species (see Figure 6-5) (City of Chattanooga 2014). A 2017 update to the ordinance (Ordinance 13251) removed this special circumstance and the requirement is now 1" citywide (City of Chattanooga 2017).

Figure 6-5. The Chickamauga crayfish and snail darter are the two endangered species found in the South Chickamauga Watersheds. Courtesy of Georgia Department of Wildlife and U.S. DOJ.

Projects which exceed the SOV standard, or voluntary projects, can generate credit coupons which are measured in cubic feet of runoff captured and managed on-site (City of Chattanooga 2014). Sites with SOV obligations can meet part of their on-site obligation with a combination of credit coupons, in-lieu fees ($45/cubic foot), and/or off-site mitigation. However, unlike DC's permanent 50% alternative compliance limit, Chattanooga allowed different amounts of alternative compliance during a two-year 'implementation period' from December 2014 to 2016 (City of Chattanooga 2014). From 2014 to 2015, credit coupons could be used citywide to meet the entirety of a site's SOV obligation, which then dropped to 50% from 2015 to 2016. After this implementation period, sites must prove the infeasibility of on-site compliance to use a credit coupon (City of Chattanooga 2014). However, before Ordinance 13251 passed in 2017, projects in the South Chickamauga Watershed could always use credit coupons to meet their additional 0.6" requirement in perpetuity. The city does not coordinate or negotiate trades (City of Chattanooga 2014).

A credit coupon multiplier privileges redevelopment or retrofit sites over new development. Credit coupons from redevelopment or retrofit sites apply at a 1:1 ratio for SOV obligation anywhere in the city but credit coupons from new development sites must be applied at a 1.5:1 ratio and can only be used for compliance of projects within the same watershed (City of Chattanooga 2014). Voluntary retrofits on non-single-family properties which generate credit coupons can also receive a water quality fee reduction which requires annual documentation submitted to the city and an inspection by a professional engineer or landscape architect every five years (City of Chattanooga 2014). This system reduces the city's need to dedicate staff resources to more frequent in-person inspections. The 2017 update removed the 1.6" requirement in the South Chickamauga Watershed and also prioritized redevelopment and infill projects by allowing a reduction in the required SOV for these projects. Brownfield redevelopment, projects with a certain minimum density or Floor Area Ratio[8], and mixed-use transit oriented development can receive a 10% reduction in the 1" SOV (City of Chattanooga 2017).

Unique Aspects of Market Design

Several aspects of the Chattanooga Credit Coupon program mirror Washington, DC's SRC program: the use of an LID ordinance as a basis for trading, incentives which prioritize certain project types or areas, and overlap with a fee reduction. Initially, Chattanooga also targeted the priority Chickamauga Watershed through a higher SOV which was compensated with the ability to use more credit coupons for alternative compliance in that watershed, although this changed with the 2017 ordinance update. Another similarity to DC exists in the calculation of credits. Just as DOEE uses a hypothetical storm to calculate the 1-gallon SRC, Chattanooga calculates cubic feet of

[8] Floor Area Ratio is a ratio of a building's floor area to the size of the lot the building is located on and thus expresses the mass of building volume on a site. Cities often restrict allowable FARs which limits the height and density of new buildings (Metropolitan Council n.d.). Encouraging higher FARs means encouraging higher density development.

SOV for credit generation by using runoff coefficients based on land use and development type (Chattanooga Public Works 2018).

Unlike DC, however, as of December 2018 no credit coupons had been sold in the Chattanooga program (Chattanooga Public Works 2018). The first coupons were issued in January 31, 2019 and it remains to be seen how these will be traded (Chattanooga Public Works 2019). Several factors might explain the lack of market activity. The phase down of the implementation period, which resulted in the requirement for technical infeasibility to use credit coupons after December 2016, may be a major factor. Increasing the properties eligible to use credit coupons could encourage their use. Additionally, Chattanooga does not facilitate or negotiate credit coupons trades. City staff noted that administrative burdens and costs resulted in the decision to be as hands off as possible in operation of the credit coupons market (Chattanooga Public Works 2018). Finally, the city does not support aggregators like DC does. However, the city does offer the Green Grant program which provides $100,000 per year in grants for commercial property owners (Chattanooga Public Works 2018). Now in its second year of operation, the program has thus far awarded grants to private schools and an industrial warehouse for green infrastructure installation. Projects completed with Green Grants automatically generate credit coupons and a fee reduction (Chattanooga Public Works 2018). The Credit Coupon program also faced legislative challenges from interest group lawsuits which somewhat stalled the program (Chattanooga Public Works 2018).

A final difference to the DC program is the lifetime nature of credit coupons, which need only be purchased once for compliance (Chattanooga Public Works 2018). Just as with the decision to avoid involvement in trades, the city chose to structure the market with one-time credit purchases due to a lack of administrative and fiscal capacity that could be dedicated to market operation (Chattanooga Public Works 2018). After the initial purchase of a credit coupons, property owners must comply with a maintenance agreement by submitting required documentation and inspections along with getting 5-year certification by a licensed professional engineer or landscape architect (Chattanooga Public Works 2019). While participation remains low, the existence of the Credit Coupon program suggests the potential for future growth. Some slight changes to the program, or future alterations in market conditions, could make the program much more popular in the future. As one of only two trading programs in the U.S., Chattanooga demonstrates forward thinking in creating flexible alternative compliance options for stormwater management.

Lessons Learned to Apply to Los Angeles

Chattanooga's credit coupons market does offer a lot of compliance flexibility which can reduce developer costs and spread out green infrastructure implementation. However, the current low participation rate suggests the need to look closely at program design for clues to market activity. Credits which represent a specific time period (e.g. one year) rather than last in perpetuity, expansions in eligible properties, and an online clearinghouse to facilitate trades could encourage continual market activity. The Chattanooga case study also reiterates the importance of layering incentives, through its combination of credit coupons, fee reductions, and grants. As described in other case studies, city staff note that the fee reduction is simply not large enough to incentivize green infrastructure adoption alone. Most developers want closer to a 3-year payback period as opposed to the standard 7-year payback period that results from a fee reduction (Chattanooga Public Works 2018). Chattanooga excludes single-family residential properties from the fee reduction and credit coupons. The city operates a RainSmart program for residences to provide rain barrels and assist Home Owner Associations (HOAs) or property owners with detention pond maintenance (Chattanooga Public Works 2018). Like Philadelphia, Chattanooga found that a separate program made more sense since residential properties are too small for meaningful fee reduction and credit generation.

Principles of Success

The case studies and guiding considerations resulted in the following five principles of success for a market approach.

Principle 1: Sufficient Market for Buyers and Sellers

As noted earlier, markets will achieve their cost-effectiveness potential only when cost differences exist across the landscape to make trades worthwhile. This requires enough properties to partake in the market as both credit generators and purchasers. For a market to operate, the watershed (or other jurisdictional unit for the market) must be large enough to garner sufficient participants. Additional support from a municipality may be required in the form of outreach efforts or municipal programs to purchase credits or generate credits via public projects.

Principle 2: Strong Regulatory Basis for Program Goals and Design

Market trades are generated by property owners seeking to meet regulatory requirements at a lower cost. The regulatory basis for a trading market, whether a cap on pollution or LID ordinance standards for development, must be strong enough and adequately enforced to generate market participation. The regulatory basis, such as a LID ordinance, often establishes the goals on which to base credits (e.g. retention, water quality).

Principle 3: Administrative Capacity to Implement

A market can only be successful if the administering entity has the capacity and knowledge to design and operate the market. Strong leadership, communication, and staff capacity is necessary to establish and oversee the market. The municipality or designated third-party administrator must continually broker trades, verify credits, and implement enforcement and monitoring.

Principle 4: Low Transaction Costs and Credit Liquidity

Transaction costs must be low enough to ensure property owners participate in the market as a financially attractive alternative compliance (for purchasers) or voluntary retrofit (for sellers) option. Sufficient information must be provided in an easily accessible format to potential credit generators and purchasers. An online database such as DC's can connect market participants and lower transaction costs. Municipalities must also have programs in place to ensure credit liquidity in the market for sufficient credits and trades. The municipality could buy credits, such as in DC's Price Lock Program, or encourage private companies to aggregate, such as when DC partnered with Prudential Financial to stimulate private green infrastructure investment (Spector 2016). Limiting the credit lifetime can also maintain long term market use.

Principle 5: Comprehensive Policy Package for Adequate Incentives

A combination of policies which includes a trading program may be required to sufficiently incentivize private property owners to install green infrastructure. A market should design credits to align with other incentive programs, such as automatically granting a stormwater fee reduction to credit-generating projects. DC's aggregator startup grants and Chattanooga's Green Grants provide examples of how grant programs can supplement potential profits from credit sales to incentivize property owners.

The Los Angeles Example and Recommendations

The Safe Clean Water Program and stormwater parcel tax passed under Measure W commits Los Angeles County to developing both financial incentives (a tax reduction and grants) and a trading market. No details on the potential trading market were included in the draft program elements. The program elements simply stated a commitment to develop the market by the August 1, 2019 deadline for providing the Board of Supervisors with the Safe Clean Water Program structure. This section analyzes the potential for a trading market in Los Angeles County and provides preliminary considerations and recommendations based on the case studies and principles of success.

The Two Market Structure Options

Measure W does not provide any guidance on how the county plans to structure a market approach but two distinct possibilities exist depending on the chosen regulatory basis for the market. First, the market can be based off the county's existing LID ordinance as found in Washington, DC and Chattanooga. Second, the market could be modeled on existing water quality trading programs like the Lake Tahoe Nutrient Clarity Trading Program and use industrial MS4 permit requirements as the regulatory basis. Each scenario is described in further detail before assessing the options using the principles of success.

LID Ordinance-based Market

Under the DC model, the county's existing LID ordinance would serve as the basis for trading. Developers would be able to meet some of the required on-site retention of the Stormwater Quality Design Volume (SWQDv) through purchase of credits generated by voluntary projects which retain runoff (Los Angeles County 2014). Such a market design would require updating the LID ordinance to allow for a certain amount of off-site alternative compliance (at present retention must be on-site unless proven technically infeasible). Previous research found potential for an LID ordinance-based market within the City of Los Angeles using the 0.75-inch SWQDv requirement (Jones et al 2018). This idea could be expanded to the county using its own LID ordinance, although multiple watersheds and jurisdictions could make it more administratively complex. One benefit of an LID ordinance-based market is that it aligns well with the other proposed Safe Clean Water Programs under Measure W. A large portion of the proposed tax reduction would be based on compliance with an applicable Industrial MS4, SUSMP, and/or LID ordinance ("Program Elements" 2018). Thus, voluntary projects exceeding an applicable LID ordinance could automatically generate both trading credits and a tax reduction. Those same standards would in turn dictate the credits regulated projects would purchase to comply. Such alignment across programs with related standards and layered incentives can make participation and administration simpler.

Industrial Permit-based Market

The other market option uses existing industrial stormwater permits as the basis for trading. In California, including Los Angeles County, industrial facilities' discharges are regulated by additional facility level permits beyond municipal level permits. As point sources of runoff that often contain higher concentrations of pollutants, these facilities must each meet specific standards outlined in industrial general permits overseen by both the State Water Resources Control Board and the relevant Regional Water Quality Control Board (RWQCB) (CASWRCB 2019). In this market structure, facilities subject to industrial general permits would be able to meet some level of water quality compliance with the purchase of credits from either other facilities exceeding compliance or voluntary retrofits. For example, the RWQCB could set a cap on discharge levels of certain pollutants (matching existing TMDLs) or on total amount of impervious area which would then be allocated among industrial facilities in Los Angeles County. Industrial facilities exceeding the standards could sell extra credits to others who do not comply. Voluntary retrofit projects could also generate credits to sell in the market based on pollutant or impervious area reduction. This option may have fewer market participants than a market based on an LID ordinance since only industrial facilities purchase credits as opposed to new developments. However, industrial facilities must comply with stricter permit requirements which may have a stronger regulatory basis than an LID ordinance. Additionally, the RWQCB may be the best entity to coordinate this type of market since it regulates industrial facilities, as opposed to the county for an LID ordinance market since it regulates development. Some of the same questions about compliance properties, market boundaries, and administration remain with both types of market structure.

Analysis of Potential Market

Since details of a potential stormwater market remain to be determined, this section highlights how the principles of success relate to the two potential market options. An official market structure must be adopted as part of the Safe Clean Water Program by August 1, 2019 ("Program Elements" 2018).

Principle 1: Sufficient Market for Buyers and Sellers

Further research must determine the potential size of both market options. Are there more developers under an LID ordinance than industrial facilities subject to industrial general permits? An LID ordinance-based market would incorporate residential and commercial developments occurring into the future while industrial facilities may remain static, decline, or grow under the industrial general permits.

Principle 2: Strong Regulatory Basis for Program Goals and Design

Both market options are based on existing regulations which would require updates or changes to facilitate trading. For example, the LID ordinance would need to be updated to allow for alternative off-site compliance without proving technical infeasibility. The industrial general permits might require changes to translate permit requirements into a cap and trade program to allow for trades. Further research should determine if the motivation for industrial facilities to lower ongoing compliance costs is stronger than the motivation for developers to meet LID ordinance requirements.

Principle 3: Administrative Capacity to Implement

One major decision involves who will run the market, which includes verification and monitoring of credits and trades. The administrator—whether the county, RWQCB, or a third-party—must have the fiscal and administrative capacity to adequately run the market to reduce transaction costs for participants and institute additional market support programs. The county may be the best fit for the LID ordinance option while the RWQCB may be the best fit for the industrial permit option. Funding is a major question; it remains to be seen how much of, and from which pool of, Measure W funding can be committed to operating a market and associated features. The 50% regional funding pool may be the best matched to fund a countywide market. Some commitment is necessary, as a hands-off approach would generate fewer trades (as in the case of Chattanooga).

Principle 4: Low Transaction Costs and Credit Liquidity

This principle relates closely to Principle 3 and highlights the importance of establishing supporting programs and policies to facilitate trades and credit-generating projects. The county may need to implement public projects or facilitate investment to generate credits. On the other hand, the county may need to purchase and retire credits to help maintain a price floor. This could be coordinated with other Measure W programs, for example, by automatically granting credits to projects funded through the regional grant program. An easy to access central database or online platform for obtaining information and registering credits or trades will be essential to lowering transaction costs and ensuring market activity. Market design should also carefully consider banking, credit lifetimes, and length of compliance periods.

Principle 5: Comprehensive Policy Package for Adequate Incentives

The market program should be linked to other incentive programs to ensure adequate financial motivation for property owners to install credit-generating projects. Layering tax reductions, grant funding, and credit generation could increase involvement by property owners. Using an LID ordinance as the basis for both trading and tax reductions can streamline the layering of incentives. However, incentives should also be designed to avoid double counting.

Recommendations

While not the only decisions necessary regarding a proposed market structure, the following three recommendations suggest several integral components of a market.

Update County LID Ordinance to Create Market

A market built on the county's existing LID ordinance would provide a strong basis for a market like DC's while aligning with the other LID ordinance-based elements of the Safe Clean Water Program. For such a market to exist, the LID ordinance must be updated to allow for more alternative off-site compliance. This should be a set percentage which does not decline over time to ensure continual use of the market.

Create Credits with Limited Lifetime and Maintenance Obligation

Setting the compliance properties of the market to have multi-year compliance periods with credits that expire after a set amount of time (e.g. how DC certifies three years' worth of annual credits at a time) can ensure continual market activity. Property owners generating credits should shoulder the maintenance obligation in order to protect credit purchasers from non-compliance due to faulty BMP maintenance.

Establish County Level Market Support Tools

Additional programs will be required to support the market. A program for the county to purchase credits (like DC's Price Lock Program) and the ability to generate new credits through public projects can balance the market and keep it running smoothly. An online database will both enable administrative tracking of credits and trades and lower transaction costs for market participants. Regional or municipal grant funded projects from the Safe Clean Water Program should automatically generate credits in order to kick start the market and allow for incentive layering.

Conclusion

This project sought to evaluate the three municipal policy approaches (regulatory, financial, and market-based) to incentivizing green infrastructure on private properties for stormwater management. Case studies and literature review identified major guiding considerations of policy design as well as principles of success for each policy type. These in turn informed recommendations for the Los Angeles County context. The main research question guiding this project was: how can Los Angeles County update its existing, and implement new, policies to expand green infrastructure for stormwater management on private properties?

Key Findings and Recommendations

The five municipal case studies (Seattle, WA; Washington, DC; Philadelphia, PA; Montgomery County, MD; Chattanooga, TN) employ a combination of the approaches. Case study descriptions, guiding considerations, and principles of success are detailed in each policy section. Figure 7-1 below summarizes the principles of success for each of the three approaches. However, two overarching high-level findings emerged across all three policy types which warrant further discussion.

LID Ordinance	Financial Incentives	Trading Scheme
● Regular pace of development and long-term adoption goals ● Clearly defined goals based on watershed needs ● Opportunity for flexible alternative compliance ● Defined implementation guidelines ● Enforcement, monitoring, and maintenance	● Legal feasibility and political willpower ● Adequate incentive amounts ● Defined goals to tailor incentive structure ● Program focus tailored to land use pattern ● Combining approaches (carrots and sticks)	● Sufficient market for buyers and sellers ● Strong regulatory basis for program goals and design ● Administrative capacity to implement ● Low transaction costs and credit liquidity ● Comprehensive policy package for adequate incentives

Figure 7-1 Principles of success for three stormwater policy approaches

First, municipal stormwater regulation serves as an important driver for policy implementation and design. Most case studies cited their municipal NPDES permit as an impetus for their green infrastructure policy or structured the policies to assist in permit compliance. Los Angeles County has an MS4 permit which should play a major role in determining the goals and standards of future policies. Indeed, the RWQCB responsible for MS4 permit enforcement listed numerous impaired water bodies in Los Angeles County for high levels of urban runoff pollution. This regulatory action already spurred the passage of Measure W, which provides the legal and financial basis for the planned policies in Los Angeles County.

Second, all five case studies highlighted the importance of layering incentives since tax or fee reductions alone are not sufficient to motivate property owners to install green infrastructure. Measure W already calls for the creation of tax reduction, grant, and trading programs which will help achieve this goal. The county must now, however, undertake the essential task of program design. This creates an opportunity to take a more holistic view of these green infrastructure policies. Rather than focusing on each separately, policies should be coordinated to ensure overlap and interaction which will advantage both the county and property owners. Streamlining standards and applications can reduce both administrative burden and property owner transaction costs. Meanwhile, layered incentives can provide stronger motivation for property owner involvement. This project made nine specific recommendations for Los Angeles County policies, shown in Figure 7-2.

LID Ordinance	Financial Incentives	Trading Scheme
● Increase opportunities for off-site and alternative compliance ● Prioritize compliance strategies to achieve specific goals ● Use LID ordinance as the foundation of a trading program	● Separate residential and commercial grant or rebate programs ● Education and outreach, technical and design assistance ● Coordination with municipalities regarding municipal funding use	● Update LID ordinance to create market ● Create credits with limited lifetime and maintenance obligation ● Establish county-level market support tools

Figure 7-2 Summary of the nine specific recommendations for Los Angeles County

The first and central component of policy development should be updating the county's LID ordinance, since it should serve as the basis for both the tax reduction and trading programs in Measure W. More broadly, the county must consider how a property owner interested in participating will view all these programs when considering a retrofit. Meanwhile, a county-wide perspective must be maintained to ensure the essential stormwater management goals are met across the jurisdiction. With increasing development and uncertain precipitation patterns from climate change, the county faces growing pressure to address water pollution, flooding, and local water resilience. All these needs can be supported with private property green infrastructure.

Future Research and Limitations

Hopefully this project will serve as a useful guide not only for Los Angeles County but for other municipalities considering the adoption of private property green infrastructure policies. The guiding considerations and principles of success for each policy approach can apply broadly in different locations, although the ultimate application of these tools will result in different choices based on the unique municipal context. The case studies, as well as the analysis of Los Angeles County, provide examples of how certain policy decisions differ by place. Many different context specific factors influence policy design. Indeed, actual program design for Los Angeles County was outside the scope of this project. Instead, the recommendations and analysis provide a starting point to understand some of the necessary considerations. Other municipalities should complement the principles outlined in this project alongside other tools and information on the unique aspects of their jurisdiction (political, legal, geographic, etc.) when determining policy design.

This project could not cover all the important aspects of green infrastructure policy design and could not anticipate every contextual feature which may affect policy decisions and success. Further research into other case studies could help illuminate other important considerations in policy design. Additionally, this project was only able to interview municipal staff members, but property owners who decide to participate (or not) in these programs are another essential perspective worth further examination.

Green infrastructure continues to expand in cities across the country as a flexible, cost-effective way to enhance stormwater management with additional multi-benefits. The opportunity exists for Los Angeles County to join the case study municipalities detailed in this project as a leader in private property green infrastructure implementation. Los Angeles County and its voters signaled a commitment to more innovative stormwater management with the passage of Measure W, which will provide new tools and stronger funding. The next step will be to build on this momentum with careful program design that leverages the power of private property across the county to meet these goals.

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Appendix A: Glossary

Term	Definition
303(d) List	List of impaired water bodies that do not meet pollution standards under the Clean Water Act.
(EPA) Consent Decree/Consent Order	Municipalities that fail to comply with the Clean Water Act through their NPDES permit must reach a settlement with the EPA that results in a legally binding Consent Decree or Order—this details actions that the municipality to reach compliance on a certain timeline.
BMPs	Best management practices are structural or managerial practices which can treat or reduce runoff and pollution. These can be gray or green infrastructure, or management practices but this project refers to BMPs in the context of green infrastructure solutions.
CSO Control Policy	Required for combined sewer systems regulated under the Clean Water Act. Alternatively, MS4 permits govern municipalities with separated storm sewers.
CSS/CSO	Combined sewer systems (CSS) are municipal systems that mix both wastewater and stormwater—regulation is meant to reduce or eliminate combined sewer overflows (CSOs) when, during storm events, too much combined stormwater and sewage in the system results in overflows and discharges of untreated water.
CWA	The Clean Water Act, originally enacted in 1972, gives the EPA the authority to regulate water pollution and forms the legal basis for the current municipal stormwater permit system.
DC Water	The entity responsible for managing the combined sewer area of Washington, DC.
DEP	The Montgomery County Department of Environmental Protection administers the county's stormwater incentive programs for property owners.
DOEE	The Washington, DC Department of Energy and the Environment is responsible for the city’s MS4 permit and operates the stormwater market trading program and established the 2013 Stormwater Rule.
EPA	The U.S. Environmental Protection Agency is the federal agency responsible for enforcing the Clean Water Act and thus creates the NPDES permit system.
ERU	An Equivalent Residential Unit is a metric used to assess stormwater fees or taxes—properties will be charged a certain amount of money per ERU of impervious area.
GARP	The Greened Acre Retrofit Program is one of the two grant programs Philadelphia offers to commercial properties for green infrastructure projects.

Green Infrastructure	A form of stormwater management that uses vegetation, soils, and natural elements to treat, infiltrate, and store stormwater.
LADWP	The Los Angeles Department of Water and Power is one of the largest water providers in Los Angeles County and primarily serves the City of Los Angeles.
LID	Low Impact Development is an approach to site and building design that attempts to maintain hydrologic function through the design of conveyance, storage, infiltration, evaporation, detention, and landscaping features. LID ordinances require new or redevelopment to design with an LID approach and use green infrastructure to reduce urban runoff.
Measure W	The stormwater parcel tax measure passed in Los Angeles County in November 2018 which created the Safe Clean Water Program.
MS4	Municipal Separate Storm Sewers are storm sewers that are separated from wastewater and thus only collect and drain water from snow/rain events. Municipalities with these systems are covered under MS4 Phase I (for large municipalities) or Phase II (for smaller entities) permits.
NPDES Permit	National Pollutant Discharge Elimination System permits include stormwater permits issued to point source polluters and municipalities under the Clean Water Act.
PWD	The Philadelphia Water Department charges the stormwater fee and administers incentive programs in Philadelphia.
RWQCB	Nine Regional Water Quality Control Boards across California monitor and enforce both municipal and industrial MS4 permits along with other Clean Water Act regulations, such as listing impaired water bodies on the 303(d) list. The Los Angeles RWQCB covers Los Angeles and Ventura Counties.
SCWP	Established by Measure W, the Safe Clean Water Program will consist of a stormwater parcel tax to fund stormwater management across Los Angeles County.
SMIP	The Stormwater Management Incentive Program is one of the two grant programs Philadelphia offers to commercial properties for green infrastructure projects.
SOV	Stay on volume is the standard of on-site runoff retention required from new and redevelopment projects in Chattanooga's LID ordinance.
SRC(s)	Stormwater retention credits are the unit of trading used in the Washington, DC Stormwater Retention Credit Trading Program.
SuDS	Sustainable drainage systems is the term used for LID features in the UK.

SUSMP	Los Angeles County was required to create standard urban stormwater mitigation plans for compliance with the NPDES permit issued by the Los Angeles Regional Water Quality Control Board. SUSMPs contain lists of BMPs required for different types of development projects to reduce urban runoff pollution and flooding.
SWQDv	The stormwater quality design volume is the on-site retention standard in the Los Angeles County and City of Los Angeles LID ordinances which corresponds to 100% on-site retention of 0.75 inches (the 24-hour 85th percentile storm event).
SWRCB	The State Water Resources Control Board is the statewide agency responsible for water quality and water rights in California. It oversees and delegates responsibilities to the nine regional boards (RWQCBs) which implement enforcement of NPDES permits for stormwater.
TMDL	Total maximum daily loads are set levels for given pollutants that cannot be exceeded in order to comply with the Clean Water Act. Impaired water bodies on the 303(d) list are assigned TMDLs for each applicable pollutant and must be below these limits by the required timeframe to achieve compliance.
WQPC	The water quality protection charge is the stormwater parcel tax charged to property owners in Montgomery County, MD.
WSUD	Water sensitive urban design is the term used to refer to LID in Australia.

Appendix B: Interview Questions

This list of questions was asked of staff members from case study municipalities during 30-minute semi-structured phone interviews. Additional follow up questions tailored to each case study municipality occurred as needed during the interviews.

1. What type of sewer system does your municipality have? (combined/separate)
2. What would you say are the primary stormwater challenges your municipality faces? Would they be categorized as water quantity, quality, or public awareness challenges (or a combination)?
3. What were the motivating factors that led to the development of your program (e.g. specific regulatory requirements, stakeholder concerns etc.)?
4. What are the specific goals of the program and how has that influenced program design? If you have multiple policies and incentives, do they have different goals?
5. Do you include both residential and commercial properties in your incentive programs? Why or why not?
6. Does your program have multiple incentives and if so, do you find property owners need to take advantage of several in order to undertake projects or is one of them enough of an incentive?
7. Are there unique aspects of your program design that you feel are influenced by the specific context of your municipality (e.g. land use, climate/hydrology, stakeholder interests, regulatory requirements, financing etc.)?
8. Do you find it less expensive to provide private property incentives than to implement green infrastructure in the public right of way? Or is there not enough suitable land in the public right of way that private property projects are necessary?
9. Have you found any specific challenges associated with operating your program?
10. How have you measured/evaluated the success of your program? Do you have certain metrics or goals that you use for evaluation?