TRANSFORMING TRADITION: A CASE STUDY OF STORMWATER MANAGEMENT IN CLARK COUNTY, WASHINGTON TO ASSESS BARRIERS TO LOW IMPACT DEVELOPMENT STRATEGIES

by

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Abstract

Transforming Tradition: A case study of stormwater management in Clark County, Washington to assess barriers to low impact development strategies

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Stormwater runoff is one of the leading polluters of Puget Sound and other Washington State waterways, adversely affecting human health and damaging aquatic and terrestrial ecosystems that depend on clean water. Discharges from traditional stormwater infrastructure, also known as point source pollution, are main contributors to this problem. The Clean Water Act National Pollutant Discharge Elimination System (NPDES) permits for municipal separate storm sewer systems (MS4s) require municipalities and counties to develop stormwater policies and implement codes and standards that help protect waters of the state from the harmful effects of stormwater discharge. In contrast to traditional stormwater management practices, NPDES permit protocols increasingly favor low impact development (LID), site-specific surface water and land use management strategies that mimic pre-disturbance water cycles, thereby managing water in situ instead of exporting it for discharge into state waterways. A mixed methods case study assesses barriers to low impact development strategies for stormwater management in Clark County, Washington through the lens of seven impediments developed by Australian researchers. The study concludes that resistance to change and clarification of legislative mandates are keystone barriers to LID strategies for stormwater management, and demonstrates the need for collaborative interdisciplinary solutions. This research is significant because the environmental problems associated with traditional stormwater management dictate a transition from conventional methods to more sustainable regimes. Assessing barriers to LID stormwater management strategies will inform efforts, enhance outcomes, and educate and inspire participants so that with time stormwater-caused water pollution will become the exception and not the rule.

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Acronyms

CCSC	Clark County Sustainable Communities
CREDC	Columbia River Economic Development Council
CWP	Clark County Clean Water Program
EDP	Clark County Economic Development Plan
EPA	U.S. Environmental Protection Agency
IT	Information Technology
LID	Low Impact Development
LIDTGM	Low Impact Development Technical Guidance Manual
NPDES	National Pollutant Discharge Elimination System
PV	Port of Vancouver
SARD	Sustainable Affordable Residential Development
SCPP	Sustainable Communities Pilot Program
SNAP	Stormwater Needs Assessment Program
SWMMWW	Stormwater Management Manual of Western Washington
UW	University of Washington
WSC	Washington Stormwater Center
WSU	Washington State University

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Chapter 1

> "[Water] is the gold standard of biological currency, and the good news is that we can conserve it in countless ways . . . Our task is to work out reasonable ways to survive inside its boundaries" (Kingsolver, 2010, p. 49).

Introduction

Professional stormwater managers are in the midst of challenging times. Overwhelming evidence indicates that traditional stormwater management schemes are unsustainable. Federal and state mandates require local jurisdictions to adopt low impact development strategies (LID) that mimic natural water cycles in order to protect receiving waters from pollutants carried by stormwater. The transformation from old to new has spawned research, innovation, unconventional partnerships, resistance, and conflict.

Stormwater runoff from disturbed landscapes causes flooding, damages aquatic and terrestrial ecosystems, and is one of the leading polluters of state waterways. In accordance with the U.S. Environmental Protection Agency (EPA) Clean Water Act, National Pollutant Discharge Elimination System (NPDES) federal stormwater mandates require local jurisdictions to develop stormwater policies and implement codes and standards to safeguard state waterways from the adverse effects of stormwater discharge. Public sector NPDES Phase I Municipal Stormwater permit holders such as Clark County in southwest Washington State serve key roles in curtailing stormwater-caused water pollution including those of technologists, policymakers, educators, monitors, and enforcers.

NPDES municipal stormwater permits have served as an impetus for positive change in stormwater management practices, particularly over the past five years. At the same time, permit requirements have been a source of conflict as jurisdictions seek clarification on policy mandates and deal with resistance to shifting regimes. Stormwater-caused water pollution has been created by innumerable actions of entire populations since the onset of urbanization and so solutions will necessarily take time and consist of a broad base of strategies and participants.

This mixed methods case study of stormwater management in Clark County assesses barriers to LID strategies. Data are compiled from peer-reviewed studies, government reports, government and private websites, journal articles, articles in periodicals, published fact sheets, newspaper articles, court proceedings, and professional discussions. The data, which exemplify the complexities of stormwater management, are examined through the lens of seven impediments described by Australian researchers Roy et al. (2008) in Chapter 3. The impediments (hereafter referred to as barriers) then provide a framework for analysis in Chapter 5. The seven barriers identified by Roy et al. (2008) are:

1. Uncertainties in performance and cost
2. Insufficient engineering standards and guidelines
3. Fragmented responsibilities
4. Lack of institutional capacity
5. Lack of legislative mandate
6. Lack of sufficient funding and effective market incentives
7. Resistance to change (Roy, et al., pp. 347-350)

The thesis is organized into chapters covering the theoretical, background, methods, and practical aspects of the case study. Chapter 1 looks at stormwater along with its impacts and policies, and examines LID. Chapter 2 begins with a discussion on pragmatic theory, moves into a review of the literature, and then presents the research methodology. Chapter 3 provides contextual information for Clark County and characterizes the county's LID and stormwater management practices. Chapter 4 contains the analysis, findings, and discussion, and Chapter 5 presents the thesis conclusions. The case study is important because it introduces interdisciplinarity into a conversation that has historically concentrated on engineering and technology.

Problems associated with traditional stormwater management call for environmentally responsible policies and practices. As a result, cities and counties are gradually adopting LID strategies, largely due to NPDES permits regulations that are becoming increasingly stringent with time. The case study characterizes some of the challenges and successes associated with LID implementation on a local scale through the perspective of the seven barriers, which are separated into three categories according to influence on LID initiatives: Keystone, Prominent, and Moderate. Findings reveal resistance to change and clarification of legislative mandates as keystone barriers, the strongest influencers of LID initiatives, primarily due to ongoing litigation that will ultimately affect the interpretation of NPDES permit requirements. Other findings suggest that NPDES permit mandates precipitated the adoption of at least some LID initiatives in Clark County, and note interdisciplinarity, community cohesion, and innovation as common characteristics of successful LID ventures. An overview of stormwater runoff provides a context for understanding stormwater management issues.

Stormwater: An Overview

Stormwater runoff and the problems associated with conventional stormwater management systems pose considerable problems for local civic entities. This chapter characterizes stormwater runoff and outlines NPDES stormwater management requirements put forth by the EPA and administered by the Washington State Department of Ecology (Ecology). LID is examined as a means to manage stormwater by mimicking pre-disturbance water cycles, thereby promoting onsite infiltration instead of offsite channelization and discharge.

Western Washingtonians are accustomed to rain pounding on rooftops, stormwater-filled roadside ditches, and ribbons of water moving swiftly along gutters and disappearing into metal grates: commonplace in a region that receives between 60-140 inches of precipitation annually (Jackson & Kimerling, 2003, p. 65). Over time urban and industrial growth in Western Washington has replaced naturally permeable forests and pasturelands with hard surfaces (e.g., pavement, rooftops, and compacted soils) that severely inhibit or prohibit the ability of surface water to infiltrate into the ground. With nowhere to go the water remains on the surface, seeking the path of least resistance. As urbanization has risen, stormwater has become problematic, and depending on factors like water volume, soil conditions, physical barriers, and terrain, stormwater can submerge roadways, scour streambeds, seep into basements, and even trigger landslides (Booth D. B., 2006, p. 7).

Stormwater runoff is widely documented as a leading cause of water pollution in the Pacific Northwest (Stark, 2012, p. 44), (Dept of Ecology, 2011) and traditional stormwater management practices continue to exacerbate this problem (Howie, Emmett, & Winz, 2011, p. 1), (Girling & Kellett, 2002, p. 700). As it flows over impermeable surfaces stormwater collects sediment, vehicle fluids, pesticides, fertilizers, pet waste, and other pollutants along the way. These hazardous hitchhikers flow with the water into stormwater infrastructure networks (Figure 1) that collect surface water, which, before urbanization, infiltrated into the ground. Some stormwater is channeled into holding ponds, but these facilities are costly to construct and maintain, they occupy valuable land, and can create eyesores and safety liabilities in neighborhoods. Most captured stormwater is carried through pipes or ditches and is eventually deposited, along with the pollutants it carries, directly into rivers, streams, lakes, and other water systems (Burns, Fletcher, Walsh, Ladson, & Hatt, 2012, p. 230), which are collectively referred to in this paper as waterways. In response to these issues, stormwater policies have evolved over time.

cityofbrandon.net

Figure 1: *Stormwater transports pollutants into infrastructure networks.*

Stormwater Policies, Then and Now

Over time, anthropogenic interference in natural water cycles has compromised the health and functionality of waterways and water-dependent ecosystems, including those on which human populations rely. The adverse effects of stormwater effluent on water quality were largely unregulated until 1990 when an amendment to the Clean Water Act instituted NPDES regulations for stormwater discharge (Dept of Ecology, 2010). NPDES permits regulate water pollution caused by stormwater that is discharged into waterways through conveyances such as pipes and ditches, which NPDES defines as point sources (US EPA, 2012). Ecology, the NPDES permitting authority for

Washington State, must follow the EPA version of NPDES regulations as a minimum; however, Ecology has the authority to enact stricter permit requirements. Similarly, NPDES county and municipal permit holders within Washington State must follow Ecology's permit requirements as a minimum, but these permit holders can enact more stringent permit requirements to address localized variations such as climate, hydrology, and water quality (Dept of Ecology, 2012, pp. I-1). This paper focuses primarily on NPDES Phase I Municipal Stormwater Permits, hereafter referred to as Phase I permits.

Phase I permits typically cover municipal separate storm sewer systems (MS4s) with populations over 100,000 and Phase II permits are issued to urban municipalities with populations under 100,000 (US EPA, 2008, p. 1). Washington State Phase I permittees are Clark County, King County, Pierce County, Snohomish County, the City of Seattle, and the City of Tacoma (Dept of Ecology, 2012, pp. 1-13). Since Clark County is a Phase I permittee, the remainder of this paper pertains to Phase I permits. Washington's Phase I permit requires permittees to develop a stormwater management program containing the following prescribed elements:

1. Legal authority
2. MS4 Mapping and Documentation
3. Coordination
4. Public Involvement and Participation
5. Controlling Runoff from New Development, Redevelopment and Construction Sites
6. Structural Stormwater Controls
7. Source Control Program for Existing Development
8. Illicit Connections and Illicit Discharges Detection and Elimination
9. Operation and Maintenance Program
10. Education and Outreach Program (Dept of Ecology, 2012, pp. 11-31)

The 2012 *Stormwater Management Manual for Western Washington* (SWMMWW) is the latest version of a five-volume guidance document that offers detailed information and strategies to assist permit holders in understanding and complying with NPDES regulations. Additionally, stormwater professionals can refer to the current version of the *Low Impact Development Technical Guidance Manual for Puget Sound* (LIDTGM) (Washington St Univ; Puget Sound Partnership, 2012) for information about LID applications, and for LID research and data. Effective stormwater management is also an important aspect of emergency management (FEMA, 2011), although the topic is beyond the scope of this paper.

In response to the need for NPDES technical guidance and training, the Washington Stormwater Center (WSC), a nonprofit consortium of Ecology, Washington State University (WSU), and the University of Washington (UW), was established by legislative mandate and a grant from Ecology in December 2010 (Washington Stormwater Center, 2013). WSC acts as a hub for emerging technologies, research and development, technical assistance, training, and is an accessible source of stormwater-related information and guidance for government agencies and the public. WSC is instrumental in forming connections among public and private stormwater professionals, developers, elected officials, policy makers, and anyone else interested in stormwater issues through training, workshops and other outreach activities. Additionally, WSC offers myriad tools to help cities and counties develop and integrate LID practices into codes and engineering standards that comply with NPDES permit requirements (Washington Stormwater Center, 2013).

Funding for stormwater management programs comes from a variety sources including stormwater and development fees, government general funds, and grants (US EPA, 2008). For example, the State of Washington had $67 million of grant funding available for stormwater construction projects in 2012 (Dept of Ecology, 2013). The next section defines LID and discusses some of elements and benefits of LID as a stormwater management strategy.

Low Impact Development (LID)

The *Low Impact Development: Technical Guidance Manual for Puget Sound* (2012) defines LID as:

> "a stormwater and land use strategy that strives to mimic pre-disturbance hydrologic processes of infiltration, filtration, storage, evaporation and transpiration by emphasizing conservation and use of on-site natural features , site planning, and distributed stormwater management practices that are integrated into a project design" (2012, p. 10).

The Phase I Municipal Stormwater Permit issued by Ecology in August 2012 (effective in August 2013) has the same definition, except for referring to LID as a "stormwater and land use management [underline for clarity] strategy" (Dept of Ecology, 2013, p. 70).

LID promotes onsite stormwater management in contrast to conventional methods that export stormwater for discharge into downstream waterways. Furthermore, LID provides other benefits including flood mitigation resulting from flow reductions and groundwater recharge through infiltration (US EPA, 2012). Visible examples of LID are bioretention facilities, rain gardens, permeable pavement, and green roofs. Bioretention facilities (Figure 2) are engineered LID features that use prescribed soil blends, vegetation, and other means to reduce stormwater flow and provide water treatment (Wash. St. University & Puget Sound Partnership, 2012). Rain gardens, on the other hand, are simple mechanisms that collect rain and stormwater on small scales to assist with infiltration and, unless engineered for specific conditions are generally not classified as bioretention facilities (Dept of Ecology, 2012, pp. 7-1). Permeable pavement is asphalt or concrete that allows water to flow through instead of trapping it on the surface. While permeable pavement is not appropriate for all conditions such as roadways with heavy vehicle turning motions, or where sedimentation is a problem, with proper maintenance permeable pavement can be a suitable LID alternative for parking lots and other residential and business applications (Stiffler, 2012, p. 1). Green roofs (vegetated roofs, ecoroofs) are engineered structures that in place of shingles or metal sheeting contain layers of soil and vegetation that provide stormwater abatement and other environmental services (Figure 3). Green roofs are common in Europe and are gaining popularity in the United States (Wash. St. University & Puget Sound Partnership, 2012, p. 217); Portland, Oregon, a national leader in green roof promotion offers an incentive of five dollars per square foot for green roof installation (US EPA, 2012). Other less conspicuous but important LID components are site planning and construction sequencing. Site planning begins early in the development planning process and characterizes historic and existing environmental site conditions in order to minimize disturbances to trees, vegetation, soil, and natural water cycles (Wash. St. University & Puget Sound Partnership, 2012, p. 12).

www.portvanusa.com

Figure 2: *Bioretention facilities are engineered LID features that reduce stormwater flow and provide water treatment.*

In the case of redevelopment, LID can aid in restoring pre-disturbance (also called pre-development, pre-urban, and pre-settlement) water cycle conditions to meet NPDES permit requirements. Construction sequencing is a phasing process that protects LID features such as permeable pavement and bioretention facilities from sedimentation, compaction, and other damage during construction activities (Hinman, 2012). For example, operating vehicles and heavy equipment during construction compacts soil, and impedes its infiltration abilities. One purpose of construction sequencing is orchestrating vehicle and equipment movement within the site at various phases of construction to maintain natural soil integrity, thereby promoting maximum site and LID functionality.

www.ecy.wa.gov

Figure 3: *Green roofs provide stormwater abatement for rooftop runoff. Some green roofs provide outdoor living space.*

A current challenge in adopting LID is that knowledge and skill sets differ from traditional stormwater infrastructure. For instance, compared to conventional concrete and asphalt, permeable pavement requires unique site preparation and installation techniques, protection of paved surfaces during the entire construction process, and special inspection and maintenance protocols. Construction and inspection professionals must be properly trained in LID methods, and qualified trainers are needed to conduct the training. In contrast to the structural collect-channel-discharge paradigms of conventional stormwater management, LID seeks first to understand the natural hydrology of individual sites and then to develop site-specific stormwater management plans. As such, the case study is well suited to a pragmatic philosophical perspective.

Chapter 2

Pragmatism: A Statement of Theory

Pragmatism as a worldview "arises out of actions, situations, and consequences" (Creswell, 2009, p. 10). References to pragmatism are found in the writings of 18th century philosophers; however, influenced by the theory of evolution, modern pragmatic movements surfaced in philosophical circles in the late 1800s in response to what were deemed as narrow-minded idealist views (Thayer & Rosenthal, 2013, p. 2). Charles Sanders Peirce (1839-1914), William James (1842-1910), and John Dewey (1859-1952) are regarded as classical pragmatists and, although there are different versions of pragmatism, James (1907) wrote:

> [A pragmatist] turns away from abstraction and insufficiency, from verbal solutions, from bad a priori reasons, from fixed principles, closed systems, and pretended absolutes and origins. He turns towards concreteness and adequacy, towards facts, towards action . . . It means the open air and possibilities of nature, as against dogma, artificiality and the pretence of finality in truth" (pp. 22, Location 384).

Creswell (2009) suggests pragmatism as an appropriate premise for mixed methods research in part because "pragmatists do not see the world as an absolute unity . . . [and] mixed methods researchers look to many approaches . . . rather than subscribing to only one way" (p. 11). Four characteristics of pragmatism as a research methodology are considering the consequences of actions, problem-centered, pluralism, and real-world practice oriented (Creswell, 2009, p. 6). Furthermore, pragmatism examines problems from a variety of viewpoints to determine "what works" (ibid, p. 10), rather than relying on ingrained beliefs and practices.

The pragmatic worldview proposes that consequences cannot be estimated outside of context (Cherryholmes, 1994, p. 16). Traditional export-discharge stormwater regimes effectively separate natural site conditions (context) from stormwater management regimes, thereby generating point source water pollution (consequences). In contrast, LID advocates multifaceted context-sensitive mimicry of in situ pre-disturbance landscape to restore natural hydrology through a mosaic of micro-local pieces. Thus, the pragmatic theoretical paradigm is particularly applicable to exploring barriers to LID stormwater management strategies in that the foundations of LID are contextual (site conditions) and consequential (source management and reduced point source water pollution). Given that pragmatism, mixed methods research, and LID promote varied approaches predicated upon individual circumstances, they also exemplify interdisciplinarity in that a single discipline (e.g., technology) cannot sufficiently respond to the complexities of stormwater systems in human environments. The literature expounds on the diverse nature of stormwater management.

Literature Review

This section highlights literature drawn from journal and periodical articles, government reports, websites, published research, books, and fact sheets. The literature first informs and characterizes LID and stormwater management and then is presented through the lens of seven barriers devised by a team of Australian researchers in 2008. Lastly, knowledge gaps in the literature are identified.

Literary discussions on LID are often combined with those of sustainable housing; also referred to as sustainable affordable residential housing (Cascadia Region Green Building Council, 2008), conservation subdivision design (Allen S. C., Moorman, Peterson, Hess, & Moore, 2012), conservation development (Pejchar, Morgan, Caldwell, Palmer, & Daily, 2007), low impact subdivision (Dietz & Clausen, 2008), or generically as green development. Although definitions of the previous terms vary somewhat, the overarching themes related to LID are the same; minimize impermeable surfaces, cluster homes on smaller spaces to preserve environmental services, and provide natural connectivity among developed sites. Recognizing LID as an integral component of sustainable housing, the literature review includes some references to sustainable housing but focuses mainly on the relationship of LID to development and redevelopment, which, for the remainder of this paper are collectively referred to as development.

Urban and industrial growth has replaced natural terrains with hard surfaces that impede the infiltration of surface water into the ground and cause excess surface water, also known as stormwater (Stark, 2012, p. 44; US EPA, 2009, p. 1). Stormwater is widely documented as a leading cause of water pollution (Howie, Emmett, & Winz, 2011, p. 1; Langeveld, Liefting, & Boogaard, 2012, p. 6868; Girling & Kellett, 2002, p. 100). Burns et al. (2012) maintain that the primary function of traditional stormwater management is capturing surface water for exportation through infrastructure networks (e.g., catch basins, pipes, and ditches), and often discharging it directly into waterways as point source pollution (p. 230).

Along with disrupting natural water flow and infiltration cycles, capture-channel-discharge stormwater management practices increase sedimentation and the incidence of pollutant discharge into waterways (Johnston & Braden, 2006, p. 35). A growing body of research shows that LID strategies provide important environmental services including water pollution remediation, flood control, and recharging of aquifers (US EPA, 2012, p. 2). In the case of combined sewer overflow (CSO) operations, stormwater is combined with sewer and processed through wastewater treatment facilities. While acknowledging that effective LID practices reduce the volume of stormwater in CSO systems, specific discussions of CSO are beyond the scope of this paper.

Stormwater management is an international concern as is evidenced by literature from countries like Portugal, The Netherlands, and Australia that point out the shortcomings of traditional stormwater management practices (Barbosa, Jernandes, & David, 2012; Langeveld, Liefting, & Boogaard, 2012; Ferguson, Brown, & Deletic, 2013). Facing extreme drought conditions Australian researchers are studying the effects of traditional stormwater management regimes and Water Sensitive Urban Design (the Australian equivalent of LID) in efforts to preserve water quality and harvest stormwater for reuse (Roy, et al., 2008, p. 347).

Professor Rebekah R. Brown is a prolific Australian researcher and respected authority on sustainable water issues and stormwater management. With a bachelor's degree in civil engineering and a Ph.D. in Environmental Studies, Brown is Director of the Centre for Water Sensitive Cities at Monash University in Australia (Monash University, 2012). Her profile describes a leader in "interdisciplinary research focused at the interface between society and technology" (ibid). As of September 2012, Brown had authored or collaborated on one book, five book chapters, thirty-three journal articles, and participated in twenty-eight conference proceedings (ibid), with varied subject matter that exemplify her interdisciplinary philosophy and abilities. Among Brown's research topics are Water Sensitive Urban Design, public policy, and the socio-technical and institutional aspects of sustainable urban water management. Brown self-cites often, probably because much of the existing research concentrates on stormwater technology or addresses sustainable development in general, of which stormwater is only one component. Separating stormwater management from the larger topic of sustainable development is important partly because of the complexities inherent in stormwater management (e.g., variability among different watersheds and individual development sites). Furthermore, other than works by Brown, little published research is available on the social science of stormwater management.

One of Brown's collaborative efforts, *Impediments and Solutions to Sustainable, Watershed-Scale Urban Stormwater Management: Lessons from Australia and the United States* (Roy, et al., 2008) synthesizes topics addressed in the literature and relates directly to this case study on assessing barriers to LID strategies for stormwater management. The seven impediments presented by Roy et al. (2008) are important because they introduce social elements into a literary conversation that has historically concentrated on engineering and technology. Economics, land use equity, and societal acceptance of new practices (e.g. the advent of stormwater management fees), go beyond engineered solutions and so must be considered when examining new stormwater regimes. Therefore, the impediments, referred to hereafter as barriers, provide a logical structure in which to frame the literature. The remainder of this literature review provides a brief synopsis of each barrier as characterized by Roy et al. (2008) and then looks at how the barrier is addressed in the literature.

1. **Uncertainties in performance and cost** (Roy, et al., 2008, p. 347)

Site condition variables and a scarcity of localized data for performance outcomes and for costs of implementing LID cause professionals involved in devising development standards to hesitate in adopting LID practices in their own communities (pp. 347-348).

Site variability, a performance factor, is exemplified in a Pennsylvania study conducted by Christopher J. Woltemade (2010), who found that mean infiltration rates on residential lawns were 69 percent higher in sites established prior to 2000 than in those developed after 2000 (p. 709). Woltemade (2010) speculates that the variations in site conditions stem from compaction by heavy equipment and disturbances of native soils and vegetation in the course of site development (p. 709). The study concludes that soil compaction in residential areas holds “profound environmental implications” (ibid, p. 710) in relation to stormwater runoff. Woltemade (2010) calls for comprehensive soil databases that span regions to provide a robust foundation from which to construct soil-modeling tools to reduce the need for field studies in conjunction with design work (p. 710).

The EPA generated six fact sheets that “directly address specific concerns . . . about adopting low impact development” practices; the concerns are cost, benefits, effectiveness, aesthetics, terminology, and maintenance (US EPA, 2013). The “effectiveness” fact sheet provides data from case studies in Seattle, Washington, Cross Plains, Wisconsin, and Philadelphia, Pennsylvania (US EPA, 2012). Although the case studies offer a semblance of localized data, they do not address site variations within states or cities. Nevertheless, the studies demonstrate ongoing efforts to produce data under a variety of conditions that could be extrapolated to other sites with similar conditions. With regard to cost uncertainties, ECONorthwest (2007) reports a paucity of single studies that compare the costs and benefits of LID with those of traditional methods (p. 2). Conversely, the *LID Technical Guidance Manual for Puget Sound*

(2012) states, “native vegetation and soils are . . . the most cost effective and efficient tools for managing stormwater quality and quantity” (p. 73).

Downstream “economic consequences” of site specific LID stormwater management are explored by Braden and Johnston (2004, p. 498), who suggest that valuing stormwater management strategies in economic terms is challenging because outcomes are based on chance variations rather than transactions of goods and services in the marketplace (p. 499). Uncertainties in performance and cost are further exemplified by a dearth of definitive data for LID infrastructure costs and long-term functionality, and by attempts to integrate environmental elements and economic methods to quantify factors such as aquifer recharge (ibid, pp. 503-504).

2. **Insufficient Engineering Standards and Guidelines** (Roy, et al., 2008, p. 348).

Engineering standards and guidelines generally encourage traditional practices, despite indications that LID has superior pollutant removal capabilities and other benefits (Roy, et al., 2008, p. 348). Conflict between standard specifications and LID techniques can be prohibitive to using LID, and professional guidance resources have yet to incorporate some LID practices as design standards because of lack of supporting data (ibid). Brown, Sharp, and Ashley (2006) use the term “technocratic expertise” to characterize circumstances where standards and guidelines developed solely within technical frameworks fail to consider political and social factors (p. 420). Technology-based criteria developed by technologists for technologists comply with technology-based codes and standards, yet yield unsuccessful results when crucial socio-political elements (Brown, Sharp, & Ashley, 2006, p. 420) are omitted; in other words, a lack of interdisciplinary collaboration.

Girling and Kellett (2002) illustrate some of the mixed messages associated with LID standards in their discussion on impermeable versus permeable surfaces using three neighborhood development models. In the study, lawns are generically referred to as "permeable cover" (Girling & Kellett, 2002, p. 106). Conversely, as mentioned in the first barrier, Woltemade (2010) found that land disturbances and the amount of time since a disturbance causes significant infiltration rate variations in residential lawns, and suggests that site-specific data are needed for accurate infiltration rate projections (p. 709). Therefore, lawn infiltration rates cannot be generically categorized for use in engineering standards and guidelines.

3. **Fragmented Responsibilities** (Roy, et al., 2008, pp. 348-349).

Water management, regulatory, and enforcement responsibilities are spread among many people in various levels of state and local government agencies, including those dealing with human health, environmental issues, and land use concerns (Roy, et al., 2008, pp. 348-349). Priorities, funding mechanisms, and coordination are inconsistent among these groups, and delineation based on "political and geographic boundaries, rather than watershed boundaries" exacerbates responsibility fragmentation (ibid, p. 349). According to Juergensmeyer and Roberts (2007), land management policies encompass a multitude of diverse, interrelated, and conflicting interests, including stakeholders with varied agendas (p. 318). Booth et al. (2007) concur, pointing to land use practices as the crux of stormwater issues and go further by eschewing a focus on individual sites in favor of managing stormwater at the "basin or landscape level" (pp. 1-2). Barbosa, Fernandes, and David (2012) acknowledge layers of decision makers and state that "a clear understanding" of variables and outcomes is required on all levels for sound decision-making and to avoid wasted resources when devising stormwater strategies (p. 6788).

4. **Lack of Institutional Capacity** (Roy, et al., 2008, p. 349)

Institutional capacity is defined as "funding, personnel, guidelines, and other resources" (Roy, et al., 2008, p. 349). Design and planning professionals must be educated about LID and watershed hydrology, and capacity for enforcement is another important component of successful LID strategies (ibid). Characteristics and ramifications of inadequate institutional capacity as outlined by Roy et al. (2008) are exemplified by sanctions incurred by the Colorado Department of Transportation (CDOT) stemming from improper stormwater management practices.

The Colorado Department of Public Health and Environment found multiple CDOT projects in violation of stormwater regulations, which triggered extensive remediation measures and initiated a "culture shift" in the manner in which CDOT prioritizes and manages stormwater (Willard & Toppi, 2012, p. 49). Along with trading half a million dollars in financial penalties for Supplemental Environmental Projects, mandatory remedies undertaken by CDOT included the revision of "policies, procedures, and construction specifications," development and implementation of extensive employee training programs, and the addition of six stormwater staff, for which special funding was required (ibid). Furthermore, accountability measures were enacted; the chief engineer was tasked with certifying official compliance documents and water quality components were added to employee performance evaluations (ibid, p. 47-48). In another example, a case study in Ames, Iowa revealed that city staff was somewhat familiar with LID concepts; however, their lack of in depth knowledge about LID discouraged adoption of

LID practices in subdivision developments (Bowman, Thompson, & Tyndall, 2012, p. 53).

5. Lack of Legislative Mandate (Roy, et al., 2008, p. 349)

In the absence of comprehensive national stormwater directives, local stormwater management policies and practices lack cross-boundary collaboration and cohesion (Roy, et al., 2008, p. 349). Consequently, efforts to advance uniform LID practices are constrained, policies are inconsistent, and human and environmental well-being is compromised (ibid). The Clean Water Act NPDES mandates are the basis of point source stormwater permitting in the U.S. The terms of the NPDES Phase I permit include six required elements (Chapter 1); the third element calls for "coordination mechanisms among entities . . . to encourage coordinated stormwater-related policies, programs, and projects within a watershed" (Dept of Ecology, 2013, p. 14); a mandate which promotes coordination and collaboration within jurisdictions and across political boundaries within watersheds. The centralized (command and control) stormwater policy regimes that were prevalent in the 70s have given way to what Zaccai (2012) refers to as collaborative and market-based instruments that include stakeholders in the policy process (pp. 84, 88). Robins (2007) concludes that understanding stakeholder views is an important precursor to "capacity building policies," especially in light of regional differences (p. 698).

6. **Lack of Sufficient Funding and Effective Market Incentives** (Roy, et al., 2008, pp. 349-350)

Transitioning from traditional stormwater systems to LID incurs costs beyond installation, including removal and/or retrofitting of existing systems, price tags associated with operation and maintenance, missed opportunities for other uses, and training programs for designers, contractors, and homeowners (Roy, et al., 2008, p. 349). Incentive strategies such as fee reductions and rebates must offer high enough financial benefits to attract businesses and homeowners (ibid, pp. 349-350). Cap-and-trade options encounter challenges in defining parameters and enforcement, and garnering a broad base of support (ibid, p. 350).

The EPA states that the presence of LID elements results in higher property values (Benefits of Low Impact Development, 2012). Bowman et al. (2012) employ several methods including surveys and "experimental real estate negotiations" to ascertain whether homebuyers value LID elements and conservation subdivisions (pp. 102-103). Although they do not precisely echo EPA's statement on the positive effect of LID features on property values, Bowman et al. (2012) suggest that homebuyer knowledge of LID systems builds value for properties with LID features (p. 111). In another study, Bowman and Thompson (2009) find that consumers indicate interest in LID; however, developers do not recognize this interest, nor do developers research what homebuyers want and are willing to pay for (p. 105). The study concludes that cities can provide incentives to developers by way of streamlined permit processes and providing market research information on consumer preferences to developers (ibid).

Researchers in North Carolina utilize surveys and case studies to investigate barriers to conservation subdivision development and identify a "lack of incentives for developers" as the dominant barrier (Allen S. C., Moorman, Peterson, Hess, & Moore, 2012, p. 246), while economic incentives were deemed by developers as the most successful strategies (ibid, p. 250).

7. **Resistance to Change** (Roy, et al., 2008, p. 350)

As discussed in Barrier 3, stormwater management encompasses diverse interests among myriad stakeholders. Along with diversity come disagreements on definitions of success and failure, knowledge gaps, and exposure to varying degrees of risk (Roy, et al., 2008, p. 350). These elements present formidable barriers that manifest as resistance to LID implementation (ibid). Resistance to change "arises when goals of subsystems are different from and inconsistent with each other" (Meadows, 2008, p. 113). The goals of LID are markedly different from traditional stormwater management. Instead of surface water exportation through infrastructure networks, LID strives to protect waterways and landscapes by mimicking pre-disturbance hydrologic cycles that promote onsite infiltration and evapotranspiration (Wash. St. University & Puget Sound Partnership, 2012, p. 10). Nevertheless, dependability, straightforward design and modeling abilities, ease of maintenance, and predictable dollar costs continue to support conventional stormwater regimes (ibid, p. 9).

The desire to avoid risk is a main motivator for maintaining the status quo (Barbosa, Jernandes, & David, 2012, p. 6792). Developers and local governments resist change to avoid the risks inherent in adopting new policies and practices. For example, the City of Battleground, Washington cites inadequate resources, perceived inequities, disagreement with proposed changes, and unclear parameters as reasons for resistance to revisions in the Phase II NPDES permit (City of Battleground, n.d.).

Belief systems surrounding property rights can create resistance to change, ironically, through an unwillingness to resist change. Peterson and Liu (2008) suggest that convictions supporting natural property rights (the right of all property owners to do what they want on their property) override direct observations and experiences of environmental degradation or destructive development practices in communities (p. 131). Hence, even in the midst of distress over landscape destruction and uncurbed development, citizens who support natural property rights are unwilling to participate in land planning forums or support sustainable agendas (ibid). Jin Xue (2012) condenses the essence of the seven barriers succinctly into a single sentence "For technological fixes to be successful, the cultural, economic, and political conditions cannot be ignored" (p. 32).

Knowledge gaps

Although the research provides examples of diverse stormwater groups and collaborative endeavors among jurisdictions, the literature review revealed no discussions on the benefits of collaboration among stormwater managers. Court challenges related to LID were not found in research papers, possibly because the topic is more suited to legal discourse than to scientific research. Other than works by Brown, interdisciplinarity associated with stormwater management is not covered in the literature, although the complexity of stormwater issues and the diversity of stakeholders clearly demonstrate a need for more research. Finally, although there is disagreement about LID with regard to NPDES permits, the literature revealed no peer reviewed research that disputes the effectiveness or sensibility of LID. In Chapter 4, the seven barriers are revisited as a foundation for analysis of Clark County stormwater policies and practices.

Methods

Case studies provide researchers with the ability to move beyond statistical data and explore the contextual aspects of a research topic. A certain amount of flexibility is inherent in a case study design, which is particularly advantageous in circumstances where the path is revealed as research progresses. Furthermore, case studies allow researchers to delve below the surface of issues, discover deeper meaning, and fill knowledge gaps that cannot be revealed by quantitative methods. In contrast, case studies run the risk of introducing subjectivity and bias into the research.

The research methodology for this case study employs a mixed methods approach to assess barriers to LID strategies for stormwater management in Clark County, Washington. A case study was selected as a means to investigate and gain a holistic portrayal of the current situation of LID strategies beyond the technical aspects of stormwater management. To reduce the potential for subjectivity and bias mentioned in the previous paragraph, data were compiled from a variety of sources that are described later in this section, and the study is then framed in the context of seven barriers established by Roy et al. (2008). The methodology is limited in that public opinion, political influences, and other social nuances surrounding each barrier are touched upon but not thoroughly explored. Nevertheless, the results are applicable to other jurisdictions because while landscapes, hydrologic conditions, and social variables might differ, dealing with stormwater-caused pollution and complying with government regulations are universal issues as is confirmed by the variety of geographical origins of the literature.

Clark County was selected for the case study because the county is the sole Phase I permit holder in southwest Washington (Dept of Ecology, 2013) and the only Phase I permit holder in Western Washington that discharges stormwater into the Columbia River instead of Puget Sound. Additionally, the county's 2011 NPDES Annual Report states that the county has very "few shared waterbodies" (p. 4) and, assuming that shared waterbodies increase the complexity of stormwater management, the results from this study are conservative in that regard. Furthermore, the geographic separation of Clark County from other Western Washington Phase I permit holders (King, Pierce, and Snohomish counties, the City of Seattle, and the City of Tacoma) provides what is presumed to be a relatively stand-alone circumstance compared to the potential interactions among other permit holders due to close proximity. Although Clark County's propinquity to Portland, Oregon is recognized, Oregon's stormwater policies are beyond the scope of this paper.

Another reason for Clark County's suitability for this study is its setting in the midst of a robust transportation hub with north/south and east/west interstate highway corridors, an international airport, maritime port activities, and a conflux of commercial railroad lines. Furthermore, Clark County's population distribution is equalized between incorporated (within city limits) and unincorporated (outside city limits) areas; in 2010 about half (53.1 percent) of Clark County's 425,363 residents lived in incorporated areas (US Census Bureau, 2013). It is expected that development (and so stormwater management) activities reflect this balance to some extent, thereby minimizing potential bias caused by predominantly urban or rural population distributions. The final reason for selecting Clark County for this study is the county's involvement in two ongoing legal challenges related to NPDES permits and LID, which elucidate barriers and offer insights into conflict generated by stormwater regulations.

Sources of qualitative data include peer-reviewed research papers, government reports and documents, government and private websites, journal articles, articles in periodicals, published fact sheets, newspaper articles, and court proceedings. Data also consist of meeting agendas, minutes, and videos, and public responses and comments related to LID and stormwater issues. Stormwater documents and county and municipal codes serve as sources for policy and standard procedures. Online documentation from the Ecology website is used to identify NPDES permit holders and as the source of a majority of the permit-related information. Court and hearing board documents characterize the nature of legal conflicts and provide information on the processes and outcomes of the proceedings. Quantitative data contribute to the study in two main areas: 1) Establishing context through census-derived statistics; and 2) Utilizing scientific studies, reports, and professional manuals to provide technical data associated with LID.

The prominent portion of the methodology is adapted from a study conducted by Australian researchers Roy et al. (2008) that was described in the literature review (Chapter 2). The seven criteria provide a logical foundation from which to assess barriers to LID strategies for stormwater management in Clark County. The same criteria are used in Chapter 4 as a foundation for analysis, which relies on widely accepted evidence that recognizes stormwater runoff as a main polluter of waterways (Howie, Emmett, & Winz, 2011, p. 1; Stark, 2012; Dept of Ecology, 2011).

The first phase of the research process involved gathering literature and government documentation related to stormwater management policies and practices, legal documents surrounding LID litigation in Clark County, and other resources. Nearly all of the written research materials were obtained as electronic files and transferred to the hard drive of a password-protected lap top computer that was used for the case study. Hardcopies of the most applicable documents were printed and the electronic versions were archived in a comprehensive organized research file that was backed up nightly onto a flash drive and weekly onto an external hard drive. Printed documents were numbered as they were collected with the goal of keeping the research inventory to a manageable level given the time allowed for the study (47 documents were printed over the course of the study). The numbering system had the unintended consequence of elevating the quality of the material because a sense of finitude encouraged judicious choices, although electronic documents (not to be printed) were collected and archived at will, as they are easily stored and retrieved. Generally, large documents (over 100 pages) and reference-only documents (e.g., technical and guidance manuals) were not printed. Websites of interest and other online resources were electronically bookmarked for future reference. An Amazon Kindle electronic reader held some reference books and, since Kindle page numbers do not necessarily correspond with hardcopy books, Kindle location numbers are included in cites from these sources.

The second phase of the research involved an inductive process of reviewing the material to further investigate relevant topics and determine common themes. Highlighter pens, underlining, and handwritten notes in margins effectively accomplished this portion of the research and the materials were then sorted by general themes:

economic, technical, natural science, social science, policy, sustainable and LID, litigation, and Clark County documents. Adhesive notepaper was attached to the front of each document summarizing main themes. The discovery of the research by Roy et al. (2008) that is mentioned earlier in this section and in the literature review (Chapter 2) precipitated a third review of the printed material with the goal of associating each with Roy et al.'s (2008) seven criteria. The material was then labeled with the number of the corresponding criterion; a majority of the material was associated with multiple criteria.

Since time constraints were prohibitive to the use of focus groups and personal interviews, professional discussions were used as an alternative. A Human Subjects Review was not required because conversations were strictly professional in nature; no personal opinions or observations were elicited during the discussions or included in this research. Three potential candidates were selected based on their involvement in large-scale stormwater management; these individuals were contacted via email and invited to participate in a professional discussion about stormwater management. Two candidates did not respond. One person, a division manager, forwarded the email to the organization's environmental manager who agreed to meet and requested specific information about the topics of discussion. This person was provided with a list of the seven barriers as potential topics and told that the actual subjects discussed were entirely up to the individual and did not need to come from the list. An informal meeting was also scheduled with a stormwater manager from a different organization. Both meetings took place in Clark County at each person's place of business, and one meeting resulted in visits to two sites in Vancouver, Washington: the Water Resources Education Center, and the Fred Meyer Grand Central parking lot where permeable pavement is installed.

With permission from the stormwater professionals, handwritten notes were taken at the meetings and later transferred to an electronic file. While the professional discussions provided little direct information for use in this study, they pointed to valuable sources of information.

This research is significant because assessing barriers to LID strategies for stormwater management in Clark County offers insights into the efficacy of federal NPDES policies on a local level, thereby informing future policy, enhancing local engagement efforts, and improving the predictability of LID stormwater management strategies and outcomes in Clark County and beyond. Chapter 3 introduces the oldest county in Washington State and characterizes the trials and achievements surrounding LID in Clark County.

Chapter 3

This chapter provides an overview of Clark County including its historical context, geography, government structure and economic base. Stormwater management in Clark County is examined including some successes and challenges, innovative practices, and conflict encountered in conjunction with LID strategies for stormwater management.

Getting to Know Clark County

Located in the southwest corner of Washington State (Figure 4), Clark County was established in 1844 as the expansive Vancouver District, reaching north to Alaska and east to the Rocky Mountains (Proud Past, 2013). Rechristened "Clarke" County in 1849, boundary adjustments formed the county's existing borders and the spelling was corrected to "Clark" County in 1925 (ibid). Washington's oldest county, Clark County is the namesake of William Clark from the Lewis and Clark expedition team that explored the Pacific Northwest in the early 1800s.

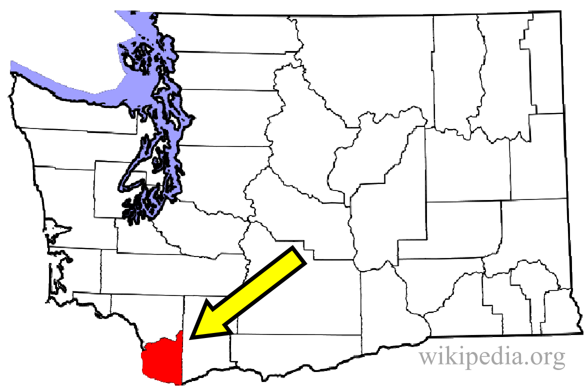
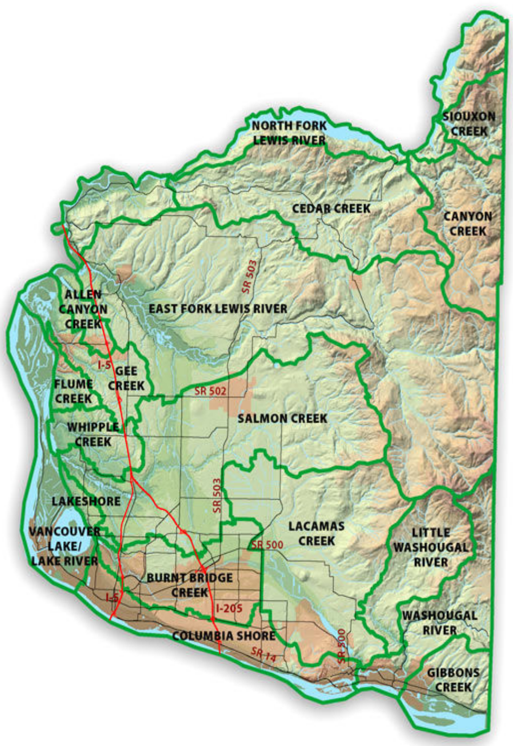


Figure 4: *Clark County in southwest Washington State*

Native tribes that populated the area including the Klickitat, Cowlitz, Clackamas, and Chinook revered the Columbia River, the salmon, and other Pacific Northwest resources that furnished their communities with food and served as the foundation of rich cultures with deep connections to the environment. Once the Lewis and Clark Expedition spread the word about the natural abundance and beauty of the region, fur traders and then settlers headed west to Clark County. Fort Vancouver was established by the British Hudson's Bay Company as a fur trading post in 1825 with a diverse population including a robust Hawaiian contingent (National Park Service, 2013; Proud Past, 2008). Eventually the fort housed the first hospital, school, library, mills, and shipyard in the Pacific Northwest (ibid); not surprising since Fort Vancouver became the Hudson's Bay Company's regional headquarters.

Located in a region of distinct natural beauty and a rich geological history, Clark County boasts 40 miles of scenic Columbia River shoreline and close proximity to an assortment of natural landscapes including mountains, forests, prairies, deserts, lakes, and streams. The county's eighteen main watersheds (Figure 5) and numerous sub-watersheds support a variety of flora and fauna and provide a multitude of recreational opportunities. In contrast, Portland, Oregon a major urban population center is just across the river and Clark County is considered as part of the greater Portland metropolitan area. Although water plays a major role in the commerce and quality of life in Clark County, curiously, the county website "Promising Future" (2012) cites the main challenges in the region as



www.co.clark.wa.us

Figure 5: *Clark County watersheds and sub-watersheds.*

traffic congestion, air quality and other priorities, but does not mention water quality as a concern.

With a population of 425,363 in 2010, Clark County contains just over six percent of the state population and covers an area of about 629 square miles (US Census Bureau, 2013). The county's population is almost evenly distributed among incorporated and unincorporated areas, with urban dwellers comprising about 53 percent of the population (ibid). Although it is the smallest of Washington State counties located along the Interstate-5 corridor, Clark County enjoys a prominent location amidst main transportation corridors for trucking, maritime, rail, and air. Interstate-5 runs north/south through the county and Interstate-205 provides a detour for vehicles to bypass the busy metropolitan Portland area. The Burlington Northern Sante Fe and Union Pacific railroads converge in Clark County for overland freight connections to the north, south, and east; and the Columbia River forms Clark County's western and southern borders, providing both economic and recreational benefits. According to Jackson and Kimerling (2003), the Columbia River Gorge is "Probably the natural corridor of greatest strategic significance . . . the only water-level route through the Cascade Mountains" (p. 31). The vibrant maritime thoroughfare bustles with tugboats, barges, various types of cargo ships, cruise ships, paddle wheel boats, and tankers that transport agricultural and petroleum products, logs, automobiles, bulk cargo, and windmill towers (Columbia River Pilots, 2009).

Number three in size and age compared with other ports in Washington State (WE CAN! Task Force, 2011, p. 3), the Port of Vancouver moved 5.6 metric tons of domestic and international goods in 2011 and a recently completed Columbia River Channel

Deepening Project that enables the port to accommodate larger ships. A railway access project that is slated for completion in 2017 is estimated to increase rail service to and from the port by 300 percent (ibid, p. 3-4). Assuming the extra capacity is utilized, this translates to more jobs for Clark County. Finally, Portland International Airport is only a 15-minute drive across the Columbia River from Vancouver, the county's main population center with approximately 165,500 residents in 2012 (US Census Bureau, 2013).

Government Structure and Economic Overview

Clark County's citizens elect three officials who serve on the Board of Clark County Commissioners (BOCC) as policy and decision makers for ordinances, planning and zoning policies, committee and board appointments, and approving county budgets. According to the county organization chart (March 7, 2013), the commissioners oversee the following departments: Community Planning, Community Development, Community Services, Public Health, Public Works, Public Information and Outreach, Environmental Services, and the Board of Equalization. The County Administrator manages the aforementioned departments and reports to the BOCC; the Clean Water Program, part of the Department of Environmental Services, is responsible for NPDES compliance.

The Columbia River Economic Development Council (CREDC), a regional entity and sponsor of the 2011 edition of the *Clark County Economic Development Plan* (EDP), describes itself as a "private-public partnership of 140 investors working together to advance the economic vitality of Clark County through business growth and innovation" that works to transform EDP goals into reality (CREDC Economic Development, 2013).

Economic growth is a mantra for many counties and cities, particularly given the economic challenges faced by communities in recent years; the EDP echoes these concerns. While, the main employers in Clark County are currently in the government, healthcare, and retail sectors (TIP Strategies Inc, 2011, p. 44), the EDP promotes an "aggressive" strategy to attract business to the area and identifies information technology (IT) and international investments as viable economic growth vehicles. (p. 2). Furthermore, the EDP suggests that a negative correlation exists between a skilled workforce and unemployment rates and looks to the county's two colleges, WSU Vancouver and Clark Community College to assist in developing a workforce that can fill the anticipated need for skilled IT workers (TIP Strategies Inc, 2011, p. 1). Tied to these goals is the creation of development-related amenities to attract businesses to the county and a quest to recruit highly educated professionals as new Clark County residents (ibid, p. 1-2).

Stormwater Management and LID in Clark County

Clark County has come a long way since the first NPDES permit was issued there in 1999. Ongoing efforts in conjunction with NPDES permit regulations have ushered in stormwater fees, sparked LID innovation, and spawned projects designed to improve stormwater management through a variety of diverse and collaborative endeavors. At the same time, NPDES regulations are the focus of litigation as Clark County argues for clarification on LID, land use equity, and environmental protection, while seeking relief from NPDES regulations that are deemed unreasonable, costly, and excessively restrictive. In an effort to improve efficiency and promote cooperative environmental efforts within the county, Clark County's Department of Environmental Services was created in 2010 by combining seven departments, including the Clean Water Program (CWP), the department responsible for stormwater management and NPDES compliance (Clark County Environmental Services, 2012).

Since 2000, Annual Clean Water Fees levied on residences, businesses, industry, government offices, schools, and churches in unincorporated Clark County has generated $4.9 million in annual revenue for stormwater programs (Clark County, 2012, p. 4). Yet the rates in unincorporated areas of Clark County are a fraction of rates paid in unincorporated King, Pierce, and Snohomish counties (Clark County Environmental Services, 2012). One urban "equivalent residential unit" (e.g., a single-family home on less than one half acre) pays $33 per year, with declining rates as residential lots increase in size (ibid); nonresidential rates are calculated using square feet of "hard surfaces" (Clark Co. Environmental Services, n.d.). A protocol was devised to evaluate and prioritize county stormwater projects.

The Stormwater Needs Assessment Program (SNAP) corresponds with the NPDES five-year permit period and through prescribed research methods and data analyses strives to "most effectively implement the NPDES permit requirements . . ., [take] an integrated, basin-oriented approach to stormwater management . . . [and safeguard water quality]" (Clark County, 2007, pp. 2-3). The results of SNAP provide recommendations for the Stormwater Capital Improvements Program and, while SNAP recognizes that deliverables provide value to a number of county departments including wetland mitigation, growth planning, and habitat and species protection, it anticipates that outside agencies also benefit from these efforts (ibid, pp. 2, 6).

Clark County and its largest city Vancouver have actively pursued a sustainable housing initiative, which includes LID components. In 2008, they partnered with the Cascadia Region Green Building Council (Cascadia) to audit county and city regulations and codes in order to expose "barriers to sustainable, affordable, residential development (SARD)" (Cascadia Region Green Building Council, 2008, p. 3). The project, which was funded by the Washington State Department of Community, Trade, and Economic Development, endeavored to identify and address barriers in order to promote "green" projects in Vancouver and unincorporated Clark County. The results of the audit characterized city and county codes as "outdated" and found that LID design components that were intended to reduce impervious surfaces, such as narrower driveway widths and a reduction in the area required to be set aside for parking, conflicted with existing county and city codes (Cascadia Region Green Building Council, 2008, pp. 12-13)

The SARD study identified barriers that were created by existing county and municipal codes and made recommendations for improvements. Using elements pointed out by SARD, the Clark County Sustainable Communities (CCSC) project, funded by a grant from Ecology (Clark County Sustainable Communities: Meeting #1, 2009, p. 2), held a series of six meetings from October 2009 to March 2010 to "engage key stakeholders to craft a regional strategy for fostering sustainable development across [Clark] County" (p. Agenda). An unusual aspect of the meetings was that representatives from a public involvement consulting firm were on hand to help facilitate productive communication among the diverse participants. The goal was for 50 percent of the jurisdictions in Clark County to adopt code changes and/or promote incentives to support sustainable communities (Clark County Sustainable Communities: Meeting #3, 2009, p.

4). One outcome was a codified pilot program (code 40.200.090) for six sustainable development projects called the Sustainable Communities Pilot Program (SCPP), which includes LID elements. According to email correspondence (in conjunction with research for this case study) with the Clark County Department of Environmental Services and a consultant involved in the SCPP, while there have been several inquiries into the program, no applicants have been accepted thus far; however, there is one promising candidate in process. The main reason given for the lack of response to the program thus far is a slowdown in development due to the economy.

In another ambitious and collaborative undertaking, the Planet Clark venture defines itself as “a public-private outreach and education group” that provides a broad scope of services and products to promote sustainable living (Planet Clark.com, 2013). One of the group’s projects, the Planet Clark Emerald House, is a single-family sustainable home built on the site of an abandoned property that was a safety concern and a neighborhood eyesore. The home, constructed according National Green Building Standards, is designed to manage all stormwater onsite with the goal of “zero runoff;” LID elements include rain gardens and amended soils to promote infiltration of stormwater that is not collected by the rain barrels attached to roof drainpipes (Planet Clark.com, 2013). The Planet Clark team is comprised of private sector green building specialists, the Evergreen Habitat for Humanity organization, WSU, and representatives from Clark County’s Environmental Services and Building Services departments. The group hopes that the innovative energy and water-efficient 1,154 square foot home will be awarded the first “Emerald” certification in the county (ibid). The Planet Clark project is a tangible example of sustainable residential building, which demonstrates how a run-down property can be redeveloped into an asset for the community and for the environment, while providing healthy living conditions for its occupants. Furthermore, it is the epitome of LID design and technology in pursuit of "zero runoff," beyond NPDES requirements of matching pre-disturbance flows.

Stormwater management agendas in Clark County have inspired innovations of sizable and humble magnitudes, encouraged entrepreneurism, and infused pride into organizations as are exemplified by the previous examples and by activities at the Port of Vancouver (PV). The port, an NPDES Phase II Municipal and an Industrial Stormwater General Permit holder in Clark County, is a frontrunner in LID stormwater management technology. The largest known bioretention facility of its kind was completed by PV in 2009 to treat industrial stormwater runoff for metals and turbidity prior to discharge into the Columbia River. The unique LID facility has returned promising results based on two years of water quality testing data that demonstrate "vastly improved removal of total and dissolved copper, zinc, and turbidity" (Port of Vancouver USA, 2013).

Going from very large to very small stormwater treatment systems, the modest yet highly effective Grattix device (Figure 6), invented by two PV employees, utilizes LID technology to remove 90-95 percent of zinc from stormwater runoff captured from galvanized metal roofs and drainpipes (Port of Vancouver USA (2), 2013). PV's bioretention facility and the Grattix have attracted attention from stormwater professionals from around the nation (personal conversation on March 25, 2013). Ecology is examining the bioretention facility for possible application on other industrial sites and a "Build Your Own Grattix" video, featuring the unit's inventors, is highlighted on the WSC website (www.wastormwatercenter.org). Lastly, port tenants are invited to join the Clean Water Challenge, a program initiated by PV to promote sustainable water practices, recognize participants' efforts, and provide guidance for implementing sustainable measures (Port of Vancouver USA (2), 2013). PV stormwater management regimes demonstrate that LID strategies can provide valuable environmental services in an industrial environment, and PV's successful LID initiatives exemplify an organizational culture that encourages and supports sustainability and innovation among its employees and business partners.

www.portvanusa.com

Figure 6: *The innovative Grattix invented by PV employees removes 90-95% of zinc from roof runoff and is simple and inexpensive to build and maintain.*

Other agendas that bring LID concepts and tools to businesses and residents include the Green Business Program and the Stormwater Partners of Southwest Washington. The Green Business Program, a Clark County initiative, combines outreach, education, and a call to action by offering county businesses the opportunity to qualify for annual certification as a Green Business. Instigated in 2011, the popular program is growing quickly with twenty-eight certified Green Business members (Clark County Environmental Services, 2012, p. 9) that represent a diverse cross-section of the business community including Frito Lay, a semiconductor foundry, financial institutions, hotels, local eateries, and an automotive repair facility. The colorful and easy-to-navigate Stormwater Partners of Southwest Washington website offers comprehensive information and tools to help private citizens, homeowners' associations, and businesses understand stormwater issues and properly manage private LID features (www.stormwaterpartners.com). The product of a grant from Ecology in 2009, the website is a collaborative endeavor by Clark County, Battle Ground, Camas, La Center, Ridgefield, Vancouver, and Washougal. Along with stormwater information and videos, the site includes contact information for all partnership entities and links to additional stormwater resources.

Litigation

According to the Phase I permit, flow control must be returned to pre-disturbance levels. When Ecology found Clark County in violation of the pre-disturbance flow control portion of the permit, the two parties negotiated an alternative (Agreed Order 7273, January 6, 2010) that allows developers in Clark County to maintain (not cause an increase in) existing conditions on development sites. Under the agreement, Clark County determines the difference between existing and pre-disturbance stormwater flow conditions and transfers the remaining mitigation to its Stormwater Capital Improvement Program, using offsite remediation locations as needed (ibid). Despite Ecology's endorsement of the alternative management regime, three organizations argue that the Agreed Order does not meet NPDES permit conditions.

The Rosemere Neighborhood Association, Columbia Riverkeeper, and the Northwest Environmental Defense Center (Rosemere) contend that Agreed Order 7273 does not meet the environmental standards of the Phase I permit. Rosemere complained to the Pollution Control Hearings Board (PCHB), who reviewed and subsequently overturned the Agreed Order. Clark County, Ecology, and the Building Industry Association of Clark County (Clark County et al.) subsequently appealed the decision to the State of Washington Court of Appeals, which in September of 2012 upheld the PCHB ruling by declining to review the case. Clark County et al. then appealed the decision to the Washington State Supreme Court, which on March 5, 2013, also declined to review the case. In the meantime, a judicial stay was lifted that clears the way for Rosemere to pursue the case on a federal level. Anecdotal information suggests that a federal court will review the case and render an opinion; however, evidence of this turn of events was not forthcoming in the course of research for this paper.

In another case, Clark County, along with other Phase I permitted Western Washington counties filed an appeal with the PCHB regarding the Phase I permit that takes effect in August 2013. Clark County asserts (in part) that the permit is "legally flawed" due to excessive costs, lack of empirical evidence supporting LID, the lack of jurisdictional control over watershed-scale planning, and that compliance with the permit in its current form risks litigation (Clark County's Notice of Appeal of Phase I Municipal Stormwater Permit, 2012). The cases are ongoing and it is unknown when decisions will be rendered and whether decisions will precipitate further legal action.

Chapter 4

The analysis phase of the study characterizes the data, identifies barriers and successes, and then evaluates the data using the seven criteria adapted from Roy et al. (2008). The resulting seven barriers are then ranked according to influence on LID into three categories: Keystone (most influential), Prominent (influential), and Moderate (least influential). The findings also highlight common traits of successful LID initiatives.

Analysis

Analyses commenced during the initial process of compiling and scanning literature, policy documents, and other resources. The materials were broadly categorized by theme, and then subcategorized by connection to the research topic and contribution to interdisciplinary perspectives (to reduce potential for bias). Further segmentation was conducted based on relevance to LID. Relevance was generally determined by the clear presence of LID or stormwater management elements, and through logical inference of connections with LID. For example, the LIDTGM (Washington St Univ; Puget Sound Partnership, 2012) obviously contains LID elements as is stated in the title. The *Clark County Economic Development Plan* (TIP Strategies Inc, 2011), while not an LID or stormwater management document, indirectly informs the topic through discussions of county development goals.

The resulting resources were evaluated in terms of the seven criteria to reveal LID and stormwater management barriers and successes. Lastly, the barriers were ranked by level of influence on LID as determined by the scale of impact on LID practices and the availability of compensatory resources. For example, in contrast to findings by Roy et al.

in 2008, ample training and educational opportunities are available for stormwater managers to compensate for a lack of professional knowledge about LID. Figure 7 illustrates the analysis process.

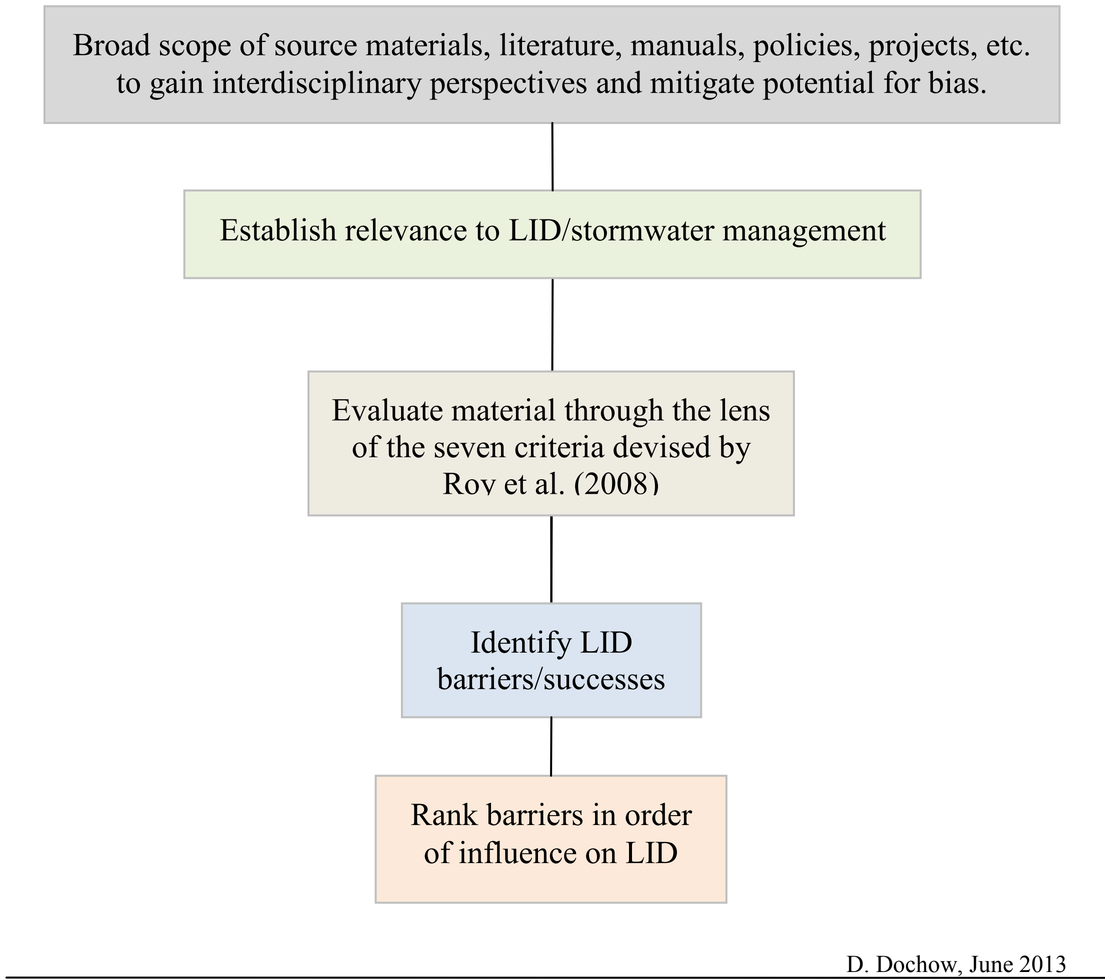


Figure 7: *Analysis of data using seven barriers devised by Roy et al. (2008).*

Roy et al (2008) state three assumptions that inform the analysis:

1. Sustainable urban stormwater management maintains the natural ecological structure and function of receiving water bodies

2. Technologies already exist that are capable of mimicking the natural water cycle and reading downstream transport of stormwater pollutants [underline added for clarity]; and
3. Sustainable urban stormwater management must be planned and implemented at the watershed scale. (p. 345).

Assumption 1 is maintained for this study and Assumption 2 is adapted as follows: 2. Technologies already exist that are capable of mimicking natural water cycles, thereby protecting downstream waterways from point source stormwater-borne pollutants (underline added for clarity). However, while recognizing watershed scales as important components of stormwater management and with the understanding that watershed-scale planning is addressed in the Phase I permit, a thorough discussion of Assumption 3 is beyond the scope of this study. Furthermore, based on the widely accepted premise that connects stormwater runoff with environmental degradation (Howie, Emmett, & Winz, 2011, p. 1; Stark, 2012; Dept of Ecology, 2011), stormwater management strategies that promote source reduction of stormwater runoff are presumed to provide valuable and desirable environmental services. As discussed earlier in this section and illustrated in Figure 7, the barriers and successes that were identified through analysis of LID materials are examined below in the context of the seven barriers.

1. **Uncertainties in performance and cost** (Roy, et al., 2008, p. 347)**:**

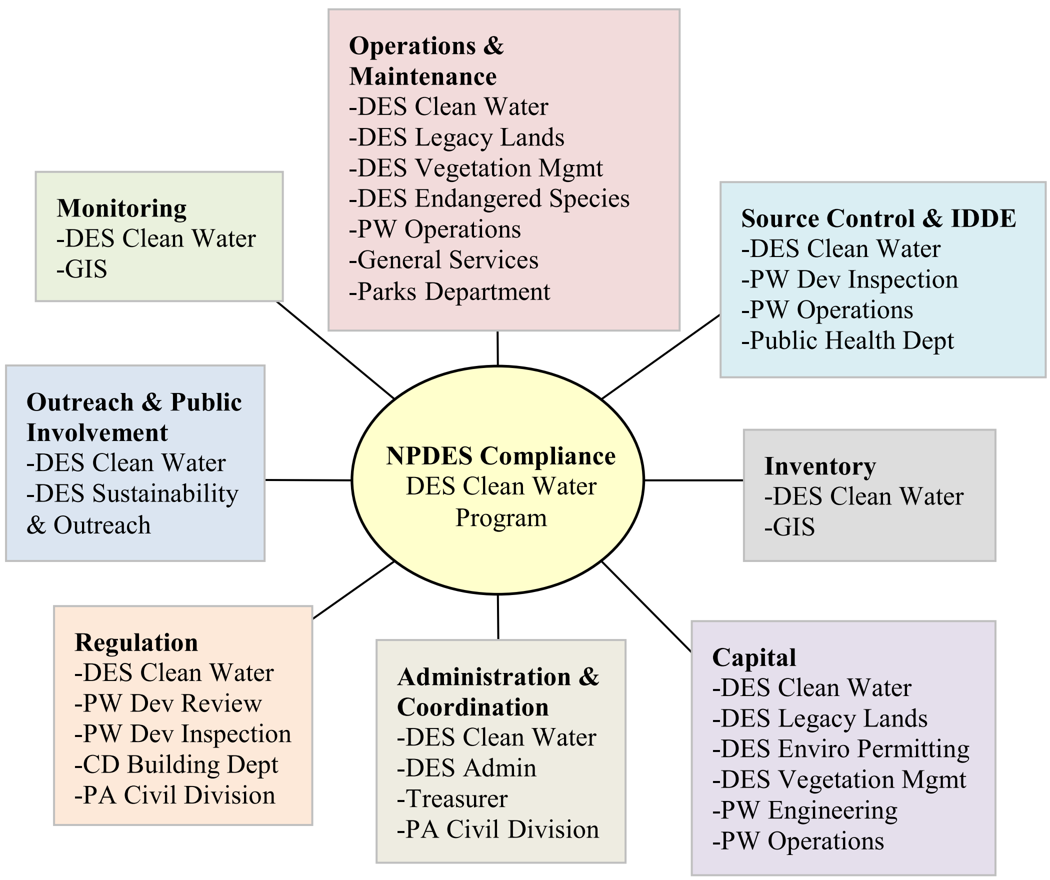
LID initiatives have progressed rapidly since the paper by Roy et al. was published in 2008. Large and small-scale projects within Clark County and throughout Western Washington have incorporated LID features, providing a variety of sources of performance and cost data. In some cases, the customized nature of LID warrants investigation of performance and costs of individual LID elements (e.g., pervious pavement, bioretention facilities) rather than looking at entire projects; however, cost data associated with materials, installation, and maintenance are available for a number of government and private projects that have incorporated LID facilities. For instance, the PV in Clark County has one of the largest and arguably one of the smallest LID bioretention features (Chapter 3), and these facilities have prompted inquiries about performance and cost from private and public stormwater managers (personal conversation on March 25, 2013). The City of Seattle website supplies a cost-benefit analysis for natural (LID) drainage systems versus traditional regimes (City of Seattle, 2013), and established installations like the Pierce County Environmental Services complex (constructed in 2004) have years of LID performance data to share. Landscape and building professionals that specialize in sustainability are other sources of cost and performance data. Washington State University (WSU) is a frontrunner in long-term LID research with its LID Stormwater Research Program in Puyallup; however, region-specific long-term performance datasets (e.g., over ten years) are not as robust. Uncertainties in performance and cost as barriers to LID stormwater management in Clark County are confounded by differing interpretations of NPDES mandates and by questions posed by NPDES permit holders about the scientific validity of LID data. Ongoing litigation on the aforementioned issues (Chapter 3) and risk management concerns associated with the adoption of new technologies create a tentative atmosphere about how LID will be applied in the future and whether alternatives will be allowed; these variables directly affect cost and performance data and are discussed further in Barrier 7.

2. Insufficient Engineering Standards and Guidelines (Roy, et al., 2008, p. 348)**:**

Conflict between standard specifications and LID techniques can be prohibitive to using LID, and professional guidance resources have yet to incorporate some LID practices as design standards because of lack of supporting data (Roy, et al., 2008, p. 348). As mentioned in Barrier 1 above, LID initiatives have progressed since 2008 and engineering standards and guidelines are still evolving. Ecology, WSC, stormwater management groups, and early adopter jurisdictions (e.g., City of Seattle) can help cities and counties incorporate LID into engineering standards and guidelines. Assistance is also available from free online documents like the SWMMWW (Dept of Ecology, 2012) and the LIDTGM (Washington St Univ; Puget Sound Partnership, 2012). Contrary to dissent over some aspects of the Phase I permit that takes effect in August 2013, Clark County is currently working on stormwater code revisions that are "flexible and tailored to multiple project types" and that (per permit requirements) identify LID as the "preferred approach" for stormwater management (Clark County, 2013). Once code revisions are drafted, stakeholders, the Clark County Board of Commissioners, and finally Ecology will have opportunities for review and comment (ibid).

3. Fragmented Responsibilities (Roy, et al., 2008, p. 348)**:**

Fragmentation of responsibilities on a local level speaks to the broad spectrum of resources and people involved in stormwater management and the potential for a lack of synchronization among these entities. Clark County addresses this barrier with an integrated organizational model and through a network of public outreach ventures in collaboration with several Clark County cities to provide consistent stormwater information to local businesses and to the public (Chapter 3). Phase I permit compliance mechanisms in Clark County utilize an integrated organizational approach that promotes collaboration among various departments (Clark County, 2012, p. 6). The NPDES Compliance section of the Department of Environmental Services Clean Water Program (CWP) acts as a hub for permit-related activities (Figure 8). Among other responsibilities, the CWP generates NPDES permit-related reports and provides engineering guidance (Clark County, 2012, p. 4).



CD = Community Development Dept
DES = Dept of Environmental Services
PW = Public Works
GIS = Geographic Information Systems Dept
PA = Prosecuting Attorney
IDDE = Illicit Discharges Detection & Elimination

Adapted from Clark County Stormwater Management Plan 2012, p. 6

Figure 8: *Clark County's integrated approach to NPDES permit responsibilities combats fragmentation by involving staff from many different departments in stormwater management activities.*

Interdisciplinary collaboration with stormwater management is one benefit of an integrated approach. Another advantage is that working relationships established through stormwater management activities can also serve as a platform for county departments to share information and cooperate on other projects. On another front, Clark County is actively engaged in collective efforts to gather and disseminate consistent information about LID and stormwater, and to provide resources to private stormwater managers and the public as is evidenced by the Stormwater Partners of Southwest Washington website (Chapter 3).

4. **Lack of Institutional Capacity** (Roy, et al., 2008, p. 349)**:**

Institutional capacity refers to human and fiscal resources, guidance, and education for stormwater professionals. Expanding upon the definition from Roy et al. (2008), institutional capacity also depends not only on education, but also on the availability of resources (e.g., training materials and qualified trainers) to meet professional training needs. In the case of Clark County, institutional capacity is intertwined with Barrier 3 (fragmented responsibilities) in that the collaborative endeavors undertaken by Clark County and its partners have positively influenced institutional capacity. For example, the integrated NPDES compliance organizational model illustrated in Figure 8 involves a number of departments, which helps educate staff not normally involved with LID practices and stormwater management, and cultivates intra-organizational partnerships that can enhance institutional capacity. Clark County further reinforces institutional capacity for LID through related research and implementing programs that gather and disseminate information about and provide assistance with LID practices (Chapter 3). SNAP researches and devises strategies for NPDES compliance in addition to recommending and prioritizing capital stormwater projects. SARD identifies institutional protocols as potential barriers to sustainable development. The follow-up to SARD, the CCSC project engages with government agencies within and outside of Clark County, with the Building Industry Association of Clark County, and with WSU to explore the integration of sustainable development projects on an institutional level (Cascadia Region Green Bldg Council, 2008, p. 19).

Ongoing collaborative efforts by WSU, WSC, scientists, and stormwater professionals combine with networking among municipalities and other NPDES permit holders to create strong networks and support systems for Western Washington stormwater managers. Guidance documents are available at no cost including the SWMMWW (Dept of Ecology, 2012) and the LIDTGM (Wash. St. University & Puget Sound Partnership, 2012), along with abundant online resources on the EPA and Ecology websites. Furthermore, Ecology recently instigated free LID training workshops developed for specific audiences including realtors, building industry professionals, landscapers and nurseries, compost manufacturers and retailers, elected officials, planning and land use decision makers, and maintenance and operations personnel (Dept of Ecology, 2013). When Roy et al. published their research in 2008, these schemes were not in place; thus, substantial progress is demonstrated in the availability of resources and training for stormwater managers.

5. Lack of Legislative Mandate (Roy, et al., 2008, p. 349)**:**

Lack of legislative mandate, as defined by Roy et al. (2008), looks at how the absence of comprehensive national stormwater directives creates a mosaic of disconnected local authorities and interferes with consistent LID implementation. In contrast to categorizing the absence of national mandates as a barrier, however, Clark County (along with Pierce, Snohomish, and King Counties) asserts that the presence of NPDES federal mandates as administered by Ecology actually creates barriers by exercising excessive control over local conditions (Clark County's Notice of Appeal of Phase I Municipal Stormwater Permit, 2012). Particular points of contention are limited local input in the selection of watersheds, interference in land use planning, and claims that some NPDES mandates conflict with state law and local codes (e.g., vestment rights) (ibid). Consequently, the barrier is not a *lack* of legislative mandates, but instead a need for *clarification* of NPDES legislative mandates.

The following example illustrates differing interpretations of NPDES mandates, which confuse the local application of national directives. Clark County Code Section 40.385.020 I(2)(a) states, "The pre-developed condition to be matched shall be the land cover condition existing at the time of the development application" [underline added for clarity] or as identified in an approved basin plan (retrieved on March 2, 2013). Conversely, the SWMMWW Volume I (Dept of Ecology, 2012), a document that provides minimum NPDES compliance guidance in Washington State, defines pre-developed condition as:

> The native vegetation and soils that existed at a site prior to the influence of Euro-American settlement [underline added for clarity]. The pre-developed condition shall be assumed to be forested land cover unless

> reasonable, historic information is provided that indicates the site was prairie prior to settlement (2012, p. G34).

Clark County's site remediation goals are less restrictive, with requirements tied to the date of development application versus pre-disturbance conditions (prior to Euro-American settlement) as defined in SWMMWW (Dept of Ecology, 2012, p. G34). When existing site conditions are similar to pre-disturbance conditions, the difference in levels of onsite remediation is negligible; however, in the instance of severely degraded sites where the disparity between existing and pre-disturbance is substantial, the impacts of policy differences are more pronounced. As mentioned in Chapter 3, Clark County and Ecology are appealing the PCHB decision that requires mitigation to pre-disturbance conditions, based on the Agreed Order (Chapter 3) between the county and state that allows partial offsite mitigation to account for differences in existing and pre-disturbance condition.

Beyond the legal challenges Roy et al. (2008) cite the absence of "national, legal mandates" as the cause of "inconsistent management policies across jurisdictions" (p. 349). However, given hydrologic, soil composition, climate, and myriad other differences among U.S. localities, it is difficult to imagine that national directives could adequately and equitably address regional and site variations, especially if the expected outcomes are consistent LID implementation and cohesion among state and local authorities. A more practical approach is reflected in the current regime; overarching minimum national mandates, administered by state agencies (e.g., Ecology in Washington State) that work closely with local governments to devise localized strategies that meet or exceed national and state minimum requirements.

Protests aside, LID stormwater management successes including the PV's bioretention facility and the Grattix, Clark County's Green Business Program, the Planet Clark sustainable home (Chapter 3), and other initiatives demonstrate that collaborative interdisciplinary efforts can successfully implement LID in local jurisdictions, while inspiring innovation and contributing to LID technology.

6. **Lack of Sufficient Funding and Effective Market Incentives** (Roy, et al., 2008, p. 349)**:**

As mentioned in Chapter 3, stormwater fees are a common source of revenue in NPDES permitted cities and counties. Clark County Clean Water fees are dedicated to stormwater management, maintenance, and capital improvement projects (Clark County, 2012, p. 5). In tandem with the financial benefits of spreading costs among residents and businesses, the act of paying stormwater fees raises public awareness about price tags associated with stormwater management. Stormwater fees generate about $4.9 million per year from 65,000 ratepayers in unincorporated Clark County, which is augmented by funds received from other county sources and from grants (Clark County, 2012, p. 4). However, escalating capital projects and other stormwater-related costs are taking a toll on the county's stormwater budget (ibid).

With regard to incentives, the findings of the 2008 SARD study state that, "Opportunities to increase requirements or incentives for LID practices . . . could be explored by both the City and County to optimize adoption of standards that match current research and technologies" (Cascadia Region Green Bldg Council, 2008, p. 13). The study also indicates that in 2008 the City of Vancouver and Clark County were in the process of revising outdated stormwater codes to allow credit for LID practices, although a review of county code archives in the course of research for this paper failed to reveal evidence of such revisions. However, pursuant to upcoming NPDES requirements to codify preferences for LID, Clark County stormwater codes are currently under review, a process that is slated for completion in 2015.

The disputed Agreed Order between Clark County and Ecology (Chapter 3) equates to a cap-and-trade market incentive for development. Instead of meeting pre-disturbance stormwater outflow conditions through onsite LID strategies as prescribed in the Phase I permit, onsite mitigation is capped at the site condition existing "at the time of the development application" (retrieved on March 2, 2013). Developers can then transfer (trade) the calculated difference between existing and pre-disturbance flow conditions to the county's Stormwater Capital Improvements Program. As demonstrated by ongoing litigation in response to the Agreed Order, a remedy intended to provide incentives (or remove disincentives) for developers creates a new set of problems, which Roy et al. (2008) describe as challenges in defining parameters and enforcement, and garnering a broad base of support (p. 350).

Clark County is also looking to incentivize development through streamlined permitting processes and fee waivers; although similar incentives were previously in place, further measures are planned. In 2012, a resolution was adopted for a pilot project that allows developers (under certain conditions) to self-certify in place of a final review by county engineering staff, thereby foregoing the cost and time involved in a final review (BOCC Meeting Minutes, 2012). A county staff report (August 21, 2012) expresses concerns over the construction quality of transportation and stormwater elements under this arrangement and the ability to address violations after developments are completed (p. 1). In another move the Clark County Board of Commissioners held a public hearing on May 7, 2013 to discuss temporary waivers of "all fees associated with the permitting, development and inspection of commercial or industrial subdivisions, and site plan approvals" and other fees related to building and traffic impacts (Notice of Public Hearing, 2013). Fees waivers would apply only to for-profit commercial and industrial developments (ibid). A video of the meeting shows that a decision was postponed pending further investigation in light of concerns raised during three hours of public comments. No mention of incentives attached specifically to LID or other sustainable development practices was uncovered in the research for this study.

According to the Clark County Sustainability and Outreach Coordinator, Clark County does not offer financial incentives for LID, however, the county contracts with consultants to assist property owners with LID guidance (email correspondence May 6, 2013). The City of Vancouver, Clark County's largest city, offers up to 50 percent credit in stormwater fees for qualifying properties that meet or exceed prescribed stormwater management strategies (Vancouver City Code Section 14.09.100), but these incentives apply only within incorporated city boundaries. Marketing incentives also take the form of projects that demonstrate LID elements; the Planet Clark Emerald House sustainable home project mentioned in Chapter 3 is an example of such an incentive. Navigating county codes for the design and construction of model projects can point out code deficiencies and can assist developers to quantify permit costs for sustainable development. Model homes provide tangible examples of materials, costs, and performance associated with sustainable building practices (see Barrier 1); and visiting a model home brings sustainable concepts to life, which can educate prospective homebuyers and generate market demand for sustainable features (e.g., LID).

The Green Business Program (Chapter 3), a recent county initiative, rewards businesses for LID and other sustainable practices by providing marketing incentives that include the use of a Green Business logo, a company profile in the Green Business Directory and on the user-friendly Green Business website, recognition for achievements, and county support for training and green initiatives. Twenty-eight annually certified Green Businesses representing a diverse cross-section of the business sector participate in the popular Clark County Green Business Program.

7. Resistance to Change (Roy, et al., 2008, p. 350)**:**

In addition to creating obstacles to adopting LID regimes, Barriers 1 through 6 represent potential motives for resistance: performance and cost, engineering standards, fragmented responsibilities, institutional capacity, legislative mandates, and funding and market incentives. The following examples illustrate the complexity of resistance to change and the role this barrier plays in legislative mandates, marketing incentives, and institutional capacity.

Resistance to LID stormwater management strategies in Clark County is exemplified by the county's appeals for alternatives and relief from NPDES mandates that are discussed Chapter 3 and mentioned again in Barriers 1, 2, and 5 in this Analysis section. The underlying conflict surrounding these ongoing legal actions is a product of incongruent interpretations of NPDES permit language, disagreement that the Agreed Order is an equal or similar alternative to LID, and contradictory views on the use of pre-disturbance site conditions as the stormwater flow benchmark. In contrast, resistance to change, in these instances through legal means, will ultimately clarify the intent and language of NPDES mandates and promote consistent interpretation and application of NPDES policies. Roy et al. (2008) suggest that managing risk causes resistance to change (p. 350); however, resistance to change can also reduce risk. Assuming that uniform policy interpretation promotes consistent standards of operation, and that standardized operating procedures result in lower risk exposures, then policy clarifications stemming from resistance to change (e.g., NPDES mandates) provide a positive outcome with regard to risk management.

Aside from legal challenges Clark County offers a number of resources that address resistance to change on a community level through education, guidance, and support. The Stormwater Partners of Southwest Washington and Clark County websites offer LID installation and maintenance guidance, along with information about sustainability research and pilot projects (e.g., the Plant Clark project). Other tools available to county citizens and businesses are LID consulting services for homeowners and businesses, and innovative outreach initiatives such as the popular Green Business Program (Chapter 3 and Barrier 6). An example of forethought in addressing resistance to change was demonstrated in the CCSC meetings where professional facilitators were on hand to foster effective communication among diverse participants (Chapter 3).

Findings

The analysis process described in the first section of this chapter categorized the seven barriers by level of influence on LID as determined by the scale of impact on LID practices and the availability of compensatory resources. Table A lists the results.

Barrier Category	Barrier No.	Barrier Name
Keystone (most influential)	7	Resistance to change
	5	Clarification of legislative mandates
Prominent (influential)	1	Uncertainties in performance and cost
	6	Lack of sufficient funding & market incentives
Moderate (least influential)	2	Insufficient engineering standards and guidelines
	4	Lack of institutional capacity
	3	Fragmented responsibilities

Table A: *Barriers 1 through 7 ranked according to influence on LID.*

The most influential barriers are labeled as Keystones because like the central structural component of a stone arch the litigation and efforts to clarify mandates that define these two barriers represent central (keystone) stormwater management policies and standards. The outcomes of the legal actions will determine the structural integrity of LID initiatives in Clark County and establish precedents that will affect other Phase I jurisdictions. While Prominent barriers are not as pivotal to LID strategies as their Keystone counterparts, these barriers are important in that they directly influence the ability to quantify resources and performance outcomes, in addition to stimulating market demand. In the case of Moderate barriers, progress is evident in Clark County, especially with regard to fragmented responsibilities. Although somewhat dependent on legal outcomes, the remaining issues can be largely addressed on a county level, as myriad resources are available to assist Clark County in defining standards and building capacity over time.

In addition to examining barriers, the analyses drew attention to characteristics of ventures that successfully incorporate LID elements including the Planet Clark Emerald House, the Green Business Program, and initiatives at the PV (Chapter 3). All enterprises involve a number of collaborators and partnerships, representation from diverse professional backgrounds, strong community connections and/or participation, and innovation. Additionally, the PV exhibits an entrepreneurial spirit and pride in accomplishment as is evidenced by the Clean Water Challenge program for port tenants (including an annual awards breakfast) and an attempt to enter the port's huge technologically advanced bioretention facility into the Guinness Book of World Records (professional discussion. March 25, 2013). Unfortunately, the efforts were met with disappointment as the Guinness organization currently has no categories to recognize green projects (ibid). Gaining an understanding of the barriers to LID strategies and identifying traits of successful endeavors provides insights into the nature of barriers and the potential for success that informs socio-technical improvements for future LID implementation.

Chapter 5

Conclusion

Peter Gleick (2009) warns that, by necessity, the way humans use water is rapidly changing: sustainability, adaptability, and creativity will shape the future of water management (pp. 197-198). The clear connection between traditional stormwater management regimes, water pollution, and other environmental consequences means that the path to the future must take a different route. Transforming tradition is not easy, especially when new regimes are markedly different from established methods, as is the case with LID and conventional stormwater management.

The study has examined stormwater management in Clark County to assess barriers to LID strategies. Seven barriers adapted from Australian researchers Roy et al. (2008) provided a framework for review of the literature and for the analysis. The findings identified Keystone barriers to LID strategies as resistance to change and clarification of legislative mandates. The chief manifestation of these barriers is litigation, the outcomes of which will either solidify or dilute NPDES LID mandates. Other barriers, such as uncertainties in performance and cost and lack of institutional capacity, present varying degrees of difficulty and success in adopting LID strategies.

Analysis of the barriers demonstrates Clark County's dichotomous relationship with LID. In the midst of ongoing litigation over LID mandates, the county at the same time promotes LID through a number of stormwater and LID-related programs that encourage community participation and collaboration, educate the public, and provide resources for urban and rural areas within the county. These disparities concur with Meadows' (2008) premise that resistance to change "arises when goals of subsystems are different from and inconsistent with each other" (p. 113). Given that LID initiatives such as public involvement, outreach and education, and coordination among county departments are mandated by the Phase I permit (Dept of Ecology, 2012, pp. 11-31), it is reasonable to conclude that Phase I permit requirements have at least in part if not fully prompted some LID programs in Clark County. If this assumption is correct, then certain LID initiatives stem from permit compliance procedures rather than from county aspirations to embrace LID concepts. Nevertheless, an examination through the lens of the seven barriers presented by Roy et al. (2008) shows positive results for internal coordination mechanisms, community involvement, innovation, and entrepreneurial endeavors in Clark County. The data suggest that professional interdisciplinarity, community cohesion, and innovation are common characteristics of successful LID ventures. A pragmatic worldview provides further insights into stormwater management concerns.

James (1907) asserts that a pragmatist "turns away from abstraction and insufficiency [and] . . . turns towards concreteness and adequacy, towards facts, towards action" (pp. 22, Location 384). Flooding is a direct consequence of excess surface water and point source water pollution is a consequence of the manner in which surface water is managed. From a pragmatic perspective, stormwater is not the problem; rather stormwater is a consequence of anthropogenic interference (site disturbance) with natural water cycles. Breaking it down further, problems associated with stormwater runoff (e.g., flooding and water pollution) are an amalgamation of consequences (abstractions) stemming from countless individual actions: one rooftop, plus one driveway, plus one parking lot, plus one vehicle leaking oil, plus one factory, and so on. The results of this study demonstrate that barriers to stormwater management represent barriers to developing mitigation mechanisms that sustainably address the consequences of an immense collection of highly diverse individual actions. Pragmatically the challenge is how to manage site disturbance activities to minimize the disruption of natural water cycles (the core problem), instead of focusing on schemes to deal with stormwater runoff (consequences).

An important difference between traditional stormwater management and LID is the perception of the problem, which as is shown above, differs markedly between the two regimes. While traditional stormwater management deals with water after it leaves a site, LID promotes strategies that manage precipitation onsite. Therefore, it is not surprising that solutions also differ, and with different solutions come different actors and different ways of acting. Brown, Sharp, and Ashley (2006) introduce the term *technocratic expertise* as "a series of technologies with little consideration of . . . socio-political strategies needed to enable political relevance and need within the community" (p. 420). Sustainable stormwater management is a community need; yet addressing traditionally defined stormwater problems with technocratic solutions exemplifies a mono-disciplinary approach. Conversely, given the vast diversity of contributors and stakeholders that are connected to stormwater issues, LID necessarily injects a pragmatic interdisciplinary approach into stormwater management by focusing on the actual problem (site disturbance) and offering customizable strategies (actions) for sustainable stormwater management.

Five years have passed since Roy et al. introduced the seven barriers in 2008. This case study updates the successes and challenges encountered by stormwater water managers through an assessment of the seven barriers to LID strategies. Revisiting the topic in five years (2018) will further illuminate the seven barriers and provide insights into the progress of LID over the course of a decade that has thus far seen major changes in stormwater management. Other suggestions for future research include a focus on potential solutions to each barrier, exploring connections between LID strategies and economic agendas (e.g., commercial development), and comparing the environmental services provided by in situ LID strategies versus offsite mitigation alternatives (as proposed in the Agreed Order).

Environmental problems associated with traditional stormwater management schemes prohibit the continuation of conventional methods. As NPDES regulations are phased in, LID is gaining a foothold in cities and counties; and if current plans remain in place, mandates for LID will become more stringent with time. Identifying barriers and collectively devising LID strategies for stormwater management will inform efforts and enhance outcomes. Most importantly, as traditional stormwater management practices transform into more sustainable LID regimes, point source pollution from stormwater runoff will become the exception and not the rule.

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