

Western Oregon Cities and Low Impact Development in Stormwater Management:

*An exploratory study of the barriers cities face and their approaches to stormwater
management*

By

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ABSTRACT

Western Oregon Cities and Low Impact Development in Stormwater Management:

An exploratory study of the barriers cities face and their approaches to stormwater management

Stormwater has traditionally been conveyed off a developed site as quickly as possible, primarily through pipes. This runoff is often stored in large ponds and/or treated in central facilities. As cities grow and development continues, more runoff is generated via impervious surfaces. Excessive runoff impacts the water quality of water bodies near and far and alters the natural water cycle. The growing volumes of runoff are making it increasingly difficult for cities across the country to manage stormwater. A new practice, Low Impact Development (LID) as applied to stormwater, aims to infiltrate runoff on site and mimic the natural hydrologic process.

Informal interviews were conducted with city staff from eighteen cities in western Oregon. The goal of the study was to identify barriers cities face toward LID implementation and approaches cities take to implement LID. The study also looked at four city characteristics; population, growth rate, geographic location and city governance to identify correlations between city characteristics and the barriers they face or approaches they take. The study reports several known, documented barriers and approaches, but also examines several newer barriers and approaches and suggests there is unique combination of barriers and approaches for each city, which may impact the ease of LID adoption in that city. The study also examines some of the inherent properties of LID and concludes that because the innovative qualities of LID, such as relative advantage and compatibility, it is a practice that will likely take decades to fully adopt. This exploratory study could provide information to complete a future more statistically sound study which could then further aid policy recommendations. Furthermore, results of this study and future studies could provide insight on the most effective and efficient methods to promote LID on a local level.

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Introduction

Research Problem

The natural water cycle on a pre-development landscape infiltrates between 10-40% of precipitation. Much of this infiltrated water travels to storage areas such as streams, rivers and lakes. Another 40-50% of this precipitation is absorbed by vegetation and evapotranspired back into the atmosphere to create clouds and begin the cycle over again. In a natural landscape, there is very little surface runoff because of the exposed soils and vegetation (Figure 1).

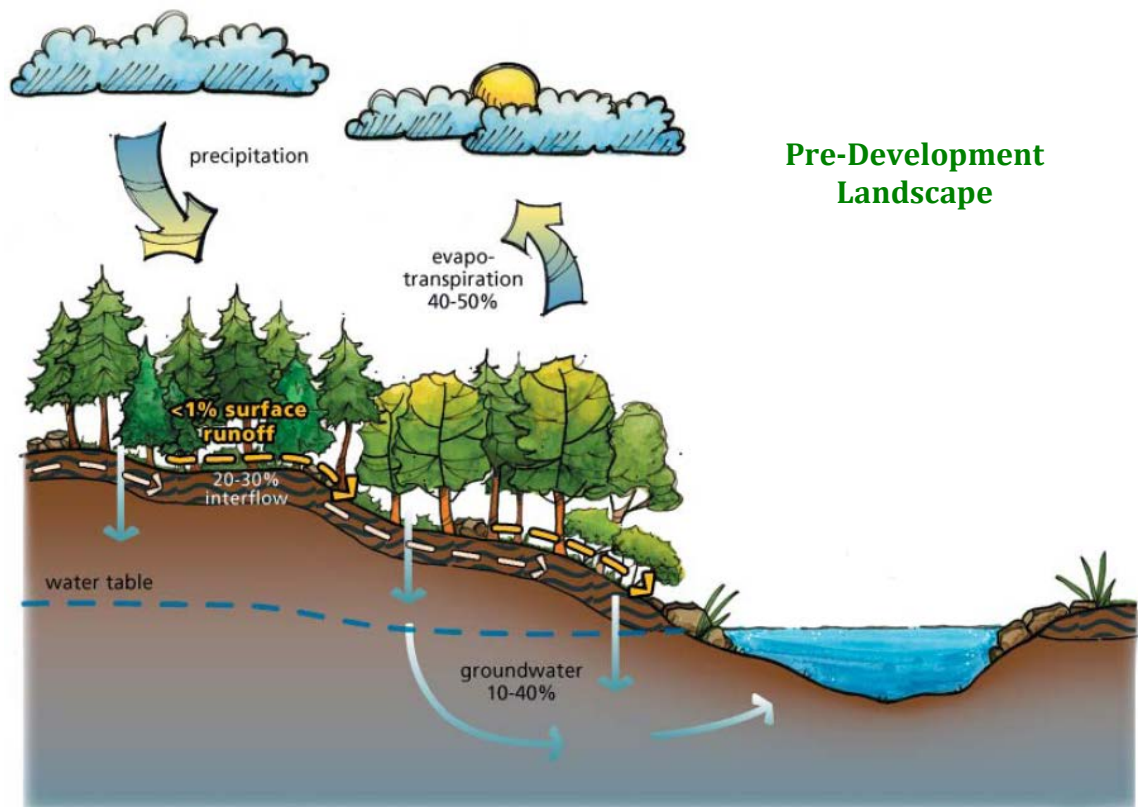


Figure 1. *Natural Water Cycle: Predevelopment Landscape*

In a developed landscape the water cycle changes. Impervious surfaces such as pavements and building footprints reduce infiltration and increase surface runoff to 20-30%. A lack of vegetation also decreases evapotranspiration to 20-30% (Figure 2).

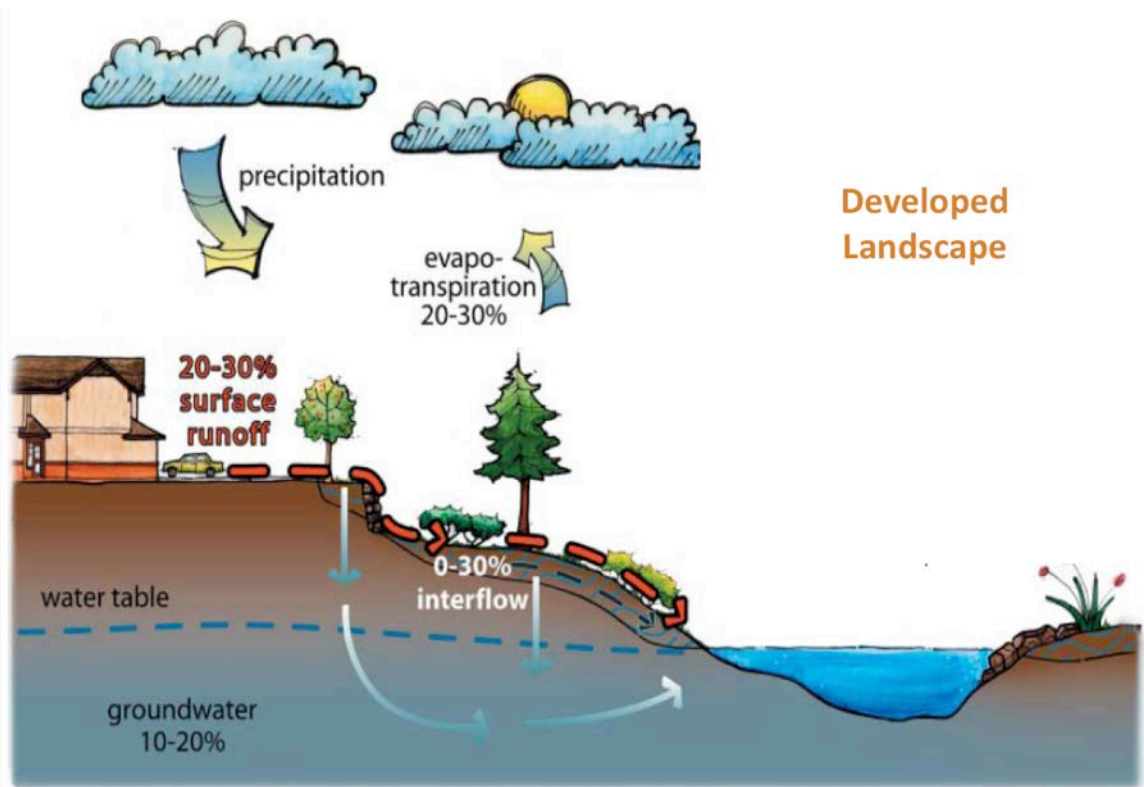


Figure 2. *Water Cycle in a Developed Landscape*

These urban changes have a significant impact on water management within a city. The challenge is to manage surface runoff in an efficient and effective manner.

Traditionally, stormwater management aimed to divert water quickly and efficiently away from a developed site. Urbanization led to the development of extensive storm drain systems requiring pipes and concrete. Outfalls from these systems contributed large volumes of runoff in a short amount of time to a single body of water (Seybert 2006). Traditional methods have contributed to many environmental issues such as eutrophication and water pollution, which threaten aquatic life and ecosystems. These ecosystems not only support wildlife, but many services in a community such as economies, recreation and health. Urbanization also alters hydrology by increasing the area of impervious surfaces such as pavements and rooftops (Huntsinger and Graybill 2007).

A growing concern for downstream impacts of stormwater runoff began in the 1970s. Today, concerns regarding stormwater have shifted in focus area, but are just as prominent. A new philosophy and practice in stormwater management treats as much stormwater as possible on site and mimics natural hydrologic processes. These new development schemes are commonly referred to as Low Impact Development (LID) through the use of Best Management Practices (BMPs). Larry Coffman of Maryland's Environmental Resource Department says, "LID is the culmination of all our thinking about how to modify the nature of development so as to maintain natural ecological function" (Hager 1993, para. 1). On-site infiltration more closely represents a natural water cycle process and can be designed to mitigate pollutant levels as well as recharge aquifers. Furthermore, this reduces downstream runoff volumes and water volumes reaching a pipe. This can be beneficial for cities with combined sewer overflow (CSO) systems such as Portland, Oregon, which treats all water reaching a treatment facility at a cost to the city. Decreasing stormwater runoff volume reduces treatment fees.

LID was first introduced in 1997 in Prince George's County, Maryland (Coffman 2002). In 1999 the city of Portland, OR came out with their first Stormwater Management Manual (which included many LID practices) and in 2005 the Puget Sound Action Team in Washington published *Low Impact Development Technical Guidance Manual for Puget Sound*. Although it has been a decade since the concept formally arrived in Oregon, cities are still struggling to adopt many LID practices despite promotion from federal agencies and educational organizations in Western Oregon. Therefore, the innovative practice of LID in stormwater appears to be on a slower timeline, more like recycling, rather than other innovations such as cell phones, iPods, or fashion trends. Implementation of LID is taking decades rather than a few years to implement widely.

Research Question

This exploratory study examines LID adoption in the context of stormwater and is focused on two main issues:

1. What barriers are cities facing in the face of LID implementation?
2. What approaches are they taking (if any) toward LID implementation?

Identifying these barriers and approaches could provide a better understanding of stormwater management in terms of what we as researchers and educators know or don't know. It could also clarify preconceived assumptions.

This study also looks at the impact of four city characteristics: geographic location, population size, growth rate and, city governance. Linking city characteristics to barriers and approaches could help categorize cities, making it easier to facilitate and promote LID through the most receptive and effective means in each city. With this information, future surveys can be designed to propose more specific questions in a consistent, comprehensive manner, in order to generate insights that can help facilitate promotion of LID.

Finally, I examine LID adoption from a theoretical perspective relating to the rate of adoption of innovations. Rogers (1983) offers insight on why some innovations are rapidly adopted within five or six years and others take several decades. He analyzes five characteristics of innovation to help explain rates of adoption and suggests understanding these properties can aid in foreseeing how a population will react. This allows innovators to develop effective presentation of an innovation. The five characteristics include 1) relative advantage, 2) compatibility, 3) complexity, 4) trialability, and 5) observability and are described in more detail in the discussion section. This approach differs from the current study in that Rogers analyses LID adoption through the characteristics of the innovation itself rather than characteristics of the adopters.

Significance of Research

Portland, Oregon has been praised for its pioneering steps in stormwater management and is a model across the nation for stormwater management and LID innovation. Despite this local example, other Oregon cities are reluctant to take similar steps. As education specialists and state agencies begin to encourage LID practices it is useful to know what actions would be most effective in this process. Several workshops held throughout Western Oregon by the Oregon Environmental Council and OSU Extension Service have offered information about LID and listened to barriers and approaches cities face during discussion periods (OEC 2009). Godwin (2003) also conducted large workshops in three

different regions of Oregon, inviting several different cities to attend a workshop to voice their concerns about LID. In addition, Huntsinger and Graybill (2007) conducted an eighteen-question online survey distributed to Oregon Association of Clean Water Agencies, Oregon Home Builders Association, Oregon Public Works Association, American Society of Landscape Architects, Oregon Chapter and Solutions Team Members and their networks looking for barriers to LID practices. Several recommendations were developed as a result of this survey.

The research from these two studies identified several common barriers to LID and stormwater management including space limitations, site specific challenges such as soils and slopes, financial challenges, code barriers, lack of resources such as knowledgeable staff, maintenance concerns and a resistance to adopt new practices. Yet, neither study included interviews with city staff, nor inquired about specific approaches used toward LID implementation. Therefore, a major contribution of the research reported here is a more detailed examination of municipalities' struggles and successes with LID. The study findings suggest there are several barriers to adoption and implementation that have not received attention. Furthermore, this research examines the possibility that it may be the innovative nature of LID practices that is responsible in part for slowing the adoption process.

A second major contribution of this research is its summary of approaches cities have or plan to take toward LID implementation. Identifying these existing approaches offers insight to practices the cities themselves consider most efficient and constructive. Education specialists can use this local knowledge as a starting point for increasing the success of LID implementation. If a city is using a specific approach, it is likely they view the approach as worthy of investing in for several local reasons, whether it be economic, physical setting (soils, slopes, etc), or one of many other factors. Providing assistance for approaches to which cities are already committed can help cities work in a way and at a pace fitting their needs rather than setting LID implementation goals too high or low. It is also more likely the city will collaborate and accept assistance from

other organizations promoting practices consistent with their values, making the LID implementation process more efficient and less problematic.

Description of Study Area (Coastal and inland Oregon)

Oregon is located in the Northwest corner of the United States. It is about 400 miles wide from east to west and 300 miles long from north to south (Figure 1).

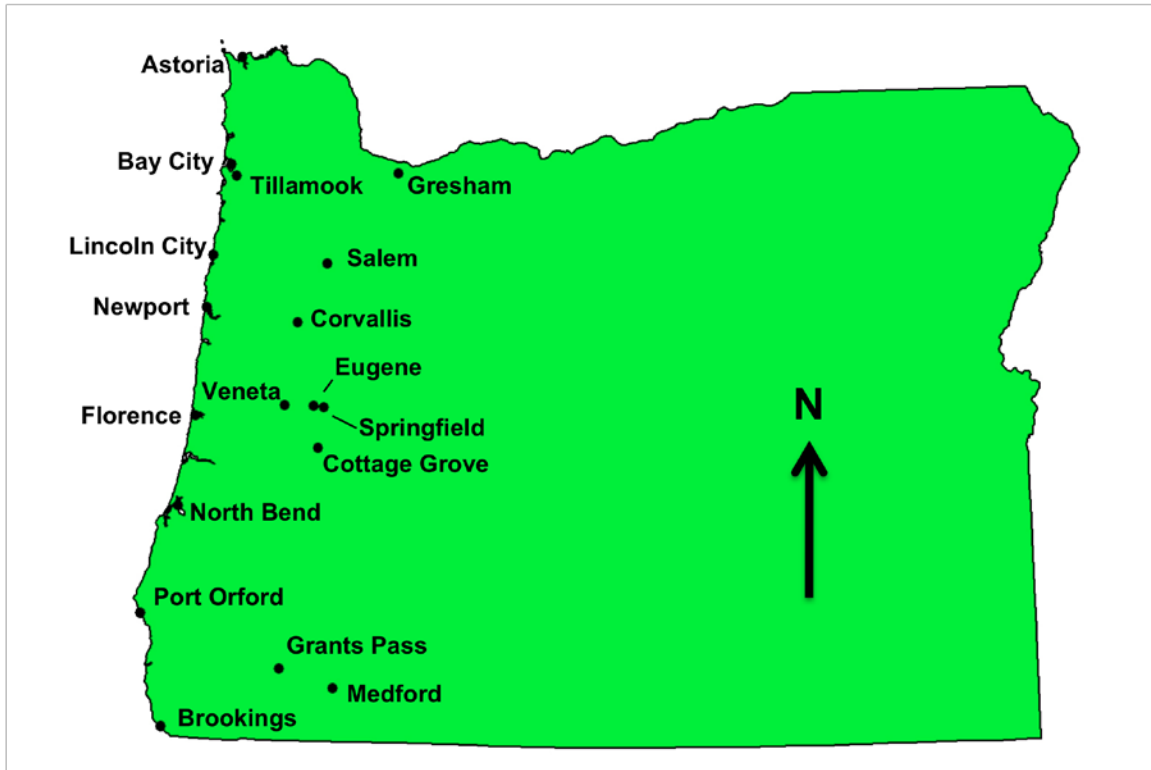


Figure 1. Location of Oregon cities where interviews were conducted.

The physical setting of Oregon varies greatly. The western third of the state, the region in which this study takes place, consists of mountainous terrain, lush valleys and rainforests. The eastern portion of the state, not considered in this study, is much more arid (Oregon 2010). Even within the western third of the state, coastal climates and physical settings west of the Coastal Mountain Range vary greatly from those inland and east of the Coast Range. Coastal soils generally tend to be porous, while inland soils tend to be organic and potentially less porous and/or more clayey than coastal soils. Coastal air temperatures rarely drop below 2°C (approximately 36°F) and inland Oregon air temperatures seldom

fall below -1°C (approximately 30°F). The more southerly the region along the coast or inland, the warmer the temperatures. Both coastal and inland regions are characterized by dry summers and wet winters. On the coast there are frequent storms with heavy rainfall in the winter while inland areas experience a more consistent, low volume rainfall in the winter. During the rainiest month on the coast, the region receives up to 30.5 cm (12 in) of precipitation. The highest volumes are found in southern regions. During the rainiest month inland, only about 21cm (8.3in) of precipitation is recorded on average. The highest precipitation volumes for the inland region are found in northern sections (OIC 2009).

Coastal cities are bound on the west by the Pacific Ocean and on the east by the Coastal Range. This often restricts development in the east-west direction creating longer cities with short drainage basins. Inland cities are less severely restricted. The valley between the Coast Range and Cascades is about 90 kilometers wide, but again cities are limited locally by their respective mountains and valleys. In southern regions such as the Grants Pass area, the landscape has much more topographic relief than in northern regions such as Portland.

Literature Review

LID in the CONTEXT of PUNCTUATED EQUILIBRIUM

Punctuated equilibrium in the policy area, as described by Howlett and Remesh (2003) is a combination of both “normal” and “atypical” policy change. Normal change is slow and conservative, involving small changes with little deviance from the status quo, while atypical change is a more radical alteration of policy development and implementation. Punctuated equilibrium is the stepped process of relatively long durations of normal policy adjustments interspersed with brief moments of innovative policy development.

The concept of LID is not revolutionary. In fact, Coffman (2002: 5) claims, “There is nothing new about LID, we’ve done it for years.” However, it is arguably a major outcome of a significant policy, the Federal Water Pollution Control Act Amendments of 1972. These amendments embodied “an entirely new approach by Congress to the problem of water pollution” (Dzurik 2003: 47). Sabatier (1988) states that core changes in policy are the result of external perturbations often arising from public focus on a perceived crisis. This can be a gradual heightened awareness such as healthcare concerns, or more abrupt, such as a terrorist attack. Following this theory, The Federal Water Pollution Control Act Amendments were not the first mention of water quality. Rather, tension had been building since *Silent Spring*’s publication in 1962 by Rachel Carson. However, the adoptions of the Amendments and their proposed actions were not merely a “gradual” change to water quality management, but rather a new approach and more atypical change.

Five years after the Federal Water Pollution Control Act Amendments, a revision was renamed the Amendments of the Clean Water Act (CWA) (Dzurik 2003). The CWA addresses national water quality, and in its beginning years, focused on point-source pollution. As these sources were attended to, the 1980’s brought awareness of non-point source pollution including runoff from various areas diverted into stormwater pipes. Part of the CWA includes the National Pollution Discharge Elimination System (NPDES).

The NPDES is Section 402 of the CWA and prohibits pollutant discharge from a point source without an approved permit (EPA 2008). Among the many culprits of pollutant discharge are Municipal Separate Storm Sewer Systems (MS4s)¹. They are required to obtain a permit to operate. In an effort to improve water quality of runoff discharged from these untreated systems, the EPA required the permit application demonstrate how the MS4 addresses specific issues. Permit requirements were put into practice in phases. Phase I was implemented in 1990, targeting cities larger than 100,000 (and some counties). Qualifiers were expected to follow four requirements:

1. Identify major outfalls and pollutant loadings.
2. Detect and eliminate sources of discharge that are not stormwater, but are entering the systems (sewer).
3. Reduce pollutants in runoff from industrial, commercial, residential areas.
4. Control stormwater discharges from new development and redevelopment areas.

(EPA 2009, River Network, 2005)

In Phase II, implemented in 1999, certain *regulated small MS4s* were expected to meet six requirements. These MS4s qualified under nationwide criteria: either 1) greater than 10,000 and with a population density of 1,000 people/square mile or 2) within an urbanized area. The Bureau of Census defines an urbanized area as one or more densely populated places that together reach 50,000 residents or more and at least 1,000 people/square mile. Alternatively, the NPDES permitting authority could designate a city as Phase II if its discharge is considered threatening to water quality. The six requirements for Phase II communities are:

1. Public outreach and education
2. Public participation/involvement
3. Detect illicit discharge and eliminate it
4. Construction site runoff control
5. Post construction site runoff control

¹ An MS4 is defined by the EPA as “a conveyance or system that is; owned by a state, city, town, village, or other public entity that discharges to waters of the U.S.; Designed or used to collect or convey stormwater (including storm drains, pipes, ditches, etc.); Not a combined sewer; and Not part of a Publicly Owned Treatment Works (sewage treatment plant)” (EPA 2009).

6. Pollution prevention/good house keeping
(EPA 2009, River Network, 2005)

Applying the theory of punctuated equilibrium to the progression of stormwater and LID, the atypical policy change (the CWA) was followed by smaller, normal policy changes including new techniques and technologies to address water quality issues and meet EPA's evolving requirements. The use of centralized treatment plants such as detention ponds surfaced as the main method to detain water volumes and settle out pollutants before slowly being released to streams and larger bodies of water. However, LID remained on the fringes of stormwater management. Federal agencies and other regulatory bodies did not perceive LID as the most rapid way to improve surface water quality in urban environments. Immediate limitations with LID, such as space and aesthetics, likely influenced this perspective. In an already established urban setting, there is little room to provide onsite infiltration; therefore diverting water to one main area for treatment is seen as preferable to allowing water to flow through the city, which can cause safety, convenience and aesthetic challenges. However, when considering stormwater management at a larger scale and in less urbanized areas, such as along county roads, the majority of counties still utilize open ditches and few pipes.

In the future, there may come a day when punctuated equilibrium comes full circle and stormwater management experiences atypical policy change. However, until then, only small changes characterize today's progression of stormwater management, following the classic and more common progression of policy.

STORMWATER MANAGEMENT AND LID

Low Impact Development with respect to stormwater management strives to mimic natural hydrologic processes. There are two ways to approach this philosophy. One is a focus mainly on facilities or structural practices such as rain gardens and swales. The Low Impact Development Center (2007) describes this as, "using design techniques that infiltrate, filter, store, evaporate, and detain runoff close to its source." A second approach uses non-structural practices such as site-planning, including curbless streets and cluster development. Both these approaches are viable and, used in concert, can

maximize the goal of LID: on site infiltration and mimicking the natural processes of the area.

It is important to emphasize here that LID is not required federally in any city. Instead, it is one of several tools available to meet water quality standards in regulatory programs of the CWA as well as reduce runoff volume. Although this study did not focus on motives for LID implementation, the application of LID is strongly driven by CWA regulatory programs such as the NPDES and Total Maximum Daily Loads (TMDLs). The Department of Environmental Quality (DEQ) develops TMDLs for water bodies impaired by pollutants such as bacteria and water temperature. A TMDL includes a Water Quality Management Plan (WQMP) describing possible strategies to meet water quality standards. The DEQ provides grants to nonprofits (e.g. watershed councils) and government agencies under the EPA 319 Grant Program to implement these management practices listed in these WQMPs. Recently, DEQ is including LID practices in WQMPs. To qualify, the applicant of the grant must also be in a basin where the 319 program has listed LID as a priority. This creates a funding source for LID. In regards to the NPDES program, Phase I cities, must renew their NPDES MS4 permit in 2010. The current draft of these permits, expected to be approved, includes a requirement for large cities to prioritize and implement LID practices (among other construction approaches) in their post-construction stormwater management programs to the maximum extent possible. (D. Godwin, personal communication, October 8, 2009 and C. Bayham, personal communication Nov. 20, 2009)(Oregon Secretary of State 2009). Though not requirements, these federal policies and guidelines are recent changes intending to support LID and ease implementation.

Stormwater management is not only a water quality issue but a water quantity issue as well. Stormwater management began in response to flooding concerns. However, the more one understands stormwater, the more one realizes how closely the two matters intertwine. Large areas of impervious surface not only contribute to increased runoff volume, but also collect pollutants such as car oils and detergents. Reese (2001) walks through the evolution and perception of stormwater management beginning with the

1800s and provides a synopsis of stormwater management history: 1) Run it in ditches 2) Run it in pipes 3) Run it in stormwater pipes 4) Keep it from stormwater pipes 5) Well, just don't cause flooding, 6) Oh, and don't pollute either 7) It's the ecology, stupid 8) Water is water is watershed and 9) Green and bear it. The history highlights the original intent of conveyance, the gradual shift to water quality concerns, and the merging of the two.

As Reese (2001) discusses, considering ecological functionality greatly increases the number of stakeholders and participants involved in stormwater management. No longer can an engineer simply calculate the needed pipe width for volume control, but rather biologists, ecologists, limnologists etc., all have valuable information to contribute to stormwater policy decisions.

Unfortunately, federal regulations with a hard deadline can cause decisions to be made in haste without bringing all stakeholders to the table, resulting in ineffective projects. That said, smaller cities without looming federal regulations might be at an advantage. "By starting simply, a local government can update its policies to mandate compliance without penalties, before eventually requiring compliance and penalizing those not abiding by stormwater friendly policies" (Bollig 2006: 64).

A shortcoming of the NPDES is that the enforcement of Phase I and II are inconsistent and unreliable, making it difficult to maintain momentum in the adoption of LID because of a lack of incentive. Fortunately, the EPA is recognizing and remedying these shortcomings. On October 15, 2009, the EPA released a Clean Water Act Enforcement Action Plan acknowledging national challenges and the need to improve several aspects of water quality preservation. The plan focuses on three aspects; concentration of enforcement on the largest water quality threats, clarification of acceptable state programs as well as consistency in applying these criteria and approving permits and finally, more reporting on pollution sources for documentation and public education purposes (EPAOECA 2009).

Summary

LID is a new way of approaching stormwater management that fits into “green” thinking. In the broader scheme of sustaining urban ecosystems, stormwater LID practices are only a small part of the puzzle, but may prove to be a very useful one. Large-scale efforts to incorporate LID into landscapes are shared by federal agencies, municipalities, developers and non-governmental organizations. It seems unlikely such practices would be so highly recommended without long-term visions from these promoters. Low Impact Development, though perhaps not ubiquitously used, is likely here to stay as method for meeting federal, state, and local water regulations. To reiterate Larry Coffman’s comment, “There is nothing new about LID, we’ve done it for years” (Coffman 2002: 5). Thus, it doesn’t appear we ever completely abandoned LID but are now looking to strengthen and increase its use.

Research Methods

Methodological APPROACH

I constructed a series of pilot test case studies using interviews focused on stormwater management and low impact development practices with city staff from 18 cities in Western Oregon. Yin (1994) describes a pilot case study as one gathering data and procedural information used to form further refined studies. Because we know little about the finer details complicating LID application in Oregon cities, this study was exploratory. It aimed to gather only two general areas of information: barriers and approaches to LID cities have implemented in the past, are currently implementing or plan to implement. The cases consist of in-depth, interviews with city staff and information characterizing each city using existing archival data.

DATA COLLECTION

I conducted purposive sampling (Robson 264), targeting nine coastal cities and nine inland cities with a variety of population sizes. I also looked for cities with different NPDES federal requirements. Because none of the coastal cities qualify under these requirements, I sought out three Phase I inland cities and three Phase II inland cities. A table of the cities interviewed is found below in Table 1.

Table 1. Characteristics of Case Study Cities.

<i>City</i>	<i>7/1/2008</i>		<i>Location</i>	<i>Governance</i>	<i>NPDES Phase</i>
	<i>% Increase since 2000</i>	<i>Pop. Estimate</i>			
Astoria	2.7	10080	Coast	Council/Manager	
Bay City	10.0	1265	Coast	Mayor/Council	
Brookings	18.1	6465	Coast	Council/Manager	
Corvallis Cottage Grove	11.0	54880	Inland	Mayor/Council	Phase II
Eugene	11.4	9445	Inland	Council/Manager	
Florence	11.5	154620	Inland	Mayor/Council	Phase I
Grants Pass	28.2	9410	Coast	Council/Manager	
Gresham	39.2	32260	Inland	Council/Manager	
Lincoln City	10.8	100655	Inland	Council/Manager	Phase I
Medford	5.3	7875	Coast	Council/Manager	
Newport	20.6	76850	Inland	Mayor/Council	Phase II
North Bend	10.6	10580	Coast	Council/Manager	
Port Orford	3.3	9855	Coast	Council/Manager	
Salem	10.4	1275	Coast	Mayor/Council	
Springfield	12.1	154510	Inland	Council/Manager	Phase I
Tillamook	9.0	58005	Inland	Council/Manager	Phase II
Veneta	7.8	4700	Coast	Council/Manager	
	46.2	4840	Inland	Council/Manager	

I contacted staff from each city via phone, e-mail or both. I explained my research and asked to meet and speak with employees associated with stormwater management such as public works directors, managers, planners, outreach coordinators and any other personnel the city felt would provide insight to my study. I then met in person and interviewed two or more available city employees of various job responsibilities and positions. Titles were not consistent across cities. For example, in one city I met with a planner and public works director. In another city, I met with a manager and water

quality specialist. The goal of speaking with multiple staff members with a variety of responsibilities in one interview was to receive stormwater information from several perspectives. An engineer may find low impact development practices challenging or approachable for very different reasons than a planner, despite both working for the same city under the same regulations, in the same physical setting. All these factors must be understood and addressed for LID implementation to take place. In one interview, only one city employee was available; however a county employee also participated in the discussion. Another interview consisted of meeting in person with one city employee and an individual involved in the city stormwater management but employed by an outside company, in addition to a phone interview with a contracted individual. Another interview was conducted via phone with only one city employee.

Interviews were semi-structured consisting of six broad questions with a series of more specific questions as potential prompts. The protocol was approved by Oregon State University's Institutional Review Board (IRB) and is attached as Appendix A (Informal Interview Questions). At all interviews I took detailed notes and all interviews were recorded (excluding the two phone interviews) with a digital recorder in the case I needed clarification of my notes.

Selection of City Characteristics

Four city characteristics, population, growth rate, geographic location and city governance were selected to examine for each city for the purpose of comparing cities of like characteristics to the barriers and approaches mentioned. I selected city characteristics that were homogenous rather than heterogeneous. Heterogeneous characteristics would need more consistent data within the city, such as density per neighborhood because density could change spatially. Instead, the selected characteristics are ubiquitous throughout the city.

Population

One of several drivers of stormwater management are NPDES permits and NPDES permits are dependent of city size and proximity to larger cities. Thus, when examining city populations, those with larger populations may either already be federally required to

think about stormwater management and LID or foresee this in the near future.

Alternatively, smaller cities will not have these regulations. Comparing population to stormwater management may provide insight to the threshold of when a city begins to consider more organized stormwater systems as well as think about LID practices as a stormwater tool.

Growth Rate

Growth rate can often be incentive for cities to make changes of many varieties including code changes, and different approaches to development. Cities with high growth rates are challenged by tasks such as preparing to serve a larger population in terms of utilities and space. Thus primary concerns and areas of focus would be expected to be different for cities facing rapid growth rates rather than cities growing more slowly. This in turn could effect how a city views stormwater management (high or low priority) and LID fitting into their community, what barriers they might face and what approaches they might take if any.

Location

Physical setting widely effects the management of stormwater and LID practices. A city with areas of porous soils will have different options for LID facilities than a city with areas of clay soils and low infiltration. Similarly, a city with high volumes of precipitation will need to manage larger volumes of water than a city with low volumes of precipitation. There are profound differences in physical setting between coastal Oregon West of the Coastal Range and inland Oregon East of the Coastal Range, but West of the Cascades Range. Considering the location of an area and comparing management strategies may reveal patterns as to how to best implement LID practices on the coast as opposed to inland.

City Governance

The two forms of government found among the cities interviewed in this study include council/manager and mayor/council. The difference between the two can be difficult to decipher even among city staff themselves. Additionally, within these two broader forms of government more specific differences can exist. For this study, I will discuss the two forms of government in a broad sense avoiding the specific differences articulated in the

charter of each individual city. Below I will attempt to articulate the difference between the two.

Council/Manager: A council elected at large or via neighborhood associations, hires a manager to be in charge of managerial tasks and carry out the decisions of the council in terms of policy. The manager usually has more experience and knowledge of laws, codes and processes of how to run a city. The manager can devote his/her time to managerial tasks as well as determining where to best invest time and money. He/she can bring things like stormwater and innovative practices such as LID to the attention of the council. The council can then make the policy decisions based on the educational information the manager has provided.

Mayor/Council: In this governance structure, the mayor does not have much political power. The council is in charge of managerial tasks such as hiring/firing employees and approves the budget. The mayor is an elected council member and volunteer, as are the council members. Thus, a mayor likely does not have the same experience and knowledge of a manager in the council/manager form of government and will carry a learning curve against him/her in terms of learning about stormwater and then bringing it to the attention of the council. The mayor acts mainly as a spokesperson for the council.

Comparing these two forms of government, one with a paid and presumed more knowledgeable manager and the other with a mayor who may or may not be well informed of city laws and managerial tactics, it appears stormwater management and LID would provoke different problems as well as a different toolbox of approaches for cities of each governance.

Population and growth rate data were collected from the Portland Research Center and governance information was collected via phone calls, e-mails and internet research. Geographic location is based on whether a city is West of the Coastal Range (Coastal) or East (Inland).

DATA ANALYSIS

After completing the interviews, I transcribed the notes and additional information obtained from the recordings. I then coded the notes, noting themes of barriers and challenges cities faced toward LID implementation and approaches they were taking (if any) toward LID implementation. When coding transcripts, the interest is in the meaning contained in phrases, sentences, and even whole paragraphs. The code describes this meaning and can be simple or complex (Miles and Huberman 1994). As an example from this study, all comments relating to community resistance, such as safety concerns and aesthetic concerns the city had heard from residents were coded as *community resistance*. Fourteen barriers and nine approaches were identified through this categorization. Every time a city mentioned a specific theme it was tallied. If a city mentioned the same theme twice in a different context, it was only tallied once. Sub-themes were also created and used to code some of the more common code themes or those of interest. This created a more detailed description of the examined barriers and approaches. If a city mentioned the same main code theme twice in a different context, the two different contexts were tallied here. For example, Table 2 below describes some of the main barriers reported by respondents. Table 3 describes how the community resistance code was further broken into sub-themes.

Table 2. *LID Barriers Described by Respondents (partial list)*

<i>Barriers / City</i>	<i>Community Resistance</i>	<i>Conflicting Needs/Wants</i>	<i>Discouraging Information</i>	<i>Lack of Knowledge (City)</i>
Bay City				X
Port Orford				X
Tillamook	X	X		
Veneta		X		X
Brookings	X		X	X
Lincoln City	X	X		

Table 3. Community Resistance Concerns Described by Respondents (partial list)

	<i>Aesthetics</i>	<i>Blocking Development</i>	<i>Cost</i>	<i>Flies/ Mosquitoes</i>	<i>Homebuilder Accountability</i>	<i>Lifestyle</i>
Astoria						
Bay City						
Brookings	X			X		X
Corvallis						
Cottage Grove						X
Eugene						
Florence						X
Grants Pass						X
Gresham	X	X				
Lincoln City						
Medford		X				X
Newport						

I then examined the data in the context of four city characteristics (city population, growth rate from 2000 to 2008, geographic location and city governance). However, before this, I looked for relationships between the characteristics using the Spearman rank correlation among each of the four characteristics, two by two (for methods see Brase and Brase 2006). I ranked each city in ascending order for population and growth rate. For the characteristic *location*, coastal cities received a “1” and inland cities received a “2”. For the characteristics, *city governance*, council/manager cities received a “1” and mayor/council cities received a “2”. For the characteristics *NPDES Phase*, cities with no phase receives a “1”, cities in phase I received a “2” and cities in phase II received a “3”.

I then created four separate tables arranging cities by these characteristics and the primary themes to reveal patterns. These Tables can be seen in Appendix B (Full Barriers Matrix) and C (Full Approaches Matrix). This was done to elucidate any common barriers or approaches similar cities might be facing and using, and therefore provide a

resource to other, similar cities. Cities were divided into two categories for each characteristic. For the characteristic *population*, a low populated city is below 10,000 and a high populated city is above 10,000. For the characteristic, *growth rate*, a natural break was used to divide between low and high growth rate and thus, a low growth rate city is considered to be below 13% and a high growth rate city is considered to be above 13%. For the characteristic *location*, those cities located on the coast are labeled as coastal and those cities located inland are labeled inland. For the characteristic *city governance*, those cities described as council/manager in the city charter or via contact with city staff, are labeled council/manager and those cities described as mayor/council in the city charter or via contact with city staff are labeled mayor/council. I then identified which city group (large/small, high/low, coastal/inland, council/manager, mayor/council), mentioned a barrier or approach most often. For this I used percentages. For example, four of nine low population cities mention the barrier *collaboration within the city*. One of nine high population cities mentions the barrier *collaboration within the city*. Thus, 44% of low population cities mention the barrier *collaboration within the city* while only 11% of high population cities mention the barrier *collaboration within the city*. I then conclude that low population cities mention the barrier *collaboration within the city*, more than cities with a high population. This was done for each barrier and approach.

Finally, to investigate what might be innately prohibitive within LID practices themselves, I related the coded data to Rogers' innovation characteristics (Rogers 1983). Using quotes from the interviews that spoke of the difficulties or approaches of LID adoption and supported each of the five innovation characteristics, I examined how rapidly and easily LID could be adopted.

Hypothesis

SUMMARY OF RANK CORRELATION

Before proceeding to my hypotheses, it is necessary to briefly summarize the results of Spearman's rank correlation as these results helped group cities and allows them to be discussed together or related to one another. The results are discussed more in detail in the results section. In this analysis NPDES Phase was included to provide insight towards

regulatory incentive, although it is not included in main four characteristics. Four pairs of characteristics result as positively correlated at a 5% significance level: 1) Population and Location (higher populations tend to be inland), 2) Population and NPDES Phase (higher population tend to be higher Phase cities), 3) NPDES Phase and Location (higher phase cities tend to be inland), and 4) NPDES Phase and Governance (higher phase cities tend to be mayor/council cities).

Hypotheses

Having established correlations among the city characteristics in order to identify how cities might relate to one another, I will now examine the cities based on their characteristics and what I hypothesize these cities will express in terms of barriers and approaches toward LID. I will preface this with the caution that these hypotheses are my personal educated ideas and speculations and I recognize they are based on many assumptions.

Population

In regards to population, stormwater management and LID, I expect to see larger populations mentioning more barriers as well as more approaches. I believe this because a larger city is likely to be more advanced in stormwater management than a smaller city, thus having a piping system and perhaps experiencing capacity or age issues with this system. A large city will have little room to grow and retrofitting areas to incorporate LID is a difficult and costly task. However, at the same time, a large city generally has more capacity (money and resources) than a smaller city and thus the ability to embark on pilot projects using LID or coordinate education and outreach to residents.

Additionally, a larger city may see more of a demand for LID than a smaller city because it is a tool which can be used to meet federal NPDES permit requirements applying to larger cities, rather than small. And finally, a study conducted by Damanpour and Schneider (2009) examining innovation characteristics and innovation adoption rates in organizations suggest that larger populated cities consist of complex environments that could encourage and more rapidly adopt innovative practices.

More specifically, I expect to see larger cities voice more concerns with barriers such as maintenance, making stormwater matter to residents, and previous systems than smaller cities. One method of maintenance is to ask residents to maintain LID facilities adjacent to their property. This can be appealing because the resident receives an aesthetic addition to their property, but can also be difficult to ensure a resident will follow through with maintenance responsibilities. In a larger city it would be more difficult to ensure owners are maintaining LID facilities than a smaller city, as there would be more ground to cover. Additionally, less residential areas or areas with apartments, would make it difficult to determine who is in fact in charge of the facility. Making stormwater matter to a community may be more difficult in a larger cities rather than small cities not only because of the diversity within a larger city, but also because of the assumption that larger city residents are less connected with their immediate environment than residents from a smaller city. They may be environmentally conscious and active in the outside world, but it is difficult to see stormwater in a largely paved and built up city. I see the barrier of previous systems as more likely in larger cities than smaller cities because their size has demanded a stormwater system to already exist. Retrofitting is a costly task as well as one that requires innovation and time to plan.

I expect smaller cities to mention barriers such as a lack of resources and prohibitive regulations. A smaller city, rather than a larger city, likely has less staff and resources available to them. Additionally, as mentioned above, there is a correlation between population and location, thus, not only do I hypothesize these smaller cities have less resources simply because of their capacity, they are also limited by their geographic location which is further from larger cities which hold much of the resources these smaller cities need. Smaller cities lack examples of how to change or create new city codes making LID practices easier to implement. They may also have less ability or knowledge to work around broader regional or national regulations. Thus, I hypothesize they will express regulations as a barrier more often than larger cities.

With respect to approaches to stormwater management and LID I expect to see larger cities, rather than smaller cities, more commonly using approaches such as collaborating

with organizations outside of the city, educating the community, approaching methods to fund stormwater, acquire information about LID, make stormwater and LID matter to the community and adjust regulation to make LID implementation more streamline and easier. In a larger city, I assume there will be more connections with other organizations because of more involvement in regional planning or regulations. Thus a larger city would tend to collaborate more with other organizations rather than a small one. A larger city would also have more capacity to educate residents than a small city and thus could use this approach more often and effectively. In respect to funding, a larger city would have more capacity than a small city and perhaps opportunities to apply for grants to fund stormwater projects. Larger cities would also have more reason and authority to implement a stormwater fee from residents because the stormwater service is more obvious to residents in a city than a rural town. I expect a larger city to more actively acquire information than a small city because they have the capacity and more interest and need to learn about LID. As mentioned earlier many larger cities face NPDES permit requirements and LID is one of many methods to meet these federal requirements. Similar to education, I hypothesize a larger city will mention making stormwater matter to resident more often than smaller cities, because they have staff, time and money to generate ideas and follow through with educational projects. There are several code examples showing how to change existing codes or create new codes which make LID implementation easier for developers and the city itself, thus, I expect larger, rather than smaller cities to mention regulation adjustments more often.

For smaller cities, on the other hand, I expect to see more approaches such as collaborating within the city and management adjustments. I believe a smaller city will have a more closely knit staff and thus more open communication and transparency. When planning for LID practices, they can more easily see the entire process from start to finish and discuss concerns, issues and barriers for different departments. Again, because of the small size of the city, I also expect management adjustments to be easier and more flexible because of the closer knit and smaller community than in larger cities, where management structure is perhaps more established.

Barriers and approaches I have not mentioned I believe either do not necessarily apply to the city characteristic, or are likely to be similar among cities both large and small. Barriers of these sort include a lack of knowledge within the community, which depends more likely on the population composition and perhaps education, money, a barrier faced by almost any organization or city, physical setting, a common perceived barrier when a city feels their slopes are too steep, soils too porous or not porous enough and precipitation is either too much, too little, too light and consistent, or too intense, and risk, a barrier all cities face when adopting an innovative practice that has been minimally tested. The approach, LID initiation, which was not mentioned, requires more extensive explanation because of the nature of the approach. In this approach, cities can either initiate LID actively from within the city, or passively via a developer, proposing to include LID facilities in a site plan. Generally, I hypothesize cities with larger populations will be mentioned either of these initiation processes more than cities with smaller populations because of a need for stormwater management consideration both because the city sees a need for it, and/or because there is pressure from federal regulations. Specifically, I expect that cities with a larger population will voice both methods of LID introduction equally because they not only have the resources of several developers who are familiar with the inland physical setting but also the self starting capacity, resources, interest and because larger cities are those with NPDES permit requirements, they also have a federal regulation drive to start LID practices. I expect smaller cities, also likely to be located on the coast, to initiate LID practices themselves more so than larger cities because developers generally come from inland areas and are not as familiar with the landscape on the coast. Additionally, they likely have fewer developers interested in their small city and potentially smaller projects. Nor do they necessarily have the capacity or funding to select a developer knowledgeable in LID (assuming an LID developer is more costly).

Growth Rate

Growth rate can have a significant impact on management decisions of a city. In a time of great growth there is a concern for capacity and future implications. Thus codes may be changed reflecting growth concerns. Alternatively, in a time of low growth other management adjustments perfecting the system might be performed. Generally, I hypothesize that a city with a high growth rate will express more barriers toward

stormwater management and LID than a city with a low growth rate because they will have less time to focus on learning a new tool, instead focusing on building new lots, modifying codes and preparing for the growth. However, I also expect a city with a high growth rate to express more approaches toward stormwater management and LID than a small city because the city may recognize the benefits of incorporating LID into new developments, which is easier than retrofitting. Much of the following hypotheses are based on the concept and assumption that a rapidly growing city has less time and resources to focus on tasks other than preparing for growth. Additionally, I do not expect a large difference in the number of barriers or approaches voiced by high and low growth rate cities because Damanpour and Schneider (2009) find in their study, contrary to previous studies, that population growth does not affect innovation adoption.

Specifically, I hypothesize cities with a higher growth rate will more often mention conflicting needs and wants, a lack of resources to implement LID, a concern for maintenance and the barrier of a previous system. A higher growth rate is more likely experiencing more development and thus bringing concerns from residents, developers and city government to the forefront. This is apt to cause conflict of many varieties. A city struggling to meet the immediate demands of growth, rather than a slow growing city, will likely have had less time to acquire resources regarding LID. Maintenance would be more of a concern for a faster growing city because they will be unsure how they will maintain new LID facilities in addition to the maintenance jobs they already have. Similarly, they may not know the incoming population character and whether or not this population will be receptive to maintaining LID facilities themselves. Finally, it may be more difficult to make stormwater and LID matter to a city population when the population is constantly growing at a rapid pace. Not only is the city preoccupied with a high growth rate, but also facing community resistance in many more forms due to an increase in population.

Alternatively, I hypothesize cities with a lower growth rate will more often voice barriers of community resistance, previous systems and regulations. Community resistance towards LID may be more prevalent in an area of slow growth because of a perception

that LID may inhibit growth. I expect cities with higher growth rates to mention the barrier of a previous system more often than cities with a slower growth rate because a slow growing city does not have as much new development in which to incorporate LID facilities and retrofitting an already existing system is, as mentioned before, costly and time consuming. Regulations may also be more of a barrier, because of less incentive to change or work towards new city codes and regulations. Often it is a higher growth rate that inspires changes in this area out of a need to prepare for new development and a larger population.

When considering approaches and growth rate, I hypothesize that cities with higher growth rates will more often mention approaches such as collaborating within the city personnel, searching for funding, and adjusting management arrangements and regulations. A city with rapid growth will be preparing for this in many ways, rather than a city, which does not foresee growth. All departments of city staff will be working to adjust to this rapid growth and thus this may encourage more collaboration within the city. A concern for adequate funds to support a larger city, could encourage a city to apply for more grants or consider residential fees (one time or user fees), thus a general search for funding could include funding for LID projects. Management and regulation adjustments are also likely to change in favor of LID in a city of rapid, vs. slower growth. This is because changes are more likely to be made during growth periods and because of the tedious, time consuming process of code revisions or creation, it is often a good idea to change several at once, one or more of these codes could be changed to ease the implementation of LID practices.

I would expect cities with slower growth rates to more often voice approaches such as collaborating out of the city with other organizations, providing education to the community about stormwater and LID, seeing to learn information about LID and stormwater management and attempting to make stormwater matter to the community. With less of a need to focus on rapid growth, a slower growing city can use this time to establish contacts and relationships with outside organizations. Similarly, they can use the time and existing resources to educate the community through presentations, pilot

projects, etc. This follows closely with making stormwater matter to the community. It is resource intensive process to generate effect ways in which to make stormwater matter. Again, acquiring information about stormwater management and new tools such as LID is more apt to be an approach taken by a city less preoccupied with rapid growth than a city growing rapidly.

Barriers and approaches I have not mentioned I believe either do not necessarily apply to the city characteristic, or are likely to be similar among cities both growing rapidly and slowly. Barriers of this sort include discouraging information which does not logically apply to growth rate, lack of knowledge within the city and within in the community, which depends more on the amount of people within the city and their education, and finally money, physical setting and risk, which as described in the population characteristic, applies widely to cities. Again, the approach, LID initiation, which was not mentioned, requires more extensive explanation because of the nature of the approach. Generally, I hypothesize cities with higher growth rates will be mention either of these initiation processes more than cities with smaller populations, simply because growth demands consideration of old and future service systems such as water delivery and stormwater management. Specifically, I expect cities with higher growth rates will take their own initiative to implement LID more so than cities with lower growth rates because a rapidly growing city has more new opportunities to install LID facilities in new developments, rather than a slowly growing city, which has little opportunity to incorporate LID from the start. Yet at the same time, I expect rapidly growing cities to also use developers more than slower growing cities for the same reasons mentioned above.

Geographic Location

In respect to a city's geographic location I hypothesize that generally, coastal cities will voice more barriers. Coastal cities are correlated with small city population sizes suggesting they have less capacity in terms of designating staff and time to stormwater management and learning about LID. Additionally, because they are spatially removed from larger cities with more information and resources, they are disadvantaged when looking to gain knowledge both as a city organization and within the community.

Following this, I predict it will be the inland cities with more approaches than coastal cities to remedy barriers they have encountered in order to meet regulations and also because they likely have more resources and capacity to experiment with different approaches.

In particular, I expect to see coastal cities voice barriers such as community resistance, a lack of knowledge within the city personnel and within the community, and a lack of resources. Coastal cities, correlated with a small population, are, generally speaking, more rural. Rural cities often resist change, complacent with their small town feel. This along with a lack of understanding stormwater management because it is likely less prevalent or established in smaller cities, would cause a higher level of community resistance than in an inland city with a larger population. As just mentioned, coastal cities also likely have less of a knowledge base in stormwater management both as a city government and community. They are smaller in population size and also physically separated from larger cities and access to resources, a lack of resources is also an expected concern most often coming from coastal cities.

Barriers I expect to see more often from inland cities, rather than coastal cities include conflicting needs and wants, barriers from previous systems, and regulations. These barriers exist mainly because of the correlation between inland cities and high population sizes. Because inland cities are more developed and may be further along in understanding stormwater management and LID, they may have recognized barriers that arise further in a project process and thus see conflicts between city goals and also among the community. Also, because inland cities likely already have an extensive stormwater system, a previous system may inhibit the adoption of LID practices. Regulations may also be more complicated or difficult to adjust in a city with a larger population (inland cities) than a smaller (coastal city).

Common approaches for geographic location are, again, commonly associated with city population size and thus will look similar to this section under *population*. However there are a couple approaches more specific to geographic location. I expect coastal cities will

mention approaches such as collaboration within the city staff, making stormwater matter to the community and management adjustments. Coastal cities tend to be smaller in population and thus, the smaller city staff needed to manage a city will allow for easier and perhaps more of a need for collaboration within the city. Coastal cities are more likely to use their water resources (ocean) for recreation and more importantly for economic gain. Thus, it is easier to make stormwater and LID matter to a coastal community rather than an inland community, which might be more detached from the benefits of their water resources. Finally, as expected from cities with smaller populations, management adjustments are perhaps easier with less city staff and smaller departments that are more flexible.

Inland cities, on the other hand, I expect will more often mention approaches such as collaboration with outside organizations, community education, funding, information acquisition, and regulation adjustments. The correlation between inland cities and a higher population supports my hypotheses for collaboration outside of the city, as a larger city will likely have more connections and relations. However, simply being closer to other larger cities geographically is also a benefit easing communication. Population also plays a role in my hypotheses for community education, funding, information acquisition and regulation adjustment. Larger (and inland) cities can more capacity to use many of these approaches, as well as there are more examples of larger cities using these examples from which inland cities can learn.

Barriers I have not mentioned I believe either do not necessarily apply to the city characteristic, or are likely to be similar among cities both inland and coastal. Barriers of this sort include the commonly mentioned money and physical setting and risk. Discouraging information is also not mentioned, because I see this as more a product of personal experiences than coastal or inland location. Maintenance could be correlated to population size, however, it seems both coastal and inland areas would be concerned with how to maintain LID facilities as they both have high concerns with their physical setting. And finally, the challenge of making it matter, though maybe a more prevalent approach for coastal cities that may depend more strongly on their water resources for

economic stability, is still a prevalent issue in inland cities, whose communities might be more detached from water resources, thus difficult to distinguish to whom the barrier applies to more. The unmentioned LID initiation approach, I expect is more commonly voiced by inland cities simply because they are within reach of various resources and educational opportunities making LID better known to inland cities than coastal cities. Specifically, I hypothesize coastal cities will mention LID initiation from within the city more so than from developers because coastal cities are farther from larger inland developments and thus, developers knowledgeable in LID and even more so from developers knowledge in LID practices applicable to coastal environments. I expect inland cities to use developers for LID implementation more often than coastal cities because developers are generally based in the inland regions and thus know more about the physical setting and how LID applies to this area. Thus coastal cities would be wary to hire inland developers and inland developers would find it difficult to work in coastal environment.

City Governance

The difference between the two forms of government, council/manager and mayor/council are very subtle, however, I expect those cities with a mayor council form or government to express more barriers than those cities with council/manager, mainly because of the knowledge a manager brings to a city and hopefully uses to overcome barriers, real or perceived. I also expect to see cities with council/manager governance mention more approaches for the same reason. A hired individual will presumably have more background in management and experience, where a mayor is more likely to be a community member and may or may not have the knowledge base to move forward in stormwater management and LID.

Specific barriers I see more commonly mentioned by council/manager governments rather than mayor/council include, conflicting needs and wants, and regulations. I expect a hired manager will have a better understanding of the workings and needs of a city and thus may see the potential conflicts between department goals and communities. Similarly, because an experienced manager has a better managerial understanding and

experience he or she may have knowledge regarding how to work around or reinterpret current regulations so they are not as impeding.

On the other hand, I see mayor/council forms of government more commonly mentioning barriers such as community resistance, a lack of knowledge within the city staff, a lack of resources, a concern for maintenance and unease over the extent of risk. Because a manager brings a wealth of information and skills to a city rather than a mayor and council, which are elected from within the community, there may be less trust in the introduction of a new practice when few government personnel have experience with the practice. This lack of managerial experience and knowledge in a mayor/council, governed city may also lead to a lack of knowledge within the government. The same concept applies to the other barriers. It is mainly the assumption of a lack of knowledge and experience within the government that leads to the belief within the city staff that the city faces more barriers. This belief may be very real, or just a misunderstanding and misperception because of a lack of knowledge. Mayors and/or councils may have less connections or knowledge of resources, where a manager may have been trained with a degree or attended workshops that have provided him or her with a wealth of resources. Mayors and/or councils may not be knowledgeable enough about stormwater and LID to know what kinds of maintenance are involved, or methods in which to implement them. Similarly, this lack of knowledge may create a feeling of more risk when considering an innovative practice such as LID for mayor/council governments, than council/manager governments.

Approaches, I would expect to be more often mentioned by council/manager governments than mayor/council include collaborating with organizations outside of the city, educating the community, finding funding sources for stormwater and LID, acquisition of information relating to LID, and making adjustments within management and regulations. Again, most of these hypotheses are based on the assumption a manager will have more knowledge and experience to promote stormwater management and LID. By simply bringing the issue to the table and providing a background as well as some

possible action plans, council/manager cities will have many more methods of approach. Because this is so consistent I will refrain from elaborating more in this section.

The only approach I expect to see a mayor/council government using more commonly than a council/manager is collaboration within the city. I expect this because a mayor is usually a part of the community, as are council members, thus collaboration is more likely to remain in house rather than explore outside organizations because there are likely less connections to other organizations or how to establish relationships of this sort without an experienced person (such as a manager).

Barriers I have not mentioned I believe either do not necessarily apply to the city characteristic, or are likely to be similar among cities managed by both council/manager and mayor/council forms of government. Barriers of this sort include discouraging information, which I believe to be based more on personal experiences, lack of knowledge within the community, based on community composition either in terms of education or environmental awareness, making stormwater and LID matter, again based more on how a community connects to its environment, the almost ubiquitous money and physical setting barriers as well as previous systems which I would expect to be based more on the infrastructure of the city rather than governance. The approach LID initiation is again unmentioned because of the need for more clarity. I expect, generally, that council/manager cities will mention LID initiation of either type more so than mayor/council cities because a manager brings a wealth of knowledge about city structure that a mayor may not be able to offer. Thus stormwater and LID practices are more apt to be recognized and discussed. Specifically, I hypothesize cities with council/manager forms of governance will take city initiative to implement LID practices because of the above-mentioned reasons. I believe cities with mayor/council forms of government will more commonly voice LID introduction via developers simply because the developer can be used to educate the city staff of these projects as well as create visuals for the public. Both tasks that require more administrative work not as present in a mayor/council government as in a council/manager government.

Results

SPEARMAN RANK CORRELATION

The results of the Spearman rank correlation show four correlations among the five compared characteristics (Table 4).

Table 4. *Correlation Matrix of Spearman rank correlation. Bold numbers represent those which have a 5% level of significance.*

	Growth Rate	Population	Location	City Governance	NPDES Phase
Growth Rate	1.000				
Population	0.193	1.000			
Location	0.468	0.628	1.000		
City Governance	0.245	0.226	0.207	1.000	
NPDES Phase	0.269	0.793	0.677	0.601	1.000

Among the city characteristics there are four correlations significant at a 5% level. In this section of analysis NPDES phase is included to help show an additional relationship. It should be recognized that NPDES phase is reflective of population size, but can also be reflective of proximity to a larger city. Using the non-parametric Spearman's Rank Correlation the data show a positive correlation of 0.628 between population and location, a positive correlation of 0.793 between population and NPDES phase, a positive correlation of 0.677 between location and NPDES phase, and a positive correlation of 0.601 between governance and NPDES phase. If we accept these correlations are correct, we can make the following assumptions; cities with NPDES permit requirements are also likely to have larger populations, be located inland and practice the Mayor/Council form of government. These cities can be expected to voice similar barrier and approaches toward stormwater management and LID. Additionally, we can assume cities with larger populations are also located inland and will also voice similar barrier and approaches toward stormwater management and LID.

CODED themes OF Approaches AND barriers

This study reports some barriers similar to those found in previous studies including financial barriers, and a lack of understanding LID practices and techniques within a city's specified environment. In addition, this study reports barriers not discussed at length in the literature and highlights the unique assortment of barriers each city faces. For example one city mentions *money, physical setting, previous system and regulations* all as barriers to create a unique combination. Alternatively, a second city mentions *community resistance, discouraging information, a lack of resources, maintenance and physical setting* to create its own unique combination. No two cities share the same set of barriers.

The results of this study report the top three mentioned approaches which cities have taken, are taking or plan to take toward LID implementation as *regulation adjustments* (eighteen cities), *management approaches* (seventeen cities), and *information acquisition* (sixteen cities). However, several other approaches follow close behind in ranking. Three cities are documented as following all nine approaches, while five cities report the same combination of eight approaches. The remaining cities all mention fewer than eight approaches with no two cities having the same unique combination of approaches. In the two groups of cities that share identical approaches there is no obvious connection between geographic location, city governance population size or growth rate.

Table 5 displays all the *barrier* themes and summarizes the barriers each city mentioned in their respective interviews. Table 6 displays all the *approach* themes and summarizes the approaches each city mentioned in their respective interviews. Cities are organized in ascending order of the number of barriers they mentioned. In Table 6, the two groups sharing identical combinations of approaches are highlighted in a lighter and darker shade of gray. Code themes are described and exemplified in the following sections: *LID Barriers* and *LID Approaches*. A more complete list of comments recorded under certain code themes are listed in Appendix D (Code themes and subcategories).

Table 5. Barriers to LID. Cities are in ascending order by number of barriers mentioned from left to right.

<i>Barriers/ City</i>	<i>Astoria</i>	<i>Bay City</i>	<i>Port Orford</i>	<i>North Bend</i>	<i>Tillamook</i>	<i>Veneta</i>	<i>Lincoln City</i>	<i>Florence</i>	<i>Corvallis</i>	<i>Cottage Grove</i>	<i>Springfield</i>	<i>Brookings</i>	<i>Newport</i>	<i>Eugene</i>	<i>Medford</i>	<i>Gresham</i>	<i>Salem</i>	<i>Grants Pass</i>	TOTAL
Community Resistance				X	X		X	X		X	X	X	X		X	X	X	X	12
Conflicting Needs/Wants					X	X	X				X			X				X	6
Discouraging Information				X								X			X			X	4
Lack of Knowledge (City)		X	X			X		X		X		X	X	X	X	X	X	X	12
Lack of Knowledge (Community)					X					X					X		X	X	5
Lack of Resources		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	17
Maintenance				X		X	X	X	X		X		X			X	X	X	10
Making it Matter			X											X			X	X	4
Money	X	X				X			X	X	X	X	X	X	X	X	X	X	13
Physical Setting	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	18
Previous System	X	X											X						3
Regulations	X	X			X		X	X	X	X	X	X	X	X	X	X	X	X	15
Risk									X			X				X	X	X	5
Other														X	X	X			3
TOTAL	4	5	5	5	6	6	6	6	6	7	7	8	8	8	9	9	10	12	127

Table 6. Approaches to LID. Cities are in ascending order of number of approaches from left to right. The shaded cities represent the groups sharing an identical combination of approaches.

Approaches / City	Veneta	Astoria	Tillamook	Corvallis	Bay City	Port Orford	Springfield	Cottage Grove	Medford	Salem	Brookings	Eugene	Gresham	Lincoln City	Newport	Florence	Granis Pass	North Bend	TOTAL
Collaborate (Out of City)				X	X	X	X	X	X		X	X	X	X	X	X	X	X	14
Collaborate (W/in City)					X	X										X	X	X	5
Education (Community)				X	X				X	X	X	X	X	X	X	X	X	X	12
Funding		X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	15
Information Acquisition		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	16
LID Initiation			X				X	X	X	X	X	X	X	X	X	X	X	X	13
Make it Matter						X		X		X	X	X	X	X	X	X	X	X	11
Management	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	17
Regulation Adjustments	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	18
TOTAL	2	4	4	5	6	6	6	7	7	7	8	8	8	8	8	9	9	9	121

LID BARRIERS

Of the fourteen categorized themes of barriers mentioned in the interviews, half were mentioned by most of the cities (Table 5).

Commonly mentioned barriers include *physical setting*, *community resistance*, *a lack of knowledge*, *a lack of resources*, *how to approach maintenance* or a concern for how tedious LID maintenance may be, and *money* (financial concerns). *Community resistance* is characterized by comments reflecting a mixture of safety concerns, aesthetics and development, but dominated by a reluctance to change lifestyles. *A lack of knowledge within the city* includes comments concerning a lack of information about LID as well as

a lack of knowledge of a city's own resources and attributes such as stream locations and soil types. *Money* or financial concerns refer to the belief that LID costs more, or simply a lack of funds, and restrictive or conflicting *regulations* are regulations that are unclear, or contradictory to perceived needs for LID (such as conflict between street width and the space required for LID practices).

Many of the above mentioned barriers have been identified in earlier studies. *Physical setting* barriers, such as soils, slopes, climate, etc., mentioned by all eighteen cities have been acknowledged by Huntsinger and Graybill (2007) and EPANE (2009). In addition, Huntsinger and Graybill (2007), Hager (1993), Godwin (2008), Coffman (2002) and EPANE (2009) all recognize the *money* concerns mentioned by thirteen cities. Huntsinger and Graybill (2007) and Hager (1993) also recognize *maintenance* barriers, cited by ten cities. *Community resistance* is also cited by Huntsinger and Graybill (2007).

Furthermore, a *lack of resources* such as staff and staff time and technologies is mentioned by seventeen cities. Godwin (2008) is addressing the need for technologies through projects such as SWAMP (OSU Extension 2009). *Regulations* are a frequently mentioned barrier (fifteen cities). These are identified by Huntsinger and Graybill (2007), NAHB (2003), EPANE (2009) and Coffman (2002), and much is being done to remedy this both within cities and federally. Breaking the theme into subcategories reveals a more detailed account. Table 7 describes specific concerns with regulations.

Table 7. Subcategories of the Regulation Barrier. Cities are listed in alphabetical order.

	<i>City Inhibitors</i>	<i>Conflict</i>	<i>Equity</i>	<i>Gov. Ambiguity</i>	<i>Gov. Inhibitors</i>	<i>Lack of City Code Clarity</i>	<i>Lack of Incentives/enforcement from City</i>	<i>Unsure of Reg. Creation</i>	TOTAL
Astoria									0
Bay City									0
Brookings			X		X		X		3
Corvallis	X	X							2
Cottage Grove				X					1
Eugene							X	X	2
Florence	X				X				2
Grants Pass	X	X		X					3
Gresham			X						1
Lincoln City	X					X			2
Medford		X						X	2
Newport		X		X					2
North Bend									0
Port Orford									0
Salem								X	1
Springfield						X			1
Tillamook		X							1
Veneta									0
TOTAL	4	5	2	3	2	2	2	3	23

Concerns about specific regulatory barriers are widely dispersed among the cities. Three cities spoke of a lack of clear standards from the government and inconsistent enforcement (*government ambiguity*). One inland city elaborates that because they were not labeled as a Phase II city (due to a lack of federal money and staff to enforce the regulation), the city lost momentum in adopting LID practices. Another coastal city notes how they do not receive much oversight or assistance from the state with regard to stormwater. In many cases the city is not even made aware of new regulations that apply to them. On the other hand, they also do not experience a lot of interference from the state, which can be an advantage. Interview participants compare these relaxed policies to

those of wastewater regulations (which were viewed as effective). Wastewater planning and construction requires detailed applications for new development, these applications are carefully reviewed and a fee is required to proceed with the plan. With this more streamlined process lacking in stormwater regulation, it is no surprise the city voices a lack of help from federal agencies when pursuing LID implementation.

Several barriers were infrequently mentioned but may offer insight to advancing LID adoption. These infrequently mentioned but valuable barriers are discussed below.

The category, *conflicting needs and wants*, includes comments about a divided community. One inland city representative comments, “some people won't pay a penny, others strap themselves to trees”. Conflicting needs also surface with different requirements for county and city design storms² and different goals among developers, engineers, irrigators and other parties. Additionally, an inland city mentions conflicts between different environmental goals; paved surfaces cut back on dust and air pollution, but decrease water quality. The same city mentions conflicting goods such as sidewalks and bioswales. Both are good. Which do you sacrifice?

Difficulty in making it matter is a barrier four cities mention, as they are finding it difficult to generate ideas for methods to make LID matter to the community. This can range from finding venues and audiences to make presentations for education, to creating incentives to which the community will be receptive when adopting this new model of stormwater management.

Risk is of course a concern for all innovative practices including LID. Five cities mention risk of various sorts ranging from apprehension for effectiveness, to community backlash, to groundwater concerns.

² A design storm is defined by the city of Portland Oregon (2008) as “design criteria used for sizing stormwater management facilities and their conveyance. Design storms are a combination of the design storm return period (which refers to the frequency) and the storm duration (which defines the rainfall depth or intensity)”.

The following are barriers infrequently mentioned or narrow in focus.

A few cities mention they were either turned away from LID practices or setback because of *discouraging information* or experiences. After an assessment of a traditional stormwater system vs. one with LID practices, an inland city concluded a LID system would be equally as costly and offer little in terms of capacity. Only the water quality infrastructure would change. This presents LID as minimally beneficial. Another coastal city recalled a bad experience with pervious pavement and is now reluctant to incorporate it into site plans.

A second uncommon barrier was one of limitations of LID as a result of a *previous system*. Two cities mention how separating the sewer and stormwater system drained much of their time and money, which could be put towards LID. Another coastal city mentions several buried drainageways causing building and drainage problems when looking to implement LID.

A third barrier, *lack of knowledge within the community*, is mentioned by five cities. It is characterized by a lack of understanding why LID is an alternative for water quality protection and flooding prevention as well as citizens who are unfamiliar city codes. Two inland cities mentioned that citizens believed there was a code preventing them from disconnecting their downspout when this was not the case. A *lack of knowledge within the community* is a previously well-recognized barrier being addressed through education programs and workshops throughout the state.

Finally, comments not fitting in any of the other themes were coded *other*. These included miscellaneous comments from four cities.

LID APPROACHES

The interviews reveal several stages of LID adoption and therefore different adoption processes. When summarized, nine main coded approach themes emerged as shown in Table 6. These approaches are already implemented, are in the process of implementation, or are a desired strategy and plan for the future. All but one,

collaboration within the city were used by more than half of the eighteen cities.

Examining the subcategories of the eight popular approaches tells a more detailed story. Like the barriers, some of the approaches are well known or understood while others are potentially more innovative.

Fourteen cities *collaborate with other organizations out of the city* to advance LID. The most popular organizations are state and local organizations, an interesting balance between top-down and bottom-up projects. In some cases, ODOT has worked with the city to create LID features within their jurisdiction, which could impact adjacent cities. In other cases school groups are improving and monitoring water quality within the city providing valuable information for the city.

In twelve cities, public outreach and *education of the community* is a prevalent approach. The most popular educational tool cited by ten cities (both small and large populations) is an example project. Though this study cannot comment on the effectiveness of approaches, it is interesting to note that example projects are both a costly and time consumptive approach compared to the use of newspaper or newsletter distribution with information about stormwater and LID. Newspaper or newsletter distribution is only used in five cities compared to the ten citations of example projects.

Pursuing *funding* was mentioned by fifteen cities with grants and community fees being the most popular sources. Only two cities mentioned federal money and almost all cities mentioned more than one source of funding with two cities mentioning four or five.

A seemingly obvious mechanism of approaching LID is *acquiring information* and sixteen cities mention this. Other cities and counties are the most popular sources of information, and only two cities cite state agencies as information sources.

Throughout the interviews it was interesting to observe many cities actively pursuing LID implementation, while other cities saw little need and were allowing the transition to occur through projects proposed by developers. This theme is labeled *LID initiation*. The

data show eight cities actively progressing toward LID and seven dependent on developers. Two cities mention both these forms of introduction. While it may be suggested that coastal cities would have fewer developers suggesting LID practices and therefore city governments would be required to initiate the transition, there is no notable distinction between coastal cities and inland cities in the manner they approach LID implementation.

Eleven cities mention they are trying to *make it* (stormwater and LID) *matter* more to the community to reveal its importance and significance. Seven cities achieve this or plan to achieve this through regulations. Other methods to *make it matter* include emphasizing aesthetics, environmental incentives and water conservation. For each of these approaches, only one city uses each respective technique. Two other interesting strategies, publicizing water information and recognition for poor or positive water use are also infrequently cited. Respondents deem publicizing water information quite effective. One city, which began publishing water losses or pipe patches, explained that these publications simply got people thinking about water. Another city noted publishing poor water quality areas as bad for the economy because tourists no longer had an interest in vacationing there. Recognition for practices such as downspout disconnection is in future plans for two cities, and one coastal city has already begun a “yard of the month” program.

All but one city mention *management* techniques as an LID approach. Breaking this category down reveals more detail (Table 8).

Table 8. Management Approaches for LID Implementation

	<i>Broaden</i>	<i>During Construction</i>	<i>Focus</i>	<i>Personnel Education</i>	<i>Logic</i>	<i>Post Construction</i>	<i>Pre Construction</i>	<i>SW Dept. Org.</i>	TOTAL
Astoria							X		1
Bay City		X	X		X		X	X	5
Brookings							X		1
Corvallis									0
Cottage Grove					X				1
Eugene			X	X	X		X	X	5
Florence		X	X	X	X	X	X	X	7
Grants Pass					X	X		X	3
Gresham		X	X		X	X	X		5
Lincoln City		X			X				2
Medford			X	X	X		X		4
Newport			X		X		X		3
North Bend		X	X	X	X				4
Port Orford			X		X	X			3
Salem	X	X	X		X		X	X	6
Springfield			X	X					2
Tillamook		X	X						2
Veneta			X			X			2
TOTAL	1	7	12	5	12	5	9	5	56

Twelve cities mention *logical* approaches in many of these management statements. For example, one city mentions the need to “see opportunities”, and describes a development project that boasted about its bioswales having ignored the adjacent wetland it could have used to save space and money. Twelve cities mention some sort of area to focus on for LID projects (water quality, new development, commercial areas) while one city also mentions they were not yet focusing specifically on LID but instead are more broadly focused on green practices which can incorporate LID, but also use different techniques.

Many approaches are used prior to construction of a development of LID practice (nine cities) such as compiling a library of information about LID, or leading by example with city projects. Seven cities mention techniques applied during construction of a project, such as allowing flex in plans if changes need to be made. Only five cities mention post construction techniques such as using non-structural practices for retrofitting or allowing a private land owner to maintain the facility.

Personnel education, cited by five cities, ranges from helping to promote the acceptance of LID practices within the city staff, as well as keeping staff up to date on new information on a regular basis.

An interesting but relatively infrequently mentioned management technique (only brought up by five cities) is stormwater organization within the city. In many cases decentralization is occurring through the input of neighborhood associations or several different departments within the city government. In other cases stormwater management is consolidated or moved to another department within public works to provide more funding or ease of organization.

Regulation adjustments are, not surprisingly, mentioned by all eighteen cities. Many of these adjustments involve either writing new or updating existing codes, however other adjustments range from allowing flex in regulations, to simplifying and streamlining the process for LID projects, to reinterpreting codes.

And finally, *collaboration within the city*, such as communication between planner and public works staff or using advisory groups is mentioned by five cities. This approach involving input from multiple stakeholders, was believed to be very successful in the long run despite the upfront time required to coordinate and compromise between the various positions. In cities with smaller population sizes, collaboration was much simpler than in the larger, more organized groups established in the larger cities.

CITY CHARACTERISTIC INFLUENCE

Comparison of city characteristics (population, growth rate, geographic location, and city governance) with barriers and approaches cities voice yields the following results.

Cities with larger populations, a faster growth rate, inland cities and cities with council/manager governance mention more barriers. It should be noted here, that the

barrier “other” has not been included in the tally because of its miscellaneous and inconsistent nature.

More approaches are mentioned by cities with larger populations, and coastal cities. Cities with council/manager and mayor/council as well as cities with high and low growth rates all mention the same *number* of approaches (Table 9a and 9b). However, these approaches are all different. For example, cities with a high growth rate might mention approaches a, b, c, and d more than cities with low growth rates, while those cities with low growth rates mention, w, x, y, z approaches more than cities with high growth rate.

Table 9a. *Number of barriers mentioned by groups of cities.*

Table 9b. *Number of approaches mentioned by groups of cities.*

BARRIERS		
	Hypothesis	Results
Population		
High	5	6
Low	4	2
Growth Rate		
High	4	9
Low	3	3
Location		
Coastal	4	1
Inland	3	9
Governance		
Council/Manager	2	9
Mayor/Council	4	3

Taking a look at this more closely, city characteristics can also be compared to the individual barriers and approaches, thus exploring patterns for cities exhibiting similar barriers and approach choices based on their population, growth rate, location and city governance. Below, I will describe the barriers and approaches, more commonly mentioned by a characterized city. Again,

APPROACHES		
	Hypothesis	Results
Population		
High	6	4
Low	2	3
Growth Rate		
High	5	4
Low	4	4
Location		
Coastal	4	3
Inland	5	2
Governance		
Council/Manager	8	4
Mayor/Council	1	4

it should be noted here, that the barrier “other” has not been included in this summary because of its miscellaneous and inconsistent nature. These results of which groups of cities mention a barrier or approach more often than their opposing group can be seen in Appendices B and C.

Population

Barriers

Cities with larger populations mention the following six barriers more than cities with smaller populations: lack of knowledge within the community, maintenance concerns, making stormwater and LID matter to the community, money, previous system concerns, and risks involved with LID. Cities with smaller populations mention the following two barriers more than cities with larger populations: a lack of resources and regulations.

Approaches

Cities with larger populations mention the following four approaches more than cities with smaller populations: educating the community, finding funding for stormwater management and LID, information acquisition and LID initiation from either the city or developers or both (for more information and correlation results regarding LID initiation, please refer to table 10 and the reported results at the end of this section). Cities with smaller populations mention the following three approaches more than cities with larger populations: collaboration within the city personnel, making stormwater and LID matter to the community and making management adjustments.

Growth Rate

Barriers

Cities with a higher growth rate mention the following nine barriers more than cities with low growth rates: community resistance, conflicting needs and wants, discouraging information, a lack of knowledge within the city staff, a lack of knowledge within the community, a lack of resources, maintenance concerns, money and risk. Cities with lower growth rates mention the following three barriers more than cities with higher growth rates: making stormwater and LID matter to the community, concerns of a previous system and regulations.

Approaches

Cities with a higher growth rate mention the following four approaches more than cities with low growth rates: collaboration within the city staff, educating the community, LID initiation from either the city or developers or both and management adjustments (for more information and correlation results regarding LID initiation, please refer to table 10 and the reported results at the end of this section). Cities with lower growth rates mention the following four approaches more than cities with higher growth rates: collaboration with organizations outside of the city, funding, information acquisition making stormwater and LID matter to the community and making management adjustments.

Location

Barriers

Coastal cities mention only previous system concerns more than inland cities as a barrier. Alternatively, inland cities mention the following nine barriers more than coastal cities: conflicting needs and wants, a lack of knowledge within the city staff, a lack of knowledge within the community, a lack of resources, maintenance concerns, making stormwater and LID matter to the community, money, regulations and risk.

Approaches

Coastal cities mention the following three approaches more than inland cities: collaboration within the city staff, making stormwater and LID matter to the community, and management adjustments. Inland cities mention the following two approaches more

than coastal cities: finding funding and initiating LID either from the city or from developers (for more information and correlation results regarding LID initiation, please refer to table 10 and the reported results at the end of this section).

City Governance

Barriers

Cities with council/manager governments mention the following nine barriers more than cities with mayor/council governments: community resistance, discouraging information, a lack of knowledge within the city staff, a lack of knowledge within the community, maintenance concerns, making stormwater and LID matter to the community, money, regulations and risk. Cities with mayor/council governments mention the following three barriers more than cities with council/manager governments: conflicting needs and wants, a lack of resources and previous system concerns.

Approaches

Cities with council/manager governments mention the following four approaches more than inland cities: information acquisition, LID initiation either via the city or developers (for more information and correlation results regarding LID initiation, please refer to table 10 and the reported results at the end of this section), making stormwater and LID matter to the community, and management adjustments. Cities with mayor/council governments mention the following four approaches more than coastal cities: collaboration outside of the city, collaboration within the city, education of the community and finding funding.

The approach, *LID initiation*, requires further explanation, as it is slightly different from the other approaches. Generally this approach recognizes whether a city is aware of how LID implementation is occurring in the city. This can occur passively by allowing developers to use LID facilities, but not directly encouraging it, or actively, by taking initiative within the city to educate, develop pilot projects or another means of implementation. If a city has not mentioned this approach, it indicates LID is generally not being incorporated into the city to a large extent. Results are as follows:

Cities with high populations initiate LID in equal frequency between the city and developers. Cities with low populations initiate LID within the city more than via developers. Cities with high growth rates initiate LID with developers more than from within the city. Cities with low growth rates initiate LID within the city more than via the developers. Cities on the coast initiate LID in equal frequency between the city and developers. Inland cities initiate LID within the city more than via developers. Cities with council/manager government forms initiate LID within the city more than via developers. Cities with mayor/council government forms initiate LID in equal frequency between the city and developers (Table 10).

Table 10. *Number of cities voicing LID initiation actively from within the city or passively via developers.*

	Population		Growth		Location		Governance	
	High	Low	High	Low	Coast	Inland	Council/Manager	Mayor/Council
City	4	4	2	6	3	5	7	1
Developer	4	3	3	4	3	4	6	1

Discussion

DATA EVALUATION

Many of the barriers mentioned during the interviews are well known and provide little new insight. Often, these barriers could be described as “perceived” rather than real barriers. With information and education many of these “perceived” barriers may either be significantly reduced or transformed into another barrier. For example, all eighteen cities identified physical setting barriers, a barrier already recognized by EPANE 2009, and many named soil (fifteen cities), slopes (nine cities), and high water (eight cities) as specific types of physical barriers. However, Coffman (2002) stresses that LID can be used in any setting with a change in the technology. The adapted structural facilities used in areas with physical setting challenges may be more complex and costly, thereby shifting the barrier from *physical setting* to *money concerns* or *lack of knowledge*. Thus *physical setting*, is a “perceived” barrier to LID, because it not actually a barrier, only one that exists because of a lack of knowledge towards LID construction. This doesn’t remove barriers a city faces in LID implementation, but it does help to clarify how to aid the adoption of LID though different types of policies. In this example, the barrier can now be alleviated with grants or loans, whereas there is little to offer for changing physical setting.

Several approaches to facilitate implementation of LID are well known and were suggested from organizations and presented in workshops. Commonly known approaches include stormwater fees and discounts. Others are simply practical and sensible decision-making (*logic*) such as taking advantage of opportunities for funding, education, or landscape opportunities and setting goals. Though these can be obvious, they are important to recognize. They can be lost when focused on a specific aspect or technique such as LID. The example in the results section referring to a development proudly exhibiting bioswales with an unused wetland area nearby demonstrates how LID can be distorted through focusing on specific techniques. LID practices aim to mimic natural hydrological cycles. What better way to achieve this than through the natural features

themselves? LID does not require the creation of a designed and labeled “BMP”. Instead it encourages creativity.

Looking for the most common barriers and approaches is interesting, however some of the less frequently mentioned barriers and approaches could be equally or more important to address to aid LID adoption. Oregon State University’s Extension Service and Oregon Sea Grant Extension employ watershed management specialists and community development educators to help communities gain a better understanding of the link between land use and water quality and the various BMP’s that could be used to protect and improve water quality. Some of their education programs focus on urban development impacts and how LID practices could help mitigate these effects. These education specialists often make decisions regarding how to best provide information and learning environments related to LID practices on a local basis. The less common barriers and approaches could be most useful in these more local applications. Education specialists and policy makers alike could benefit from examining both these barriers and approaches.

A goal of this study was to examine barriers cities face and approaches cities take toward LID implementation and relate these to city characteristics (population size, growth rate, geographic location and city governance). Connections of this sort could help group cities into those more apt to adopt method *A*, *B* or *C*, for LID implementation. Ideally, this grouping system could be expanded to other cities not included in this study. Below I will compare hypothesized results to actual results of the study. For those results that differ from the hypothesis I will provide a possible explanation.

Returning to the hypothesized results relating to expectations of city characteristics and the frequency of mentioned barriers and approaches, the data show only two hypotheses about barriers are proven true in the actual results (Table 9a and 9b). The two supported hypotheses are cities with larger populations and higher growth rates voice more barriers. In some cases, such as the prediction relating to location and approach frequency, the difference is minimal. Additionally, methods used to determine whether cities with a

certain characteristic voiced more or fewer barriers and approaches are based on percentages. These percentages can be very close. Thus, when it is determined that, for example, cities with council/manager governments mention regulations as a barrier more frequently than cities with mayor/council forms of government, it is only by a small margin (0.800 v. 0.846).

Below I will provide an educated explanation for why the results may have differed from the hypothesis. The results show inland cities voice more barriers than coastal cities. This may be because inland cities are also associated with larger cities and larger cities may be more advanced in stormwater management both because they are larger cities needing to service more residents and many are also required to obtain NPDES permits which necessitate meeting certain stormwater discharge requirements. Often, new barriers arise as a project progresses, thus, perhaps coastal cities have not encountered some of the barriers mentioned by inland cities. Council/manager governed cities unexpectedly voiced more barriers than mayor/council governed cities. This could be attributed to a similar concept as cities that are farther along in the stormwater process. Assuming a manager will bring experience and organizational knowledge to a city, perhaps this knowledge actually creates more questions, concerns and barriers to LID. Considering the summarized barrier results, it is interesting to note that larger, faster growing, inland cities governed via council/manager are those voicing the most approaches. Thus, it may be that those cities further along in the process see more barriers. One could speculate that perhaps the cities who mention fewer barriers or are presumed to view LID as a feasible task on account of seeing less barriers, but instead are actually a step behind and in fact naïve or unaware of the complications of LID. Alternatively, they could be more optimistic, flexible, and innovative and thus see LID as less burdensome than those cities who are more advanced in the stormwater process.

All the hypotheses regarding approaches were not supported by the results. The results show that cities with large populations and coastal cities voice more approaches than cities with low populations and inland cities. Slow and rapid growth rate as well as both forms of governance reported equal frequencies of approaches. Cities with a high

population, as mentioned before are more apt to be a Phase I or II city and required to meet permit requirements for stormwater management. Thus, because they are pressured to address this topic, they may be considering and experimenting with multiple tools to meet NPDES requirements, one of which could be LID. The fact that coastal cities mention more approaches than inland cities is interesting because this does not correspond to the population results despite the statistical correlation between geographic location and population. Perhaps coastal cities voice more approaches toward LID and stormwater management because they anticipate the NPDES requirements in the near future. They see this period, prior to the enforcement of regulations, as a time to prepare and experiment at a relaxed pace that might allow the city staff and community to adapt to new practices, methodology and even mind set involved with LID practices. The lack of difference in number of approaches within the characteristics of growth rate and governance is also interesting. A high growth rate could encourage LID approaches because of a need to prepare for future development, and as Damanpour and Schneider (2009: 509) suggest, “may promise a larger tax base and motivate local governments to adopt new practices to increase the scope and quality of services”. However, a slow growth rate could also allow time to investigate and experiment with LID practices before implementing them in actual developments or as Damanpour and Schneider (2009: 509) suggest, “a declining tax base may motivate local governments facing low population growth to adopt new practices to increase the efficiency of internal processes and delivery of services”. Because the difference between the two forms of governance are quite subtle, it is not necessarily surprising that neither form uses more approaches than the other. Additionally, Damanpour and Schneider’s (2009) study supports the idea that city governance managers have little effect on innovation adoption when compared to city population and urbanization. However, this study also reports that the presence of a city mayor “negatively affects innovation adoption” (Damanpour and Schneider, 2009: 507) perhaps a reflection on non-elected organizational leaders to innovate when trumped by an elected official.

The comparative results of each individual barrier and approach are shown in Appendix B. Below I will discuss those results that differ from the hypothesis and suggest an explanation for the results.

Population

The barriers *community resistance*, *conflicting needs/wants*, *discouraging information* and *lack of knowledge within the city* are all mentioned in equal frequency by both high and low populations. This may be because these barriers are a product of community composition, perspective, knowledge and character rather than city population size. A *lack of knowledge within the community* is more commonly voiced by cities with a high population, which may be related to the fact that larger cities tend to have more resources such as universities and thus a more educated community. A concern for *money* is mentioned most by cities with a large population and is perhaps related to the fact that many larger cities cannot grow more or create new developments with new LID practices. Instead, they may need to focus on retrofits, which are more costly than installing LID facility from the start. The final barrier to consider is *risk*, most often mentioned by cities with high populations. This may be true because there is less room for flexibility within a largely populated city. An experimental practice gone wrong could cause upset in several areas such as finances, and effectiveness. The more people affected, the more trouble for city staff, residents and thus, the more risk.

Approaches data show that cities both high and low in population *collaborate with outside organizations* in equal frequency. Perhaps this reflects on the networking capacities of cities both large and small. Larger cities may have more connections with organizations such as the state, while smaller cities might collaborate more with other cities, or more local entities. *Regulation adjustments* are also mentioned in equal frequency among cities of high and low populations. This may be because adjusting regulations is no easier or difficult in a smaller or larger city. In fact, looking ahead, regulations adjustments are also mentioned in equal frequency though out all city characteristics (growth rate, geographic location and governance), however, this is because all eighteen cities mention regulation adjustments. Perhaps because adjustments

to regulations are made on a regular basis it is not a foreign practice, thus incorporating adjustments to encourage LID is one of the easier approaches.

Growth Rate

Cities with higher growth rates express the barrier *community resistance* more often than cities with lower growth rates. This may be because of the belief that LID will slow growth or because a high growth rate already implies significant changes in a community, thus an additional innovation will add more “unknown” to the future of a city.

Discouraging information, a lack of knowledge within the city staff relating to LID as well as *a lack of knowledge within the community* relating to LID are all voiced more often in cities with high growth rates than those with low growth rates. I have little explanation for these results. Discouraging information could come from numerous places, workshops, personal experiences, lectures, and literature and a lack of knowledge seems to be more closely tied to a city’s education rather than a city’s growth rate. Thus I cannot fairly speak to these results without additional information. The barrier of *making stormwater and LID matter to a community* is mentioned more often by low growth rate cities than cities of high growth rate. A lower growth rate may correspond to a lack of change and a resistance from the community to adopt new mindsets in which stormwater is visible and prioritized. *Money* is mentioned as a barrier more often by cities with high growth rates rather than low growth rates and this is likely a result of money invested in preparations for city growth, perhaps paying staff, funding development projects and thus leaving little money for pilot projects of education and outreach targeting LID practices. *Regulations*, mentioned more often by cities of high growth rates rather than low growth rates, could be indicative of new regulations cities are facing as they grow larger such as NPDES. And finally *risk* is more often mentioned by cities of high growth rates rather than low growth rates and can be justified by a concern for implementing a new practice (LID) in a new development when little is known about the longevity, or effectiveness of such a practice. Will the development need to be retrofitted in the near future because of the risk taken with LID?

In respect to approaches and growth rate, differences between the hypotheses and result are found in three approaches. Cities with a high growth rate express *community*

education as an approach more often than cities with a low growth rate. Perhaps because of the growth itself and a need to bring awareness of stormwater into the community so that it is understood and accepted, as well as the recognition of a need to manage it differently to compensate for future growth. *Funding* is mentioned as an approach more often by cities with low growth rates rather than cities with high growth. This is perhaps because there is a slower economy in the low growth rate cities and thus city income. And finally, *regulation adjustments* are mentioned in equal frequency and discussed above in the *Population* section.

Geographic Location

Community resistance is mentioned in equal frequency by both coastal and inland cities suggesting that coast and inland communities alike are concerned with the uncertainty, unfamiliarity and perhaps the belief that by improving or augmenting stormwater management and systems, it will encourage or inhibit growth. Inland cities voice *a lack of knowledge within the city staff as well as within the community*. Inland cities also mention *a lack of resources* more than coastal cities. This is interesting because it was expected that coastal cities, being further spatially from resources and further from larger cities would voice these concerns. However, perhaps because of the further advancement in stormwater management and federal requirements, inland cities are faced with a greater learning curve regarding LID and thus are struggling to learn these practices in an efficient manner as well as collect resources in which to do so. *Maintenance* is a concern more so in inland cities than coastal cities. Perhaps this is because inland cities tend to have less porous soils and thus may require adjustments to LID facility designs that may require more monitoring in the first few years of the facility as well as pipe replacement in future years. Inland cities mention *making stormwater and LID matter to the community* more often than coastal cities. This might be due to the tendency of inland cities to be larger and more developed, thus residents are possibly less aware of environment surroundings and ecosystem services. *Money* is also mentioned more often by inland cities than coastal cities. This is interesting because inland cities, tending to be larger in population, would be presumed to generate a larger income. However, because larger cities perhaps have a larger road network, there is the potential for more projects. This leaves little money for stormwater management, which up until recently, has been

lower on the priority list than road networks. Coastal cities mention *previous systems* as a barrier more often than inland cities and this is perhaps because of the more rural nature of coastal cities and a lack of current stormwater systems. Thus, when preparing to install a system or portion of a system, stormwater ditches buried decades ago are discovered and change the anticipated landscape and water flow of the terrain. Finally, *risk* is more often mentioned by inland cities than coastal cities. Following a common theme throughout these explanations, this may be due to further advancement and experience in stormwater management inland cities have over coastal cities. Having seen innovations falter or fail to meet expectations can certainly raise risk concerns.

Four approaches show unexpected results in relation to geographic location. All of which are ties: *collaboration with organization outside of the city*, *community education*, *information acquisition* and *regulation adjustment*. The fact that four of the nine approached are mentioned equally between coastal and inland cities suggests these four tactics are applicable regardless of location and that location does not necessarily help to dictate how to best approach LID. *Collaboration with outside organizations* was also tied among population size, thus perhaps explicable via these means. *Community education* is perhaps evenly distributed because of its adaptable and widely applicable nature to any kind of community. *Information acquisition* is yet another widely applicable approach with several methods depending on location. Coastal cities could use internet research or web conferences, while inland cities attend workshops. And finally *regulation adjustments* are discussed above in the *Population* section.

City Governance

The subtle differences between the two forms of government found in this study make the disparities between differently governed cities quite interesting. *Community resistance* is mentioned more often by cities with council/manager forms of government than mayor/council cities. This may be due to a lack of trust by the community in a hired manager rather than a mayor who is elected at large and also a member of the community. Mayor/council cities mention *conflicting needs/wants* more often than council/manager cities, perhaps because a mayor, unfamiliar with organizational and managerial protocols does not prioritize stormwater as much as other city systems or

needs. *Discouraging information* is more often voiced in council/manager cities as opposed to mayor/council cities. This could be a result of a bad experience the hired manager has encountered in previous cities. In council/manager cities, *a lack of knowledge within the city* as well as *a lack of knowledge within the community* is more often expressed than in mayor/council cities. This is interesting, because it was presumed a manager would bring a wealth of information regarding stormwater which would in turn educate both staff and community. However, LID is relatively new and it could be that the transfer of information has not occurred yet, or is just beginning. *Maintenance* is also voiced more often in council/manager cities than in mayor/council cities and it attributable to the knowledge a manager has of operational duties and the maintenance of city service systems. Council/manager cities voice *making stormwater and LID matter to the community* more often as a barrier than mayor/council perhaps because they are also making more of an effort to do so. In looking at the approaches, this is true. Council/manager cities are also using the approach *making it matter* more often than mayor/council cities, thus they are apt to run into more barriers when trying to do this simply because they are deeper into the project. *Money* is mention more often by council/manager cities than mayor/council cities. Again, this may be because of a better understanding of administrative duties and capacity because of the hired manager. Interestingly, mayor/council government run cities mention *previous systems* as a barrier more often than council/manager government run cities, a result possibly because a mayor elected at large from the community, perhaps has known no other system than that which exists, and thus sees the current system as irreplaceable (either financially or because he/she feels it is effective). And finally, *risk* is mentioned mostly by council/manager cities rather than mayor/council cities. Perhaps this is a result of the commonly mentioned theme that understanding more the details of LID can at first be overwhelming and without adequate information can seem untested and uncertain. Thus a manager, who assumingly knows a little more about stormwater systems than a mayor, will be more concerned with the effectiveness and longevity of LID.

Four approaches differ from the hypothesized results. Mayor/council cities mention collaborating with organizations outside of the city more often than council/manager

cities. This is perhaps because of local connections established within the community. A manager might be new to the city and though he/she brings new information, perspectives and experience, is not as likely to have applicable connections or relationships with other organizations. Mayor/council cities also mention the use of community education more often than council/manager cities. One explanation for this is because mayor/council cities do not have a manager who hypothetically organizes, researches and administrates such approaches; mayor/council cities might look to other organizations (supported by the fact they also collaborate more with outside organization) to learn about innovative practices. Mayor/council cities also mention funding approaches more often. It would be interesting to learn if there is a correlation between form of government and city wealth which would help explain this variable. And as always, *regulation adjustments* are mentioned equally by each governed city and discussed above in the *Population* section.

LID Initiation Explanation

The approach *LID initiation* has previously been examined in more detail because, though the approach reflects on which cities recognize the initiation and at least beginnings of implementation of LID within their jurisdiction, the approach can also be broken down into active (city) and passive (developer) initiation. Here I will discuss these results in more detail (Table 11).

Table 11. *LID initiation comparison between hypothesized results and actual results (~ : denotes a lack of hypothesis because the characteristic and barrier did not seem relevant or denotes a tie in the results).*

Population	City		Developer	
	Hyp.	Result	Hyp.	Result
High	~	~	~	X
Low	X	~		
Growth				
High	X		X	
Low		X		X
Location				
Coast	X			
Inland		X	X	X
Governance				
Council/Manager	X	X		X
Mayor/Council			X	

Population

Cities with both high and low populations mention active initiation from within the city equally. Thus interestingly enough, population, in this study, does not effect whether a city actively pursues LID. Perhaps this is because cities with a high population are looking for tools to meet NPDES requirements and cities with low populations are able to approach LID at a more relaxed and experimental pace because NPDES is not a pressing issue, but rather in the near future.

Growth Rate

Cities with low growth rates voiced the use of active (city) and passive (developer) LID initiation more often than cities with high growth rates. This may be related to the idea that cities with low growth rates are less preoccupied with future growth and have more time and resources to devote to experimenting with innovative practices and encouraging developers who also use these practices.

Geographic Location

Inland cities mention active (city) LID initiation more than coastal cities. This is perhaps related to NPDES requirements. Simply waiting for developers who use LID to propose projects will not help inland cities meet federal requirements in a timely manner.

City Governance

Cities with council/manager government forms mention passive (developer) initiation more often than cities with mayor/council forms of government. This result is difficult to explain, however, it may be that a council/manager government is more involved with and/or aware of developers and their techniques, thus more apt to encourage or recognize developers using LID practices.

The examination and results of relations among city characteristics and mentioned barriers and approaches, presents interesting and useful data for those both learning and informing others about LID practices. Those looking to approach LID education can ask,

What approaches of education and areas of focus related to barriers and approaches might work best in cities of a certain populations, growth rates, location and city governance?

The themes created in this study suggest that cities share some of the same barriers and approaches even though the barriers and approaches are all presented slightly differently due to specific contexts. This is likely a result of several factors including social, environmental and political city characteristics as well as the unique combination of barriers or approaches with which the city identifies. For example, a city with *money* and *regulation* barriers may approach their financial situation differently than a city with *money* and *conflicting needs* barriers, even though they share a common barrier: money. One city may be wealthier than the other, or may require less money to solve the supplementary barriers they are facing. Additionally, an example found within the data shows two cities, sharing similar characteristics, both coastal, similar is population size, and sharing the same city governance also voice similar barriers: *community resistance, a lack of resources, maintenance concerns, physical setting* and *regulations*. Similarly, they both voice similar approaches, *community education, funding, information acquisition* and others. Yet, the manner in which they approach, for example, *community education* and *funding* is different. One city has created a master plan and makes community meeting available on local television stations in an effort to educate the public, while the other city does not. Similarly, the same city that has created a mater plan also uses urban renewal projects and general funds to help finance stormwater projects, while the other city looks to grants to finance their stormwater projects. It is difficult to determine the cause of these differences within the context of this study, however, one hypothesis could be city capital.

Interestingly, some of the barriers mentioned by cities are also included in the approaches they take. This suggests some of the approaches many cities are using and perhaps consider most important are also the most difficult to implement efficiently and effectively. For example, while eleven cities described *make it matter* as an approach to

stormwater management, four of these same cities also identify difficulty in *making it matter* as a barrier that must be overcome. One inland city says:

It's an ongoing challenge... connecting individual behaviors to the impact on water quality and so we put a lot of resources into stormwater education, we are always looking for different ways to get the message, or messages across.

And a coastal city mentions:

We tried to take the outreach to preexisting groups, which was more difficult than we thought... Some people don't have meetings or they are closed.

Similarly, fifteen cities mention *regulations* as a barrier, but all cities have made some sort of *regulation adjustment* as an approach. The fact that solutions to these barriers are being pursued indicates cities have recognized or perceive their importance in advancing LID. It does not, however, speak to the effectiveness of the approach. This study did not investigate approach effectiveness. Many of the approaches are so newly implemented (or have not yet been implemented), this information is difficult to evaluate.

In a different context, while the state is one of the most common organizations to collaborate with for LID projects, the policies and assistance of the state are also described as unclear and minimally helpful, with only two cities mentioning the state as a source of information for LID. One inland city mentions, *we don't get a lot of help, or oversight, or interference from the state*. If cities are looking to the state for help, it may be necessary to understand more clearly what potential collaborators need from the state and formulate more concrete, consistent guidelines.

The lack of correlation between city characteristics such as population, growth rate, geographic location and city governance is surprising and may be an artifact of the research design that did not presume to weight the relative importance of different barriers and approaches. Instead this project was designed to characterize and catalogue a full range of barriers and approaches identified by coastal and inland cities as they

approach stormwater management. *Appendix E* (Survey Questions) provides several suggested questions that emerged from the eighteen interviews and could be used in future surveys. A survey of this type could produce results that could be statistically tested since respondents would each have the opportunity to consider whether or not a particular issue is a barrier to LID adoption in their city, and it would then be possible to tally the number of times a barrier is mentioned.

ATTRIBUTES OF INNOVATION

As mentioned earlier, Rogers 1983 offers insight to attributes of innovation aiding in understanding the rate of adoption of an innovative practice. Below I will describe each of these characteristics and how LID practices may fall into each category so that we may see what inhibitors exist within the innovation itself, rather than examining the characteristics of the cities. Three attributes - relative advantage, compatibility, and complexity - have been statistically shown as most influential in adoption rate, while trialability and observability, are statistically less effective (Rogers 1983). Finally, in the final section, *Conclusions and Policy Suggestion*, I will make suggestions as to how these attributes of innovation can be used by educators of LID or promoters of LID (such as cities) to further the implementation of more eco-friendly stormwater management practices.

Relative Advantage

Relative advantage or incentives, refers to the extent to which a new practice or idea is superior to previous practices. Superiority equates to faster LID adoption. The measured metric varies among innovations. Rogers discusses two of the most common metrics, economic and status. Mainly, *is it cheaper?* And, *will there be recognition and praise for adopting such practices?* LID faces many difficulties in terms of relative advantage. In many ways it is a preventive innovation, making it difficult to show or prove its relative benefits. These benefits are only visible in the future when water quality is improved, flooding is minimized, and costs are reduced. Cost may be perceived as one of the largest drivers of municipal decisions and thirteen cities mention *money* as a barrier to LID. However, Rogers cites studies showing economic incentive is not necessarily the primary driver for adoption. In many cases, social approval or a decrease in discomfort supersedes

economics. This suggests that due to the potential high cost of LID, especially in a difficult physical setting, it may prove effective to emphasize other relative advantages more immediately visible such as added aesthetics and open space, both improving quality of life and bringing character to a city without asking for lifestyle changes or funding from the community. Additionally, incentives can be created at the city level through fee discounts or recognition of those who adopt innovative LID. Still, such incentives have not proven effective for many cities as noted in the quote below from an inland city discussing stormwater fee discounts:

Those [fee discounts] sound good and they are recognition of the efforts that folks make who do stormwater management on site. But they are not a huge incentive, in part because the dollar which we're dealing with... They are a "feel good" sort of thing.

A respondent from an inland city elaborates on the difficulties associated with stormwater fee discounts:

In terms of financial incentives, that's a tough one because we are always struggling, it seems, financially, to figure out where to put our limited resources. The other kinds of incentives... recognition and marketing, that's one of the best incentives and/or supporting roles we can play is to recognize development or individual customers that do a good job of stormwater management.

Compatibility

The *compatibility* attribute addresses whether an innovation works with existing values and past experiences. The more compatible the new and old values and experiences, the faster the adoption. In this realm, LID may face its largest obstacle. Twelve cities comment on community resistance as a barrier to LID adoption. Nine subcategories are included in this theme, identified by one to three cities as a concern. The most frequent concern, cited by eight cities, is about lifestyle change. Two rural cities mention a resistance to skinny streets, reducing impervious surface and allowing space for bioswales and rain gardens. Community members want space to park multiple vehicles, RVs and other "toys". Many cities mention the difficulty of changing old habits

especially for engineers who are accustomed to, familiar and comfortable with pipe designs. One city mentions their citizens want green lawns instead of gardens and fruit trees, not trees with abundant leaves that will need to be raked in the fall. Trees with a large canopy are beneficial for water quality because they shade stormwater exposed to daylight. This reduces water temperatures for aquatic life.

Practices embodied in LID, though not particularly unique or revolutionary in themselves, do challenge the way we have previously dealt with stormwater and how we live our lives today. No longer does stormwater management focus on conveyance and moving water off site, but instead it focuses on the opposite – on site infiltration. It will certainly require a shift in the way cities and individuals across the state manage stormwater. One inland city representative clearly described this shift:

But for the last 100 years or so, as we've developed our communities, the goal was to get that raindrop into something gone. Now, there's water flowing everywhere when its raining, but people just don't see it... The biggest paradigm shift that people are going to have to realize for all of this to really, really work, is that when they open their door... from time to time there is going to be water there...It's a convenience people have shared in the development of their communities for quite some time...Now its going to be an inconvenience that they are going to have to recognize... It's going to start localized flooding. We can manage this so we don't make property or life damage, but it's something people are going to have to get used to.

Complexity

Complexity examines the degree to which an innovation is easy to understand.

Innovation adoption decreases as the complexity of the approach increases. Generally, LID is a simple concept of mimicking the water cycle, something most people learn by the time they have reached a high school geology or earth science class. However, technical details of LID construction can be overwhelming, especially to small cities without engineering expertise or minimal capacity. One must determine how much excess runoff will be generated from a new impervious surface in a specified design storm and create and size a facility such as a rain garden to handle that volume. Sizing is dependant on highly variant infiltration rates and runoff volumes. Additional questions

are: *what kind of soil and what kind of plants to include?* All must be addressed for a properly functioning LID facility or system. In traditional approaches, engineers can determine that a certain diameter pipe will carry *X* volume of water to a large detention facility. Problem solved (so we think). Two inland cities voiced these concerns about complexity. In the quotes, they are making reference to more specific areas rather than conceptual ideas surrounding LID:

If we knew standards and had ideas, I think we could design it in-house.

That's the thing with all this LID and stormwater management, it is a very, very steep learning curve. It takes an incredible amount of training and terminology. It really becomes overwhelming.

Trialability

Trialability refers to how easily an innovation can be piloted prior to full implementation. If small projects can be tested before larger projects are implemented, the adoption rate of an innovation increases. This is perhaps one of the few advantages of LID. Rain gardens and other LID practices can be built in backyards, or city parks to provide examples without huge reconstruction. In this way, LID may slowly replace the previous stormwater system. Ten cities mentioned using example projects as a way to educate the community as summarized below by a coastal city:

We took city money, for our city projects, and tried to set the bar and examples so we created a couple rain gardens, we did a green, LID parking lot and so that way we can point out to the developers and the suppliers around here and say it works, here is how it works, here is what it looks like, here are some options.

Observability

Observability is how visible the results of innovation are to potential adopters. Looking at the data, fifteen cities mentioned *acquiring information*, mostly from other cities and counties, as well as conferences, workshops, classes, and meetings. However, Rogers refers not only to how visible results of innovation are, but how easily communicated results are to those not involved in the project. For LID this can be challenging not only because collecting and distributing data can be difficult, but also because what works in

one city may not work in another due to physical setting. In fact what works on one side of the road, may not work on the other! Thus in some cases, communication among cities may be irrelevant. The city of Portland, Oregon is trying to set up examples and many of the cities interviewed mention looking to Portland for guidance in an effort to not reinvent the wheel or risk their money and time on a practice that does not work. Yet, one inland city, which began with the Portland manual, admits they would have been better off to start from scratch because their various city characteristics were so different.

The deeper we got into it, the more we realized if we had started from scratch we would have been better off.

In light of these five attributes on innovation, it is easy to see why LID practices are adopted slowly if at all. There is little immediate and visible relative advantage, it requires a large paradigm shift in the ways people approach stormwater management, it can be difficult to understand the details of LID facility installation, observed water quality improvements linked to LID projects are not immediately observable because it takes time for water quality to improve, and though there are more example LID projects daily it is rare to see innovative LID facilities successfully transferred to other cities because of different site characteristics.

SIGNIFICANCE OF LID ANALYSIS

After examining the characteristics of cities and finding there is little relation between population size, growth rate, geographic location and city governance to the barriers a city faces and the approaches taken to implement LID, it is interesting to note which barriers are most commonly faced and which approaches are most frequently used. Additionally, it might be helpful to look to some of the cities that have faced many barriers and experimented with several approaches. Furthermore, these barriers and approaches can also be correlated to attributes of innovation (Rogers 1983) and help educators promoting LID understand more clearly what the barriers are and how to mitigate them. In many cases even explaining the barriers in a more general sense to cities will help to stimulate efforts for LID adoption because cities will better comprehend the situation and actions needed. Education efforts, a simple-solution, are

being made across Oregon through workshops led by OEC targeted at city staff, developers and engineers alike (OEC 2009). However, though this introduces the topic, LID still appears to be difficult to approach at the city level and the extensive amount of information involved with learning the principles, techniques and technologies of LID can be time consuming and overwhelming.

Limitations and Future Research

LIMITATIONS

The data collected from eighteen interviews can be considered preliminary work that provides the foundation for understanding issues of stormwater management and LID adoption in Western Oregon. There are several limitations to this study that can be addressed in follow up surveys. First, it should be noted that many of the barriers and approaches used by one city and not another, may indeed be applicable to both cities, but because of the nature of an open-ended interview, some participants choose to focus on certain barriers more than others. I cannot say whether this relates to the intensity of the barrier or if the participants were tuned into a specific barrier because it was brought up in conversation or questions. Similarly, the interview topics likely tended toward the available participant's expertise, such as an outreach coordinator, public works, planner, etc. A lack of a certain expertise often limited the amount of information covered in that topical area. In a written survey, respondents can be asked about all barriers and approaches.

Second, group interviews have both positive and negative implications for gathering information. Group interviews were chosen to obtain several perspectives about stormwater management and LID. A public works employee likely has different concerns and aspirations for LID than a planner. However, information may have been withheld during interviews so as not to offend/step on toes of other participants. Also, discussed topics can be dominated by the most pressing concern of one or more participants.

Third, distinctions between green practices and LID may be blurred in respondents' minds. The project focus was clearly presented as stormwater management and LID; however, LID and green practices are similar and easily lumped together because in many cases they strive for the same goal of mimicking natural processes. As a result, cities may have spoken of barriers or approaches that did not apply to stormwater LID specifically. For example they may have mentioned community resistance against using recyclable or sustainable building materials such as strawbale houses. This mention of

community resistance was recorded and coded as the barrier *community resistance*, however, does not directly apply to LID and stormwater management.

Fourth, the interviews were conducted using open-ended questions designed to allow participants to come up with their own descriptions of barriers and approaches. Thus, though the same concepts were discussed, the same specific questions were not always asked of each participant, meaning there was not consistent data collection. This methodology was intended to maximize opportunities to gain fresh insights into barriers and approaches to implementation of LID. However, since this approach does not require respondents to indicate whether or not they experience a particular barrier or use a particular approach, it precludes the use of tests of statistical significance from these interview data. Additionally, only a handful of Oregon cities (eighteen) were interviewed. Both the lack of consistent data collection and small sample size would result in a relatively weak rank sum statistical analysis that would add little to the study.

Along the lines of statistical analysis, Spearman's Rank Correlation is helpful to see patterns and thus was included to help group cities and make connections and assumptions about city characteristic, barriers and approaches. However, it should be noted that this correlation is not necessarily cause and effect. We cannot say why these patterns occur and it may be a result of a third characteristic not considered within the two characteristic correlations or even within this study.

Survey question suggestions

By nature, exploratory research is limited in several aspects. One of the most evident limitations in this study is that it was designed to elicit information from city personnel about their perceptions of the barriers to LID adoption and implementation rather than to collect a consistent and specific set of data from each city. As a result, the data collected are not appropriate for statistical tests of significance. As is typical of exploratory research, the study may have evoked more questions than it answered. In this sense, the insights gained and new question that have emerged from the study are positive characteristics. It becomes obvious that progress has been made when looking at a

comparison of what information this study began with and what this study acquired and can offer for future research.

Prior to this study, little knowledge pertaining to specific city stormwater management and LID practices existed for Western Oregon. It would have been nearly impossible to produce formal interview questions or a survey to gather relevant and constructive information. This study has provided a better understanding of the range of barriers and LID approaches used by a sample of Western Oregon cities. As a result, I am able to more clearly articulate specific research areas and create questions that are pertinent to advancing the use and acceptance of these practices. A list of these questions can be viewed in *Appendix E* (Future Suggested Survey Questions).

CONCLUSION AND POLICY AND ACTION SUGGESTIONS

As noted in the introduction, there are no federal regulations requiring the adoption of LID. Rather, it is a tool or technique used to meet flooding and water quality requirements and it is becoming an increasingly accepted and encouraged practice over time. There have been federal policy adjustments since this study began that are working to promote LID adoption. First, LID practices are now included in Water Quality Management Plans (WQMPs) created by DEQ as a guide to meet Total Maximum Daily Loads (TMDLs). This qualifies certain organizations to apply for grants for projects related to LID under EPA's 319 Grant Program, relieving a financial barrier mentioned by many cities. Although cities with Phase I permits do not qualify for the 319 Grant Program, many cities will be renewing their permits in 2010 and are being advised to prioritize and implement LID (D. Godwin, personal communication, October 8, 2009). Second, a policy change that occurred very close to completion of this study, if executed in full, will aid enormously in stormwater management and LID adoption by outlining general actions to reduce the inconsistency and ambiguity of federal regulations. "The Clean Water Act Enforcement Action Plan" has three goals, 1) concentration of enforcement on the largest water quality threats, 2) clarification of acceptable state programs as well as consistency in applying these criteria and approving permits, and 3) more reporting on pollution sources for documentation and public education purposes (EPA/OECA 2009). Wallis 2008: 94 notes that:

The federal government does not have the same direct authority over local land use decision as the states, but it exercises enormous indirect power. It exercises this power through laws regulating specific aspects of the environment such as the quality of air or water, ... It exercises this power... to achieve desired goals....

Although the federal government plays an important role in land use planning, which is closely correlated to stormwater management, the government is often perceived as creating more barriers than bridges. Furthermore, trust levels in the federal government tend to be low. Thus, local governments, through the input of their residents, can work toward more regional goals and use small scale planning to achieve a consenting

community and higher quality of life having addressed local needs and gaining local trust that may be difficult for federal agencies to address (Wallis 2008).

The combination of federal involvement and local or regional efforts may greatly accelerate the adoption of new stormwater practices. Because many cities are already thinking about stormwater management, water quality and LID, if the government commits and prioritizes these principles, many cities will find it easier to progress in stormwater management because of clearly outlined goals and standards, as well as streamlined processes. As shown in the results, several cities are pursuing approaches to LID implementation that they also regard as significant barriers. Therefore, identifying ways to connect the community to stormwater management and creating incentives to use LID practices is an area of improvement for both municipal and state agencies or departments. Easing the process of regulation adjustments and uncovering regulations that will promote LID adoption are also advantageous tactics for educators and federal agencies to consider.

Because LID is not specifically required by federal or state regulations, additional non-regulatory incentives could aid greatly in increasing adoption. Federal regulations can move slowly through the system, thus education specialists promoting LID can focus on incentives for communities that are not yet engaging in LID, approaching the issue from the bottom up. As Rogers (1983) discusses, economic incentives are not necessarily the primary motivation. Social incentives are often equally or more effective. The results of this study support this idea. Five cities mention efforts to connect the community to stormwater and several other cities mention tactics such as promoting aesthetics, recognition for LID practices, and publicizing water information. Other approaches used such as emphasizing the positive environmental impacts of LID are indirectly associated with improving quality of life. Additionally, several cities commented on the success of these approaches and the difficulty of promoting stormwater fee discounts. Thus incentive promotions could include not only financial aid, or helping to find resources and information to develop LID, but showcasing the more abstract incentives mentioned above. Thus, it may be wise to direct the limited time and resources of educators

promoting LID to strengthening these community connecting incentives. Each development or retrofit site has the potential to create a unique landscape that functions to manage stormwater. The challenge is finding the opportunities within the site, whether it be the adjacent wetland, topography or supportive community.

As evidenced by this study, a completely supportive community is rare. The theme *conflicting needs/wants*, exemplifies both a paradigm shift and a lack of communication and collaboration among parties at a regional level. Paradigm shifts are, as mentioned earlier, a long-term transition involving education and outreach, pilot projects and reliable data to prove efficacy of LID practices. Communication and collaboration can also be time consuming, but these efforts allow potential for successful stormwater management. For example, one city mentioned conflicting needs with irrigation districts wanting water to remain in pipes to reach and irrigate crops. As the city considers LID practices, infiltrating stormwater throughout the city, they will no longer provide a large supply of water to the irrigation district. In this case, identifying common goals and areas the two parties are willing to compromise is crucial to establishing LID with support from the surrounding districts.

This highlights the importance of regional watershed planning. Water management is particularly difficult for two reasons. First, is the land-water connection. Actions on land strongly effect water behavior, hydrology, and water quality. Second, water moves. As LID efforts are undertaken by one city, it is difficult to control upstream or downstream actions. As mentioned above, implementation of LID in one city may have negative effects on surrounding areas. Thus, it is important to collaborate on a regional basis. Fourteen cities mention collaborating with organizations outside of their city, either on projects or for information acquisition as one of their approaches to stormwater management, suggesting that they are already involved in regional planning at some level with room for improvement.

Other suggested policy adjustments can be seen within the nine approaches taken by the eighteen cities. Administrative reorganization and/or decentralization was voiced as

successful throughout the interviews and could offer positive results for many cities. Consolidating departments such as parks and recreation, street maintenance and stormwater may provide more funding for stormwater tasks as well as coordination of efforts among these three tasks. Including more stakeholders and expertise in stormwater decision-making also has shown to be effective. Many cities use input from neighborhood associations or create advisory groups to obtain public ideas and values. Additionally, other cities encourage collaboration between the city planner(s), public works, and developer(s), again attempting to coordinate activities likely to affect stormwater. Including all parties from the start was voiced as optimal to a centralized approach because many obstacles can be identified and addressed from the start, rather than during or after project completion.

When examining the attributes of innovation cited by Rogers (1983), it is also possible to recognize the inherent limitations of LID, elaborated in the discussion section, and then remedy these limitations or promote the advantages. Portland, Oregon is one of the Nation's leader in stormwater management and exemplifies this approach in several manners. Let us examine each of these attributes, how Portland has applied them and then apply them to a chosen city within this study.

Relative Advantage

One of the most commonly thought of relative advantages is cost. Portland addresses this attribute by providing a Clean River Rewards Program. For those residents who manage stormwater on their property, via techniques such as disconnecting downspouts signing up for this program offers a discount on their stormwater fee. It is difficult to apply this tactic to some of the smaller cities in the current study because many cities do not a) have a stormwater system b) do not have a stormwater fee. In some cases, stormwater fees are strongly opposed by the community and are a delicate topic city staff members prefer to avoid. However, in those cities where this tactic is applicable, it could provide not only a financial incentive, but social incentive as well, as neighbors see neighbors participating in the program and looking for social approval, a second, and perhaps even more influential form of relative advantage (WERF 2009).

Compatibility

Social change and acceptance of innovations is an on going challenge for all cities. There will always conflict and divides among residents and city staff. However, I see one of the most effective approaches to making residents comfortable with innovations is a gradual introduction and education, much like Portland, Oregon's green street projects and school projects. These tactics are widely applicable throughout cities in this study. These projects are closely tied to the *trialability* attribute discussed below. Several public streets in Portland have been retrofitted with stormwater planters, pervious pavement and other BMP facilities to control stormwater on site. These green street projects are within the city jurisdiction (right of ways), but Portland mentions that near by residents were consulted for aesthetic appeal of the projects. The positive feedback the city has received about these projects is likely a result of the collaborative, transparent work. Portland has also works with neighborhoods willing to experiment with these practices. These examples, across the city, provide residents with concerns, or resistance to LID a concrete, visible example, change and thus the opportunity to make a more educated decision to support or reject LID practices to manage stormwater. Portland, Oregon has also promoted LID facilities in schools. This not only remedies stormwater concerns for neighboring residents caused by large areas of impervious surfaces at the school, but also provides an educational opportunity for students and the next generation to learn about stormwater management (WERF 2009).

Complexity

The city of Portland recognizes the complexities of stormwater management and LID. Although the concept itself is relatively simple, imitation of the natural hydrologic cycle and on site infiltration, some of the specifics of facility construction especially under varying physical environments can be challenging. Thus, Portland's stormwater manual "is designed to ease calculations, streamlining formulas with simple coefficients, allowing users to plug in their numbers and get straightforward results (WERF 2008: p. 4). Additionally, the city created a stormwater management plan outlining tasks to complete to meet new NPDES requirements. This processes of taking inventory and

setting up monitoring stations to determine where the city was already meeting requirements and where it needed to focus on improvements, aided not only in an understanding of the systems and how LID was applicable, but also expedited, in the long run, meeting regulations.

Applying these strategies to minimize the complexity of LID as an innovation to smaller cities, which do not have NPDES permit requirements is quite different. Not only is the concept different because of a lack of requirements, but also because cities without requirements tend to be smaller and population and thus less likely to have the capacity to start monitoring programs or develop a stormwater plan, or manual which simplifies LID facility construction for all. Yet, there are several suggestions that could apply here and in fact, are already in progress. The first is technical assistance from organizations outside of the city. The SWAMP project, is a StormWater Assessment and Management decision-support Process (OSU Extension 2009). This is an on-line tool streamlining construction of LID facilities and providing educational documents such as factsheets about LID facilities and processes. It aims to help local governments and developers, thus is could be quite applicable to the smaller towns with less capacity to learn about and implement LID practices.

Making use of volunteer groups, school projects or watershed councils could also lessen the financial burden of monitoring or inventorying stormwater systems. The creation of a stormwater management plan, though useful, can be much more challenging however, could be eased by following Portland, Oregon's tactic of creating a Stormwater Policy Advisory Committee (SPAC), built of stakeholders from several backgrounds (engineering, city organizations, landscape architects, and designed to brainstorm stormwater management approaches (WERF 2009). For the final steps of actual Management Plan composition, a city could apply for grants to fund a temporary position or hire out.

Trialability

This attribute was mentioned above in *compatibility* where Portland was using smaller projects such as green streets as a form of demonstration projects and gradual introduction to LID stormwater management. This attribute could prove to be a less risky and encouraging “selling” point of LID. Instead of large-scale projects, which cause financial concerns as well as the consequences of a failure, smaller-scale demonstration projects can create a learning opportunity for both city personnel and community members alike. Portland has found that community members are now asking for the city to implement LID projects in their neighborhoods and also how they can contribute to the efforts (WERF 2008).

Thus, in smaller cities, these smaller projects are also applicable. However, smaller cities again face the capacity concern. Many do not have funding for stormwater management other than to maintain what already exists, if that. Here, I will reiterate recruiting, volunteer groups, watershed councils and school groups to help get these projects started.

Observability

Portland, Oregon speaks to this attribute in the sense that they encourage other cities to reach out to one another as well as use the internet and overseas examples. However, they also emphasize the importance of working with the community, stakeholders and local experts to find a solution to stormwater management that best fits the needs and wants of the specific city. Portland itself is an example cities can look to increase the *observability* of this new innovation. However, many cities big and small recognize that what works in Portland does not necessarily apply to them. Educators of LID as well as organizations looking to promote LID may find it helpful to research and provide a wide range of approaches and methods to overcome barriers in an effort to encourage creative thinking for how LID can work in the desired location. The more observations made by adoptees, the more knowledge, concepts and education they will have to create their own unique LID practices and stormwater management system.

Challenges for LID adoption and implementation come from two directions. On one hand, innovative practices like LID have inherent attributes that present many inhibitors.

These inhibitors include the fact that future advantages are not readily visible, community and professional resistance to change can span long periods of time, and complexities in facility design make understanding the details of LID installations difficult. On the other hand, cities are facing many drivers to adopt innovative LID such as federal regulations, social pressure for a greener city, long-term cost advantages, and less maintenance as well as a more functional stormwater system.

Though these two directions present challenges, the more we investigate and understand these challenges the more effectively they can be addressed and used to educate about LID and Rogers' (1983) attributes of innovation can be used to an organization advantage when promoting LID. Furthermore, many cities voice that though they see LID and green practices as a difficult paradigm shift, they do not see it as a passing fad or trend. They feel it is something here to stay. That belief and support can be the catalyst for LID promotion and policy change.

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Appendices

- A. Informal Interview Questions
- B. Full *Barriers* Matrix and ranking of characteristics
- C. Full *Approaches* Matrix and ranking of characteristics
- D. Code Themes and Subcategories
- E. Future Suggested Survey Questions

Appendix A. Informal Interview Questions

The Adoption of Low Impact Development Practices in Oregon

Semi-Structured Questions for:

City personnel of Oregon cities in coastal Oregon and the Willamette Valley

1. Can we start out talking about how you became interested in stormwater?

[prompts]

- i. What is rewarding about your position?
- ii. How long have you been working with stormwater?
- iii. How long have you been working for [name of city]?

2. Can you tell me a bit about your current stormwater infrastructure?

- i. What is the primary method used for controlling runoff?
 - Infiltration? Piping?
- ii. What is the condition/functionality of your current stormwater infrastructure?
 - When was it first installed? Is it/was it working well? Will/did pipes need to be replaced?
- iii. Is your current infrastructure designed to adequately collect and convey stormwater from new developments?
 - If not: what types of assessments do you plan to use to identify problems and make adjustments for the future?
- iv. Are you preparing for increased growth in your city? How so?

3. Can we now focus on the social aspects of stormwater management in your community?

- i. In your opinion, what is the awareness of stormwater issues in your community?

Does the community know its function, issues that may result of malfunction, etc.?

 - Can you rank this awareness on a scale of 1-5, 5 being the highest awareness, 1 the lowest awareness? (This is of Stormwater in general, not necessarily of LID)
- ii. In your opinion what concerns the public most in relation to stormwater? (Water quality, flooding etc)
 - How do you know this? Voiced at public meetings, phone calls, etc.
- iii. What efforts or actions within the city would you consider “green” oriented in relation to stormwater?
 - Why do you consider these “green?”

- iv. How do you communicate with the community about stormwater management? What seems to work? What doesn't? Community meetings, complaints, newsletters, etc.?
- v. In your opinion how would you rank the level of public involvement in stormwater management in your city on a scale of 1 to 5? Five being the most involved and 1 being the least.
 - Involved is defined as attending meetings, participation in votes (if there are any), voicing concern or praises, etc.

4a. [Directed to cities that have not yet begun a transition to LID practices]

Can you give any insight about what you see for the future management of stormwater in (name of city)?

- i. Do you have a long-term plan for stormwater management?
- ii. Are there new stormwater practices you are considering either for retrofitting or in new developments? (In future, plan on suggesting/developing new requirement practices?)
- iii. Are these practices intended only in specific areas or for specific applications?
 - Only in retrofit areas? New developments? Certain environmental conditions?
- iv. How would you compare these alternative practices to the original practices in terms of cost?
- v. What steps will you take to prepare for this transition to adopting new stormwater practices?
 - How are you approaching these new practices? Pilot projects? Public Outreach?
- vi. How do you plan on funding this transition?
 - Stormwater fee, system development charges, sewer and water fees, Limited Improvement District, street department, street and road tax, general fund.
- vii. What are the primary barriers for managing stormwater in your community?
 - Which are the most prominent. Why do you say so?
 - Are Ordinances a barrier?
- viii. What do you think it would take for new practices to be considered AND adopted/allowed?
- ix. How would you rank expected community acceptance of new LID stormwater practices on a scale of 1 to 5 (5 being the highest acceptance, 1 the lowest acceptance)? Why?
 - Acceptance is defined as allowing LID practices to be implemented. (This is in respect to how you plan to introduce LID, require, promote, etc.)

OR

4b. [Directed to cities that have already begun a transition to LID practices]

Can you reflect on your transition to LID practices to manage stormwater?

- i. How did LID gain momentum in your city? Was LID introduced to your city in a particular way?
 - Numerous ways?
- ii. Was the city considering different LID practices or methods of implementation?
- iii. How would you compare the chosen practices to the past practices in terms of cost?
- iv. What steps did you take to prepare for this transition?
 - Public Outreach, Community Meetings
- v. How did you fund this transition/update to your present stormwater management systems?
 - Stormwater fee, system development charges, sewer and water fees, Limited Improvement District, street department, street and road tax, general fund.
- vi. Were/are these practices intended only in specific areas or for specific applications?
 - Only in retrofit areas? New developments? Certain environmental conditions?
- vii. What were/are the primary barriers for managing stormwater in your community?
 - Which are the most prominent. Why do you say so?
- viii. What action do you think was most helpful for considering and adopting these practices?
- ix. Which, if any, past/current policies/standards/ordinances/codes do you think pose a barrier to LID practices?
 - How do you plan/did you overcome these barriers?
- x. How would you rank community acceptance of new LID stormwater practices on a scale of 1 to 5 (5 being the highest acceptance, 1 the lowest acceptance)? Why?
 - Acceptance is defined as allowing LID practices to be implemented.

5. Let's turn now to some of the organizational issues related to stormwater management. How is stormwater management structured in your city?

- i. What are the various jobs/roles contributing to stormwater management (public works, GIS, engineer).
 - What's the age range of staff working on stormwater issues? What's the average age?
 - How long have your personnel worked for the city?
- ii. What tasks can be performed in house? Which are hired out?
 - Does the city have an engineer? Water quality specialist? GIS analysis, etc.
- iii. What is the relationship you have with these groups or individuals outside of city personnel involved in stormwater planning?
- iv. Which job oversees the majority of stormwater issues?
- v. Are you limited in considering alternative stormwater practices (LID) by the expertise of existing personnel
 - Engineers, planning staff, etc.? Can you provide examples?
- vi. Are there outside influences for stormwater management?

- Government regulations? Other cities? Community?
- Which is the most prominent? Why do you say so?
- vii. What outside expertise/support is available to your city?
 - Partnered with other cities? Gov? Contractors? Internet?
 - Which do you use most? Least?

6. Finally, can you tell me a bit about the physical setting or environmental conditions of your community that have an impact on stormwater management?

Geology	Soils	Slopes	
Water tables	Water Quality	Precipitation	Climate

- i. Which do you consider the most limiting when considering LID practices?
 - Which is the least concerning?
- ii. At what scale do you generally manage stormwater?
 - Regional, Neighborhood, Site level

Well, that's all the questions I have. What questions do you have for me?

Appendix B. Full barriers matrices organized by population size, growth rate, geographic location and city governance. A line separates the groups within each characteristic. Dotted sections indicate a barrier is mentioned more often (based on percentage) by the corresponding group.

Population	City	Community Resistance	Conflicting Needs/Wants	Discouraging Information	Lack of Knowledge (City)	Lack of Knowledge (Community)	Lack of Resources	Maintenance	Making it Matter	Money	Physical Setting	Previous System	Regulations	Risk	Other	TOTAL
1265	Bay City				X		X				X	X	X			5
1275	Port Orford				X		X		X	X	X		X			5
4700	Tillamook	X	X			X	X				X		X			6
4840	Veneta		X		X		X	X		X	X		X			6
6465	Brookings	X		X	X		X			X	X		X	X		8
7875	Lincoln City	X	X				X	X			X		X			6
9410	Florence	X			X		X	X			X		X			6
9445	Cottage Grove	X			X	X	X			X	X		X			7
9855	North Bend	X		X			X	X			X		X			5
10080	Astoria					X	X	X	X	X	X	X	X	X	X	4
10580	Newport	X			X	X	X	X	X	X	X	X	X	X	X	8
32260	Grants Pass	X	X	X	X	X	X	X	X	X	X	X	X	X	X	12
54880	Corvallis					X	X	X	X	X	X	X	X	X	X	6
58005	Springfield	X	X			X	X	X	X	X	X	X	X	X	X	7
76850	Medford	X		X	X	X	X	X	X	X	X	X	X	X	X	9
100655	Gresham	X			X	X	X	X	X	X	X	X	X	X	X	9
154510	Salem	X			X	X	X	X	X	X	X	X	X	X	X	10
154620	Eugene		X		X	X	X	X	X	X	X	X	X	X	X	8
	TOTAL	12	6	4	12	5	17	10	4	13	18	3	15	5	3	127

<i>Growth Rate % (2000-2008)</i>	<i>City</i>	<i>Community Resistance</i>	<i>Conflicting Needs/Wants</i>	<i>Discouraging Information</i>	<i>Lack of Knowledge (City)</i>	<i>Lack of Knowledge (Community)</i>	<i>Lack of Resources</i>	<i>Maintenance</i>	<i>Making it Matter</i>	<i>Money</i>	<i>Physical Setting</i>	<i>Previous System</i>	<i>Regulations</i>	<i>Risk</i>	<i>Other</i>	TOTAL
2.7	Astoria									X	X	X	X			4
3.3	North Bend	X		X			X	X			X					5
5.3	Lincoln City	X	X				X	X			X		X			6
7.8	Tillamook	X	X			X	X				X		X			6
9.0	Springfield	X	X				X	X		X	X		X			7
10.0	Bay City				X		X				X		X			5
10.4	Port Orford				X		X		X	X	X		X			5
10.6	Newport	X			X		X	X		X	X	X	X			8
10.8	Gresham	X			X		X	X		X	X		X	X	X	9
11.0	Corvallis						X	X		X	X		X	X		6
11.4	Cottage Grove	X			X	X	X			X	X		X			7
11.5	Eugene		X		X		X		X	X	X		X		X	8
12.1	Salem	X			X	X	X	X	X	X	X		X	X		10
18.1	Brookings	X		X	X		X			X	X		X	X		8
20.6	Medford	X		X	X	X	X			X	X		X		X	9
28.2	Florence	X			X		X	X			X		X			6
39.2	Grants Pass	X	X	X	X	X	X	X	X	X	X		X	X		12
46.2	Veneta		X		X		X	X		X	X		X			6
	TOTAL	12	6	4	12	5	17	10	4	13	18	3	15	5	3	127

<i>Location</i>	<i>City</i>	<i>Community Resistance</i>	<i>Conflicting Needs/Wants</i>	<i>Discouraging Information</i>	<i>Lack of Knowledge (City)</i>	<i>Lack of Knowledge (Community)</i>	<i>Lack of Resources</i>	<i>Maintenance</i>	<i>Making it Matter</i>	<i>Money</i>	<i>Physical Setting</i>	<i>Previous System</i>	<i>Regulations</i>	<i>Risk</i>	<i>Other</i>	TOTAL
Coast	Astoria									X	X	X	X			4
Coast	Bay City				X		X				X	X	X			5
Coast	Brookings	X		X	X		X			X	X	X	X	X		8
Coast	Florence	X			X		X	X			X	X	X			6
Coast	Lincoln City	X	X				X	X			X	X	X			6
Coast	Newport	X			X		X	X		X	X	X	X			8
Coast	North Bend	X		X			X	X			X	X				5
Coast	Port Orford				X		X		X	X	X	X				5
Coast	Tillamook	X	X			X	X				X	X	X			6
Inland	Corvallis						X	X		X	X	X	X	X		6
Inland	Cottage Grove	X			X	X	X			X	X	X	X			7
Inland	Eugene		X		X	X	X		X	X	X	X	X		X	8
Inland	Grants Pass	X	X	X	X	X	X	X	X	X	X	X	X	X		12
Inland	Gresham	X			X	X	X	X		X	X	X	X	X	X	9
Inland	Medford	X		X	X	X	X			X	X	X	X		X	9
Inland	Salem	X			X	X	X	X	X	X	X	X	X	X		10
Inland	Springfield	X	X				X	X		X	X	X	X			7
Inland	Veneta		X		X		X	X		X	X	X	X			6
	TOTAL	12	6	4	12	5	17	10	4	13	18	3	15	5	3	127

<i>City Governance</i>	<i>City</i>	<i>Community Resistance</i>	<i>Conflicting Needs/Wants</i>	<i>Discouraging Information</i>	<i>Lack of Knowledge (City)</i>	<i>Lack of Knowledge (Community)</i>	<i>Lack of Resources</i>	<i>Maintenance</i>	<i>Making it Matter</i>	<i>Money</i>	<i>Physical Setting</i>	<i>Previous System</i>	<i>Regulations</i>	<i>Risk</i>	<i>Other</i>	TOTAL
Council/Manager	Astoria									X	X	X	X			4
Council/Manager	North Bend	X		X			X	X			X					5
Council/Manager	Corvallis						X	X		X	X		X	X		6
Council/Manager	Lincoln City	X	X				X	X			X		X			6
Council/Manager	Veneta		X		X		X	X		X	X					6
Council/Manager	Cottage Grove	X			X	X	X			X	X		X			7
Council/Manager	Brookings	X		X	X		X			X	X		X	X		8
Council/Manager	Eugene		X		X		X		X	X	X		X		X	8
Council/Manager	Gresham	X			X		X	X		X	X		X	X	X	9
Council/Manager	Medford	X		X	X	X	X			X	X		X		X	9
Council/Manager	Salem	X			X	X	X	X	X	X	X		X	X		10
Council/Manager	Grants Pass	X	X	X	X	X	X	X	X	X	X		X	X		12
Council/Manager	Florence	X			X		X	X			X		X			6
Mayor/Council	Bay City				X		X				X	X	X			5
Mayor/Council	Port Orford				X		X		X	X	X					5
Mayor/Council	Tillamook	X	X			X	X				X		X			6
Mayor/Council	Springfield	X	X				X	X		X	X		X			7
Mayor/Council	Newport	X			X		X	X		X	X	X	X			8
	TOTAL	12	6	4	12	5	17	10	4	13	18	3	15	5	3	127

Appendix C: Full approaches matrices organized by population size, growth rate, geographic location and city governance. A line separates the groups within each characteristic. Dotted sections indicate an approach is mentioned more often (based on percentage) by the corresponding group.

Population	City	Collaborate (Out of City)	Collaborate (W/in City)	Education (Community)	Funding	Information Acquisition	LID Initiation	Make it Matter	Management	Regulation Adjustments	TOTAL
1265	Bay City	X	X	X		X			X	X	6
1275	Port Orford	X	X		X			X	X	X	6
4700	Tillamook					X	X		X	X	4
4840	Veneta								X	X	2
6465	Brookings	X		X	X	X	X	X	X	X	8
7875	Lincoln City	X		X	X	X	X	X	X	X	8
9410	Florence	X	X	X	X	X	X	X	X	X	9
9445	Cottage Grove	X			X	X	X	X	X	X	7
9855	North Bend	X	X	X	X	X	X	X	X	X	9
10080	Astoria				X	X			X	X	4
10580	Newport	X		X	X	X	X	X	X	X	8
32260	Grants Pass	X	X	X	X	X	X	X	X	X	9
54880	Corvallis	X		X	X	X				X	5
58005	Springfield	X			X	X	X		X	X	6
76850	Medford	X		X	X	X	X		X	X	7
100655	Gresham	X		X	X	X	X	X	X	X	8
154510	Salem			X	X	X	X	X	X	X	7
154620	Eugene	X		X	X	X	X	X	X	X	8
	TOTAL	14	5	12	15	16	13	11	17	18	121

<i>Growth Rate % (2000-2008)</i>	<i>City</i>	<i>Collaborate (Out of City)</i>	<i>Collaborate (W/in City)</i>	<i>Education (Community)</i>	<i>Funding</i>	<i>Information Acquisition</i>	<i>LID Initiation</i>	<i>Make it Matter</i>	<i>Management</i>	<i>Regulation Adjustments</i>	TOTAL
2.7	Astoria	X			X	X			X	X	4
3.3	North Bend	X	X	X	X	X	X	X	X	X	9
5.3	Lincoln City	X		X	X	X	X	X	X	X	8
7.8	Tillamook				X	X	X		X	X	4
9.0	Springfield	X			X	X	X		X	X	6
10.0	Bay City	X	X	X		X			X	X	6
10.4	Port Orford	X	X		X			X	X	X	6
10.6	Newport	X		X	X	X	X	X	X	X	8
10.8	Gresham	X		X	X	X	X	X	X	X	8
11.0	Corvallis	X		X	X	X				X	5
11.4	Cottage Grove	X			X	X	X	X	X	X	7
11.5	Eugene	X		X	X	X	X	X	X	X	8
12.1	Salem			X	X	X	X	X	X	X	7
18.1	Brookings	X		X	X	X	X	X	X	X	8
20.6	Medford	X		X	X	X	X		X	X	7
28.2	Florence	X	X	X	X	X	X	X	X	X	9
39.2	Grants Pass	X	X	X	X	X	X	X	X	X	9
46.2	Veneta								X	X	2
	TOTAL	14	5	12	15	16	13	11	17	18	121

<i>Location</i>	<i>City</i>	<i>Collaborate (Out of City)</i>	<i>Collaborate (W/in City)</i>	<i>Education (Community)</i>	<i>Funding</i>	<i>Information Acquisition</i>	<i>LID Initiation</i>	<i>Make it Matter</i>	<i>Management</i>	<i>Regulation Adjustments</i>	TOTAL
Coast	Astoria				X	X			X	X	4
Coast	Bay City	X	X	X		X			X	X	6
Coast	Brookings	X		X	X	X	X	X	X	X	8
Coast	Florence	X	X	X	X	X	X	X	X	X	9
Coast	Lincoln City	X		X	X	X	X	X	X	X	8
Coast	Newport	X		X	X	X	X	X	X	X	8
Coast	North Bend	X	X	X	X	X	X	X	X	X	9
Coast	Port Orford	X	X		X			X	X	X	6
Coast	Tillamook					X	X		X	X	4
Inland	Corvallis	X		X	X	X				X	5
Inland	Cottage Grove	X			X	X	X	X	X	X	7
Inland	Eugene	X		X	X	X	X	X	X	X	8
Inland	Grants Pass	X	X	X	X	X	X	X	X	X	9
Inland	Gresham	X		X	X	X	X	X	X	X	8
Inland	Medford	X		X	X	X	X		X	X	7
Inland	Salem			X	X	X	X	X	X	X	7
Inland	Springfield	X			X	X	X		X	X	6
Inland	Veneta								X	X	2
	TOTAL	14	5	12	15	16	13	11	17	18	121

<i>City Governance</i>	<i>City</i>	<i>Collaborate (Out of City)</i>	<i>Collaborate (W/in City)</i>	<i>Education (Community)</i>	<i>Funding</i>	<i>Information Acquisition</i>	<i>LID Initiation</i>	<i>Make it Matter</i>	<i>Management</i>	<i>Regulation Adjustments</i>	TOTAL
Council/Manager	Astoria				X	X			X	X	4
Council/Manager	Brookings	X		X	X	X	X	X	X	X	8
Council/Manager	Cottage Grove	X			X	X	X	X	X	X	7
Council/Manager	Florence	X	X	X	X	X	X	X	X	X	9
Council/Manager	Grants Pass	X	X	X	X	X	X	X	X	X	9
Council/Manager	Gresham	X		X	X	X	X	X	X	X	8
Council/Manager	Lincoln City	X		X	X	X	X	X	X	X	8
Council/Manager	Newport	X		X	X	X	X	X	X	X	8
Council/Manager	North Bend	X	X	X	X	X	X	X	X	X	9
Council/Manager	Salem			X	X	X	X	X	X	X	7
Council/Manager	Springfield	X			X	X	X	X	X	X	6
Council/Manager	Tillamook					X	X	X	X	X	4
Council/Manager	Veneta							X	X	X	2
Mayor/Council	Bay City	X	X	X		X			X	X	6
Mayor/Council	Corvallis	X		X	X	X				X	5
Mayor/Council	Eugene	X		X	X	X	X	X	X	X	8
Mayor/Council	Medford	X		X	X	X	X		X	X	7
Mayor/Council	Port Orford	X	X		X			X	X	X	6
	TOTAL	14	5	12	15	16	13	11	17	18	121

Appendix D. Code Themes and Sub-Categories

Barriers

1. Community Resistance
 - a. Aesthetics
 - b. Blocking Development
 - c. Cost
 - d. Flies/Mosquitoes
 - e. Homebuilder Accountability
 - f. Lifestyle
 - g. Preserve Identity
 - h. Safety
 - i. Standing Water
2. Conflicting Needs/Wants
 - a. City Divide
 - b. City Goals
 - c. County
 - d. Developers-Engineers
 - e. Environment
 - f. Goods
 - g. Irrigators
3. Discouraging Information
 - a. Bad experience
 - b. Need both traditional and LID systems according to professional assessment
 - c. False information Distribution
 - d. Discouraging Facts
4. Lack of Knowledge – City
 - a. Local Application
 - b. Need Specialist (ex. engineer, percolation tests)
 - c. Other
 - d. Physical Setting
 - e. Retrofitting
 - f. SW guru – someone who knows all aspects
 - g. Unfamiliar with LID
5. Lack of Knowledge Community
 - a. Don't understand need for LID
 - b. Physical Setting (ex. don't know location of waterways)
 - c. Unfamiliar with codes
6. Lack of Resource
 - a. Accessing Information
 - b. Lack of Examples
 - c. Local developers-engineers
 - d. Mitigation Banks
 - e. Space
 - f. Staff time/Staff
 - g. Technology

- h. Time
- 7. Maintenance
 - a. Enforcement
 - b. Other
 - c. Quantity
 - d. Whose Responsibility
- 8. Making it Matter
 - a. Community connection (difficult to identify)
 - b. Outreach opportunities (difficult to find)
- 9. Money
 - a. Costly
 - b. Lack Money
 - c. Restrictions (ex. grants with limitations on how money can be used)
 - d. Other
- 10. Other
 - a. Lack of Development has stalled LID
 - b. Complexity
 - c. Convincing key staff members
 - d. Feel out of control with many different facilities
- 11. Physical Setting
 - a. Climate
 - b. Flat
 - c. High water table
 - d. Other
 - e. Slopes
 - f. Small Basins
 - g. Soils
 - h. Unstable Geology
 - i. Valley Setting
 - j. Variance (of soils, slope, etc.)
 - k. Waterway
 - l. Wetland
- 12. Previous System
 - a. CSO
 - b. Buried drainage ways
- 13. Regulations
 - a. City Inhibitors
 - b. Conflict
 - c. Equity
 - d. Government Ambiguity
 - e. Government Inhibitors
 - f. Lack of City Code Clarity
 - g. Lack of Incentives or Enforcement from City
 - h. Other
 - i. Unsure how to create effective regulations
- 14. Risk

- a. Cost
- b. Environment
- c. Proven effectiveness/functionality

Approaches

1. Collaborate Outside City Governance (working with another entity or using their resources)
 - a. Broader Organization
 - b. Engineers/Consultants
 - c. Local Organizations
 - d. OSU
 - e. Other City/County
 - f. State Agency
 - g. Watershed Council/Group
2. Collaborate Within City Governance
3. Education of Community
 - a. CB label
 - b. City Workshops
 - c. Example Projects
 - d. General (general mention of outreach and education)
 - e. Information Pamphlets
 - f. Master Plan
 - g. Newspaper/Letter
 - h. Other
 - i. Website Information
4. Funding
 - a. Capital Improvement Project
 - b. Federal Money
 - c. Fees from Community
 - d. General Fund
 - e. Grant
 - f. SDC Fees
 - g. Urban renewal
5. Information Acquisition
 - a. City Data – (ex. physical setting, water quality, infiltration)
 - b. Conferences/Workshop/Classes/Meetings
 - c. General
 - d. Internet
 - e. Organizations/Associations
 - f. Other Cities/Counties
 - g. State Agency
 - h. Watershed Council/Group
6. LID Initiation
 - a. City
 - b. Developer
7. Make it Matter – How the city is making the community care about SW. What aspects are they “selling”?
 - a. Aesthetics
 - b. Community Connection
 - c. Cost effective
 - d. Financial Incentive

- e. Environment Incentive
 - f. General Incentives
 - g. Marketing
 - h. Other
 - i. Publicize Water Information
 - j. Recognition
 - k. Regulation
 - l. Water Conservation
8. SW Management toward LID
- a. Personnel Education
 - i. Work on Staff acceptance
 - ii. Keep Current
 - b. SW “dept” Organization
 - i. Decentralization
 - ii. Reorganize Departments
 - c. Logic
 - i. Small Steps
 - ii. Start Early
 - iii. Be Creative
 - iv. Take advantage of opportunities
 - v. Consider Alternatives
 - vi. Incorporate when easy
 - vii. Keep a neutral stance
 - viii. Start somewhere – take a risk
 - ix. Think ahead
 - x. Know what NOT to do
 - xi. Use local knowledge
 - xii. Make goals
 - xiii. Use natural system, use what already exists
 - xiv.
 - d. Pre Construction
 - i. Acquire Information
 - ii. Approach from several angles
 - iii. Planning Department Adjustments (ex. zoning, conservations zones)
 - iv. Localize
 - v. Lead by example
 - vi. Prevention – stop pollution before it enters the system
 - vii. Prepare for developer resistance
 - viii. Streamline/Simplify
 - ix. Use/create design standards
 - x. Only change when required
 - e. During Construction
 - i. Aesthetics
 - ii. Allow Flex
 - iii. Work on a Case by Case basis
 - iv. Make Adjustments

- v. Make each site responsible
 - f. Post Construction
 - i. Let Public/Home Owner Assoc. Maintain
 - ii. Use Non Structural Practices for Retrofit
 - g. Focus in
 - i. Fix Current Issues
 - ii. Focus on Commercial
 - iii. Focus on New development
 - iv. Focus on WQ
 - v. Only change when required
 - h. Broaden out
 - i. Focus on Green Practice rather than LID specifically
- 9. Regulation Adjustments
 - a. Allow Flex
 - b. Consistency
 - c. Don't Inhibit
 - d. Make Recommendations
 - e. Reinterpret
 - f. Small Specific Code Changes
 - g. Streamline/Simplify
 - h. Write/Update

Appendix E. Future Suggested Survey Questions

Below is a list of questions generated from the exploratory study. In italics are suggestions for how to present the question. These questions and/or themes are not properly formatted to fit a survey. Rather they are intended to guide a future researcher in data collection, allowing for flexibility when taking into consideration the context and environment in which these questions will be distributed. Additionally, it allows the following researcher to claim the survey their own.

1. Age of participants

Perhaps there is a connection between what a younger vs. older personnel brings to the table in terms of new ideas and perspectives.

2. How long a participant has worked with the city?

3. Does the participant live in the city?

4. How familiar is the participant with the term LID? Define this term in a stormwater context.

5. Does the city use Design or Performance Standards?

6. Does the city focus more on Flooding or Water Quality?

7. What types of expertise does the city have or lack?

Perhaps a series of checkboxes and other _____ to add in. (GIS, WQ specialist, Engineer)

8. What types of outreach are used and how often?

Checkboxes (public meetings, homeshows, talks, flyers, articles)

9. Where does the city obtain information (information sources)

Checkboxes (federal sources, internet, workshops, other cities, experts)

10. What methods of communication does the city use to obtain information from other cities?

Checkboxes (newsletters, workshops, meetings, e-mail)

11. What other entities does the city work with?

This could be on projects or another form of collaboration

Checkboxes (counties, government agencies)

12. What funding sources does the city use?

Checkboxes (grants, fees, city funds)

13. What is the major driver to the change in stormwater management?

(a flood event, regulations, community request, financial benefit)

14. What is the city income? What is the income for stormwater.

Basically how much do they have to work with?

15. Where is the city on a timeline of stormwater management

Do they have a stormwater management plan? For how long? How often is it updated? Does it include LID practices, etc.

16. If approaches have been implemented and had time for reflection, how effective were the approaches?

17. List barriers faced when looking to implement LID and rank the barriers in order of relative importance.