Diffusion of Innovations and Stormwater Management Systems in Eugene, Oregon

Source: Green Living Made Easy (2009)

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Abstract

The Clean Water Act (CWA) of 1972 and the amendments that followed in 1977 and 1987 had a significant impact on how states, and by extension, the cities within those states, manage stormwater as it relates to surface water. The CWA was established as a response to point source pollution and regulates pollutant discharge into U.S. waters. However, even with the implementation of these measures further testing of water quality in the 1990s found that water quality was still being affected by other sources of pollution, namely nonpoint source pollution. Stormwater runoff, a type of nonpoint source, is known to be a major contributor to water degradation. Therefore, stormwater management is an important component in reducing nonpoint source pollution to address water quality and quantity issues as outlined in the Clean Water Act. The federal government, in order to pursue reduction in nonpoint source pollution, is encouraging municipalities to look to their residents to voluntarily adopt measures that help reduce nonpoint source pollution through stormwater management strategies. This pilot study uses Everett Rogers' diffusion of innovation theory to understand why thirteen individuals in Eugene, Oregon reached the decision to adopt stormwater management systems on their properties.

Executive Summary

The Clean Water Act (CWA) of 1972 and the amendments that followed in 1977 and 1987 had a significant impact on how states, and by extension, the cities within those states, manage stormwater as it relates to surface water (EPA, 2011; U.S. EPA, 2011c). Beginning in the late 1980s and early 1990s it was found that nonpoint source pollution was a major factor in water degradation. As part of regulating discharges into the nation's water bodies, all municipalities and counties with populations over 50,000 are required to obtain a Municipal Separate Storm Sewer System (MS4) permit from the National Pollutant Discharge Elimination System (NPDES). The MS4 permit requires an outreach and education component in the municipality's stormwater management plan, because of the diffuse nature of stormwater runoff and the existing infrastructure of separate storm sewer systems. It is difficult and expensive to have a comprehensive system that is able to handle not only the increased runoff, but also the increased pollutants inherent in the runoff. The education and outreach component of the MS4 permit is designed to have municipalities encourage their residents to adopt stormwater management systems as a way to reduce the pollutant and increased water load into the local water bodies. Therefore, this pilot study is an attempt to understand why individuals chose to install stormwater management systems at their place of residence.

In an attempt to answer this question, the study design was based on principles from Everett Rogers' theory, *diffusion of innovations*. This theory discusses how an idea is spread through a community. The important considerations of the spread of stormwater management systems are addressed by Rogers' decision-making process. This is a five-stage process that involves an individual (1) becoming aware of the innovation, (2) forming an opinion about it, (3) choosing to adopt or reject it, (4) implementing it, and (5) affirming or denying the continued use of the innovation. The decision-making process is further influenced by the rate of adoption factors: relative advantage, compatibility, complexity, trialability, and observability; and adopter characteristics: innovator, early adopter, early majority, late majority, and laggard. These characteristics influence the probability that an individual will adopt the innovation.

The research questions use the theory to understand why individuals chose to install a stormwater management system at home:

- How well did the decision-making process described by Rogers fit the study participants' decision-making?
- How does the environmental context affect the rate of adoption in stormwater systems?
- How have adopter categories and characteristics influenced individuals to adopt stormwater management tools?

Thirteen interviews were conducted between May and October 2011. The study participants were adults with an installed stormwater management system at their place of residence. The study area was Eugene, Oregon, as it is a municipality with an MS4 permit and stormwater management plan that has an action item related to stormwater outreach and education. The interview results were analyzed by grouping the interview questions under the relevant research questions.

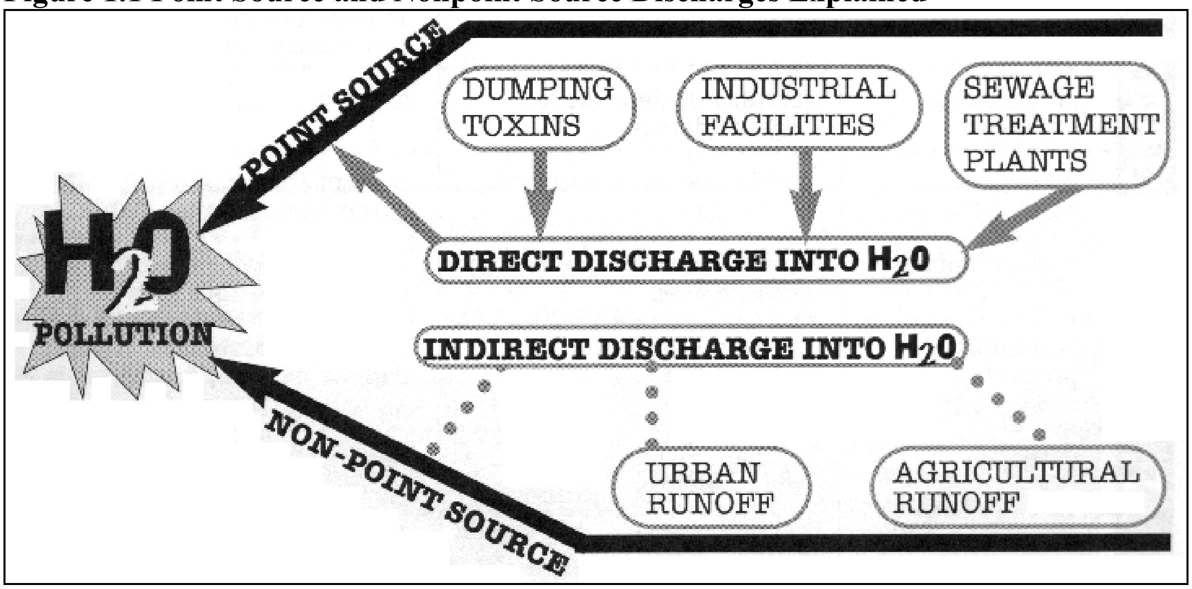
The analysis of these results showed that Rogers' diffusion of innovations model was not an entirely useful application in this study. The decision-making processes that individuals underwent were classified according to the five stages described by Rogers with the addition of a cost-benefit analysis. The rate of adoption and environmental context theme organized respondents' motivations for adoption and the factors that made the process more or less attractive. Major motivations were found to be: aesthetics, water problems, or environmental concerns. Additional factors for example included political environment and trialability. For some participants being able to try or see other stormwater management systems was an influential factor in considering adoption themselves, because it reduced the uncertainty associated with the system as it was apparent that it worked. Others found that the code requirements for stormwater management systems were restrictive and that the City should employ a more flexible approach to stormwater management in order to encourage wider adoption by residents.

Additionally, adopter categories were applied to understand the role that an individual's personal characteristics might play in influencing his propensity for adopting an innovation. In the case of this study, it showed that participants were located on the beginning part of the spectrum for stormwater management systems adoption (i.e. they adopted before the average person). To summarize, individuals in the study had a strong environmental ethic and innovativeness that influenced their decision-making process as categorized by Rogers that led to their adoption of a stormwater management system.

Chapter 1: Introduction

The Clean Water Act (CWA) of 1972 and the amendments that followed in 1977 and 1987 had a significant impact on how states, and by extension, the cities within those states, manage stormwater as it relates to surface water (EPA, 2011; U.S. EPA, 2011c).[1] The CWA was originally established as a response to point source pollution and regulates pollutant discharge into U.S. waters (EPA, 2011). However, even with the implementation of these measures, further testing of water quality in the 1990s found that water quality was still being affected by other sources of pollution, namely nonpoint source pollution (Novotny & Brown, 2007; Lin, Gang, & Deng, 2009). The difference between point and nonpoint source pollution is shown in Figure 1.1. Point source pollution is typically derived from industrial facilities or sewage treatment plants, whereas a major contributor to nonpoint source pollution is stormwater runoff. According to the *National Water Quality Inventory: 2000 Report to Congress,* urban stormwater is a leading contributor to water quality impairment (United States, 2005).

Figure 1.1 Point Source and Nonpoint Source Discharges Explained



Source: Lake Pontchartrain Basin Foundation (2001) *Lessons on the lake: Water pollution*

The findings that urban stormwater degrades the quality of water in the U.S. led to a reevaluation of stormwater management best practices resulting in low impact development (LID) techniques. The incorporation of LID techniques is in direct contrast with conventional stormwater management systems, which focus on draining runoff via, what is known as a Municipal Separate Storm Sewer System (MS4), as quickly as possible into the local water bodies. The problem with conventional MS4s is that the stormwater transported and discharged into the water bodies is typically untreated and contains any chemicals, trash, or "pollutants" that the stormwater collects as it flows over impervious or saturated surfaces (U.S. EPA, 2011a). To proactively prevent or reduce the entrance of harmful pollutants into an MS4 the CWA requires

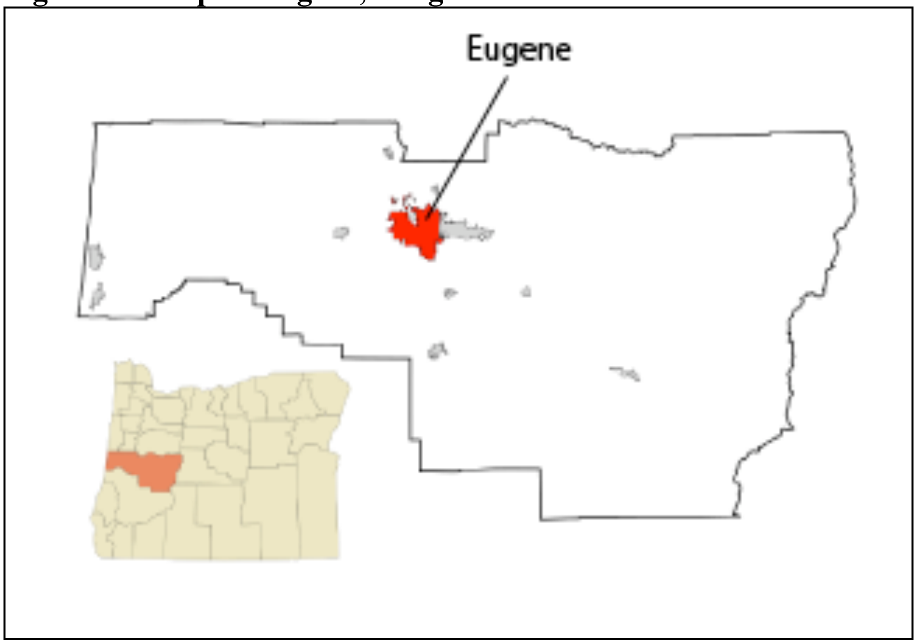
[1] The 1987 amendment specifically required the establishment of a stormwater discharge program (U.S. EPA, 2011c).

that the MS4 operator obtain a permit from the National Pollutant Discharge Elimination System (NPDES), in addition to developing a stormwater management plan (U.S. EPA, 2011b).

Permit holders are divided into Phase I and Phase II categories. “The Phase I category was established in 1990 and requires medium and large cities or certain counties with populations over 100,000 to obtain a NPDES permit (U.S. EPA, 2011b).” Phase II permittees were not a focus of this study and are not discussed here. Under an MS4 Permit, permittees are required to have an outreach and education strategy to address stormwater concerns in the community. It further states that the stormwater program must: “(I) Continue to implement a documented public education and outreach strategy that promotes pollutant source control and a reduction of pollutants in stormwater discharges. [...] (II) Provide educational materials to the community or conduct equivalent outreach activities describing the impacts of stormwater discharges on water bodies and the steps or actions the public can take to reduce pollutants in stormwater runoff (Oregon Department of Environmental Quality, 2010, Section 4d).” The MS4 permit shows that the federal government sees stormwater management as an important component in reducing nonpoint source pollution to address water quality and quantity issues as outlined in the Clean Water Act. It also highlights the role that municipalities are expected to fulfill with regard to their MS4 permits with a focal point on encouraging residents of the respective municipalities to voluntarily adopt measures that help reduce nonpoint source pollution through stormwater management strategies. In using outreach strategies to educate the public about stormwater runoff it is important to understand the factors that might influence individuals’ decisions to adopt such systems.

Accordingly, this pilot study investigates why individuals installed stormwater management systems at their place of residence. Study participants are individuals in Eugene, Oregon with installed stormwater management systems on their properties. For the purposes of the study Eugene is delimited by the urban growth boundary (UGB) as shown in Figure 1.2. The ultimate goal of this study is to apply Rogers’ theory to the interview results to understand individuals’ decision-making processes, the influencing factors on rate of adoption, and a composite of the individual as an adopter. These findings will help to encourage others in Eugene to adopt a stormwater management system, thereby, reducing nonpoint source pollution in the City of Eugene.

Figure 1.2 Map of Eugene, Oregon



Source: U.S. Census Bureau

Organization of this Report

Chapter 2 presents definitions relevant to this report. Chapter 3 provides an overview of Everett Rogers' diffusion of innovations theory. Chapter 4 discusses the methodology for this pilot project. Chapter 5 is the application of Rogers' theory to the interview results. Chapter 6 discusses the implications of the study. Chapter 7 then concludes with future research opportunities and a summary of the report.

Chapter 2: Definitions

Nonpoint source pollution is defined as "commonly coming from diverse diffuse sources including urban stormwater, agriculture, and hydromodification, etc. (Lin, Gang, & Deng 2009, 1996)." Nonpoint source pollution occurs when there is rainfall and the water that is not absorbed by the ground then finds its way to the nearest waterway. Since the water is running along the surface it picks up contaminants that are then carried into the water supply.

Stormwater management systems are any technology that in some form deals with stormwater runoff, more specifically rainwater is detained on the interviewee's property in some form for a time period that depending on the system's set-up may or may not enter the city's stormwater system. This includes green roofs, rain catchments, rain gardens, bioswales, and additional low impact development technologies.

These technologies are defined using the U.S. EPA's Fact Sheets on Low Impact Development:

- *"Bioretention cells*, commonly known as rain gardens, are relatively small-scale, landscaped depressions containing plants and a soil mixture that absorbs and filters runoff.
- *Cisterns and rain barrels* harvest and store rainwater collected from roofs.
- *Green roofs* are rooftops partially or completely covered with plants.
- *Permeable and porous pavement*s reduce stormwater runoff by allowing water to soak through the paved surface into the ground beneath (U.S. EPA, 2010)."
- "An *infiltration trench* (also known as an infiltration galley) is a rock-filled trench with no outlet that receives stormwater runoff (U.S. EPA, 2006)."
- "A *vegetated swale*, [also known as a bioswale], is a broad, shallow channel with a dense stand of vegetation covering the side slopes and bottom (U.S. EPA, 1999, 1)."

Chapter 3: Literature Review

Diffusion of innovations is a useful theoretical construct for examining why residents chose to install stormwater management systems at their place of residence, as it provides a decision-making model to explain the process of how an innovation is adopted. Therefore, the focus of this literature review is to explain the theory on diffusion of innovations, its applications and critiques. Everett Rogers first developed the theory diffusion of innovations in 1962, and has since revised the model several times, most recently in 2003.

What is Diffusion?

"*Diffusion* is the process by which an *innovation* is *communicated* through certain *channels* over *time* among the members of a *social system* (Rogers, 2003, 11, emphasis original)." Defining each of these components is necessary to comprehend the extensiveness of the diffusion of innovations. Diffusion in Rogers' (2003) context includes both the planned and spontaneous spread of an innovation. However, Greehalgh et al. (2004) distinguish between planned diffusion and spontaneous diffusion in which planned diffusion (active role in spreading the innovation) is dissemination and the spontaneous spread of an innovation is a passive method, defined as diffusion. According to Stoneman (2002), diffusion is concerned with the process of incorporating an innovation from knowledge of the innovation to its actual use. In simplified terms it is a way to describe "the spread of new ideas, practices, and goods" regardless of the nature of transmission (i.e. active or passive) (Arnould, 1989, 240). These flows of innovations can be vertical or horizontal in nature (Stoneman, 2002; Wejnert, 2002) A vertical flow of innovation describes the diffusion process as higher status or prestige individuals adopting an innovation that is then spread to lower status or prestige individuals (an example being a boss and one of his employees). Innovations that are transmitted horizontally involve individuals of the same status or prestige (i.e. CEO to CEO). Therefore, diffusion can be spontaneous or planned and transmitted vertically or horizontally, but the main idea is that it represents the flow of adoption for an innovation. However, as stated by Ormrod (1990), advances in technology (i.e. communication and transportation) affect diffusion theory and it may not be able to explain the spread of innovations as accurately because of the dilution of distance and associated influences.

What is Innovation?

Innovations can be processes, technologies, or ideas, whose aspect changes in some manner (Innovation, 2011). An innovation is not necessarily something that is brand new; rather if an individual is experiencing it for the first time it is considered an innovation (Rogers, 2003; Damanpour, 1991). There are multiple types of innovations, one of which is the preventive innovation (Damanpour, 1991; Rogers, 2003). A preventive innovation is implemented in order to ward off or mitigate the effects of an undesirable future event (Rogers, 2003). An example of a preventive innovation is the topic of the study, stormwater management systems. A stormwater management system serves to reduce pollutant levels in water bodies, but given the esoteric nature of water quality management when potable water is readily available from the city can make it difficult to show the potential benefits of the system. Due to the nature of preventive innovations it is challenging to show potential adopters the benefits of these innovations. Understanding what an innovation is and how it is diffused through communication channels can impact innovation adoption directly.

Communication Channels

Communication channels are the distributing mechanism of a novelty between individuals in a social system (Greve et al., 1995; Rogers, 2003). Building on Rogers' definition of a communication channel, Henrich (2001) argues that "the dynamics of diffusion" rely on culturally biased communication exchange. Thus, creating the idea that communication channels are inherently biased and that the role of diffusion in the spread of innovations is affected further by economics, social structure, politics, and environment (Connell and Cohn, 1995; Rogers, 2003; Wejnert, 2002; Savage, 1985; Negri & Brooks 1990; Ormrod, 1990). Not only does biased cultural transmission affect the rate of adoption of an innovation, but it also builds on the inherent imitation factor as first discussed by Tarde in the early 1900s (Rogers, 2003; Van den Bulte & Stremersch, 2004). Imitation can be linked to the idea of social contagion in which the spread of an innovation is influenced by other members' use of the innovation including their insights and knowledge of it (Van den Bulte & Stremersch, 2004). In sum communication channels are not necessarily just the verbalization of a new idea but the individual's interaction with it as portrayed to other members of society. The use of communication channels are influenced by the overarching social system. A social system touches on social norms and provides a structure of behavior in which people behave and interact in an institutionalized manner (Rogers, 2003). The link between communication channels and a social system influences how an innovation is spread.

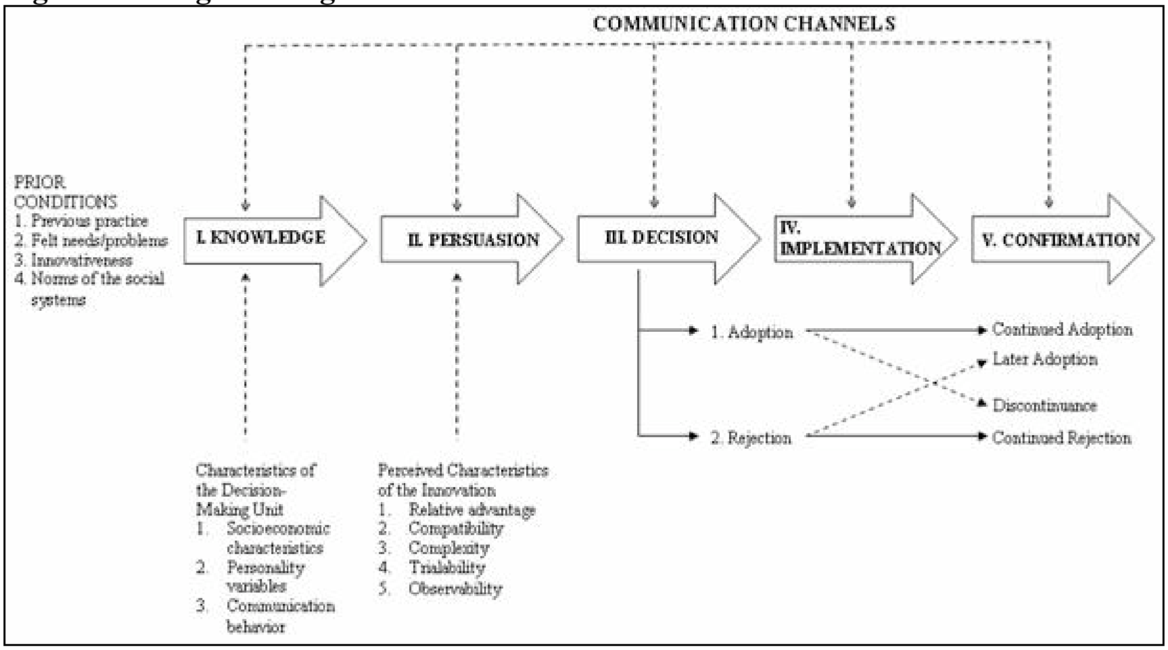
Time

The use of time as a variable in diffusion of innovation sets it apart from other theoretical constructs (Rogers, 2003). Applying time to diffusion research relies on the individual's memory of his decision-making process, the characteristics of the individual as an adopter (that is, how soon he adopted the innovation), and the rate of an innovation's adoption in a social system (Rogers, 2003; Savage, 1985; Weisburd & Lum, 2005; Wejnert, 2002). Adopting an innovation can also be constrained by the timing of the decision and whether or not it is "right" as conceived of by other members of the social system (Savage, 1985; Van den Bulte & Stremersch, 2004). Thus, time as a factor in diffusion research has multiple influences on how innovations are conceived, received, and incorporated.

The Decision-Making Process

The decision-making process known by Rogers (2003) as "the *innovation decision process*" is composed of five stages (168, emphasis original). The five stages are those that involve an individual or organization (or some other decision making body) (1) becoming aware of the innovation, (2) forming an opinion about it, (3) choosing to adopt or reject it, (4) implementing it, and (5) affirming or denying the continued use of the innovation (Greenhalgh et al., 2002; Nam & Barnett, 2010; Rogers, 2003; Weisburd & Lum, 2005). Figure 3.1 illustrates the five stages and shows how they are connected to the environmental context and rate of adoption factors. An overview of each stage is provided and will be described as (1) the knowledge stage, (2) the persuasion stage, (3) the decision stage, (4) the implementation stage, and (5) the confirmation stage. Although these stages are a type of social construction they provide a basis for understanding complex thought processes and insight into "human behavior change (Rogers, 2003, 195)."

Figure 3.1 Stages in Rogers' Diffusion of Innovations



Source: Everett Rogers (2003) *Diffusion of Innovations,* 170

The Knowledge Stage

According to Rogers (2003) three types of knowledge inform this stage: awareness knowledge, how-to knowledge, and principles knowledge. These highlight the knowledge we seek in understanding an innovation from its existence to how it works and what its advantages and disadvantages are. The knowledge types work to dispel the uncertainty associated with an innovation.

It is argued that there are types of exposure and/or perception that influence an individual's knowledge of an innovation. These are selective exposure and selective perception. Selective exposure plays a role in this stage as it describes how individuals attenuate themselves to ideas that fit with their beliefs. That is if an innovation resonates with an individual and her attitude it increases the probability of noticing the innovation and perhaps adopting it later on. Selective perception also plays a role in the knowledge stage. Selective perception is based on the individual having an existing need that lacks a solution (Rogers, 2003; Weisburd & Lum, 2005). The absence of need affects the perception of an individual, as there is no driving force to find a solution for an unperceived problem. Therefore, an individual is not paying active attention to potential innovations around herself. However, these ideas contrast and need does not necessarily mean an individual recognizes she has a problem that needs solving. On the one hand, there are examples that directly contradict selective perception, such as the fashion or video game industries. In these cases it is the innovation that drives the need to have it. On the other hand, there are other factors at large and people may know about the innovation, but have not adopted it (Ormrod, 1990).

The Persuasion Stage

Rogers (2003) use of the term persuasion relates to an individual's attitude construction that then informs changes the individual makes (Wejnert, 2002). In other words, the act of motivation according to Geen et al. (1984) is "the operation of inferred intrapersonal processes that direct, activate, and maintain behavior (3)." This supports the role of external and internal forces in an individual forming his attitude as described by Rogers (2003). The persuasion stage is also the active information seeking stage. In this stage an individual discusses the innovation typically with friends and family. The individual then internalizes their opinions and the opinions of friends and family that will either reinforce or oppose their attitude about the innovation (Rogers, 2003; Wejnert, 2002).

The Decision Stage

The decision stage is the stage where the individual having actively pursued information on the innovation has chosen whether to adopt or reject it. Rogers (2003) considers two types of rejection possible: active and passive rejection. Active rejection means that the individual thinks about adopting the innovation but then does not follow through with complete adoption. Passive rejection means that the individual does not think the innovation merits any deliberation about use and does not adopt it.

The Implementation Stage

The implementation stage is where the individual puts the innovation into action. It is no longer a matter of just weighing decisions; rather it is a concrete experiential stage to which he or she puts the innovation to the test (Rogers, 2003).

The Confirmation Stage

The confirmation stage is the stage where the individual chooses to either continue using the innovation or completely reject it. The individual's choice is additionally influenced by positive and negative behavior reinforcements that deal with the innovation. These behavior reinforcements can cause a state of dissonance in the individual and can influence her to react in a manner opposite her original stance, in order to reduce the discordant feelings now associated with the innovation. Rogers (2003) categorizes discontinuance as having two causes: replacement and disenchantment discontinuance.

Discontinuance

A replacement discontinuance means that the individual has found a different innovation to take the place of the innovation originally incorporated (Arnould, 1989; Nam & Barnett, 2010; Rogers, 2003). A disenchantment discontinuance is caused when an individual is unhappy with how the innovation has functioned or is contrary to how he believed it would operate (Rogers, 2003).

Alternative to Rogers' Decision-Making Process

Damanpour (1991) incorporates a simplified model of Rogers' decision-making process. Instead of having a separate knowledge, persuasion, and decision stage; he uses an *initiation stage* that consists of "all activities pertaining to problem perception, information gathering, attitude formation and evaluation, and resource attainment leading to the decision to adopt (362, emphasis added)." His version of the *implementation stage* also differs from Rogers' in that it includes "all events and actions pertaining to modifications in both an innovation and an organization, initial utilization, and continued use of the innovation when it becomes a routine feature of the organization," thus, combining the implementation and confirmation stages

(Damanpour, 1991, 562, emphasis added). Damanpour's approach, however, is essentially the same as Rogers' decision-making process, as it only differs in the number of stages applied to someone's decision-making process.

Two contrasting approaches to Rogers' decision-making process (and thereby Damanpour's) are discussed in Henrich's (2001) article. The first is promulgated by Gladwin and Butler and is summarized in three steps: "(1) individuals evaluate alternatives using low cost experiments to gather information, (2) these decisions become codified in cultural rules, and (3) these rules are transmitted (unbiased) to the next generation (as quoted in Henrich, 2001, 996)." Basically, he is saying that the change-driver in human behavior is in the performance of a cost-benefit analysis of an innovation (Henrich, 2001). However, Henrich critiques this approach and demonstrates that the "dynamics of diffusion" rely "on some form of biased cultural transmission (Henrich, 2001, 992)." Biased cultural transmission relies on the idea that people are influenced by three types of biases. These are described as direct (someone's inherent traits), prestige (influence from someone of a higher social status), and conformist (influenced by what the majority prefers) bias. Henrich's model ties to the modes of diffusion as a vertical or horizontal process as discussed by Wejnert (2002) and may provide an improved understanding of how individuals are influenced in their decision-making process not found in Rogers' model. Contemplating the role of biased cultural transmission and cost-benefit analysis could potentially simplify the categories of Rogers' diffusion of innovations model.

Additional critiques of diffusion research applied to the decision-making process, as put forth by Rogers (2003) are that diffusion theory needs to improve its grasp on why a decision-making unit chooses to adopt an innovation. It also needs refrain from determining that an innovation failed because of an individual or the system, and realize it is a multi-factor cause that takes into account the self-reported recall data. The self-reported recall data is especially critical as it relies on the individual to remember past behavior and thought patterns, which as time goes on gets increasingly fuzzy. Adding to the perceived failure of an innovation is that a majority of the research done with this theory does not focus on failed innovations; instead it is applied to successful cases of innovation diffusion. The determination of an innovation's "successful" diffusion is affected by these factors, but does not incorporate the idea that the innovation-decision process may be culturally biased as well and introduces the importance of factors in innovation adoption and the environmental context (Arnould, 1989; Rogers, 2003).

Rate of Adoption and the Environmental Context

The rate of adoption for an innovation is affected by multiple factors, such as relative advantage, compatibility, complexity, trialability, and observability (Nam & Barnett, 2010; Ormrod, 1990; Rogers, 2003; Savage, 1985). Perceptions of innovation traits as related to the rate of adoption can further affect the adoptability factor (Savage, 1985). Additional factors include the environmental context in innovation diffusion, specifically geographic settings, societal culture, political conditions, and globalization and uniformity (Ormrod, 1990).

Relative advantage is the perception that an innovation is improving upon the individual's current situation (Greenhalgh et al., 2002; Rogers, 2003; Weisburd & Lum, 2005). This improvement can be in terms of social status, economic profitability, self-enhancement, and so forth so long as the individual believes he or she derives some form of benefit from the innovation.

Compatibility is an important factor in introducing innovations, in that an innovation must lend itself to the attitudes and beliefs of the population to which it is being introduced. Compatibility issues must address "existing values, needs, and past experiences of potential adopters (Arnould, 1989; Greenhalgh et al., 2002; Ormrod, 1990; Rogers, 2003, 240)." If innovations are not compatible with these categories it can lead to nonadoption by the population.

Complexity deals with the perception of how difficult an innovation is to use (Greenhalgh et al., 2002; Ormrod, 1990; Rogers, 2003). If it has a perception of high technicality and low ease of use then it will affect the rate of adoption, as people will feel that they do not have the skills to use the innovation.

Trialability is the possibility of using an innovation on a trial basis (Greenhalgh et al., 2002; Rogers, 2003). This allows individuals to experiment with the innovation on a less permanent basis and form a better idea of how the innovation works. The individual that tries the innovation may also serve as a vicarious experience of the innovation for others (such as friends and family) and may further influence their decision-making process about the innovation (Rogers, 2003).

Observability can influence other members in the social system to adopt a new idea, because they can see drawbacks and benefits to an innovation implemented by someone else thus reducing their uncertainty about it (Arnould, 1989; Greenhalgh et al., 2002; Rogers 2003).

The *environmental context* of an innovation plays an important role in its diffusion (Ormrod, 1990; Wejnert 2002). An innovation typically evolves to some specific indicator such as its "geographic settings, societal culture, political conditions, and globalization and uniformity (Wejnert, 2002, 310)." These indicators represent consequences on a private and public scale and further illustrate that locality shapes how the innovation is received (Arnould, 1989; Ormrod, 1990; Savage 1985; Wejnert, 2002). Therefore, the attributes of an innovation must be considered for its successful implementation.

Role of Incentives

Incentives can also influence the adoption of an innovation (Savage, 1985). However, the innovation must be perceived by the organization that is offering the incentive to be of some benefit to the population. There are many types of incentives such as mandates, subsidies, and discounts to serve as a mode of speeding up innovation adoption. Incentives and mandates play a major role in getting people to adopt preventive innovations (Rogers, 2003).

Consequences of Innovation Adoption

Adopting an innovation has consequences that can be either positive or negative, but often contain a combination of both. Consequences as defined by Rogers (2003) hinge on the changes an innovation introduces either through its adoption or rejection by members of a social system (Savage, 1985).[2] Berger (2005) critiques the lack of follow-up research on the consequences of innovation adoption or rejection and states that it is important to address as it may influence an

[2] For a more detailed discussion about the consequences of adopting an innovation see Rogers (2003).

individual's attitude towards future innovations. Consequences in general terms can never be entirely deduced; therefore, incorporating an innovation will always contain some measure of uncertainty.

Adopter Categories and Characteristics

Rogers describes five types of adopter categories (with the caveat that they are idealized types) based on the timing of the implementation of the innovation (2003). The adopter categories are: (1) innovators, (2) early adopters, (3) early majority, (4) late majority, and (5) laggards (Nam & Barnett, 2010; Rogers, 2003). Three variables are used to describe characteristics of adopter categories. These variables are socioeconomic characteristics, personality variables, and communication behavior. Adoption of an innovation is further influenced by an individual's personal characteristics (Nam & Barnett, 2010; Ormrod, 1990).

Innovators can be equated to adventure seekers (Savage, 1985). They typically have more monetary resources (Rogers, 2003; Savage, 1985) and because of their resource security are more confident and able to deal with uncertainty associated with innovations. Because of their risk-taker role they tend to be less bound by social norms and have a wider range of social contacts. Therefore, they serve as a catalyst for the introduction of a new idea into a social system.

Early adopters are integrated slightly more into the local social system. However, they command a level of respect because of their judicious decision-making and subjective evaluation of an innovation. This serves to decrease the uncertainty associated with the new idea. Furthermore, in their role as opinion leaders they can trigger the tipping point for the widespread adoption of an innovation (Rogers, 2003).

Early majority are next on the adoption scale and adopt an innovation right before the average person. They are more integrated in the social system and are integral to the spread of a new idea. Although, they tend to deliberate longer before implementing the new idea, and because of this they do not serve as opinion leaders (Rogers, 2003).

Late majority are adopters due to social norms and economic pressure. They tend to adopt a new idea after the average person and are skeptical of the innovation. The late majority has scarcer resources and so the system must favor adoption, in order for the innovation to be safe to implement (Rogers, 2003; Wejnert, 2002).

Laggards adopt an innovation last. They tend to be socially isolated and are suspicious of change. Their decision-making is based on past experiences and traditional values. However, this can be considered rational as they have more limited resources and need to be completely certain that the innovation will not fail (Rogers, 2003; Wejnert, 2002).

In defining the adopter categories, it is possible to see the role that the characteristic variables (socioeconomic characteristics, personality variables, and communication behavior) play in determining who is an innovator and who is a laggard.[3] However, Greenhalgh et al. (2002) argue

[3] A more detailed description of these categories can be found in Rogers (2003).

that there is no statistical evidence supporting Rogers' adopter categories and characteristics, and that they purport stereotypes and sanitize how an individual interacts with an innovation. Gatingnon and Robertson (1985) also state that adopter categories are questionable, as the findings associated with these constructs are not empirically consistent (Henrich, 2001). Furthermore, it does not only place emphasis on the "innovators" and so forth, but it also contributes to the perpetuation of pro-innovation bias as studies typically only focus on successfully diffused innovations (Henrich, 2001). Henrich (2001) further argues that individuals are equal in their likelihood of adopting an innovation, but the influential factor in continuing the spread of the innovation may be reliant on the economic success of the individual. Therefore, those who have low income and innovate are not likely to trigger the further spread of a new idea, because people are less likely to copy them and because the spread of the idea is stopped they are not considered innovators (Henrich, 2001). Another critique of the theory is that the innovation-decision process may be culturally biased (Arnould, 1989; Rogers, 2003). Therefore, care should be taken when applying Rogers' adopter categories.

Summary

Diffusion of innovations is a comprehensive theory that is not represented in its entirety here. The literature review provides key theoretical aspects that will be used in the study to understand why individuals adopted stormwater management systems. The decision-making process with its five stages will be used to see if there is a trend in the diffusion of stormwater systems as it relates to the individual adopter and his decision-making process. Decision-making processes are further influenced by internal and external factors. These factors are described as the rate of adoption factors and the environmental context. Examples of these factors include the perceived benefit of the innovation and geographic conditions. However, the decision-making processes and adoption factors are additionally complicated by the adopter categories and characteristics. These categories attempt to explain how the individual's attitude towards innovation affects when and how he adopts the new idea. The inclusion of critiques on Rogers' diffusion of innovations is necessary to understand the weaknesses and strengths of the theory and will help form the context of whether applying Rogers' theory is useful in analyzing the study results.

Chapter 4: Methodology

This pilot study investigates why individuals in Eugene, Oregon have chosen to install stormwater management systems on their property. The study design was based on principles from Everett Rogers' diffusion of innovations theory. The interview guide was created with the theory's parameters in mind and the results derived from the interviews were examined using it. Understanding individuals' motivations to adopt these systems may be used to address the emphasis of the Clean Water Act and MS4 permit requirements for municipalities to focus on the reduction of nonpoint source pollution in their communities.

Research Questions

This pilot study is an attempt to understand why individuals chose to install stormwater management systems at their places of residence. There are three components to this question:

- How well did the decision-making process described by Rogers fit the study participants' decision-making?
- How does the environmental context affect the rate of adoption in stormwater systems?
- How have adopter categories and characteristics influenced individuals to adopt stormwater management tools?

Data Collection

The study area of this project is Eugene, Oregon. It has a population greater than 100,000 and is categorized as a Phase I City. As a Phase I City it has a NPDES permit and the requisite stormwater management plan in place. Part of the purpose of the stormwater management plan according to the NPDES MS4 permit guidelines is to incorporate education and outreach activities to encourage residents to adopt a stormwater management system in order to help reduce the amount of pollutants entering the local water bodies. For example, in the *City of Eugene, Oregon Stormwater Management Plan* (2011) there is an action item (A1) called Stormwater Education that focuses on: "planning, developing, implementing and revising as necessary a program to provide stormwater information and education to homeowners, […] and the general public about the impacts to stormwater quality and natural resource values from both point and non-point sources of pollution."

Subjects for the research project are adults that live in Eugene and have incorporated stormwater management systems at their place of residence. To generate a list of interviewees that fit these criteria, I first contacted Jenna Garmon of the Office of Sustainability for the City of Eugene, who then compiled a list of individuals for contact. I also contacted Master Gardeners, a branch of OSU Extension Service, and the local utility company, Eugene Water and Electric Board. The local utility company declined to provide contact information of potential interviewees. To generate additional interview subjects I asked participating interviewees if they knew of someone that fit the criteria for an interview that would be interested in being interviewed. This method is known as snowball or referral sampling and is used when interview subjects are difficult to find (Frank & Snijders, 1994).

To conduct this study I used qualitative semi-structured interviews of individuals that have installed stormwater management devices. In cases where the individual did not have time to meet for a personal interview, interviews were then conducted via email (two interviews) or phone (one interview). A total of 13 interviews were conducted between May and October 2011. Each subject participated in one interview ranging from 15 minutes to an hour and a half in time. The interviews were typically conversational in nature barring participants' time constraints, in which case the interview guide was followed more closely to expedite the interview process. When possible interviews were digital-audio recorded and then transcribed, in other cases handwritten notes were taken and then transcribed. In the case of emails, the interviews were in typed format.

The interviews focused on three major themes found in the theory of diffusion of innovations: the decision-making process (Table 4.1), rate of adoption and environmental context (Table 4.2), and adopter categories and characteristics (Table 4.3). (For the Tables please see the Appendix to see how the questions were grouped under each research question.) One caveat of the question grouping is that some answers to the questions had overlap in the themes and greater theoretical application. The questions under the decision-making process dealt with the steps an individual undertook to implement the innovation, such as research performed, potential influences, and lessons learned. The questions that addressed how the environmental context affected the rate of adoption took into account individuals' motivations for the adoption of the stormwater management system, the benefits and challenges of the system, as well as potential influences. Lastly, the research question that discusses adopter categories and characteristics looked at when the stormwater system was adopted, the decision-making process of the individual, and if the individual potentially influenced other community members.

The transcriptions and typed material were analyzed by thematic categories according to Rogers' diffusion of innovations theory. Under the larger categories exist smaller subcategories that represent further analysis of the interview results. Using quotes from the interviews further supplemented the analysis and supported the observations found in diffusion of innovations. The results of the analysis are found in the findings and provide a comprehensive overview of the "how" and "why" found in the research question, in order to bridge the gap between the theory and practical application of diffusion of innovations.

Study Limitations

Study limitations are evident in this pilot project. A major limitation was the sample size of thirteen people. As these thirteen people represent the adopter population of the study, it is difficult to determine how typical they are of the general population. Further, constraining this study was the parameter that study participants were limited to those who had voluntarily installed stormwater management systems. The *Eugene City Code Section 9.6790-9.6796* regulates stormwater management for the city and requires that new development and redevelopment (within certain parameters) incorporate city approved stormwater management systems into the site design. These regulations further determine the design standards in order to ensure that the stormwater management systems are functional and appropriate for the site. The mandates therefore reduced the available sample population. Although, for the purposes of the study it was beneficial to not include individuals with mandated systems, since it provided a more comprehensive study as to why an individual would choose to implement a stormwater management system. However, due to the small sample size it shows that the innovation is not as widespread and this affected the study in the analysis of adopter categories as the nature of the late majority and laggard categories show that these individuals would not adopt the innovation unless absolutely necessary. Another limitation that is inherent in the theory application itself is the tendency to look at only adopters of innovations. This identified weakness in the theory is continued in this study and so does not provide a comprehensive picture of adopters and nonadopters, thus further promoting pro-innovation bias. A further constraint that is not addressed by this study is the notion of recall. Respondents are asked to remember what their thought processes were in the past. Recall is problematic, because the greater the time period that has elapsed since the adoption of the innovation the likelihood of "fuzzy memory" increases. Despite the study limitations this pilot project will attempt to address the how and why of innovation adoption through Rogers' theory as applied to residents in Eugene that fit the study criteria.

Chapter 5: Findings

The application of diffusion of innovations in the context of this study deals with the individual as the unit of decision-making. The innovation in this study is a stormwater management system. Thirteen different individuals were interviewed to understand how adopter characteristics and the decision-making process as discussed by Rogers influenced individuals to adopt stormwater management systems on their property. The application of the theory will cover individuals' decision-making process, adopter categories, and rate of adoption.

Overview of Individuals

Individuals that were interviewed had a wide range of stormwater management systems in place and some had multiple systems. The most common system was rainwater catchments. Other systems in place were bioswales, rain gardens, paver/permeable surfaces for driveways/walkways, detention ponds, infiltration trenches, and a green roof (see Table 5.1). The date of system installation ranges from the early 1990s to 2010, as shown in Table 5.2.

Table 5.1

Stormwater System Type	Number*
Bioswale	3
Detention/Retention Pond	2
Green Roof	1
Infiltration Trench	1
Paver System	3
Rain Catchment	9
Rain Garden	3

*In some cases people had multiple types of features, the ones that were classified as the same type are counted only once.

Table 5.2

Installation Times	Number/Year
1991	1
1992	1
2001	1
2002	1
2006	1
2007	2
2008	4
2009	1
2010	1
Continuing*	3

*Started the initial installation in a given year, but are continuing to add new features.

Demographics

The demographics of the study participants are generalized observations made during the interview process. Overall, respondents appeared to be Caucasian, middle to upper-middle class, in their late thirties or older, and owned their own homes. Most respondents had some sort of higher education background as disclosed during the interviews.

Decision-Making Process

The decision-making process is composed of five stages that involve an individual: (1) becoming aware of the innovation, (2) forming an opinion about it, (3) choosing to adopt or reject it, (4) implementing it, and (5) affirming or denying the continued use of the innovation (Greenhalgh et al., 2002; Nam & Barnett, 2010; Rogers, 2003; Weisburd & Lum, 2005). However, the decision stage is not discussed in the findings as all study participants had installed their systems. The decision-making process individuals underwent serves to demonstrate how people went from knowing about stormwater management systems and their motivations to the actual installation of the system.

The Knowledge Stage

According to Rogers (2003), three types of knowledge inform this stage: awareness knowledge, how-to knowledge, and principles knowledge that work to dispel the uncertainty associated with an innovation. In order to understand awareness knowledge, individuals were asked to recall how they first learned about the stormwater management system that they installed. Generalizing the responses, they fall into four categories: through work experience (either in the line of work or place of work), education (self-learning through online resources, courses, presentations, or higher education involved with green building), word of mouth and general interest (from friends, seeing example sites, reading magazines, etc.), or unknown. Representative of awareness through work experience, one respondent talked about his work at a utility company and through his line of work he was exposed to a lot of construction and stated that he first became aware of stormwater management systems "probably through my work (Interview 1A, 2011)." Another respondent said that she learned about stormwater management systems "through the City actually" as part of her work (Interview 2C, 2011). However, one respondent could not recall any one instance where he first learned about stormwater management systems and said, "[…] it's not like I had this sort of like, I was 12 years old and I saw a catchment, and I was like gah, I'm going to do that […] (Interview 1D, 2011)." These responses show that interviewees were not necessarily able to pin down the exact moment they first became aware of stormwater management, but they do show the variety of exposure that may have contributed to their awareness of these systems.

The how-to and principles knowledge were addressed by asking interviewees about their research and the steps they undertook to add a stormwater management system on their property. Respondents provided a wide range of answers regarding this question. Research, if subjects conducted any, constituted online resources, books and garden magazines, seminars, existing projects, talking to a professional, or some combination thereof. The type of examination interviewees carried out further influenced the steps they took in the adoption of their stormwater management system. Some respondents had a defined water problem and in order to solve the problem they chose to install a system that had a holistic benefit.

Selective exposure plays a role in this stage as it describes how individuals attenuate themselves to ideas that fit with their beliefs. Examples of selective exposure occurred when individuals were exposed to stormwater management systems. One respondent said, "[that she] saw one at a friend's house," and another stated that "[she was] just interested in green building and green gardening practices (Interviews 3C & 2D, 2011)." These examples show that having prior exposure to stormwater management technology increased the likelihood of innovation adoption.

Selective perception is based on the individual having an existing need that lacks a solution (Weisburd & Lum, 2005). In four of the interviews the initial driver to install the stormwater management system was a pre-existing problem with water on the property. These water drainage problems serve as examples of selective perception, and include basement and driveway flooding, broken pipes to the stormwater system, and concern for flooding the neighbor's property. One interviewee stated that she "never would have elected to do it [bioswale] unless my system had broken down. And then I had to do something, so then I did something creative instead of routine (Interview 3B, 2011).” Another respondent said, “I didn’t want to make her yard [his neighbor’s yard] swampier than it was already, and I was sure I was going to be doing that, so I had a kind of an additional, like a personal motivation (Interview 3D, 2011).” These statements acknowledge a given problem that lacked a solution, giving rise to selective perception and the eventual installation of stormwater management systems.

The Persuasion Stage

Rogers (2003) use of the term persuasion relates to an individual’s attitude construction that then informs the changes the individual makes. The persuasion stage is the active information seeking stage, and often involves asking family and friends their opinions about the innovation. When asked directly if they were influenced by someone to install their stormwater management system, five of the interviewees said ‘no’ and four did not answer the question. In four cases, respondents did see systems at either friends’ houses or other places. They said that it did influence their decision to adopt a stormwater management system as it made the idea more accessible and showed that it worked, thereby increasing confidence in the system.

The Implementation Stage

The implementation stage is where the individual puts the innovation into action (Rogers, 2003). Installation of stormwater management systems was split between the individual putting together their own system or hiring a professional landscape architect/permaculture consultant. About six interviewees either had the professional fully or partially install the system depending on the individual’s expertise level. Based on the interview process it could be argued that the landscape architect influenced the individual to install the system, but the findings suggest otherwise. One respondent said that she did reading about stormwater management systems and then relied on the design firm to design the project (Interview 2D, 2011). Another individual said that she went and looked at an existing project and got the information for the design firm from there (Interview 3B, 2011). These processes showed that the individuals actively sought a professional landscape architect to install the system and although they may have been influenced in the design itself, the process was one they initiated. When interviewees hired the landscape architect that constituted the decision-making process. The seven that installed their own system in some cases carried out additional research on city code requirements, applied for necessary permits, referred to consultants and then installed their system. Seven respondents approached their system as an experiment in progress and cited an increase in personal knowledge related to stormwater management.

The Confirmation Stage

The confirmation stage is the stage where the individual chooses to either continue using the innovation or completely reject it. Significantly, all stormwater systems are still in place and functioning, completing the decision-making cycle. To further supplement this idea of confirmation, respondents were asked if they would expand their current system or add other stormwater management features. Five individuals outlined future plans for expansion. Five stated they would keep the system the same, and of these five, four cited that property size was a factor that limited the addition of more stormwater management features.

Discontinuance

There are two types of discontinuances: replacement and disenchantment. Although none of the interviewees discontinued their stormwater management systems, they were given the chance to reflect on their experience with their stormwater system, and were asked if they would change anything based on their experience. Four of the respondents said they would not change a thing. Two interviewees said they would make minor changes to their systems to increase functionality, such as adding another valve or two or installing an energy efficient pump. In three cases, an additional rainwater tank would be ideal to keep from having to switch over to city water. One respondent did cite that if she had the option to do it over again, she would not, because of the increased maintenance.

Alternatives to Rogers' Decision-Making Process

Rogers' decision-making process does not specifically address the role cost-benefit analysis plays in affecting individuals' choices to adopt or not an innovation. Additionally, Henrich (2001) discusses biased-cultural transmission and refers directly to how individuals are influenced by other members in a social system, which affects the rate of adoption for an innovation. *Cost-benefit analysis* as discussed by Gladwin and Butler as a component of innovation diffusion is beneficial to understand as it influences decision-making processes (as discussed in Henrich, 2001). In terms of money most respondents said that the cost-effectiveness of these systems are minimal, because the cost of water in Eugene is cheap. "Part of the problem is that when you get your water bill, I think EWEB sells water for, it's like two dollars, two and a half dollars, for a thousand gallons. This these tanks, when you look at it from that kind of an economic analysis, don't really make sense… (Interview 1D, 2011)." Another respondent said he installed his system "for environmental reasons, not for cost reasons (Interview 4A, 2011)." On the other hand, other respondents mentioned stormwater reduction fees on their bill and not using potable water to irrigate with "saves hundreds." One individual said that if it happens to be new construction and the landscape is being installed it is cheaper to create a stormwater management feature than installing a traditional yard. In related monetary costs interviewees stated savings in preventive costs, such as saved money on concrete work that would potentially have to be done had she not diverted the water that flooded her basement or extending the life of a roof. Others cited reduced costs from not having to use a lawn mower and gas to maintain a lawn. And in some cases the cost-effectiveness is not monetary rather the value is in the quality of the water or the pleasure derived from having the system. Evaluating the results of the interviews shows that cost-benefit analysis shows that motivation plays a more significant role in respondents' decisions to adopt a stormwater management system. Although, it is possible that where water is more expensive cost-benefit analysis would play a significant role in the individual's decision-making process. Biased cultural transmission was shown to have relevance in this study as direct bias is influenced by the individual's motivations in adopting a stormwater management system. Prestige and conformity biases are more difficult to quantify in this study, as different questions would need to be asked to directly answer whether these biases influence the individual's choice to adopt. However, a tenuous link exists that relates prestige and conformity biases to the research in the cases of respondents that were influenced by others in adopting stormwater management systems.

Rate of Adoption and Environmental Context

The rate of adoption for an innovation is affected by multiple factors, such as relative advantage, compatibility, complexity, trialability, observability, and environmental context (Nam & Barnett, 2010; Ormrod, 1990; Rogers, 2003; Savage, 1985). The environmental context sufficiently covers Rogers' consequences and is not discussed separately.

Relative advantage is the perception that an innovation is improving upon the individual's current situation (Greenhalgh et al., 2002; Rogers, 2003; Weisburd & Lum, 2005). The benefits of stormwater management systems can be categorized as environmental motivations, aesthetic motivations, and drainage problems (as described under selective perception).

Environmental Motivations: In all the interviews there was some mention of the environmental benefits that having a stormwater management system brings. These can be summarized into the following categories:

- Habitat
- Water Conservation
- Reduced Maintenance
- Sustainability
- Education/Business
- Preserving Water Quality
- Psychological Wellbeing
- Resiliency

Habitat refers to the wildlife habitat that is created surrounding certain types of stormwater management systems. Interviewees cited an increase of diversity in wildlife around their houses. "I see quail, I see deer, I see lots of butterflies… (Interview 3A, 2011)." Another interviewee had the goal of "trying to provide little microhabitats for bugs and birds and butterflies, who have always lived in the Willamette Valley… (Interview 2C, 2011)." Interviewee 2B said that there has been an increase of diversity of bugs and birds in the yard. In general, removing a lawn and putting in stormwater management systems increased the diversity of flora in an area and attracted wildlife; a benefit as far as the respondents were concerned.

Water conservation is directly related to the rainwater catchment systems. In these cases the interviewees are harvesting rainwater and using it to water their landscapes or gardens. In one case, an interviewee has the house set up to use the rainwater as the main water source for six months of the year. As one interviewee said "it's just nice to have water… (Interview1D, 2011)." Having the rain catchment systems reduces their reliance on city water and makes use of an existing resource to conserve potable water through rainwater irrigation.

Reduced maintenance was a motivation in installing a stormwater management system, and was a theme in four of the interviews. Reduced maintenance can be applied to the reduction in time spent on lawn and yard maintenance, as stormwater systems tend to be self-maintaining. Although, in one case, an interviewee reported that she has actually seen an increase in maintenance (i.e. weeding). However, two other respondents mentioned that having installed these systems meant that they did not need to follow the typical maintenance schedule necessary to have a green lawn (such as chemical applications and lawn mowing). By not having a traditional lawn these respondents also said that their landscapes were more sustainable because they are not applying chemicals or using a gas powered lawn mower. Additionally, one individual said that the current trend of having a traditional grass lawn might change as water becomes scarcer (Interview 1B, 2011). These ideas of reduced maintenance and sustainability further show the existing thread of environmental ethic and relates to the more basic aspect of sustainability in education.

Interviewee 1B (2011) said that he built the house as an educational tool so that people could see what sustainability looks like. Four of the interviewees also said they used the building of stormwater systems as a self-education project with the added benefit of being able to educate other people about stormwater management. In the case of the green roof it will help the roof last longer and also provides a cooling benefit for the house. Furthermore, in a couple of cases the stormwater systems are also a showcase for their businesses.

Water quality was also cited as a goal for installing stormwater management systems by keeping the stormwater on site. As interviewee 2C (2011) said "part of [it] is my environmental management ethic, and wanting to do my part about trying to … 'mimic the natural hydrograph.' So keeping as much of the water on your property and recharging the aquifer and having nature do the work for both water quantity management and water quality management." Interviewee 2B said that their goal was to slow down the stormwater so that the water could filter through the stormwater features on their property and reduce the amount of pollutants entering Amazon Creek.

In a couple of interviews, respondents said that the stormwater management system gave them a sense of psychological wellbeing. As interviewee 4A (2011) said, "I think the psychological, [...], effect about sort of doing good or feeling, oh this is rainwater, this didn't have to be processed and chlorinated and treated and pumped just so that I can water, you know, my blueberries, this is actually clean rainwater, and it's fun doing it." Another respondent said that, "there's a psychological benefit knowing that all winter long, only half as much of my water is going into the municipal stormwater system than otherwise would (Interview 2D, 2011)." It is in this sense of positive impact that these interviewees feel they are contributing to the environment.

Resiliency was an added factor in having a stormwater management system. The idea of resiliency is having water available should the city water supply fail for any reason. The resiliency factor was mentioned in relation only to individuals that harvest rainwater. Interviewee 1C said that, "there is a little extra peace of mind when we have stored water on hand that could be used during emergencies." This was a repeated theme for four other interviewees (Interviewees 3C, 4A, 1D, & 2A, 2011). Thus, for environmental factors alone interviewees had multiple motivations in installing their stormwater management system.

Aesthetics: Eight of the interviewees stated that aesthetics influenced in some part their decision to implement a stormwater management system. One interviewee stated, "[…] our main purpose, 90 percent of it, was the look … [in installing a rain garden] (Interview 1A, 2011)." Water features served as functional but aesthetic points of stormwater management systems.

In short, there are a multitude of benefits (i.e. relative advantage), from environmental to drainage issues to aesthetics that individuals in Eugene have chosen to install stormwater management systems.

Compatibility is an important factor in introducing innovations, in that an innovation must lend itself to the attitudes and beliefs of the population to which it is being introduced. Interviewees' disposition toward stormwater management was compatible. As illustrated by one respondent "even though I sort of, I knew the place, there was a kind of level of understanding that I thought I would like to know it better, and be able to live here somehow more harmoniously (Interview 3D, 2011)." The compatibility factor is also shown in the motivations of individuals installing their stormwater management system, especially the environmental ethic that was a common thread in interviews.

Complexity deals with the perception of how difficult an innovation is to use. On the whole, interviewees did not view stormwater management systems as complex. A supportive viewpoint in terms of the complexity of a stormwater management system as stated by one individual was "it's not a difficult concept to understand […]. Here we're having a slightly sloped series of small water catchments […] with gravel in them […] and the idea is to slow the water down and filter it, and that's not a difficult thing to understand (Interview 3A, 2011)." This was a representative view of all respondents in the study and their opinion that stormwater management systems are technically straightforward.

Trialability is the possibility of using an innovation on a trial basis. In interviews where individuals had more than one stormwater management feature the initial systems tended to be treated as a learning experiment. These features further influenced respondents' adoption of systems and gave them more confidence to "play" around with how the features were made, planted, and installed. In one case someone was installing his rain catchment under a patio to blend it into the landscape. Additional examples of trialability factors can be found in observability factors and the knowledge stage.

Observability can influence other members in the social system to adopt a new idea, because they can see drawbacks and benefits to an innovation implemented by someone else thus reducing their uncertainty about it (Arnould, 1989; Rogers 2003). The factor of observability was mentioned in at least three interviews. One respondent when consulting with a friend about her water drainage problem said, "[…] I bet there's something you could do above ground. And we looked at, or she mentioned the project, the roof project at Sequential Biofuels (Interview 3B, 2011)." Another individual said, "I knew about places that had rain gardens… [Did it influence your decision to install a rain garden?] … Probably, cause I knew they worked (Interview 2D, 2011)." Regarding the uncertainty about installing a rain catchment system, one interviewee mentioned that in seeing a friend's rain catchment "it made it much more accessible of an idea to see one in action and increased my confidence in doing one myself (Interview 3C, 2011)." These quotes highlight the role that observation plays in influencing others to adopt a stormwater management system.

Environmental context focuses directly on indicators such as "geographic settings, societal culture, political conditions, and globalization and uniformity (Wejnert, 2002, 310)." Reviewing the environmental context of stormwater management systems in this study creates a holistic overview of how the innovation's context affects its adoption rate. Geographic settings focused on soil type as a challenge, especially when designing a rain garden. Interviewees said that if you have clay intensive soils the water will not percolate into the soil. Another challenge was the lack of access to native plants for planting in stormwater management systems, particularly native wetland plants. Further geographic challenges can be attributed to the location of the house in proximity to trees, as in two cases the gutter systems that feed into the rainwater management system clog up from the tree debris and then the individual has to go up on the roof and unclog the gutters. Falling under political conditions and globalization and uniformity, challenges identified included city code requirements[4] and reliable information access, such as landscape companies that actually have the ability to install stormwater management systems. The societal culture aspect is adequately represented by Rogers' rate of adoption and decision-making process.

Role of Incentives

Incentives can include mandates, subsidies, and discounts. Incentives such as subsidies and discounts were known about in two cases. These include a reduction in stormwater fees or reduced permitting costs. Eleven of the individuals interviewed though did not know, did not mention the incentives, or thought that the City did not provide incentives for stormwater management. One respondent when asked about the cost-effectiveness of her system said, "[there are] no cost savings, the City doesn't reward you (Interview 2D, 2011)." This serves to emphasize that the participants of the study installed their stormwater management system derived from the other benefits they mentioned and not out of monetary concerns, as eleven stated in financial terms that it was more expensive.

Adopter Categories and Characteristics

Rogers describes five types of adopter categories (with the caveat that they are idealized types) based on the timing of the implementation of the innovation (2003). The adopter categories are: (1) innovators, (2) early adopters, (3) early majority, (4) late majority, and (5) laggards (Rogers, 2003). Time plays an important role in the adopter categories as it determines whether one is called an innovator or a laggard or falls somewhere between. Time is determined by when the systems were first installed (shown in Table 5.2) and from the sample size it shows a peak in 2007 and 2008. This may have been related to being able to see an already adopted stormwater management system or simply a shift in the perception on stormwater as related to the environment. Potential influential trends would require more study on the time component.

Although time has a major role in creating the adopter categories, another important aspect to consider is adopter characteristics. In this study it was found that people fell on the range from innovator to early adopter to early majority. Categorizing the individuals on this scale was weighted more heavily by the actions the individuals undertook in their decision-making process, because of the memory recall criticism, time of adoption was not weighted as heavily in determining adopter categories. The innovators and early adopters were more likely to experiment with their stormwater systems and if something did not work properly try something new. The early majority tended to leave the system operating at its status quo, meaning that they

[4] The City of Eugene has design standards for stormwater management systems.

did upkeep work on it, but did not experiment with it, particularly when a consultant was hired for the installation process. Thus, adopter categories and characteristics influenced the how of individuals' innovation adoption.

The innovators of this study tended to learn about the idea and go for it. In the words of one interviewee "it's been kind of seat-of-the-pants, […], I learned a certain amount, and then just went my sort of low-tech engineering way about it." Another respondent said, "but I didn't know anybody doing this stuff." A quote that really describes the innovator as a risk-taker was provided by one subject saying, " I compost my own shit out there." As Rogers (2003) says because of their risk-taker role innovators tend to be less bound by social norms and serve as a catalyst for the introduction of a new idea into a social system.

The early adopters serve as opinion leaders and tend to decrease uncertainty associated with a new idea. In one respondent's work role he said, "I've always as a designer, promoted myself as a green guy, and a green expert […] and since I was promoting a lot these ideas to people, I figured, well, I better have done it at least once, and know a little more about some of that stuff." Having installed systems at his house and the type of business he has sets him up as one able to dispel uncertainty about stormwater management systems. Early adopters are also associated with judicious decision-making and being able to make subjective evaluations about an innovation. Therefore, they tend to consult with experts on the innovation a little more and be more careful in their installation of it. Some respondents mentioned contacting professionals in the area of stormwater management systems to address questions related to their systems, such as planting mixes or water usage guidelines. They also took part as demonstration homes for organized tours put on by BRING, the Green and Solar Tour, or other green tours. These early adopters may trigger the tipping point for the widespread adoption of an innovation.

The early majority has a longer deliberative time period on innovation adoption and tends to adopt after the early adopters. Respondents that fit this category were more influenced by other people or places that had existing stormwater management systems. As shown in this quote "I met some people who became my friends and saw the systems they put together. It made it much more accessible of an idea to see one in action and increased my confidence in doing one myself." The need for increased confidence of the functionality of the system, but the willingness to adopt before the average member of society is what characterizes an early majority adopter.

Chapter 6: Implications

Theory Application

Understanding the why or how of individuals adopting stormwater management systems as detailed by Rogers' diffusion of innovations is in itself a multilayered process. As stated previously the decision-making process is a social construct that attempts to describe human behavior. Human behavior in and of itself is influenced by multiple factors that in one person can cause one reaction and in another quite the opposite. The implications of the use of diffusion of innovations in this study are discussed here. The distinct stages in Rogers' theory although helpful are difficult in application. The first three stages contain elements that are not mutually exclusive. This also holds true for the last two stages. Therefore, using Damanpour's (1991) decision-making process would simplify the application process used to understand decision-making in individuals. The two-stage model incorporates the first three stages into an *initiation stage*, and the last two stages are defined as the *implementation stage*. Applying the decision-making process in two stages may have provided a clearer discussion of how the individuals in the study chose to install a stormwater management system. Also, a further point for consideration in this model would be the inclusion of a cost-benefit analysis.

The cost-benefit analysis put forth by Gladwin and Butler is not relevant to the adopters of this study unless it is only considered in terms of nonmonetary costs and benefits (Henrich, 2001). However, it may be an important aspect for future studies of potential adopter populations. This is a significant implication as it shows people have different motivations driving their adoption behavior. Thus, it emphasizes the need of the promoter of stormwater management systems to have a multi-faceted approach to outreach and education efforts. This implication supports the concept of selective exposure more than it supports selective perception. It is easier to see how selective exposure affected the individuals in this study and illustrates how having an environmental ethic shows the positive attenuation to the adoption of stormwater management systems. Selective perception was a relevant factor in four cases and provides additional understanding in how the adopter population of this study developed their awareness. The implications of this need to be considered in terms of outreach and education, posing stormwater management systems as solutions to existing water problems on a property, such as drainage issues or flooding. Raising the awareness of the potential adopter populations is key to the further spread of stormwater management systems.

Awareness is further influenced by the rate of adoption factors the components of which were applicable to the study. The findings showed relative advantage as particularly important in the decision-making process. It demonstrates that perceived benefits strongly influence the decision-making process. Therefore, if individuals are shown the benefits of a stormwater management system it will influence the decision-making process, as long as it meshes with their existing attitudes. This further is linked to the factors of compatibility and complexity. However, the factors of compatibility and complexity are found to be more appropriate in their incorporation into the environmental context (as discussed later) as it relates to the social component of it and explains the context in which the innovation is being introduced. As these factors are heavily reliant on the individual's value system and technical level it would be logical to understand these factors as they inform the process of projecting if an innovation will successfully spread. It is necessary to be able to address these concerns in the spread of stormwater management, because if the innovation is not compatible or too complex it reduces the likelihood of adoption. However, trialabilty and observability are legitimate categories for rate of adoption factors.

Trialability and observability of an innovation are not clearly distinct categories and difficult to apply as the one distinguishing feature is that someone tries the innovation on a trial basis, but he can further serve as a vicarious trial for others and therein lies the problem. Observability is being able to observe the innovation as installed by someone else and if part of the trialability factor serves as a vicarious observation process. In this study the application of trialability resulted in findings that were related to observability. This blurred the distinction between the categories and it may simplify the process to have the observability factor as the overarching factor with a subcomponent being trialability when it is relevant to the study.
Another aspect that is important in the rate of adoption factors is the environmental context.

Rogers does not specifically discuss the environmental context in his overview of the five factors of adoption. It was found to be necessary to have a component to address what the existing "environment" where the stormwater management system will be introduced. The geographic environment served to understand local geographic conditions, such as soil suitability or housing location that would be more difficult to address only using Rogers' rate of adoption factors. Additionally difficult to address only using Rogers' adoption factors was the political condition and effects of globalization and uniformity of Eugene. It was under this category that it was possible to talk about the effects of stormwater management system regulations on the ease of implementing a stormwater system. The societal culture was represented adequately with Rogers' rate of adoption factors of compatibility and complexity. However, to simplify the process of rate of adoption factors and the use of the environmental context it would be easier to address first the environmental context, followed by the factors of adoption deemed relevant (relative advantage and observability). Then establishing the decision-making process (similar to Damanpour's, 1991) and how it is influenced by the environmental context and rate of adoption factors. This will allow a fuller categorization process to occur when looking at the adopter and nonadopter population.

As Ormrod (1990) states, it is unclear how technology has affected the diffusion of an innovation. Therefore, this raises concerns about Rogers' adopter categories and characteristics. It is difficult to apply these categories, as they are heavily reliant on socioeconomic characteristics. Although Rogers (2003) states that these are idealized categories that raises the question of how have adopter categories been influenced by technology when the diffusion of an idea is more difficult to pinpoint to a specific source. It can be assumed that the communication channels as discussed by Rogers have a new dimension of complexity with the introduction of the Internet. Therefore, the application of Henrich's biased cultural transmission[5] is more relevant than Rogers' adopter categories. The application of these biases to the adopter population in the study is easier to address, because biased cultural transmission's strength is that it does not assign people to a category based on their socioeconomic standing, rather it looks at a more comprehensive external factor that influences the individual's inherent beliefs (which can be understood through the analysis of his motivations). Understanding whether an individual is

[5] These are described as direct (someone's inherent traits), prestige (influence from someone of a higher social status), and conformist (influenced by what the majority prefers) bias.

more influenced by prestige or conformist bias improves the process in which someone is promoting stormwater management systems, because it directly informs the outreach and education process. If someone knows that a certain individual is predisposed to prestige bias then she knows that she needs to have someone of higher social status promote the stormwater management system. If the potential adopter population is influenced heavily by conformist bias then it is a matter of finding potential adopters willing to adopt before them to make stormwater management systems widespread.

Overall, diffusion of innovations is a complex theory with many overlapping components and subcomponents. As shown in the implications the relation between different categories can often be blurred, and finding what is the inherent message can be difficult to grasp. Streamlining the decision-making stages from five to two as shown by Damanpour (1991) may allow a method of understanding these processes in a connected manner and reduce the redundancy of some of Rogers' stages. Further implications on the rate of adoption factors show that the environmental context needs to be considered, as it would provide the context to understand why relative advantage, compatibility, complexity, observability, and trialability factors are important to the diffusion of an innovation. However, these factors can also be simplified in their application. The environmental context would contain the compatibility and complexity factors. Relative advantage would remain the same and the observability factor would have a subcomponent of trialability. Therefore, as the environmental context and factors of adoption help inform the decision-making process the diagram would follow a hierarchy of:

- ↓ Environmental context
- ↓ Rate of adoption factors
    - ↓ Relative advantage
    - ↓ Observability
- ↓ Decision-making process
    - ↓ Initiation stage
    - ↓ Implementation stage
- ↓ Adopter categories or model of biased cultural transmission

Finally, Rogers' adopter categories are difficult to apply and may not be accurate in their application. It fails to explain how someone in the case of this study would apply it to designing his outreach and education strategy for stormwater management. Henrich's (2001) biased cultural transmission provides a practical application of looking at adopter characteristics that could be directly incorporated into designing a diffusion model for stormwater management systems.

Direct and Indirect

General implications in terms of the research results were manifold. One of the key takeaways from this research is the multitude of motivations that influenced individuals to adopt a stormwater management system. As shown in the findings an environmental ethic was a strong component in choosing to install a stormwater management system, but further consideration also showed that aesthetics or an existing water drainage problem influenced their actions. Part of the environmental ethic showed the importance of education and outreach around stormwater management systems. Either as an influencing factor or "doing their part" for the environment, individuals benefited from having available resources to learn about stormwater systems. In some cases they are also involved in educating the public by participating on home tours involved with green technologies. Education and outreach are also shown to be a strong factor in promoting the adoption of stormwater systems. However, it was also noted that resources could be made more readily available by the City, such as compiling a list of contractors with the ability and experience to install a stormwater system, but not limit it to ‘certified’ contractors. Another resource deficiency was the difficulty in obtaining native plants. Native plants were used in about four cases on swales and rain gardens to further contribute to a holistic environmental aspect by providing animal habitat and may provide a point for further water usage reduction as native plants require less water.

Incentives could influence further adoption by other community members that are not motivated by an environmental ethic, especially as related to a preventive innovation (i.e. stormwater management system). Incentives the City offers could also be promoted so that more people know about them. Some of the study results showed that there is a negative perception about the City and its view on innovations/innovators, such as the stringency of code requirements.

Some respondents noted that the stormwater system regulations in place for the City of Eugene are too stringent and it is therefore suggested that the City reevaluate the code requirements for stormwater management practices. An additional implication would be to evaluate the effectiveness of the Stormwater Education action item in the *City of Eugene, Oregon Stormwater Management Plan* (2011). Then based on the evaluation the City could take steps to create individualized outreach and education strategies to promote stormwater management.

Chapter 7: Conclusion

Future Research Opportunities

Further work that needs to be done is determining the feasibility of extrapolating the results from the findings to encourage other community members to adopt stormwater management systems. This would involve understanding who comprises the potential adopter population, because of the need to specify the outreach and education strategies to each segment identified. An additional research question could be: how does the structure of households influence adoption behavior in terms of stormwater management? One interview observation supports this notion of family life influencing landscaping choices and the potential installation of a stormwater management system. In this case a respondent stated that she did not need a lawn anymore as her children were all grown up and so taking out the lawn was feasible. This question could look specifically at households with children and compare them to those without children. Does it contradict with the traditional notion of having a lawn for play space for families with children? Other work that would make a considerable contribution to the literature would be designing a study around adopters and nonadopters of stormwater water management systems. Having a study that included nonadopters would provide relevant information to understand why people do not or have yet to adopt a stormwater management system. This could contribute to change agencies' outreach strategies to encourage further adoption of these systems. Other potential research could look at the role of change agents in influencing individuals to adopt stormwater management systems. A change agent is someone that influences a community member's decision-making process (Rogers, 2003). Change agent examples are the City of Eugene, BRING, or EWEB. It would also be interesting to see if a similar study could be done where water is not cheap to determine if stormwater management systems have are relevant to a cost-benefit analysis. This additional work could then further exploration of incorporating cost-benefit analysis into Rogers' decision-making framework to see if that has a significant influence on the theory or not. An additional question around this topic area would be: is the cost-benefit analysis better represented by relative advantage or are there components within each that would be relevant to the decision-making process? Consideration should also be given to research on the environmental context as introduced in this study and to understand the intersection between Rogers' rate of adoption and the environmental context. Does the proposed framework introduced in the implications section provide an improved understanding for the decision-making process? As shown in the future research section there is more research to be done not only on stormwater management system diffusion, but also the theory itself.

Summary

The pilot study was intended to understand according to Rogers' diffusion of innovations the decision-making process and motivations of individuals for installing a stormwater management system on their properties. The resulting research derived from the one-on-one interviews was divided by three overarching themes with specific interview questions categorized by theme. The analysis of these results showed that Rogers' diffusion of innovations model was not an entirely useful application in this study. The decision-making processes that individuals underwent were classified according to the five stages described by Rogers with the addition of a cost-benefit analysis. The rate of adoption and environmental context theme organized respondents' motivations for adoption and the factors that made the process more or less attractive. Major motivations were found to be: aesthetics, water problems, or environmental concerns. Additional factors for example included political environment and trialability. For some participants being able to try or see other stormwater management systems was an influential factor in considering adoption themselves, because it reduced the uncertainty associated with the system as it was apparent that it worked. Others found that the code requirements for stormwater management systems were restrictive and that the City should employ a more flexible approach to stormwater management in order to encourage wider adoption by residents. Regardless, these factors enable us to see the factors that influenced respondents to install their system.

Additionally, adopter categories were applied to understand the role that an individual's personal characteristics might play in influencing his propensity for adopting an innovation. In the case of this study, it showed that participants were located on the beginning part of the spectrum for stormwater management systems adoption (i.e. they adopted before the average person). To summarize, individuals in the study had a strong environmental ethic and innovativeness that influenced their decision-making process as categorized by Rogers that led to their adoption of a stormwater management system.

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Appendix

Interview Questions

What kind of stormwater management system (i.e. rain catchment, rain garden, green roof, bioswale, etc.) do you have?

When did you install this system?

Why did you decide to install the stormwater management system?

How has it functioned (i.e. well, lots of maintenance, etc.)? Is there anything you would do differently knowing what you know now?

How did you first learn about stormwater management (or the system currently in place) (i.e. word of mouth, magazine, newspaper, etc.)?

After finding out about this system what research did you do before committing to install your system?

Did you follow any specific steps in your decision-making (i.e. pricing, asking other people who have similar systems, etc.)?

Did you know someone that had a stormwater management system?

    Did that influence your decision to install one?
    If yes, who (not necessarily name, rather friend, co-worker, etc.)?

What has been a challenge in having such a system?

What has been a benefit in having such a system?

What kind of cost-savings has the system generated for you? This can be a rough guess/estimate? How many people use it? For what purposes is the water used if applicable?

In the future, how do you see yourself collecting or storing water? (Would you expand your system given the option, would you change it?)

Has anyone expressed an interest in your stormwater system?

In the larger picture do you think your adoption of this system has any effect on the city as a whole?

Do you think the city should encourage residents to adopt these systems?

    Why/Why not?
    Should it be a different organization if the city is not a trusted source?

Is there a question that I did not ask, but should have? What is it?

Tables 4.1-4.3: Question Groupings

Table 4.1. Decision-Making Process

1. Is there anything you would do differently knowing what you know now?
2. How did you first learn about stormwater management (or the system currently in place) (i.e. word of mouth, magazine, newspaper, etc.)?
3. After finding out about this system what research did you do before committing to install your system?
4. Did you follow any specific steps in your decision-making (i.e. pricing, asking other people who have similar systems, etc.)?
5. Did you know someone that had a stormwater management system?
    a. Did that influence your decision to install one?
    b. If yes, who (not necessarily name, rather friend, co-worker, etc.)?
6. In the future, how do you see yourself collecting or storing water? (Would you expand your system given the option, would you change it?)

Table 4.2. Rate of Adoption and Environmental Context

1. What kind of stormwater management system (i.e. rain catchment, rain garden, green roof, bioswale, etc.) do you have?
2. Why did you decide to install the stormwater management system?
3. How has it functioned (i.e. well, lots of maintenance, etc.)?
4. What has been a benefit in having such a system?
5. Did you know someone that had a stormwater management system?
    a. Did that influence your decision to install one?
    b. If yes, who (not necessarily name, rather friend, co-worker, etc.)?
6. What kind of cost-savings has the system generated for you? This can be a rough guess/estimate? How many people use it? For what purposes is the water used if applicable?
7. What has been a challenge in having such a system?
8. Do you think the city should encourage residents to adopt these systems?
    a. Why/Why not?
9. In the larger picture do you think your adoption of this system has any effect on the city as a whole?

Table 4.3. Adopter Categories and characteristics

1. When did you install this system?
2. Has anyone expressed an interest in your stormwater system?