RESIDENTIAL IRRIGATION IN OLYMPIA, WASHINGTON:

AN EVALUATION OF LOCAL WATER CONSERVATION POLICY

AND USER BEHAVIOR

by

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ABSTRACT

Residential irrigation in Olympia, Washington: An evaluation
of local water conservation policy and user behavior

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Water conservation is of growing concern for municipal governments and utility managers. Uncertainty in population growth, changes in water demand, and the reliability of water supply have led to some state and local governments to implement water conservation policies. Water supply concerns are managed by governments and utilities, but water demand is largely the result of user behaviors. In Olympia, Washington, the local government has implemented a six year Water System Plan in accordance with a mandate issued by state legislation. Water conservation outreach has been conducted for the past six years that encourages water customers to reduce consumption by providing education, economic triggers, and incentives for efficiency upgrades. The City of Olympia has surpassed the water use reduction goals it set forth in the Water System Plan of 2009, despite intermittent participation in conservation programs by its customers. In order to explore the outdoor water use behavior of residents in Olympia, a survey was distributed to ten neighborhoods throughout the city. The theory of planned behavior was used as a model for survey design. Survey results were assessed by analysis of variance (ANOVA). Surveys that were returned showed no significant difference between neighborhoods, socio-economic criteria, or ownership status in opinions of water conservation. Analysis of specific survey question groups found significant differences along the behavioral factors of the theory of planned behavior. A majority of respondents indicated interest in receiving more detailed information on utility billing statements. Incorporating behavioral analysis and the findings of conservation behavior research in water conservation policy has the potential to reduce demand. The reliability of future water supplies will depend on effective demand management. In order to effectively reduce demand, water user behavior must be strategically addressed in future policy implementation.

Table of Contents

List of Figures and List of Tables... v
Acknowledgements... vii

Chapter 1: Introduction... 1

Chapter 2: Literature Review... 6
Residential Water Conservation Research... 7
Spatial and Psycho-Social Analyses in Water Conservation Research... 10
Conservation and the Theory of Planned Behavior... 13
Methods... 21

Chapter 3: Federal, State, and Local Water Conservation Policy... 24
Federal Water Conservation Policy... 25
Water Conservation Policy in Washington State... 29
Water Conservation in the City of Olympia... 33

Chapter 4: Analysis... 42
Survey Design and Implementation... 42
Behavioral Scoring Method... 44
Survey Analysis and Results... 45
Discussion... 51

Chapter 5: Conclusion... 55

Bibliography... 58

List of Figures

Page

Figure 1:
The City of Olympia is located at the southernmost point of the Puget Sound 2

Figure 2:
A model of the theory of planned behavior depicts three factors that influence how intention does not always lead to intended behavior. 15

Figure 3:
The map of the United States shows the uneven participation in federal WaterSense conservation initiatives. 27

Figure 4:
Pooling of municipal water on street from the use of an automated irrigation system in SE Olympia at mid-day in July, 2014. 40

Figure 5:
Map of survey distribution across ten neighborhoods in Olympia. 43

Figure 6:
ANOVA analysis of question #23 by social norm relative behavioral score with post-hoc comparisons labeled above Likert responses. 47

Figure 7:
ANOVA analysis of question #28 by social norm relative behavioral score with post-hoc comparisons labeled above Likert responses. 47

List of Tables

Table 1:
Water consumption by tiered rate structure shows that the heaviest users do not respond to price signals. 34

Table 2:
One-Way ANOVA analysis of lawn aesthetics indicates comparable influence of both personal and social norm behavioral factors. 48

Page

Table 3:
Water conservation questions about respondents' neighbors and their corresponding behavioral relationships. 49

Table 4:
Water conservation attitudes are shown in mean relative scores across groups of different duration of residency in Olympia. 51

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Chapter 1: Introduction

Water conservation in urban areas is an issue of growing concern for municipal governments and utilities that manage water supplies. Throughout the developed world, water management authorities are facing the threat of shortage in water supply due to growing populations (Breyer, Chang, & Parandvash, 2012), drought (Kenney, Goemans, Klein, Lowrey & Reidy, 2008; Marks, 2006), and the potential risk of future climate change (Frei, Armstrong, Clark & Serreze, 2013).

Water authorities have a responsibility to achieve water supply goals that will ensure adequate supply into the future. This responsibility is fulfilled by limiting waste in delivery systems, monitoring existing source levels, developing further water sources if necessary, and ensuring the system can deliver to all of the authority's customers in peak demand times. Another way that utilities have approached water supply issues is through programs designed to manage demand. Water conservation programs implemented to reduce customer demand have produced mixed results. Despite educational outreach, financial incentives, and in some cases regulatory penalties, water conservation programs have produced varied and inconsistent results in water demand behavior.

In the City of Olympia, Washington, the City government manages the Drinking Water Utility. The Utility Water System Plan for 2009-2014 indicated that increases in demand will exceed the existing system capacity by 2021, with shortages increasing to 2.33 million gallons per day (Mgd) by 2028 (City of Olympia Public Works Department, 2009). To address this shortfall the City is developing three new sources for its municipal supply. Once these new sources are operational the City will have ensured adequate supply for the next 50 years. A caveat of this adequate 50 year supply is a continued reduction in demand, despite population forecasts that project 68% growth by the year 2035 (Thurton Regional Planning Council [TRPC], 2012). The Utility has demonstrated gains in system efficiency, and between 1996 and 2007 water use declined 14% whereas connections to the system increased by 23% (Olympia, 2009). As the City of Olympia Capital Facilities Plan (2013) forecasts 20,000 new residents in the next 20 years, the management of water demand will be a critical component of maintaining reliable supply.

The stated conservation goal of the Olympia Water System Plan (2009) is to reduce water use by 5% per connection between 2009 and 2014. The plan established a new tiered rate structure to trigger price signals for customers with higher consumption, set goals for reduced waste in the system, provided efficient technology rebates and incentives for customers, and set goals for increased outreach to promote conservation practices. A major focus of this outreach program has been residential outdoor water use. The outreach primarily consisted of updated website information and brochures that were included with customers bi-monthly water bills.

Figure 1:*The City of Olympia is located at the southernmost point of the Puget Sound; city boundaries shown here in white.*

Research presented in this document evaluates the efficacy of the City of Olympia's residential water conservation outreach program and incorporates behavioral analysis of residents' opinions of water conservation. The research is presented as an independent student project, and does not reflect official views of the City government or staff. The City will conduct its evaluation based on water consumption data. The research explores the water conservation knowledge and attitudes of City residents. The methodology employed is designed to determine if there are neighborhood effects on water conservation behavior that result in significant differences between neighborhoods.

The Water System Plan (2009) acknowledges the subjective nature of outdoor water use by stating: "[b]ecause outdoor watering is tied greatly to cultural and aesthetic values and practices (such as having a green lawn), this strategy focuses on eliminating wasteful irrigation practices by providing customers with ways to irrigate more efficiently" (p. 6-17). The Plan, however, states no formal strategy for how to address residents' behaviors in order to encourage greater conservation.

The thesis assumes that outdoor water use, in non-agricultural settings, is the most discretionary and least necessary for basic living needs. Therefore, in order to increase conservation of outdoor water use, outreach programs must recognize the subjective norms that support outdoor water use. By approaching this research utilizing the framework provided by the theory of planned behavior (Ajzen, 1991), the thesis explores a critical component of residential water conservation that the City has not addressed: residents' behavior patterns.

The theory of planned behavior (TPB) was conceived as a pragmatic framework to understand how behavioral intentions actually become behavioral performance. The theory has been incorporated into many behavioral studies focused on health (Godin & Kok, 1995), education (Cizek, Bowen & Church, 2010), and marketing (Kalafatis & Pollard, 1999; Rivera-Camino, 2012). Increasingly, the theory has been applied to study environmental behaviors, such as in the workplace (Greaves, Zibarras & Stride, 2013), in the adoption of new soil conservation methods (Wauters, Bielders, Poesen, Govers & Mathijs, 2009), and in water conservation (Lynne, Casey, Hodges & Rahmani, 1995; Lam, 2006; Lee & Tansel, 2013). Through the use of this theory, the research described below is designed to identify neighborhoods that are behaviorally predisposed to positively view water conservation. Identifying neighborhoods along these criteria could assist targeting pilot conservation programs in the future.

The study of water conservation is inherently interdisciplinary. Natural sciences are used to explain the status of our water resources, and provide innovative methods for expanding those resources. Policy must be studied in order to learn from previous iterative adjustments to ensure viable water supply into the future. And, as this author argues, the science of behavior should be incorporated to both the natural science and the policy of water conservation. Just as the main cause of human health degradation in the U.S. is due to modifiable behaviors (Mokdad, Marks, Stroup & Gerberding, 2004), so too are the challenges that face our shared environment. This research draws direct inspiration from a paper by Akerlof & Kennedy (2013), in their call to "[e]xplicity utilize evidence from social and behavioral sciences in the design of conservation initiatives."

In the case of Olympia's home water conservation program, the policy has been in place for the past five years and is set for an iterative update. This thesis provides an evaluation of the conservation program's outreach. It evaluates the program for its education efficacy, and utilizes the theory of planned behavior to better understand what factors are affecting water conservation behaviors. The research concludes with a discussion of demographics, policy measures, and behavioral tools that may be employed in future conservation policy strategies. Guided by a philosophy that every community is particular in its subjective norms, this research demonstrates that policy decisions must incorporate aspects of the behavioral sciences in order to influence greater water conservation. A mixed methods approach is utilized, incorporating a 41 question survey and basic housing stock data.

The following chapters include a review of relevant literature on residential water conservation and conservation behaviors; information and studies on water management in Olympia, Washington; research and data analysis methods and results; a summary, discussion, conclusion; and a bibliography complete the thesis.

Chapter 2: Literature Review

The study of residential water conservation has produced a rich and varied literature. The research has set forth in quantifying usage patterns across spatial, demographic, technological, ecological, and behavioral criteria. The following literature review presents a synthesis of material across many disciplines that illustrates a field in some disagreement, as much of the findings are case specific, and often the result of place-based variations. Further discrepancies arise from the various theoretical and design aspects of water conservation research. Common themes that arise include local environmental conditions that provoke conservation research, efforts to isolate behavioral components of water usage, and the interdisciplinary use of behavior theory to understand conservation behavior.

Understanding water use patterns is most commonly studied by finding correlations along spatial, economic, and demographic criteria. These criteria are adept at explaining variation in overall residential home use. Larger homes typically have more water fixtures, can house more people who consume water, and are often more expensive. When we narrow our attention to *outdoor* residential water consumption, we encounter subjective criteria that are more difficult to quantify and predict. Outdoor water use is largely used for maintaining lawns and gardens, filling swimming pools, and washing cars. Status, tradition, and perceived cultural norms are pressures to maintain a higher level of outdoor water consumption. As noted by Janmaat (2013), "[l]andscaping choices are public statements, and therefore will reflect complex social influences." These 'complex social influences' were not in the scope of his paper, as we will see is true of much of the outdoor water conservation literature.

In order to address the gaps in many water conservation studies, this literature review turns from the state of water conservation research to the developing field of environmental behavior. Environmental behavior reserarch employs study designs from socio-psychological disciplines, and recent reviews have advocated for behavior analysis to be incorporated into policy design. The review concludes with criticism of the Theory of Planned Behavior, and the use and misuse of the Likert scale for behavioral research.

Residential Water Conservation Research

Literature regarding water conservation research studies is often conducted in areas that are climatically drier. Often these research sites are experiencing other pressures that threaten the reliability of water supply, such as increasing population growth, or increasing drought conditions. Studies often employ spatial analysis to determine variation in water demand and attempt to understand these variations through demographic data and housing characteristics (Breyer, Chang, and Parandvash, 2012; Janmaat, 2013; Giner, Polsky, Pontius, and Runfola, 2013). These studies often conclude with policy suggestions for how to manage land development and water demand.

The state of Texas is experiencing both diminishing precipitation and increasing population are reducing water reserves. In 2012, Hermitte and Mace produced a report for the Texas Water Development Board that surveyed the water use across 259 cities for the years 2004-2011. The study relied on monthly water bills to determine annual and seasonal patterns of water consumption. As the water bills do not differentiate between indoor and outdoor use, the authors created a proxy method to determine outdoor use. This method relies on a weighted average per city based on the number of single-family connections, and derives a statewide weighted average by summing the averages of the 259 cities. The research found that between 20 and 53 percent of all water consumption was for outdoor use. There was not a strong correlation between outdoor use and precipitation levels. However usage did increase during 2011, which was a particularly dry year. The authors attribute the variability in their findings to the low temporal resolution of the data (monthly water statements).

Another arid state that is experiencing rapid population growth is Utah. Seventy percent of water consumption in the state is residential. Hasenyager and Klotz (2009) employed a mixed method of surveys, water bill data, and evapotranspiration data to determine water usage across 17 cities in Utah. An unstated number of residents were randomly selected for receiving the water use survey. In order to determine the relationship between home characteristics and water use patterns, the surveys collected data including persons per household, square footage of home, and lot size which were compared with the respondents' water bills. Outdoor water use was calculated as the difference between consumption in summer months and winter months. Common patterns in water conservation research were found: larger homes and homes with more residents consume more water; homes that irrigate with manual sprinklers use less than automatic systems; most residents water more than their turf grass requires; and residents who were aware of conservation media campaigns use less water than residents who are unaware.

In Aurora, Colorado, water use compares with Utah, where residences make up 70-80 percent of consumption. Model analysis of residential consumption patterns before and after the drought of 2002 demonstrated up to 30 percent reduction of water consumption during the drought. Due to the mix of strategies employed by the water utility, it is unclear whether it was water pricing, regulatory penalties for excessive use, or educational campaigns that reduced demand (Kenney et al., 2008). A three tiered water rate structure demonstrated the influence demographics have on consumption patterns. Wealthier, older people tend to live in larger homes that consume more water. Water Smart Readers distributed by the Aurora utility that allow residents to monitor their water consumption in real time contributed to reduced demand. Kenney et al. (2008) concludes that the entire suite of demand management strategies is effective, however their research was unable to determine the exact effect of each individual strategy.

The demand management described by Kenney et al. (2008) is largely reactive, in that higher water rates and information campaigns were established after drought conditions made previous consumption excessive. In order to develop proactive water demand management, high resolution water meters are utilized to provide residents with real-time consumption data. When installed throughout research participants' homes, the actual water usage is found to be higher than the residents previously stated (Beal, Stewart, and Fielding, 2013). Participants were grouped into high, medium, and low water users, based on self-identified water use patterns. Self-reported high users were found to actually use less than self-reported medium users. Further analysis found that users demand less water when their billing statements include local use averages. The disparity between water use attitudes and actual consumption suggests water demand can be reduced if consumers are given more information about their actual usage (Aitken, McMahon, Wearing, Finlayson, 1994; Willis, Stewart, Panuwatwanich, Jones, and Kyriakides, 2010).

Spatial and Psycho-Social Analyses in Water Conservation Research

Literature describing residential outdoor water consumption in the developed world often explores psycho-social drivers of water use. The residential landscape of manicured lawns and gardens is associated with social status that originates from the estates of the French and British elite of the 17^{th} century. The entrenched values associated with these landscapes have become part of the identity of homeowners (Feagan and Ripmeester, 2001). Challenging the social norm of irrigated and chemically treated lawns therefore is interpreted as a personal affront to homeowners who prefer to maintain lawns. The social driver to maintain a lush residential landscape is such that in cases of regulatory penalty for irrigating during drought, some homeowners will accept monetary penalty rather than let their landscape wilt (Ozan and Alsharif, 2013).

In order to explore the social drivers of different lawn maintenance methods in Kelowna, British Columbia, Janmaat (2013) employs a spatial analysis of annual water consumption. Through mathematical modeling, the study finds a spatial lag between water use clusters, supporting other findings of housing stock and demographics as drivers of water use. Novel water saving strategies are reported to be most effective in a clustered fashion, in order to encourage greater conservation program participation through social mimicry. This conclusion is somewhat tenuous due to the method of analysis, however the positive influence of social mimicry is supported by Nassauer, Wang, and Dayrell (2009). In a survey of 494 Michigan residents, participants chose what front yard landscape design was preferable. The types of designs were comprised of turf grass, wooded yards, and innovative designs that incorporate native plants. When the surrounding homes were turf grass, the respondents favored the ecologically innovative yard design the least. When all the yards were innovative, the turf grass was least desired, with a native garden design ranking highest.

The maintenance of turf grass is associated with higher water consumption, and homes with in-ground sprinklers use 35 to 47 percent more water than homes that do not (Mayer and DeOreo, 1999). Replacing grass with gardens comprised of native plants that require less water during hot summer months is a strategy for residences to demand less water. Remote sensing analysis of Ann Arbor Michigan demonstrated a tendency among residences to have a clustering effect of front lawn gardens. A property was found to be 2.4 times more likely to have an easement garden if another property within 30 meters had one as well (Hunter and Brown, 2012). This analysis demonstrates the influence of social norms on residential landscape management, however does not include actual water consumption in its analysis.

Social mimicry is not ubiquitous in the water conservation literature. An investigation to the role of Homeowners' Associations in the suburbs of Baltimore found that residential landscaping is in part explained by personal preference (Fraser, Bazuin, Band, and Grove, 2013). Attitudes in response to water restrictions in Australia were researched across urban, suburban, and rural boundaries. Spatial criteria did not explain the variation in attitude, but demographic criteria such as age, income, and education did (Pearce, Willis, Mamerow, Jorgensen, and Martin, 2012). Attitudes towards the environment were found to be the most predictive criteria when researching residential water consumption in Gold Coast City, Australia (Willis, Stewart, Panuwatwanich, Williams, and Hollingsworth, 2011). There was no spatial component of the study in

Gold Coast City, however, so any spatial clustering effect of social norms cannot be determined.

The literature on residential water consumption and its social drivers is comprised of disparate methods, disciplinary perspectives, and scales of analysis. The academic study of residential landscapes can be described as a developing field, with under five publications per year in the mid-1990's to over thirty per year by 2010. A review of this literature subject synthesized 256 papers and found that outdoor residential water use was strongly related to the type of ground cover and vegetation present, the irrigation technology utilized, and the variability of climate (Cook, Hall, and Larson, 2012). Single scale analysis often makes comparisons between studies difficult due to place-based and cultural variability.

A study in Australia (Syme, Shao, and Po, 2004) found that positive attitudes towards conservation corresponded with reduced outdoor consumption. Using a similar questionnaire and structural equation modeling method as Syme et al. (2004), a study in Mexico found that environmental attitudes were the least predictive for actual consumption (Corral-Verdugo, Bechtel, and Fraijo-Sing, 2003). Due in part to the inability to compare different single-scale, place-based studies, Cook et al. (2012) recommends further research should address the knowledge gaps between landscapes and regions. Their synthesis provides a conceptual framework for future interdisciplinary research that consist of four main study areas: ecology of residential landscapes, management decisions, multi-scalar human drivers, and legacy effects.

Conservation and the Theory of Planned Behavior

The water conservation literature described above makes use of the terms "attitude" and "behavior" in order to describe the beliefs of residential water consumers. With the exception of Syme et al. (2004) and Corral-Verdugo et al. (2003), none of these studies employ the methods of behavioral sciences. Psycho-social research has examined environmental behavior since the early 1970's, employing a simple linear model that assumed people would rationally develop pro-environmental behavior if they were provided environmental education. This model was soon found to be inadequate, as subjects' environmental attitudes may have shifted due to educational programs, but changing behavior patterns is very difficult. Many management agencies, however, still maintain the assumption that there is a knowledge deficit that prevents pro-environmental behavior (Owens, 2000). The field of environmental behavior has progressed and no longer attributes as much significance to environmental attitudes, acknowledging that social norms and personal agency provide important roles. Kollmuss and Agyeman (2002) presents a complex model of pro-environmental behavior as a result of three internal drivers, six internal barriers, and six external barriers.

The rapid development of the field of behavioral change research has produced a variety of protocols and theoretical frameworks that makes the application of the science difficult. Akerlof and Kennedy (2013) present a five-point strategy for conservation policy practitioners to use in order to incorporate the findings of behavioral change research:

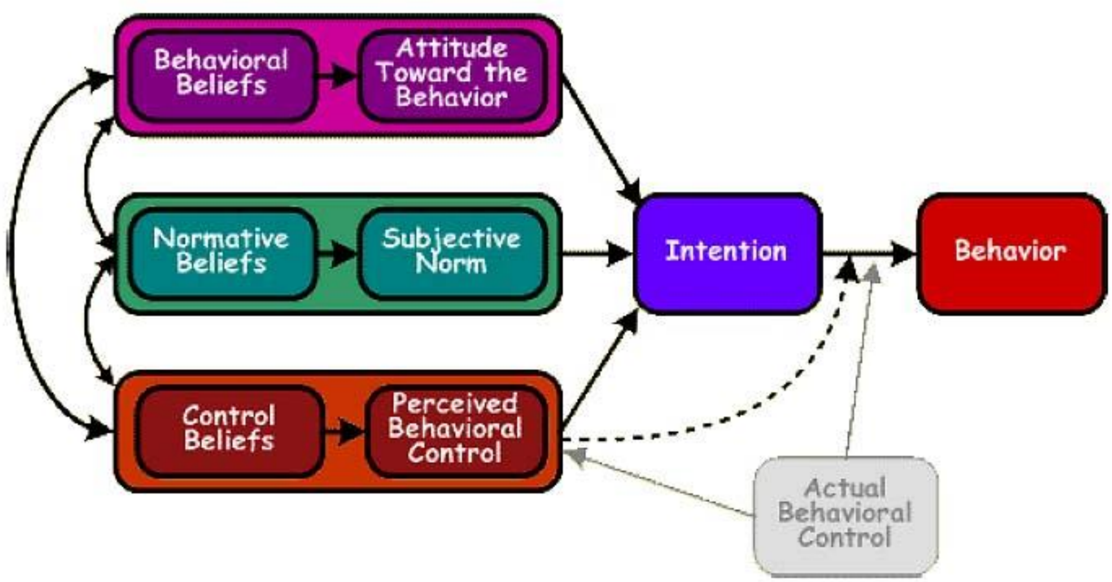
- Promote favorable attitudes towards conservation, as they correlate with pro-environmental behaviors (Bamberg and Moser, 2007)

- Increase personal agency by removing barriers and portraying positive role modeling, and providing informational feedback
- Facilitate emotional motivation, as emotions have been found to affect judgment, cognition, and physiology (Lench, Flores, and Bench, 2011)
- Communicate supportive social norms, which can overlap with personal norms and promote a sense of fairness; and
- Alter the context of the choice of conservation practices so that complexity is reduced and individual agency is preserved

These strategies are intended to promote environmental behavior that has a greater motivation than produced by historical strategies of regulation and incentives. A study in Georgia illustrates how these behavioral concepts can affect residential water consumption. Ferraro and Price (2013) provided three different requests for water conservation to residents: technical advice on how to reduce usage, a weak social norm request to reduce usage, and a strong social norm report that directly compared the subjects' usage with other residents in the area. By comparing the water usage of the groups with different conservation messaging, the research found the greatest reduction in use was achieved by the strong social norm report. This was achieved by providing informational feedback, communicating supportive social norms, and altering the context of the decision making process.

One of the theories that contributed to the five strategies above is the theory of planned behavior (Ajzen, 1985; 1991). The theory of planned behavior (TPB) has been implemented in over 200 behavioral studies with such diverse subjects as medicine (Ceccato, Ferris, Manuel, and Grimshaw, 2007), drunk driving (Chan, Wu, and Hung, 2010), tourism (Quintal, Lee, and Soutar, 2010), and hunting (Shrestha, Burn, Pierskalla, and Selin, 2012). Akerlof and Kennedy refer to the TPB as "[a]rguably the most influential of the [behavioral] theories" (2013), in part because it has an empirical design. A review of thirty TPB papers found that the theory could explain two-thirds of the behavioral changes studied (Hardeman et al., 2002). A meta-analysis of 185 papers found that the theory could explain 27 percent of the change in behavior (Armitage and Conner, 2001).

The theory of planned behavior consists of three constructs: personal attitudes, perceived social norms, and perceived behavioral control in regards to a specific behavior (Figure 2). These three factors determine one's intention to perform a particular behavior.



Source: Ajzen (2006)

Figure 2: *A model of the theory of planned behavior depicts three factors that influence how intention does not always lead to intended behavior*

The discrepancy between intentions and actual behavior is explained by the perceived behavioral control, or the factors that prevent one from conducting the behavior. The simplicity of the TPB model has encouraged researchers to augment the theory in order to explore other factors that explain behavior.

Much of the literature pertaining to the TPB is in the medical and psychological fields. Increasingly, there have been applications of the theory in environmental and conservation studies. One of the first applications of the theory involved a structured survey of strawberry farmers regarding their preferred method of irrigation (Lynne, Casey, Hodges, Rahmani, 1995). Farmers were encouraged by local water authorities to adopt microdrip irrigation technology in order to reduce waste in irrigation. Installation costs for the upgrade ranged from $500 - $40,000 per acre, and the study hypothesized this cost was a key factor in prohibiting widespread adoption of the technology. The study's interviews revealed that it was in fact the coercive control of the water authorities that contributed to a perceived lack of personal control by the farmers. Adopters of the technology were more prone to do so if they were influenced by their community, despite the high installation costs. The policy implications of this study suggested softer regulation and stronger incentives would be more productive in achieving consumption goals.

In Blagoevgrad, Bulgaria, a study on residential water conservation incorporated the TPB with other variables including demographics, environmental attitudes, and environmental education. The complete model explained 27 percent of the variation between intentions to conserve water and actual conservation behavior, and 35 percent of the variation was explained by the TPB alone (Clark, 2005). A study of water supply restrictions in Taiwan sought to predict people's intention to save water using the TPB and a modified the TPB model. In this case the modified model accounted for 37 percent of the variation between intention and actual behavior, while the TPB alone produced 13 percent (Lam, 2006). Both of the studies above use interviews, questionnaires, and modified the TPB models, but employ different methods of quantitative analysis. In Bulgaria the modified model attributed lack of conservation information as most prohibiting conservation behavior, whereas the modified model in Taiwan identified personal attitude to save money was more significant than the collective good of the community.

The studies above identify personal attributes as key in explaining variation in conservation behavior. In a marketing study of preference for more expensive "green" products over less expensive products with similar environmental impact, social norms were found to be the key driver of consumer behavior. Consumers preferred products that offered less luxury than "non-green" products of comparable value, but instead offered greater social status (Griskevicius, Tybur, and Van Den Bergh, 2010). This study's method relied on hypothetical, context-based questionnaires and not actual behavior, rendering its use of the TPB incomplete.

Personal beliefs and social norms were found to be the predictors of the adoption of soil conservation techniques on Belgian farms (Wauters, Bielders, Poesen, Govers, and Mathijs, 2010). It was previously believed that the farmers did not adopt the alternative tillage method due to the difficulty or high costs associated with that behavior (perceived behavioral control). Through the use of TPB analysis on survey results, however, it was found that the farmers did not personally believe in the practices. This belief was supported by their community, strengthening their reluctance to change behavior. The application of the TPB in this context indicated further study was required in order to determine how best to change those personal beliefs in order to facilitate behaviors that would improve soil quality.

Variations in model constructs and analysis methodology are common in the TPB literature on conservation behaviors. Researchers have altered the theory to include model components based on context-based variables. While many of these studies find that TPB positively explains actual conservation behaviors, the variety of analysis methodology makes generalizations difficult. While some studies go to great lengths to describe their analysis (Greaves, Zibarras, and Stride, 2013), some do not report specific calculation methods at all (Budeanu, 2007). Overall, however, the process of TPB research is very similar, in part due to the efforts of the theory's author to provide detailed guidelines for its use (Ajzen, 2006).

The theory of planned behavior is not without its critics. In its application to study health-related behaviors, Ogden (2003) finds that the theory's constructs act as interventions that alter the subjects' behavior and cognition. This prohibits the model from being tested as it cannot make accurate observations of the actual relationship between intentions and behaviors without affecting the subjects' normal routines. Further criticism is directed at the inability of the theory to test hypotheses in a structured manner. The review Ogden provides demonstrates that of the 47 articles reviewed there was great discrepancy in which factor of the TPB was significantly affecting behavior (attitude, social norm, or perceived behavioral control). Ogden continues (p. 425): “[f]urther, all of the articles examined left much of the variance unexplained, with explained variance ranging from 1% to 65% for behavior and 14% to 92% for behavioral intentions.”

Criticism has also focused on the inability of the TPB to explain behavior that does not match intentions, and that it does not specify how to modify cognition in order to change intention and behavior. (Sniehotta, 2009). Recently, Sniehotta, Presseau, and Araujo-Soares have gone so far as to claim that the persistence of the TPB prohibits other more explanatory theories from developing, and call for the theory to be "retired" (2014). This article quickly elicited a rebuttal from Ajzen, who developed the theory. Contrary to Sniehotta et al. (2014), Ajzen asserts that the feedback that occurs once a behavior is carried out can be predicted with the TPB. This misunderstanding shows that the critics have a "poor understanding of the TPB and of the nature of psychological research" (Ajzen, 2014). It should be noted that Sniehotta has authored 80 academic publications, many of which use TPB.

Beyond the structural criticisms of the theory's ability to predict or change behavior are less frequently discussed critiques of a method in behavioral surveys: the Likert scale. Likert scales are ordinal data, and represent a ranking rather than a continuous nominal interval. As ordinal data, any analysis of their central tendency must rely on the median or mode and must rely on non-parametric analysis. In a commentary on the misuse of Likert scales in medical research, Jamieson (2004) points to the common mistake of conducting parametric analysis of variance (ANOVA) and reporting the mean when using Likert data. Interestingly, the commentary cites two misuses of Likert that appear in the same publication as Jamieson (Santina and Perez, 2003; Hren et al., 2004).

Norman (2010) disagrees with the contention that only non-parametric analysis can be performed on Likert data, and points to the past 70 years of research that have been conducted this way. Carifo and Perla (2007) argues that Likert scales differ from Likert items. The items are individual responses, whereas the scales are collections of Likert items across multiple themed questions, and are therefore interval data. A parametric approach is then valid as long as the Likert scales meet the “standard psychometric rule-of-thumb criterion of comprising at least eight reasonably related items.”

Likert scale analysis has been critiqued for the subjective nature of the language used in the questionnaires. In order to parse out the impact a participant's frame of reference can make on Likert results, Ogden and Lo (2011) provided the same questionnaire to students, town residents, and homeless people. This Likert data was then compared to free text written responses to a set of similar questions. The Likert analysis found the homeless group to be more content and friendlier than other groups, but this result was not found in the free text data.

This literature review has described the relevant literature pertaining to the study design that will be described below. Water conservation literature is interdisciplinary, place-based, need-based, multi-scalar, and often produces findings that are idiosyncratic. The goal of water conservation research, however, is very much the same across scales and locations: to learn how to encourage and sustain reduced consumption of water resources. Cultural and demographic drivers continue to keep water usage higher than practitioners recommend. Efforts to incentivize the adoption of more efficient technologies have met resistance from water users, so conservation research has incorporated behavioral components to its studies.

This mixed conservation/behavior approach, however, has produced literature that is so varied in methodology that makes it difficult to advance the field of conservation behavior. This has inspired Akerlof and Kennedy (2013) to call for bringing together "[behavioral] theoretical experts and [policy] practitioners to select and define the most influential behavioral interventions, synthesize across theories and unify them with practice, and identify future needs and areas of research."

The developing field of conservation research that employs behavior science methods has contributed literature that begins to address the needs stated by Akerloff and Kennedy. Standardized methods produced by experts in psycho-social disciplines have been applied to understand the behavioral drivers behind water consumption. The findings demonstrate that the variability in the adoption of conservation practices is place-based, and can be driven by factors that are attitudinal, social normative, or a lack of personal agency. These findings have then been used to assist policy makers in tailoring programs to address those prohibitive drivers.

Methods

The residential water conservation research presented here employs a behavioral science methodology with basic demographic and temporal components. The design allows for an exploratory analysis of the personal attitudes, perceived social norms, and perceived behavioral control residents experience when considering water conservation practices. Using a survey design, the methods presented by Ajzen (2006) are augmented to include topics that were drawn from the City of Olympia's water conservation outreach program. An item also included in the survey determines how long participants have resided in Olympia. These components combined with a control for neighborhood effects allows for conservation behavior analysis between neighborhoods. Further analysis is possible for exploratory comparisons among all neighborhoods with individual City conservation program effects on conservation behavior of residents.

Surveys were distributed to 100 homes each in ten randomly selected neighborhoods within Olympia, and postage-paid envelopes were provided for participants to return the surveys for analysis. The 41 question surveys were comprised of eight “Yes or No” questions based on the Olympia water conservation outreach program, one question regarding how long participants have lived in Olympia, and thirty conservation behavior questions based on the design provided by Ajzen (2006) and Francis et al. (2004). Behavioral questions were on a 5-point Likert scale. An additional question was added to determine if participants would like to receive billing statements that showed their average usage as compared with their neighbors (as demonstrated in Ferraro and Price, 2013). Another additional question determines whether or not participants would be interested in smart meters in different regions of their homes (as demonstrated in Willis et al., 2011).

The research described below was not intended to explore the predictive capability of the theory of planned behavior. As such, there is no component of the surveys that addresses participants' intentions to conserve water. Each of the three constructs of the theory of planned behavior were designated ten questions each. Behavior questions were written such that five questions directly measure each theory construct and five questions indirectly measure each theory construct. Relative behavioral scores were then calculated for each behavior construct (Francis et al., 2004) and analysis of variance (ANOVA) was calculated between neighborhoods.

This analysis method was designed to determine if there is a neighborhood effect on conservation behavior in the City of Olympia. The assumption is that neighborhood effects will be detectable as demonstrated by Nassauer, et al. (2009), Hunter and Brown (2012), and Janmaat (2013). This is intended to serve as a pilot study that can inform future water conservation programs. New programs will have to be tested in small areas before implementation across the City. The conservation behavior research design requires a spatial component in order to target future test conservation programs effectively.

The next chapter will address water conservation policy at the Federal, State, and local levels. A brief history of Federal policy is followed by an introduction to water conservation policy in Washington State. The rest of the chapter is dedicated to the study area for this thesis, the capitol City of Olympia. It is a city where water supplies are of concern due to a growing population and uncertainty in future precipitation, much like the studies described above. Previous efforts to appeal to residents to practice conservation have met mixed results, and in the coming year officials will draft a new five-year water system plan.

Chapter 3: Federal, State, and Local Water Conservation Policy

Water conservation throughout much of history has focused on maintaining adequate water supply and quality to ensure agriculture is robust. Failure to irrigate with conservation practices has been attributed to the decline of the Sumerian civilization and Southwest Native American civilizations due to salinization of land and water (El-Ashry, Schilfgaarde, and Schiffman, 1985). It is only with the advent of municipal water delivery systems in the 20th century that the field of water conservation has turned its focus to residential consumption.

This chapter demonstrates the recent shift in water conservation focus by providing an overview of Federal water conservation policy. Federal water conservation policies are confounded by conflicting ideologies between changing administrative regimes, the complexity of overlapping jurisdictions and management plans, and a general lack of political will to dictate what each state or region should do. By executive decree and congressional funding practices over the past three decades, individual states have been left to choose whether or not to implement water conservation policies.

Washington is a state that has put forth the mandate to its municipalities to create and manage active water conservation programs. An overview of Federal water conservation is provided below that demonstrates the deference to state management and a preoccupation with resource management instead of demand management. Washington State policy is described and illustrates the state-by-state approach used in the United States for water conservation policy. The review of the water conservation program in Olympia provides a snapshot of the relatively new implementation of new policy in water conservation at the municipal level.

Federal Water Conservation Policy

The first formal review for water conservation policies was requested by President Harry Truman in 1950. Truman created the National Water Resources Policy Commission (NWRPC) by executive order 10095 and charged the commission with the task of providing a comprehensive review of the state of the nation's water (Truman, 1950). The resulting report, "A Water Policy for the American People," provided the first assessment of all of the nation's fresh waters (United States National Water Resources Policy Commission, 1950).

Major findings of the Commission addressed the need to conserve water for agricultural purposes and the need for municipal and commercial water to receive adequate treatment and distribution. The report was the first policy document that called for the management of water resources to address the entire hydrological cycle and to create management plans for entire river basins. The report's recommendations primarily served as guidance for the management of floodplains, the development of hydropower, and the distribution of water rights for agriculture and industry.

The National Water Commission (NWC) was a formalized federal office that continued the priorities of the NWRPC. Formed in 1968, the NWC created methods for evaluating watersheds, mapped many watersheds throughout the nation, and provided analysis that interpreted water resources within cost-benefit, environmental, and social criteria. The NWC produced an influential report in 1973, titled "Water Policies for the Future," (United States National Water Commission, 1973).

The NWC report of 1973 provided many recommendations that were implemented and many that were not. The report is the first to call for the establishment of a user-pay system of water distribution and the first to predict that meeting future water demand will require conservation and efficient use in agriculture and municipal use. The user-pay system was conceived to trigger price signals for heavy users to reduce consumption. A recommendation of the report that has never been fulfilled was the call to update federal laws and legal institutions to adequately address water needs at a national level.

The Water Resources Council was created in 1965 and served as the coordinating agency that provided grants and set standards for the assessment of water supplies and creation of watershed management plans. Cody and Carter (2009) describe the volume and quality of water assessments created by the Council as “unprecedented” in federal resource management. By 1978, however, the Carter Administration targeted many of the Council's programs for defunding. In 1983 the Reagan Administration disbanded most of the large-scale river basin commissions. Funding for the Water Resources Council was soon revoked and states were then required to take a more active role in watershed management. The initial legislation that founded the Water Resources Council has never been repealed, but the last funding for the Council was issued in 1983.

Formalized institutional approaches to water conservation have been politically problematic, so individual agencies have established public-private partnerships in order to increase water conservation. The Environmental Protection Agency (EPA) started its WaterSense accreditation program to encourage best conservation practices in industry, commercial, and manufacturing. Since the program's start in 2006, the EPA reports 757 billion gallons of water have been conserved through the adoption of approved equipment and methods (EPA, 2013).

The EPA has established criteria for a variety of devices that consume energy and water in homes. Private sector professionals that value conservation work with the agency to receive certification and the EPA then provides their contact information for potential clients. The collaborative method works around the lack of coordinated federal policy and Figure 3 shows how unevenly the WaterSense program has been adopted

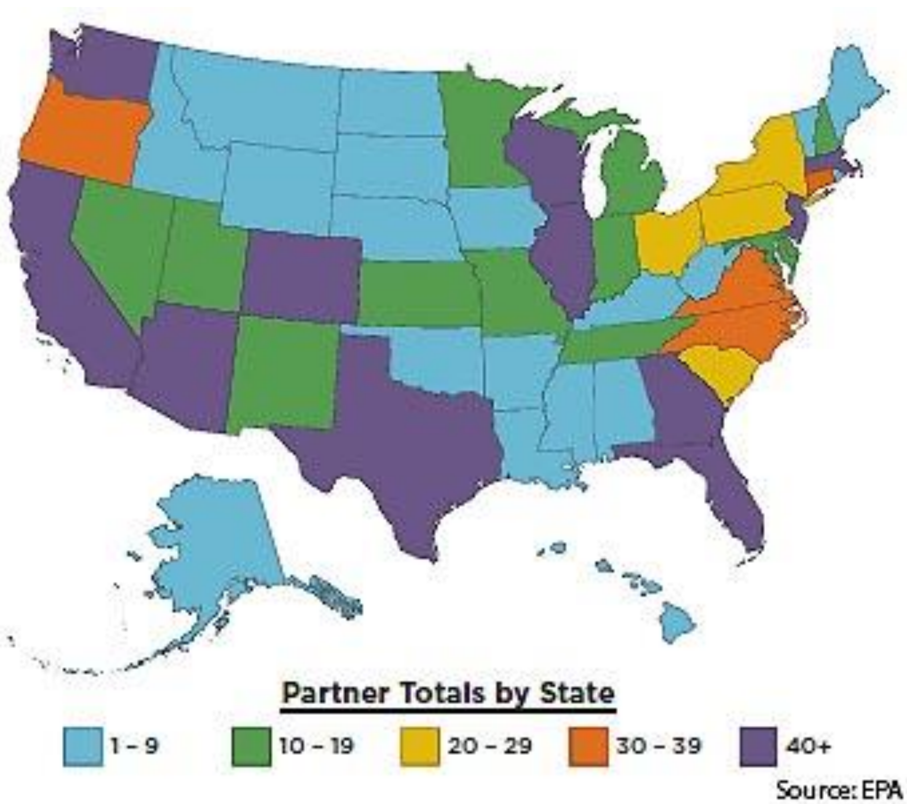


Figure 3: *The map of the United States shows the uneven participation in federal WaterSense conservation initiatives*

around the country. The piecemeal approach to water conservation has drawn sharp criticism from Galloway (2011), who states, “[s]ince the 1970s, we have become increasingly confused about fundamental management of U.S. water resources.”

Executive orders are another one of the many piecemeal strategies to establish water conservation policy at the federal level. In recent years, these orders have not pertained to the entire country, but rather only to the management of federal facilities. Executive order s 13123 (1999), 13423 (2007), and 13423 (2009) have all set benchmarks for federal facilities to achieve lower consumption of water and energy. Respectively, from Presidents Clinton, Bush II, and Obama, these executive orders have incrementally raised the bar on efficiency programs at the more than 500,000 buildings that the federal government operates across the country.

The preceding brief summary of federal water conservation is not comprehensive, but demonstrates the shift away from federal involvement in conservation activities towards state management and the initiative of the private sector. The federalist system of government in the United States enables states to craft resource policies that are best suited for local factors, and agency grant programs can bypass legislative gridlock by providing conservation incentives. Water resources are dispersed across the landscape and this often involves multiple jurisdictions with legacy policies that are not always in concert. Congressional and executive policies “have resulted in many agencies and organizations being involved in different but related aspects of federal water policy. This dispersed arrangement complicates management of large river systems and estuaries...” (Cody and Carter, 2009, p.2).

Congress has not enacted any major national water policy legislation since the 1965 Water Resources Planning Act, which established the formation of the Water Resource Council. State authorities have taken leadership on water resource management and conservation programs. The number of states that have enacted water conservation mandates went from nine in 1990 to 23 in 2005. A study by Mamunur, Maddaus, and Maddaus (2010) found there was a significant correlation between states' commitment to water conservation and their expected population and water security. The study concludes that it may take national legislation or public interest group pressure to facilitate widespread adoption of state water conservation policy across the country.

Water Conservation Policy in Washington State

Washington State water conservation policy bears some similarities to the transitions of priority that are shown in federal policy. Washington policy carries a legacy of western expansion that focuses on acquisition and transfer of water rights as populations grow and move about over time. By the late 20th century, several legal challenges against state policy prompted the legislature to enact a comprehensive municipal water law. In 2003 a new law was written to settle historical debates regarding inequity in the application of water rights' policies between developers and municipalities. Also within the new municipal water law were water conservation protocols and benchmarks for municipalities. By 2007, state agency rules were approved and present the criteria that shape the municipal water conservation programs across Washington.

Water rights are most commonly allocated by government to water users for specific volumes of water that are to be withdrawn over specific time periods. Most water rights have a “use it or lose it” clause that provides the rights will be transferred to another user if the water right is not used in its entirety for a given amount of time. These water right abandonment clauses were intended to prohibit speculators and to encourage beneficial water use.

Throughout the development of the western United States a series of federal court rulings established legal precedents that allowed municipalities more leniency with water rights abandonment clauses. Contrary to speculators that may attempt to appropriate a water right larger than they require in order to profit from that right's transfer, municipalities were seen as requiring larger than necessary appropriations to accommodate future population growth. Court rulings in Idaho, Wyoming, and Colorado were in agreement, resulting in what has since been called the 'growing communities doctrine,' (Gravley, Feldman, and Derr, 2012). Under the informal set of principles in the growing communities doctrine municipalities appropriated water rights that were not in jeopardy of water right abandonment due to incomplete usage.

In Washington State the abandonment of a water right for incomplete usage is codified under RCW 90.03.030. No Washington court ruling or legislation expressly exempts municipalities from water right abandonment. The Washington State Department of Ecology (Ecology) was responsible for issuing rights to municipalities once infrastructure was constructed. The rules for exact volume appropriation for municipalities were unclear and were brought to court in the 1998 landmark case *Theodoratus v. Department of Ecology* (Kray, 2008). The Washington Supreme Court acknowledged that Ecology was not authorized by law to determine water rights based on system capacity, but refused to address how the law pertained to municipal water rights.

The Washington State legislature enacted House Bill 1338, titled the Municipal Water Law (MWL) in 2003, to address the legal uncertainty of municipal water. There were considerable contentions among stakeholders to the contents of the bill, including concerns that the bill was unconstitutional and that it changed legal definitions such that developers could file for water rights as if they were municipalities (Turner, 2003). Opposition mounted a legal case against the MWL where tribal interests and other stakeholders filed two parallel suits under the names *Lummi Indian Nation v.State of Washington* and *Burlingame v. State of Washington.* After a series of appeals, the Washington State Supreme Court unanimously upheld previous rulings in support of MWL.

Wrapped within the contentious 2003 Municipal Water Law were new mandates on water conservation. The Department of Health is directed by the MWL to manage a mandatory conservation program and ensure that municipalities are meeting efficiency standards, meeting distribution leakage standards, and maintaining water conservation reporting standards (Gravley et al., 2012). To fulfill the directives in the MWL, the water use efficiency (WUE) program was created by the Department of Health, and the first guidelines to the program were finalized and distributed to all municipalities across the state in 2007 (Washington State Department of Health, 2007).

Within the water use efficiency program are several key goals for all state municipalities. Water production meters are required for all municipalities to measure the volume of water produced or purchased for distribution by 2007. Consumption meters are required for all connections to ensure accurate billing and to provide customers with usage information. All municipalities must have consumption meters installed by 2017. Monthly and annual data collection is required for production and consumption, and system leakage must be calculated from this data. All municipalities are required to keep system leakage under 10% of total production volume (Washington State Department of Health, 2011).

The Department of Health requires that each municipality make its own water use efficiency program. A WUE plan consists of goal setting and performance evaluation, funding considerations such as partnering with nearby water systems, developing incentives and price structures to encourage customers to reduce consumption, and an education and public forum component. These WUE programs are required to be evaluated and updated every six years, but allows for municipalities to update them more frequently in order to evaluate the results of new conservation strategies.

Components of the WUE that pertain to metering, leakage, and data are considered supply-side efficiency measures. Demand-side strategies include informational outreach, tiered rate structures to trigger price signals to heavy users, developing a conservation website, and providing incentives and rebates for customers to acquire efficient components. Compliance with the WUE program requires that utilities with more service connections must provide more demand-side efficiency measures to customers (Figure 4). The Department of Health acknowledges that hardware and equipment upgrades are quantifiable measures, while education and outreach programs are the most unquantifiable in terms of water use reductions. Some of the outreach methods the Department suggests in the WUE guidebook are:

- Sending water savings tips to customers in the annual water quality report.
- Sending the Department of Health's *Stop Water Waste* brochure once a year.
- Educating customers to identify and repair leaks.
- Educating customers about the economic benefits of installing WaterSense fixtures.
- Including water consumption history on billing statements.

The deadline for utilities to have set water use efficiency program goals was mid-2009. Municipalities throughout Washington have just recently finished the first period of WUE program implementation and will soon update their programs and submit new plans. The Department of Ecology is tasked with issuing water rights and working with municipalities to ensure adequate supply for projected growth. The Department of Health is directed by legislation to manage and oversee municipal water conservation programs. Through an iterative process the water use efficiency program is intended to reach customers and compel them to reduce usage by way of economic signals, incentives for efficient water devices, and educational outreach. The following section highlights how the City of Olympia has developed its conservation program.

Water Conservation in the City of Olympia

In 2009 the City of Olympia completed its first Water System Plan in accordance with the Washington State Department of Health Water Use Efficiency (WUE) program. The plan addresses all aspects of providing municipal water, including population forecasts, supply-side management issues, legal framework considerations, costs of operation, and water conservation, among other topics. A key management priority of the water conservation program is "[c]omplying with new water efficiency requirements," (City of Olympia Public Works Department [Olympia], 2009, p. S-2). Prior to the mandate of HB 1338 for municipal water conservation programs Olympia had implemented its own program. The City of Olympia has maintained a water conservation program since 1996, but participation has been intermittent. Going forward in 2015 the City will be developing a new Water System Plan as required by the WUE program.

The City of Olympia started a water conservation in 1996 that introduced a tiered water rate structure. The structure uses economic signals to reduce usage, and heavier users are subject to higher rates. The structure of the three tiered rate was designed to reduce summer consumption, but as reductions weren't satisfactory as fourth tier was introduced in 2004.

The City reports that between 1996 and 2007 despite connections to the utility system increasing by 23.2 percent actual consumption decreased by 14.6 percent (Olympia, 2009). The time frame reported includes the 2004 four-tiered rate structure. The new fourth tier was designed specifically to target the greatest consumers in summer months. Consumption in Olympia reduced after the passage of the four-tier structure, however it is not clear if the cooler summers of 2005 and 2007 contributed to reduced demand.

An examination of consumption patterns of water consumption for each tier of the pricing structure demonstrates that some usage does not respond to price signals. Table 1 shows usage for the years 2004 – 2007 by tiered rate and the fourth tier consumed more than the third tier for that time period (Olympia, 2009).

Table 1: Olympia Municipal Water Consumption by Utility Rate (Million Cubic Feet)

	Tier 1	Tier 2	Tier 3	Tier 4	Total
2004*	78.00	37.35	14.67	20.57	150.59
2005	75.47	3.19	10.70	12.06	130.42
2006	78.03	35.42	13.58	18.87	145.90
2007	79.77	32.02	10.45	11.79	134.03

*Cells highlighted in grey represent 2004 data analyzed as if there were four tiers in 2004.

Table 1: *Water consumption by tiered rate structure shows that the heaviest users do not respond to price signals. (Adapted from Olympia, 2009).*

Through a partnership with the Lacey-Olympia-Tumwater Treatment plant (LOTT) the City has secured over $7 million in grants for home fixture upgrades. A major component of the rebate programs was the high-efficiency toilet giveaway. Residences with toilets using three gallons or more per flush are eligible to trade their toilets for free toilets that use 1.1 – 1.6 gallons per flush (LOTT, 2010). The reduction in water use provided by these toilet upgrades on average 13,500 gallons per year. By 2014 the free toilet program was canceled and $100 rebates were offered for eligible residences instead (LOTT, 2014).

Water fixture upgrade incentives from the City also include water saving kits that include low-flow showerheads, faucet aerators, and leak detection kits. Residents were informed of the free kits through the mail and were invited to pick them up from the utility. Initially this program distributed 150 kits per year, but by 2006 the program only distributed 35 kits per year. The City adjusted its strategy and in 2007 began mailing kits directly to residents' homes. Mailed kits were sent only to residents that requested the kits, but the new strategy increased participation to 150 kits per year between 2007 – 2009 (Olympia, 2009). The City estimates that the water saving kit program will save over 3 million gallons for 2009 – 2014. It should be noted that these savings are based on the assumption that 90 percent of mailed kits will be installed.

The City's comprehensive water conservation program also addresses the business and public sectors. Rebates are provided for businesses to upgrade fixtures and several schools in the City public system have received restroom and kitchen retrofits. In 2007 the City increased its rebate program from 50 percent to 75 percent of the cost of equipment and systems efficiency upgrades. This program is purely voluntary and between 2006 – 2007 three businesses and two schools participated.

The security of the water supply is a major consideration of the City in the crafting of water conservation policy. McAllister Springs is the source of 84 percent of Olympia's water and is the only source that provides water all throughout the year (Cuykendall et al., 2008). The pumphouse that delivers water from springs was constructed in the mid-1940s and relies on outdated technology. Further concerns come from the springs' close proximity to I-5 and the potential for an accident to introduce toxins to Olympia's primary water supply.

Arguably the greatest concern stems from the inability for the springs to provide adequate water for projected population growth. The City of Olympia projects that 1,000 new residents will move to Olympia per year until 2035. Water production from McAllister Springs would be insufficient for the increased demand, which would result in a deficiency of 2.33 million gallons per day by 2028 (Olympia, 2009). Despite the seriousness of local water supplies that are unable to meet local demand, the projected shortfall has not been part of City outreach education. Even when discussing with a local reporter about the rationale for moving the City's primary source from McAllister Springs to an upland wellfield, Olympia public works director Rich Hoey is not reported to have mentioned the projected shortage of water (Batcheldor, 2012).

The water conservation strategies described above are all designed to reduce indoor water consumption. Indoor use makes up 77 percent of all use, with 8 percent attributed to irrigation, and 15 percent sold wholesale to neighboring municipalities (Olympia, 2009; Olympia City Council, 2007), . Single-family homes are the largest consumer block on the utility system, using 40 percent of City water. Two percent of residential use is attributed to outdoor irrigation use. The remainder of this chapter will cover the City of Olympia's residential outdoor water conservation program.

The Water System Plan for 2009 – 2014 introduced an expanded set of services for meeting outdoor residential consumption goals. A series of bi-monthly fliers and brochures were mailed to all utility customers to inform them of ways outdoor water use can be reduced. Among those services were free residential irrigation system audits that were provided for customers with the highest use. Previous efforts to engage residents in outdoor water conservation had seen declining participation. The City offered free irrigation audits and landscape consultations for its highest use customers but participation had declined from 2005 – 2007. By 2014, the City was offering a contract position for a professional irrigation auditor (City of Olympia, 2014).

The expanded outdoor water conservation program offered a new set of incentives through rebates educational outreach through mailers and the City's water conservation website. A variety of free devices were offered, available to residents who provide a copy of their utility bill to City offices. Eligible residents can receive free rain gauges, free hose timers, and a free outdoor water kit. Also available for eligible residents is a rebate on rain barrels ranging from $20-$60.

The educational component of the outreach brochures for 2009 – 2013 demonstrates a shifting priority in City goals. The summer brochures for 2009, 2010, and 2011emphasized lawn care practices that demand less water. Removing water intensive sod, replacing grass with native plants, installing barrels to collect rain water, and inspecting watering devices to ensure proper functionality were common topics (City of

Olympia 2009;2010;2011). The brochures also included check lists and pledge forms intended to help residents prioritize their outdoor water system and garden upgrades.

By 2012, the City shifted its outreach to ensure customers are ensuring their home watering practices do not endanger City water quality. Water system backflow can occur when there are sudden pressure changes, such as when a fire hydrant is opened or if there is a sudden large leak. If residents do not have backflow prevention devices, water that has become stagnant in their systems can potentially be drawn into the City system. Backflow is particularly dangerous from irrigation systems where the water has the greatest likelihood of contamination. For 2012 and 2013 these messages were only educational, as there were no related services or incentives offered in relation to backflow.

The addition of backflow to the educational outreach of the water conservation program may be in part due to a change in the Olympia Municipal Code. In October, 2011, the City added a provision to existing water safety code that calls for water connections to be shut off if contamination is detected. Furthermore, all costs for installation, maintenance, and testing of backflow prevention devices are the responsibility of the property owner (City of Olympia, 2011).

The Olympia Municipal Code (OMC) has included laws that address water supply and water safety since at least 1969. In the Municipal Code there is also a provision that prohibits the waste of water provided by the City utility. Waste is defined in OMC 13.04.080 as the application of water to a landscape such that impervious areas are watered or "significant runoff" occurs (City of Olympia, 2011). Failure to comply with the water regulations can result in discontinuation of water service, or fines ranging from

$50-5,000. At the time of this report it appears that there has been absolutely no enforcement of either codes that pertain to backflow prevention or waste of water.

A review of the City of Olympia water system budget process reveals systemic contradictions with its water conservation program. The 2014 Adopted Operating Budget for the City of Olympia (2014) indicates that the operational budget of the utility is dependent upon steady consumption. “Slowdown in development activity, effective water conservation efforts and wetter summers in recent years have resulted in lower than anticipated revenues. As a result, in 2012 we increased the ready-to-serve fee to better reflect fixed costs for the utility, and proposed a three year plan to phase in additional increases to this portion of the rate,” (p. 144).

The City is dependent upon utility use charges to fund its operational costs, which also include the costs associated with maintaining its conservation outreach program. For the fiscal years 2012, 2013, and 2014, system-wide consumption per connection reduced 8.1 percent, 7.7 percent, and 7.3 percent, respectively. The reductions are greater than the 5 percent system-wide reduction that was stated in the Water System Plan of 2009. The administrative and fiscal structure of the City water utility was not in the scope of this research. However, the above statements from the 2014 City Budget raise concerns regarding the viability of the City's water conservation program.

The above review of the City of Olympia's water conservation policy demonstrates a pragmatic and adaptive approach to resource management. The City developed an incentive based outreach program upon its own initiative prior to any legislative mandate. Upon receiving such a mandate through the passage of HB 1338, the City implemented its first six-year Water System Plan in accordance with guidelines set by the Department of Health. The outreach program has met mixed results in participation levels and has been required to adjust its level of rebate incentives due to changes in funding. Despite the challenges of changing water demand behavior the City has surpassed its water conservation goals.

Along with the reported success of reduced consumption are complications in policy and implementation that deserve attention. Nowhere in the conservation program's outreach has there been an effort to educate the public exactly how finite local water resources are. Existing municipal codes that prohibit the waste of water have rarely, if ever, been enforced. Figure 4 is an example of the many water customers throughout the City that maintain wasteful water use behaviors despite outreach efforts. The funding of

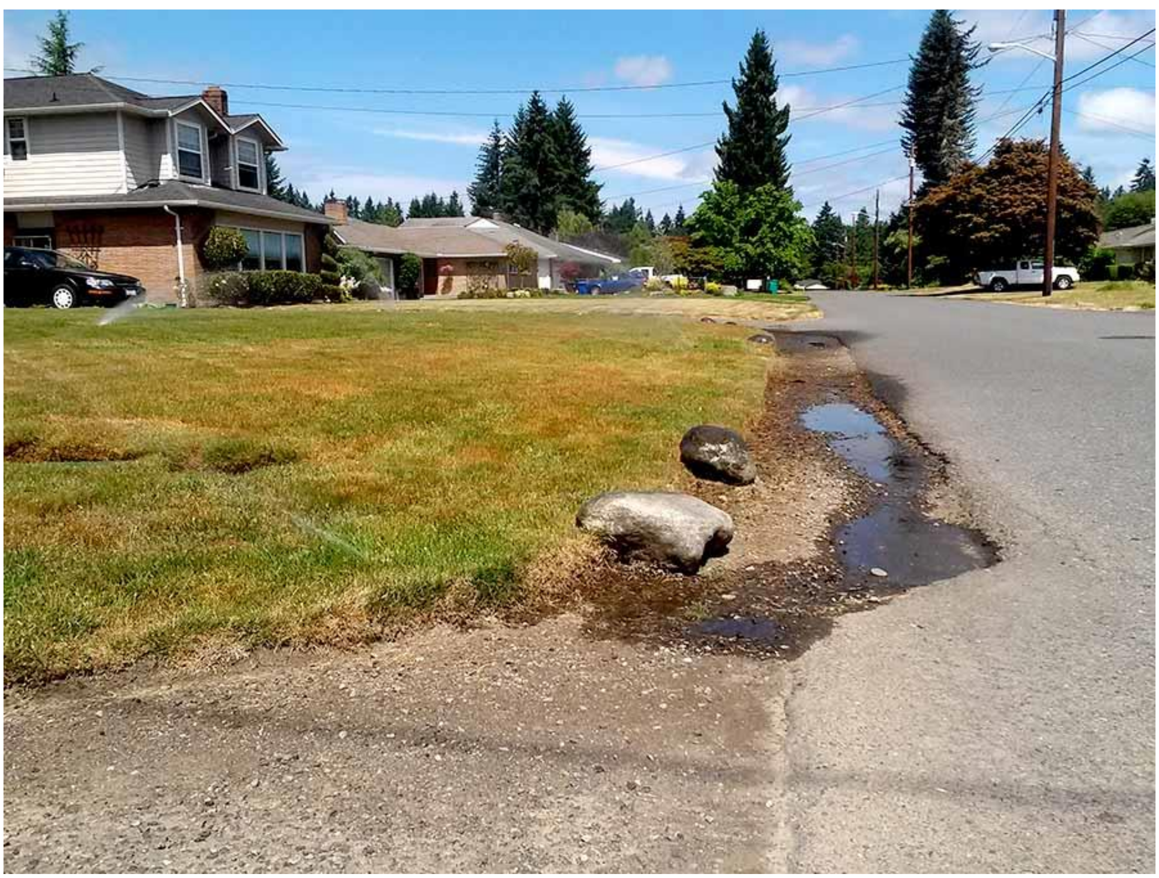


Figure 4: *Pooling of municipal water on street from the use of an automated irrigation system in SE Olympia at mid-day in July, 2014.*

the utility is based in part on usage rates, requiring the routine increase of other line-item fees. There is a potential for this combination of policies to render water customers uniformed about their public resource while suffering punitive fee increases for reduced consumption. Also limiting outreach potential is the City policy to send utility billing statements exclusively to property owners. The policy prohibits tenants from monitoring their usage or receiving educational materials.

The next chapter presents analysis of residential home water use surveys. The survey includes aspects of the City's water conservation brochure outreach and integrates behavioral analysis methods as described in Chapter 2. The research is based on the inquiry of how to improve the City of Olympia's water conservation outreach program. The findings reported below are concluded with a discussion on future policy opportunities that may increase water conservation in Olympia by incorporating the methods of behavioral analysis.

Chapter 4: Analysis

The following chapter on analysis reports the analysis of the City of Olympia's water conservation outreach program and the behavioral aspects of residential water conservation. The methodology used in creating and analyzing the survey are described. Following which, the mixed statistical analysis will be described, and the test results will be reported. Discussion on the implications of the analysis results concludes the chapter, and provides possible policy opportunities. The final chapter will conclude this research with a summary and further discussion.

Survey Design and Implementation

The water conservation survey was designed to evaluate residents' opinions and behaviors with their home irrigation, provide a scoring method to determine dominant behavior drivers, and determine residents' interest in novel methods of reporting home water information. The 41 question survey consists of eight “Yes/No/Not Applicable” questions about home irrigation methods, one question about how long residents have lived in Olympia, thirty questions that utilize the theory of planned behavior, and two questions to ask if residents would be interested in more in-depth of their home water usage. Surveys were delivered to neighborhood clusters that were randomly selected from a numbered grid of the City, as depicted in Figure 5. Of the 1,000 surveys distributed to homes, seventy were returned for this analysis.

Survey questions pertaining to the theory of planned behavior were crafted to fit the methods described in Francis et al. (2004). Questions were written with a 'stem' statement that is designed to elicit the opinion of the participant, which is chosen from a

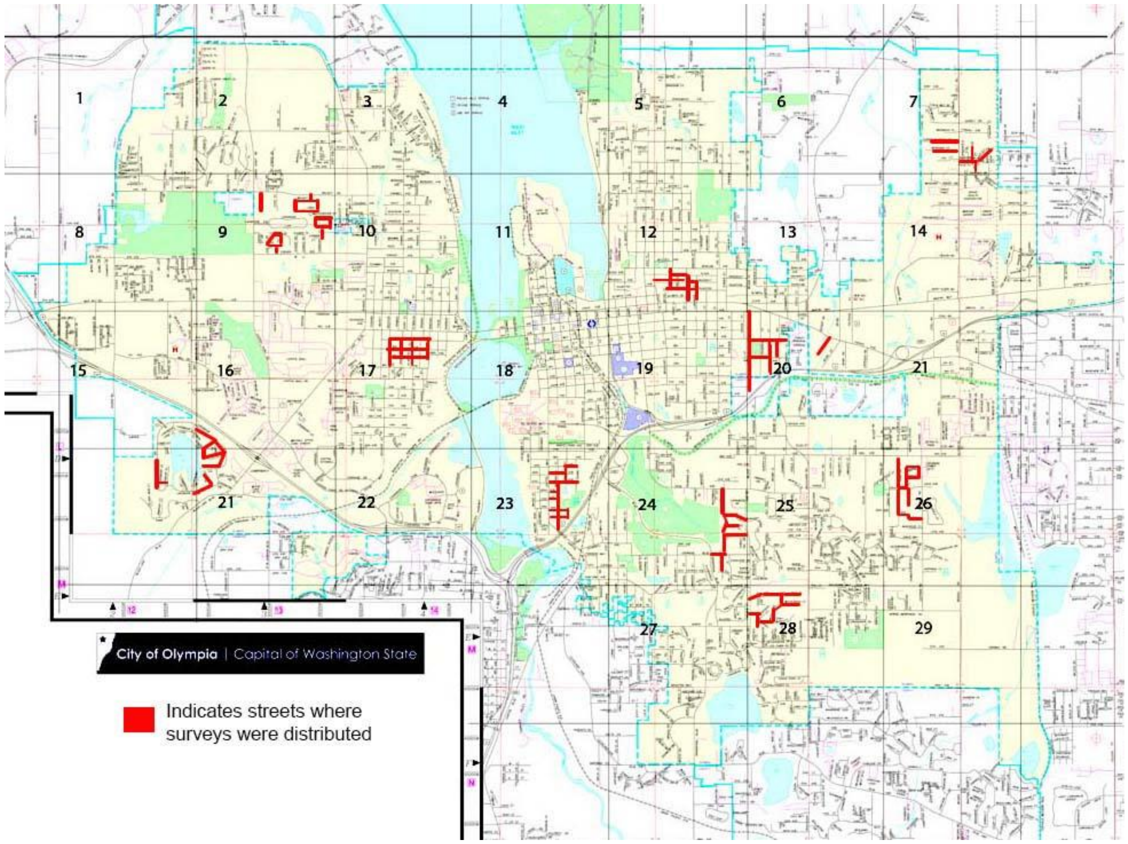


Figure 5: *Map of survey distribution across ten neighborhoods in Olympia*.

5-point Likert scale. Ten questions are written to target each of the three major constructs of the theory of planned behavior (personal attitude, social norm, perceived behavioral control). For each construct, one question is written to measure opinion directly, and the other is written to measure opinion indirectly. To describe residents' personal attitudes on water conservation, five questions were written to describe the strength of their behavioral beliefs (Strongly Agree to Strongly Disagree), and five questions were written to describe how residents would evaluate outcomes of water conservation (Very Desirable to Very Undesirable). Question pairs are written with very similar language, but are reworded to describe either participants' beliefs or their evaluation of outcomes.

For a measure of social norm, five direct questions were written to describe what participants think a person should do (Strongly agree to Strongly Disagree), and five indirect questions were written to describe what participants believe people actually do (Very Much to Not at all). Measuring perceived behavioral control is done by framing five questions around what beliefs participants have that make it difficult to perform the behavior (Very Likely to Very Unlikely). The following five questions are written to assess the power of these beliefs to influence their behavior (Much Easier to Very Difficult).

The conclusion of the survey inquires if residents would like to have utility billing statements to include their usage in the context of other homes in their area (Ferraro and Price, 2013), or if they would be interested in multiple home water monitors throughout their house that they could monitor (Willis et al. 2010).

Behavioral Scoring Method

Five-point Likert scale answers were allocated numerical values from -2 to 2. Behavioral scores were calculated for each respondent by summing the total of the product of each behavioral contstruct's direct and indirect questions. Resulting in the following formula for behavioral attitude, demonstrating which direct question number was paired with which indirect question:

$$A = (\#10 \times \#16) + (\#11 \times \#15) + (\#14 \times \#17) + (\#13 \times \#18) + (\#12 \times \#19)$$

The range of possible behavioral score is from -20 to 20. A high positive score indicates a respondent has a positive attitude towards outdoor water conservation and a high negative score indicates a strong negative attitude.

For this scoring method to be accurate, it should be noted that questions must be worded in order to highlight the nuanced meaning of the question it is to be paired with. Questions that provide answers with reversed scaling will provide the opposite results in behavioral scoring (due to the negative aspect of the Likert scale in this method). This relative scoring method is outlined by Francis et al. (2004) and offers a simpler method of behavioral analysis than the methods presented by Ajzen (2006), Lam (2006), or Greaves et al. (2013).

Survey Analysis and Results

Analysis of variance (ANOVA) of behavioral scores was conducted with SAS JMP software version 10.0 for each theory construct by neighborhood. Results showed no statistical difference between any of the neighborhoods for personal attitude, social norm, or perceived behavioral control beliefs on water conservation. Preliminary assumptions of ANOVA analysis were not met by Levene's test, F-ratio probability statistics ranged from 0.37 to 0.88, and post-hoc Tukey analysis demonstrated that the neighborhoods belong to one group when analyzed along behavioral scores.

Surveys that were filled out and returned did not evenly represent the neighborhoods surveyed. For instance, the Fir Southeast neighborhood returned seventeen surveys while the Southwest neighborhood only returned one. ANOVA analysis of the sample group with the Southwest neighborhood removed also produced insignificant results.

Chi-square contingency table analysis of water conservation program survey items were found to be insignificant. The ownership of irrigation systems in homes were not a significant predictor of the willingness to receive augmented utility billing statements or the willingness to have water meters throughout participants homes. Sixty-three percent of participants are interested in receiving more information on their billing statements, and forty-five percent of participants are interested in multiple home water meters they can monitor.

Median home value and median income were analyzed for significance against behavioral scores, interest in augmented billing statements, and interest in multiple home water meters. Chi-square logistic fit tests produced insignificant, confounding results. Socio-economic variables are not predictors of home water conservation behaviors in this survey.

The effect of individual questions about residents' opinions of the City proved to have significant relationships with water conservation behavioral scores. Question 23 prompted participants with "I should save water because the City of Olympia recommends it." For analysis of the relationship between these answers and the city-wide social norm behavioral score, this question produced a significant relationship to the social norm behavioral score, $F(4,66) = 7.03$, $p<0.0001$. Question 28 was written as the indirect couple to question 23, and had significant response in social norm behavioral score, $F(4,66) = 2.97$, $p = 0.026$. Post-hoc Tukey tests of the analysis above shows two distinct groupings of social norm scale when asked about the City, as depicted in figures 6 and 7.

The results from City related questions suggest there are distinct groups of opinion among residents across neighborhoods. Positive survey responses represent residents that value cooperation with City initiatives. The distinct groups in these

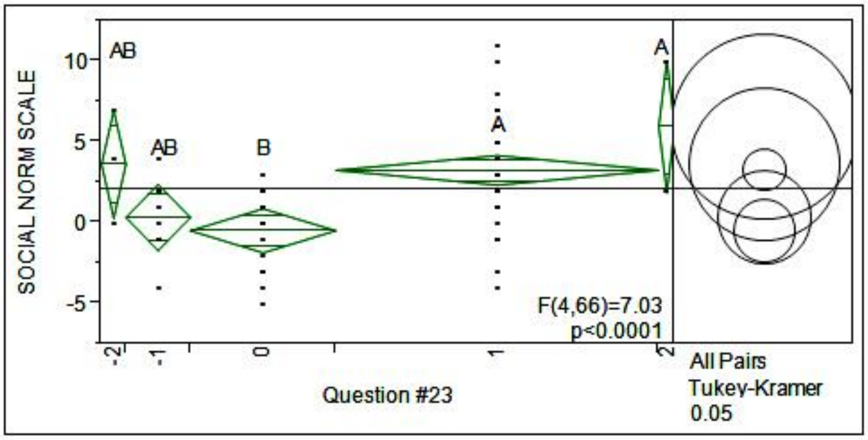


Figure 6: *ANOVA analysis of question #23 by social norm relative behavioral score with post-hoc comparisons labeled above Likert responses.*

ANOVA results show an overlap in opinion between those respondents who had no opinion and those who do not value cooperation with City initiatives. This suggests the social norm behavior response of those who are in support of the City's conservation program is stronger than those who are indifferent or disinterested. It is possible that the

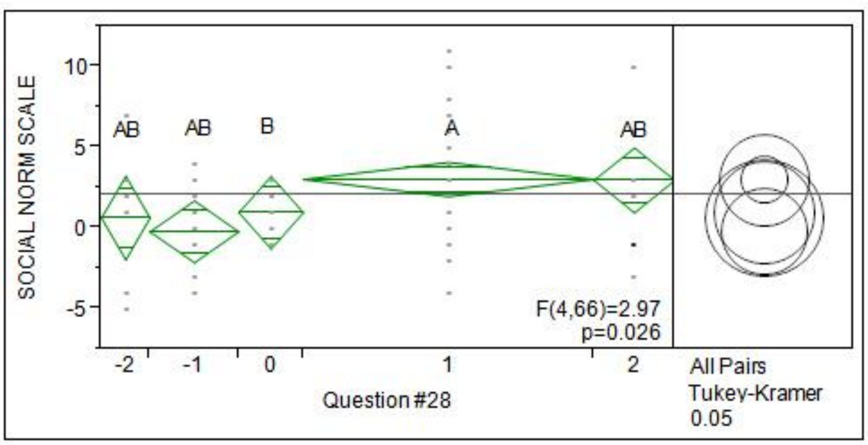


Figure 7: *ANOVA analysis of question #28 by social norm relative behavioral score with post-hoc comparisons labeled above Likert responses.*

difference between the two statistical tests on these two related questions is the result of language effects from the writing of survey questions.

Analysis of questions that pertain to opinions of lawns that brown during dry summer months provides significant relationships between aesthetic preferences and personal attitude and social norm behavioral scores. Perceived behavioral control scores were not significantly related to lawn aesthetics, and both personal attitude and social norm behavior scores produced comparable ANOVA results. Table 2 highlights the similar social and personal value residents place on the appearance of their yards.

Table 2. One-Way ANOVA Analysis of Lawn Aesthetics

Question 14	Personal Attitude	Social Norm
F Ratio (4,66)	2.64	2.92
p Value	0.042	0.028
Question 16		
F Ratio (4,66)	3.21	2.81
p Value	0.018	0.033

Table 2: *One-Way ANOVA analysis of lawn aesthetics indicates comparable influence of both personal and social norm behavioral factors.*

The effects on behavioral attitudes by neighbors was explored with three direct and three indirect questions (questions 21, 22, 24, and 26, 27, and 29, respectively). Question 21, which states, “neighbors should talk to each other about ways to save water in the yard,” was paired with question 27 that stated, “talking with my neighbors about water conservation is important to me.” Question 21 was significantly related with perceived behavioral control score groupings, $F(4,66) = 2.90$, $p = 0.028$. Question 27 was significantly related with social norm scores, $F(4,66) = 14.2$, $p<0.0001$. Post-hoc Tukey's test analysis for question 21 shows two groups that are higher on perceived behavioral control for both strongly positive *and* negative responses. Post-hoc analysis of question 27, however, shows a split between the pairwise groups, with positive responses significantly different from indifferent or negative responses.

The analysis results of these paired questions demonstrate how survey language can influence results. The respondents who most negatively responded to the prompt in question 21 that “neighbors should talk to each other” were statistically similar in their perceived behavioral control scores to those who most positively responded. The indirect phrasing of question 27 elicited responses that show positive responses are significantly related to higher social norm behavior scores. This suggests it is not important whether respondents talk with their neighbors about water conservation, but how they do it. The imperative statement “should” in question 21 may have influenced high perceived behavioral control scorers to choose either strongly positive or negative reactions.

Table 3 further demonstrates how important language usage is in eliciting survey data. The four questions pertaining to neighbor relations and water conservation that produced significant relationships with all three behavioral score factors. These findings

Table 3. One-Way ANOVA Analysis of Neighbor Relations

	Question	F Ratio (4,66)	p Value	Behavior Factor
21.	*Neighbors should talk to each other about ways to save water*	2.90	0.028	Perceived Behavioral Control
27.	*Talking with my neighbors about water conservation is important to me*	14.2	<0.0001	Social Norm
24.	*My neighbors will disapprove if I don't water my yard enough*	4.78	0.0019	Perceived Behavioral Control
26.	*The way my neighbors use water in their yard is important to me*	6.38	0.0002	Personal Attitude

Table 3: *Water conservation questions about respondents' neighbors and their corresponding behavioral relationships.*

suggest that the social aspect of residential water conservation is complex and involves multiple aspects of human behavior.

Paired questions exploring the impact of the perceived work involved with practicing residential water conservation produced interesting analysis results. Question 34 stated “trying water saving methods in the yard will make more work for me to do,” and provided a 5-point likelihood scale. Question 39 stated “using water saving methods in my yard that weren't time consuming would make saving outdoor water,” and provided a 5-point scale from very difficult to much easier. Response analysis of question 34 significantly relates with perceived behavioral control, $F(4,66) = 7.83$, $p<0.0001$. Post-hoc analysis demonstrates the two significantly different groups split evenly between the positive and negative responses. Question 39 elicited only no opinion or positive responses.

The perceived work required to reduce water usage is shown by this survey to be significant behavioral control that prevents more residents from practicing outdoor water conservation. While question 39 does not produce significant statistical results, there were no respondents that disagreed with the statement.

One direct and one indirect question in the survey explored the role water conservation information plays in residents' conservation behavior. Question 32 stated “if I knew how to save water in our yard I would try conserving water,” and provided a 5-point likelihood scale. Question 36 stated “if I had more information about saving water outside it would make conservation,” and provided a 5-point scale from very difficult to much easier. Neither question produced a significant behavioral relationship, but question 36 elicited no negative responses. Like the behavioral control of perceived work required for outdoor water conservation, residents expressed a positive opinion towards the role of information and conservation.

Analysis of the relationship between duration of residence in Olympia showed that respondents who have lived in Olympia 5 – 10 years had significantly higher personal attitudes toward water conservation than all other residence groups, $F(4,66) = 4.27$, $p = 0.0039$. Table 3 shows how mean personal behavior scores differ between groups of different residence durations.

Table 4. Mean Personal Attitude Behavioral Score by Residence Duration

Residence	Pairwise Group		Mean
5 – 10 years	A		4.73
20+ years		B	1.10
10 – 20 years		B	0.647
1 – 5 years		B	-0.222
1 year or less		B	-2.33

Table 4: *Water conservation attitudes are shown in mean relative scores across groups of different duration of residency in Olympia.*

Negative relative behavior scores indicate a negative attitude towards water conservation.

Discussion

Behavioral analysis is provided for the water conservation beliefs of respondents in Olympia, Washington. The survey method was adapted from Ajzen (2006), behavioral scoring method was provided by Francis et al. (2004), and statistical analysis was conducted by analysis of variance with SAS JMP software. Survey data was found to be significantly related to the three contributing behavior groups that comprise the theory of planned behavior. As this survey did not elicit responses particular to the water conservation intentions of respondents, it is not possible to conduct the predictive analysis of the theory of planned behavior. It does, however, provide an explanatory, relationship-based analysis of conservation behaviors and behavior types.

Respondents who reacted both positively and negatively to questions regarding compliance with City conservation goals were ranked higher in the social norm behavior score. Likewise, respondents with high social norm scores both negatively and positively reacted to a question that uses the imperative "should" when referring to how to talk to neighbors. Ignoring possible language effects in the survey process, these results suggest there is an aversion to coercive messaging among Olympia residents.

The significance of the lush green lawn is demonstrated in this survey analysis, both in personal attitude and in social norm behavior score. The cultural weight of these landscapes is not only deeply rooted in our culture, but has the potential to serve as a point of social conflict if challenged (Feagan and Ripmeester, 2001). Future efforts to challenge this cultural norm for the purpose of water conservation must acknowledge these behavioral factors. One previous effort to trigger cognitive dissonance in order to inspire water conservation did so by directly challenging participants' beliefs in order to trigger a "hypocrisy effect" to motivate participants. Dickerson, Thibodeau, Aronson, and Miller (1992) conclude that this approach produces more lasting effects than distributing printed information to target populations. It should be noted, however, that both the experimenters and the participants in Dickerson et al. (1992) were female college students. Utilizing a confrontational information campaign to inspire water conservation would likely produce less compliance in the demographically diverse context of a city.

Neighborhood selection in this survey was based on a random number grid method and an intentional selection within those quadrants of the neighborhoods with the highest density. This was a pragmatic and structural decision. In order to explore neighbor effects it would not have been as informative to have selected homes on properties over an acre in size. The presumption was that interactions with neighbors would be lower where houses are further apart.

The survey revealed that relationships between water conservation and neighbors are significantly related to all three of the behavioral constructs in the theory of planned behavior. Programs that successfully involve neighborhood groups, therefore, may have the ability to engender comprehensive conservation behavior changes. Monroe (2003) explores social marketing strategies and concludes that significant life experiences and environmental based education are the most productive strategies to encourage conservation behaviors. There are active programs in Olympia that utilize these strategies to manage invasive plants and improve salmon-bearing streams. The Olympia water conservation program to date does not incorporate these strategies.

To develop conservation programs, Monroe (2003) adds that research can assist policymakers by identifying barriers to conservation that exist in the target audience. To that end, this survey has identified two barriers: a lack of water conservation information and a lack of convenience associated with practicing water conservation. The Olympia water conservation brochure mailing campaign was apparently not effective, did not reach its audience, or respondents were not yet residents of the City at the time of mailing. That the majority of respondents have resided in Olympia for five years or more suggests that the brochures were simply not read by some residents.

Another barrier perceived by respondents was the inconvenience of outdoor water conservation. This may be related to the effort required to install native plants or water by hand. In order to determine what aspect of outdoor conservation that is inconvenient for residents, a follow up study is required. Survey questions that were designed to determine if the cost of water was a significant variable in conservation behavior produced insignificant results. Also insignificant in this survey analysis were questions that directly referenced the reliability of the City's water supply.

It is possible that cost and reliability of the City's water supply would be best explored using other methodology than found in behavioral analysis. One survey had a message written by its respondent that indicated frustration with the City's annual utility price increases. The reliability of water available in Olympia appears to be largely unknown by its residents. Informal conversations with residents throughout this research indicated most residents believe there is ample supply. This may be due to the high level of precipitation in this region. As respondents indicated an interest in receiving more information about water conservation, it would likely encourage conservation if water supply status updates were provided to residential water customers on a regular basis.

Finally, this research demonstrated that a majority of residential water customers are interested in receiving more information about their home water use. Actual home water use is often higher than residents' perceived home water use, (Beal, et al., 2013). When residents receive augmented utility bill statements that include their home water use as compared to local averages, it has been shown that consumption is reduced (Ferraro and Price, 2013). The utilization of social normative messaging can be incorporated with traditional conservation messaging to directly target and influence conservation behavior. It is possible that providing Olympia residents with increased personal water use information will encourage more water conservation than can be achieved through informational mailers alone.

Chapter 5: Conclusion

Municipal water conservation is a balancing act between water supply and water demand. The City of Olympia has developed a water conservation program that is relatively aggressive compared to other municipalities in Washington. The City has undergone extensive planning and negotiation with State agencies in order to develop a more secure and productive water supply. And the City has developed an outreach program designed to encourage conservation that incorporates education, economic signals, and incentives for home upgrades. Despite these accomplishments there are many water customers who do not practice water conservation behaviors.

Water conservation outreach can be described as a behavioral intervention. This thesis presents a method for evaluating a municipal water conservation outreach program that incorporates behavioral analysis. A major goal of the research is to address the need to "include social science research within conservation programs in designing strategies, selecting behavioral targets, and evaluating results," (Akerlof and Kennedy, 2013, p.1).

To this end, the research has produced results that can inform new water conservation policies in Olympia. Nearly two-thirds of respondents indicated they are interested in receiving more information about their usage in their billing statements. The inclusion of water use information that compares one customer's use against local average consumption has been found to be effective in reducing demand (Ferraro and Price, 2013). The increased information is described as producing a positive response due to perceived social norms. The inclusion of this information would likely be inexpensive to implement and could serve as an opportunity to monitor any changes in demand after implementation.

The research also shows the mixed behavioral responses that arise from receiving normative imperatives from the City government. Social norms are drivers of water consumption patterns that support conservation *and* increased use. The complex relationship between personal attitudes and water demand behavior may therefore be best addressed by incorporating behavior strategies through social mechanisms (Dolnicar and Hurlimann, 2010). The research indicates that there is a disconnect between favorable conservation attitudes and actual conservation behavior that is in part due to the difficulty of adopting conservation practices. Policy that addresses this behavior through social strategies may be able to bypass negative attitudes toward the City that would prohibit the adoption of new water use behavior.

The City of Olympia expects continued population growth for the foreseeable future. The research presented here indicates there is a relationship between water conservation attitudes and the duration of residence in Olympia. As the City continues to refine its conservation outreach program it is important that special attention be given to educating new residents. Existing outreach is primarily delivered along with billing statements that are required to be sent only to property owners. As a result of this billing policy over one-third of Olympia residents do not receive their water use information or water conservation brochures (U.S. Department of Housing and Urban Development, 2012).

Behavioral studies can inform the development of municipal conservation programs that influence desired conservation behaviors. The development of conservation outreach that is based on the behavioral sciences should be the result of collaboration between policy practitioners and behavior specialists. An adaptive approach to implementation would phase in conservation strategies incrementally and incorporate empirical analysis of the results. The specific components of municipal water conservation plans are crafted by individual cities and towns. The City of Olympia has the opportunity to develop a conservation outreach program that is designed as a demand behavior intervention. There are only so many possible methods for improving water supply efficiency. The reliability of future water supplies will be determined by how water demand is managed.

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