ANALYSIS OF FOUR GOVERNANCE FACTORS ON WATER GOVERNING AGENCIES' EFFORTS TO INCREASE WATER REUSE IN THE SAN ANTONIO REGION

A Thesis

by

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ABSTRACT

Water reuse has the potential to supply nearly 24% of needed water in the San Antonio Region; however, the impact of securing water reuse sources and coordinating water governing agencies to do so should not be underestimated. Most of the literature on water reuse has focused on the technological, economic and social aspects of reuse. This research adds to the limited literature on water reuse governance by identifying key governance-related factors that contribute to increasing water reuse within the water planning regions of a rapidly growing city. Specifically, the research tested the impact of four governance-related hypotheses on efforts to increase water reuse by the water governing agencies in the San Antonio Region, defined as the Region L and Region K planning boundaries of the Texas Water Development Board (TWDB). The impacts of frequency of communication with the TWDB, familiarity with the TWDB water strategy supplies (2017 Texas State Water Plan), the type of water governing agencies, and the scale of agencies were all variables tested against agencies' efforts to increase water reuse in the San Antonio Region. A questionnaire was sent to water governing agencies in the San Antonio Region with specific questions to address the above hypotheses. The response rate to the questionnaire was 39.3%. A cross tabulation between each variable and the agency efforts to increase water reuse was calculated. Seven regression analysis models were calculated to test for statistical significance among the factors and their impact to increase water reuse efforts by agencies. Results show nearly 70% of agencies in the San Antonio Region have efforts to increase water reuse by only 0-10%. Among the four tested hypotheses, frequency in communication with the TWDB was statistically significant in increasing agencies' efforts towards reuse. Results from testing these hypotheses will help water managers identify key governance-related factors that contribute to increased water reuse by water governing agencies.

DEDICATION

To my baby sister Melissa Papulski—bright, beautiful and full of immeasurable potential. Don't let the thoughts of others, or your present circumstances determine your future steps. The sky is your limit. No matter the distance I will always love you.

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NOMENCLATURE

DPR	Direct Potable Reuse
EPA	Environmental Protection Agency
IPR	Indirect Potable Reuse
IRWM	Integrated Resources Water Management
NRC	National Research Council
SAWS	San Antonio Water Systems
TCEQ	Texas Center for Environmental Quality
TWDB	Texas Water Development Board
TWRI	Texas Water Resources Institute

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1. INTRODUCTION

This thesis examines four hypotheses related to the amount of effort agencies invest toward achieving the Texas Water Development Board's (TWDB) water reuse goals in the San Antonio Region. The four hypotheses herein rely on the same dependent variable - the amount of effort agencies invest on water reuse issues as reported by the individuals working in those agencies. The focus of the research is to examine the relationships between this dependent variable and four separate, independent variables that have potential to increase water reuse efforts by agencies. As suggested by previous water governance literature, these independent variables include people's familiarity with the Texas Water Development Board's water supply strategies in the 2017 Texas State Water Plan; frequency of communication with TWDB; scale of agency; and type of agency.

The San Antonio Region represents a unique case in that it is a region faced with increasing drought, and a rapidly growing population. According to the Texas Water Development Board (TWDB) by 2020 the region will face a 11% gap in its water supply and demand, and this gap will grow to nearly 44% by 2070 (see figure 1). State planners and water managers are thereby faced with developing plans to secure water for the future of the region, making the need and push to develop new sources of water a pertinent topic on the water management agenda.

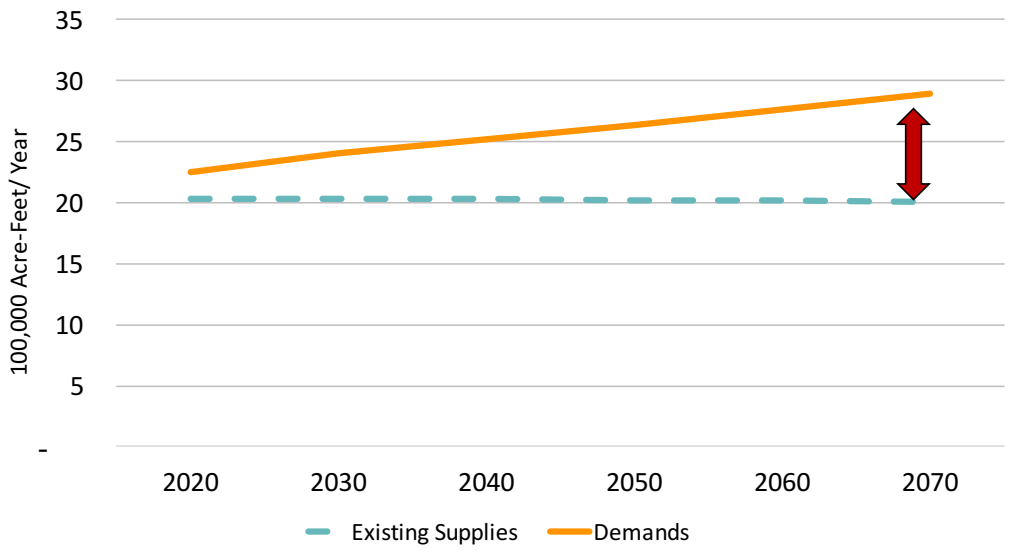

Figure 1. Projected Annual Water Demand and Existing Water Supply in the San Antonio Region. The San Antonio Region will face a 44% water gap by 2070. Adapted from TWDB 2017 State Water Plan data, courtesy of TWDB.

With rapidly growing populations, compounded by increasing temperatures, securing our nation's water supply has never been more critical. State water planning agencies, such as TWDB, are tasked with preparing states for future water needs. Therefore, understanding the level of coordination between state and local water management governing agencies will be helpful in developing policies that support targeted state and national water management strategies and goals.

This research specifically targets the TWDB's water reuse strategy supply goal for the San Antonio Region and seeks to identify factors contributing to the level of coordination between state and local water governing agencies within the region in support of this goal. The San Antonio case study represents an area with a large potential for water reuse, a rapidly increasing population, and a large projected gap between its water supply and water demands that must be addressed by a state water planning agency: making it a good choice for this work.

2. LITERATURE REVIEW

2.1 Past Approach to Water Reuse: Technological, Economic, and Social

In a field where technology and science have played predominant roles to push for a new source of water, the importance of political science to expand agency potential of reuse should not be undermined. Technological advances in wastewater management and water reuse have come a long way to produce reused water as a viable potable water product. Past research that has highlighted the technological advances in wastewater treatment (Adin and Asano, 1998; Fabres et al., 2017; Azis et al., 2017; Wen et al., 2015) has opened doors to make water reuse projects possible. Economic research analysis of water reuse has highlighted the economic benefits of water reuse (Otoo et al., 2015), as well as cost-benefit analysis of switching to reuse from other sources (WateReuse, 2006; National Research Council, 2012b). Furthermore, federal, state, and local loans and grants have been adopted in an effort to support water reuse projects. Most recent research on water reuse has focused on social adaptation to water reuse, focusing on the effects of public acceptance in adopting water reuse technologies.

These three approaches are prominent in even some of the most well developed water reuse projects and have enabled communities in Texas, the United States, and across the globe to increase their water reuse portfolios. While these technical, economic, and social breakthroughs aided the expansion of water reuse as a source of water, space remains for identifying ways to expand water reuse. To date, the research done regarding the impact of governance on water reuse is minimal and varies in focus. Often local, regional and state water governing agencies minimally coordinate regarding shared water goals, including goals to increase water reuse. Research about ways to expand water reuse would benefit from an improved understanding of the coordination that local and state water governing agencies have regarding water reuse strategies and from

identifying those agencies that have a greater potential for reuse. Figure 2 depicts pasts and future approaches to water reuse research, with the goal of expanding on water governance research. The emerging discipline of water governance is one worth pursuing to discover the potential means for increasing water reuse in a given region and this potential for increased water reuse may lie within the discipline of water governance.

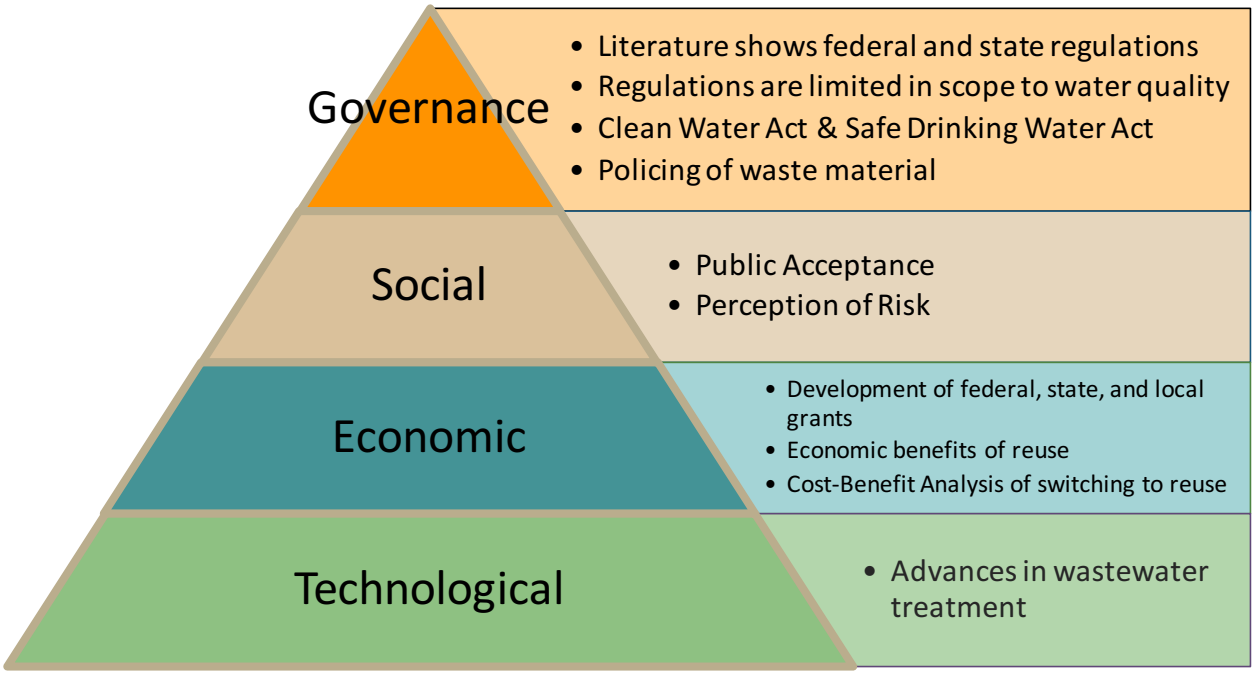

Figure 2. Past and future research approaches to water reuse. Technological and economic approaches have formed the base of water reuse science. Most recently research on social acceptance of reclaimed water has contributed to the base of knowledge. Water governance research on water reuse is relatively new and has potential to contribute to increasing water reuse.

2.1.1 Social Approach: Public Acceptance of Water Reuse

Since the 1970's, the body of social-science knowledge focused on water reuse has targeted the individual and community levels, addressing the public's acceptance of water reuse. A

significant amount of survey based research has been done to ask respondents about their willingness to use different kinds of alternative water sources. Variables found to have positively influenced attitudes toward recycled water include trust in authorities associated with recycled water use (Hurlimann and McKay, 2004; Hurlimann 2007b; Po et al. 2005; Lohman and Milliken, 1985; Jeffrey and Jefferson, 2003); knowledge and information about recycled water (Lohman and Milliken, 1985; Flack and Greenberg, 1987; Jeffrey and Jefferson, 2003; Tsagarakis and Georgantzís, 2003; Hurlimann et al., 2008); negative perception of risk (Hurlimann, 2008; Hurlimann et al., 2008; Po et al., 2005); past experience with alternative water source (Dishman et al., 1989; Flack & Greenberg, 1987; Hurlimann, 2007a; Lohman & Milliken, 1985; Olson et al., 1979; Sims & Baumann, 1974); health concerns (Dishman et al., 1989; Marks et al., 2006; Olson et al., 1979; Baggett &. Jeffrey, 2006); and perception of good water quality (Higgins et al., 2002; Hurlimann et al., 2008; Po et al., 2005; Baggett et al., 2006). Demographic variables including older age (Hurlimann, 2007a; Dolnicar, 2009); younger age (Lohman and Milliken, 1985; J. McKay 2003); gender (being male) (Lohman and Milliken, 1985; Konstantinos P. Tsagarakis et al., 2007; Hurlimann, 2007a; Dolnicar, 2009); and level of education (Bruvold, 1972; Flack & Greenberg, 1987; Hurlimann, 2007a; Robinson et al., 2005; Lohman & Milliken, 1985; Dolnicar & Shafer, 2009) impact acceptability of recycled water.

Overall the association with positively influencing attitudes to recycled water is low, especially for age. One study found that "shared identity," or the public's increased level of trust in their water authority, was associated with people's lower perception of risk, in turn leading to a higher level of acceptance of wastewater reuse (Ross et al., 2014). The importance of this large body of knowledge surrounding the public's acceptance of water reuse, is it identifies key variables impacting people's acceptability of water reuse. Moreover, without community acceptance of

water reuse, water governing agencies would have a difficult time pushing for more reuse: understanding the attitudes of constituents and the factors influencing those attitudes is a critical factor. Although existing studies have identified key variables impacting water reuse, they have primarily focused at the individual or community level. While these household studies may be important to whether people can adapt their behaviors, they say little about the drivers of state or local policies calling for or supporting greater water reuse. Further research is needed to identify key variables that impact state and local agency water reuse efforts.

2.2 Water Reuse Governance

A radically evolving field, such as wastewater treatment and reuse, often suffers from a lack of alignment between regulatory, legal, economic, public understanding, and public policy (National Research Council, 2012). Most of the literature unravelling the social science and public policy aspects of water reuse highlight federal and state regulations applicable to water reuse, and many of these have a water-quality focus. While the EPA does not have any formal reuse regulations, states are given the primacy of water reuse policy. Legal literature on the topic notes that the current regulatory framework creates barriers to water reuse.

2.2.1 Water Quality Focused: EPA Regulations

The Clean Water Act (CWA) and the Safe Drinking Water Act (SDWA) provide the core requirements for potable water reuse; federal laws identify water quality criteria and standards. Though CWA and SDWA are not explicit 'water reuse' regulations, they do provide a foundation from which states can further develop potable water reuse. These laws are the primary basis by which tap water is kept safe for people to drink (USEPA, 2017).

2.2.2 EPA as Guide

EPA serves the states to monitor and evaluate performance of water treatment technologies in order to protect the health of communities. The EPA's support began with the first pioneers in water reuse: Los Angeles County Sanitation District (1962), Orange County Sanitation District (1976), and the Upper Occoquan Service Authority (1978). Recent EPA literature on water reuse includes the 2012 Guidelines for Water Reuse and the 2017 Potable Reuse Compendium. The 2012 Guidelines for Water Reuse were originally published to provide informational guidelines in support of water reuse and not mandatory regulations governing reuse. The guidelines include a discussion of water reuse projects in the US, advancements in reuse as applied to wastewater treatment technologies, case studies, as well as factors contributing to expansion of water reuse (USEPA, 2017).

The 2017 Potable Reuse Compendium supplements the 2012 Guidelines for Water Reuse, outlining key science, technical, and policy considerations regarding the practice. EPA encourages water reuse but neither requires nor restricts it. The role of the EPA is to provide support to states, tribes, and communities working toward implementing potable reuse projects. The EPA leaves primacy in the allocation and development of water resources to the state (USEPA, 2017).

2.2.3 State as Regulator

Water reuse regulations specifically exist at the state level: no states have formal regulations or guidelines governing direct potable reuse (DPR). DPR facilities are considered on a case-by-case basis in Texas, as they are throughout the US (USEPA 2017). This flexible approach shows the commitment to accommodating reuse projects in order to supply water.

The Texas Commission on Environmental Quality approves water reuse projects on a case by case basis. Steinle-Darling (2015) showed that the approval process for DPR in Texas is in

accordance with the innovative/alternative treatment clause in state regulations 30 TAC 290, which allows "any treatment process that does not have specific design requirements" listed in that chapter be permitted on a case-by-case review by the regulatory agency TCEQ. This approach allows for greater flexibility to onboard projects proposed by utilities all across the state, and to more quickly meet the needs for parts of the state that are faced with urgent needs to supply additional water supplies.

The two DPR projects currently in operation in Texas include: Big Springs and Wichita Falls. The DPR project in Wichita Falls (July 2014) was implemented as an emergency action for supplying water. Steinle-Darling (2015) highlight several more DPR projects that have been proposed for TCEQ approval. These projects represent a range in types of water reuse projects and include a range of direct-to-distribution projects like the El Paso Water Utilities (EPWU), to indirect projects such as the Laguna Madre Water District (LMWD), or even more indirect to de facto equivalents, such as the Gulf Coast Water Authority (GCWA). The projects proposed for approval illustrate that Texas' DPR regulatory approach can be applied to potable reuse projects with a range of 'directness,' and show that the case-by-case approach is flexible in order to accommodate the water needs and demands of the regions (Steinle-Darling, 2015).

2.2.4 Limitations

Sanchez-Florez et al. (2016) analyzed federal and state regulations applicable to water reuse. The authors highlight limitations in the regulatory system at the national and state scales. These limitations include a restricted scope focusing on water quality. While the Clean Water Act (1972) and the Safe Drinking Water Act (SDWA) provide the base of set federal regulations regarding the quality of reused water, policy regarding reuse at the state and local levels are mostly driven by guidelines, which have limited power due to the low enforceability nature of guidelines.

As it stands, each state and city is responsible for its own water reuse policy. With limited federal regulatory reuse framework coupled with only suggested guidelines at the state and local levels, Sanchez-Florez et al. show that the current regulatory framework is creating barriers for potable water reuse to expand (Sanchez-Flores et al., 2016).

To date, no federal regulations exist that are specific to reuse, however the Clean Water Act and Safe Drinking Water Act, do affect the quality of water used for reuse (National Research Council, 2012).

Currently, each state and city is responsible for its own water reuse policy. Limited federal regulatory reuse framework, coupled with only suggested guidelines at the state and local levels show that the current regulatory framework creates barriers for potable water reuse to expand (Sanchez-Flores, Conner, and Kaiser 2016). To date, no federal regulations exist specific to reuse, however the Clean Water Act and Safe Drinking Water Act, do affect the quality of water used for reuse (National Research Council, 2012).

2.2.5 Legal and Socio-Economic Factors Contributing to Reuse Success

Beyond the literature of loose regulations and governance structures formed around water reuse, the work of Meehan et al. (2013) analyzed and compared four indirect potable reuse (IPR) schemes from the US and Australia in order to identify key factors that contribute to successful IPR project implementation. While the article highlights the policing of waste material, a predominant role of governance within water reuse projects, other key factors are divided into legal, socio-economic, and techno-scientific categories. The legal and socio-economic categories Mehan et al. outline are part of IPR project governance, and include having existing institutional frameworks for regulating water rights and water quality and a system of financial support coming from local governments through bonds and taxpayer support. Political support from local, state,

and federal representatives also proved to be successful. The authors' attribute the following techno-scientific aspects part of successful IPR project governance: markets for advanced technologies purchased by utilities, engineering expertise to operate plants and to affirm public safety, and extensive infrastructure network coverage allowing for access and to limit access inequality (Meehan et al., 2013).

2.2.6 Policy Recommendations from the Literature

While the National Research Council (NRC) shows that the expansion of water reuse could significantly increase the nation's total available water resources, the report recommends adjustments to the federal regulatory framework that could improve public health protection for both planned and de facto reuse and increase public confidence in water reuse (National Research Council, 2012). They find that the expansion of water reuse for the nation would include federal reformation of water reuse policy (National Research Council, 2012) thereby increasing public confidence in water reuse.

While the majority of water reuse is addressed by different federal regulatory programs, there is no integrated approach to the reuse process. NRC recommends that federal regulations provide a minimum standard of protection and have the potential to increase public confidence in water reuse projects and ensure that they do not compromise public health (National Research Council, 2012).

2.3 Assessing Governance Factors that Contribute to Reaching Successful Water Management Goals

Previous research focusing on the collaboration among water agencies toward achieving a shared water goal has typically aimed to understand factors that contribute to reaching these specific water-related goals. This literature review points to three major case studies that have

focused to unpack the inter-complexities of water governance, assessing which governance factors lead to regions accomplishing their targeted water management goals. These studies have been done in order to understand single factors that contribute to accomplish shared goals.

Over the past decade these three studies have originated from across the globe including China, Europe and the California within the United States. Research aimed to explore these factors have utilized questionnaire responses from stakeholders and from water governing agencies to collect data for analysis (Huang et al. 2017; Newig and Fritsch 2009; Lubell and Lippert 2011).

Literature points to four predominate factors that impact agencies' ability to reach shared water goals. These factors include: agencies' level of collaboration/ cooperation with other water governing agencies, agencies familiarity with high priority water policy, type of organizations involved, and the scale of governing agencies.

Collaboration/Cooperation: Lubell and Lippert (2011) surveyed California Bay Area stakeholders using questionnaires in order to assess whether participation of Integrated Resources Water Management (IWRM) among stakeholders helped them achieve integration goals. Findings propose that collaboration among organizations did in fact aid in the area integrating IRWM practices.

Huang et al. 2017 examined collaborative approaches to inter-agency water governance through the use of responses from questionnaires. The questionnaire made use of responses using a Likert scale. In this Chinese case study, respondents could report on their intensity of cooperation among municipal departments of Dongguan on a scale of 1 to 7. Results showed departments only achieve partial cooperation among departments.

Familiarity with Policy: In the study done by Huang et al. (2017), the level of familiarity was used to address familiarity among municipal departments --asking if they knew the policy interests of the most active water management governmental agencies in Dongguan.

Scale of Agency: Current environmental policies in Europe and in North America promote collaboration at multiple governance levels as a means to reach more sustainable environmental policies, as well as a more effective and lasting policy implementation. In the research done by Newig and Fritsch (2008) geographical and multi-level governance scales are factors analyzed and considered on their impacts on environmental policy outcomes.

Type of Organization: Furthermore, the study done by Lubell and Lippert (2011), also assessed the achievement of IWRM goals by evaluating its success amongst the organizational types of water management agencies. The study includes the three most involved organizational types: NGO, local government, and water district.

3. OBJECTIVES AND HYPOTHESES

3.1 Objectives

The objectives of this research are to (1) identify the types and scales of agencies central to contributing water reuse in the San Antonio Region, and (2) identify if agencies are working to increase water reuse in the San Antonio Region.

3.2 Hypotheses

Four hypotheses have been developed to test for governance related factors that impact agencies efforts to increase water reuse in the San Antonio Region. Hypothesis 1 and 2 specifically target objective 2 (described in section 3.1) by exploring factors related to coordination with the Texas Water Development Board that contribute to increased water reuse efforts. Hypothesis 3 and 4 specifically target objective 1 (described in section 3.1) by testing which types of water governing agencies are increasing their efforts to reuse water, and at what scale (local, regional, state) these agencies are from. For each hypothesis, the null (H0) and alternative hypotheses (Ha) are listed below.

3.2.1 Hypothesis 1:

H0: People in agencies who are more familiar with Texas Water Development Board's (TWDB) water supply strategies in the 2017 Texas State Water Plan are not in agencies or organizations with greater amounts of effort to increase water reuse.

Ha: People in agencies who are more familiar with Texas Water Development Board's (TWDB) water supply strategies in the 2017 Texas State Water Plan are in agencies or organizations with greater amounts of effort to increase water reuse.

3.2.2 Hypothesis 2:

H0: People in agencies who communicate more frequently with TWDB do not have greater amounts of effort to increase water reuse.

Ha: People in agencies who communicate more frequently with TWDB have greater amounts of effort to increase water reuse.

3.2.3 Hypothesis 3:

H0: People in local scale agencies do not have greater amount of efforts to increase water reuse compared to those in regional, and/or state agencies.

Ha: People in local scale agencies have greater amount of efforts to increase water reuse compared to those in regional, and/or state agencies.

3.2.4 Hypothesis 4:

H0: People working for water utility agencies do not have greater amount of effort to increase water reuse compared to private company, groundwater, river authority, research/extension, and state regulatory/planning agencies.

Ha: People working for water utility agencies have greater amount of efforts to increase water reuse compared to private company, groundwater, river authority, research/extension, and state regulatory/planning agencies.

4. CURRENT STATE OF WATER REUSE IN TEXAS AND THE SAN ANTONIO REGION

4.1 Defining Water Reuse

Water reuse refers to water that is used more than once to expand an available water supply (AWWA, 2016)**.** Water reuse occurs in various forms. Advancements in water treatment technologies allow for communities to reuse water for drinking, irrigation, and industrial purposes such as for cooling power plants. The types of water reuse are defined here: *recycled* or *reclaimed* water refers to water that has been reused more than once; *de facto reuse* refers to surface waters used as a drinking water source and that have been subjected to upstream wastewater discharges; *non-potable reuse* is recycled or reclaimed water that is safe for irrigation and industrial purposes, but not used for drinking; *potable reuse* is recycled or reclaimed water suitable for drinking (AWWA, 2016).

4.2 Water Reuse in Texas and San Antonio

4.2.1 Water Reuse History in Texas and San Antonio

The first documented application of water reuse in Texas dates to the 19th century. The primary uses of reused water have changed over time. Early application was for agricultural irrigation; later, water reuse was applied for industrial and municipal non-potable uses (such as irrigating golf courses). Many entities have most recently planned indirect potable reuse schemes (Texas Water Development Board, 2011).

Water reuse in San Antonio also dates to the late 1890's and early 1900's. During this time, the earliest recorded use of sewage was used irrigation of agricultural land. In the 1960's industrial use was practiced by the City Public Service of San Antonio. This public service built Braunig and

Calaveras Lakes to help provide cooling water for power generation. In 2000, water reuse extended to municipal uses in San Antonio. At this time, the San Antonio Water System (SAWS) completed construction of eighty miles of pipeline to provide reclaimed water to users in San Antonio. The reclaimed water is used to augment water flow along the San Antonio river walk, to irrigate golf courses, parks and landscaped areas, to cool towers producing energy, and other industrial and commercial uses. At the beginning of the project's implementation, it was the largest of its kind in the nation (Texas Water Development Board 2011).

4.2.2 San Antonio Water Systems and Water Reuse

Currently, the public utility owned by the City of San Antonio, the San Antonio Water System (SAWS), provides 130 miles of pipeline to distribute reclaimed water to users in San Antonio. SAWS is the largest directly recycled water delivery system in the United States. The system can provide up to 35,000 acre-feet per year (29 million gallons per day), which allows for large amounts of water to be conserved from the Edwards aquifer (SAWS 2017). While their efforts to increase water reuse in the San Antonio Region have been significant, the TWDB and the regional planning groups for the area still see a large potential for water reuse to supplement the San Antonio Region's water supply.

4.2.3 Water Governance and Water Reuse in the Texas

While TWDB is the primary state water planning agency, there are many other water governing agencies that have jurisdiction over water resources in the San Antonio Region. An introduction to the water governing agencies in the San Antonio Region, guides us in thinking about how much coordination with other state and local agencies, TWDB must do in order to accomplish the targeted strategic supply goal of water reuse.

A preliminary study done on the governance of Water-Energy-Food Nexus for the San Antonio Region, found nearly fifty water governing agencies with legal authority for managing water resources in San Antonio, TX (Portney et al., 2017). These agencies include water service providers, wastewater service providers, storm water control districts, drainage districts, groundwater management areas, groundwater conservation districts, river authorities, other groundwater and surface governing bodies (Portney et al., 2017). The presence of this many agencies in San Antonio, often with similar responsibilities, raises concern about the level of coordination among them.

At present, little research has been done on the level of coordination between local and state water governing agencies, the level of coordination unknown. While the Texas Water Development Board is responsible for planning for the state's water resources, the lack of research on coordination between state and local water agencies makes it unclear how TWDB is able to carry out their plans and accomplish the goals prescribed in their five-year water plan.

Water reuse is identified by TWDB to have the potential to provide 24% of San Antonio's future water needs: it would make sense that all other water governing agencies be on board with such a high potential source. Though TWDB lists water reuse as a high potential source, the degree to which other agencies have efforts to increase water reuse to its full potential is unknown. In other words, what is the effectiveness of a state planning agency if there is little communication of their plans to other, smaller agencies? Although TWDB advises the state on how to plan for water, the issue raised is how to coordinate with local agencies to ensure goals are implemented and procured. These questions, then define the aim of this research: to understand how factors between state and local water management governing agencies impact efforts to increase water reuse in the San Antonio Region.

4.3 Water Reuse Potential for the San Antonio Region

The 2016 population estimate for the city of San Antonio is 1.5 million people (U.S. Census Bureau 2017a). San Antonio, Texas is ranked among the top twenty most rapidly growing cities in the United States, and is fourth among the most rapidly growing cities in Texas, after Houston, Dallas-Fort Worth, and Austin (U.S. Census Bureau, 2017b). According to the United States Census Bureau, San Antonio is third amongst cities with the largest numeric increase between July 1, 2015 and July 1, 2016, with Phoenix, AZ was first and Los Angeles was second (U.S. Census Bureau 2017b). The City of San Antonio also experienced a12.4% increase in population from 1.3 million people in 2010 to 1.5 million people in 2016 (U.S. Census Bureau, 2017b). With such a rapidly growing population, the region of San Antonio must plan for future water and resource availability.

The interactive feature of the TWDB's 2017 State Water Plan estimates that water needs in the San Antonio Region are expected to increase from 573, 634 acre-feet per year of water in 2020 to 995,247 acre-feet per year in 2070 (TWDB 2017). Figure 3 shows the projected water reuse strategy supplies and water needs for the San Antonio Region by decade, and the percent of the region's water needs that water reuse strategy supplies are capable of filling: on average, water reuse can provide 24% of the needed water in the San Antonio Region.

TWDB plans include five alternative sources of water to augment the region's needs. Five major sources of strategic supply include increasing surface water resources, seawater desalination, demand reduction (through conservation and drought management), groundwater withdrawals and water reuse. Of these five sources, demand reduction (conservation) is expected to help supply 40% of the San Antonio Region's water needs, and surface water an additional 24%. Water reuse is the third largest expected supply, anticipated to relieve nearly 18% of the region's

water needs. Figure 4 shows the percent of five types of water strategy supplies in 2070 for the San Antonio Region to help meet region's water needs. With such a rapidly growing population, the TWDB's water reuse strategy for the region has large potential to help fill the region's water needs, and if accepted by other water governing agencies in the San Antonio Region would help secure water for their future.

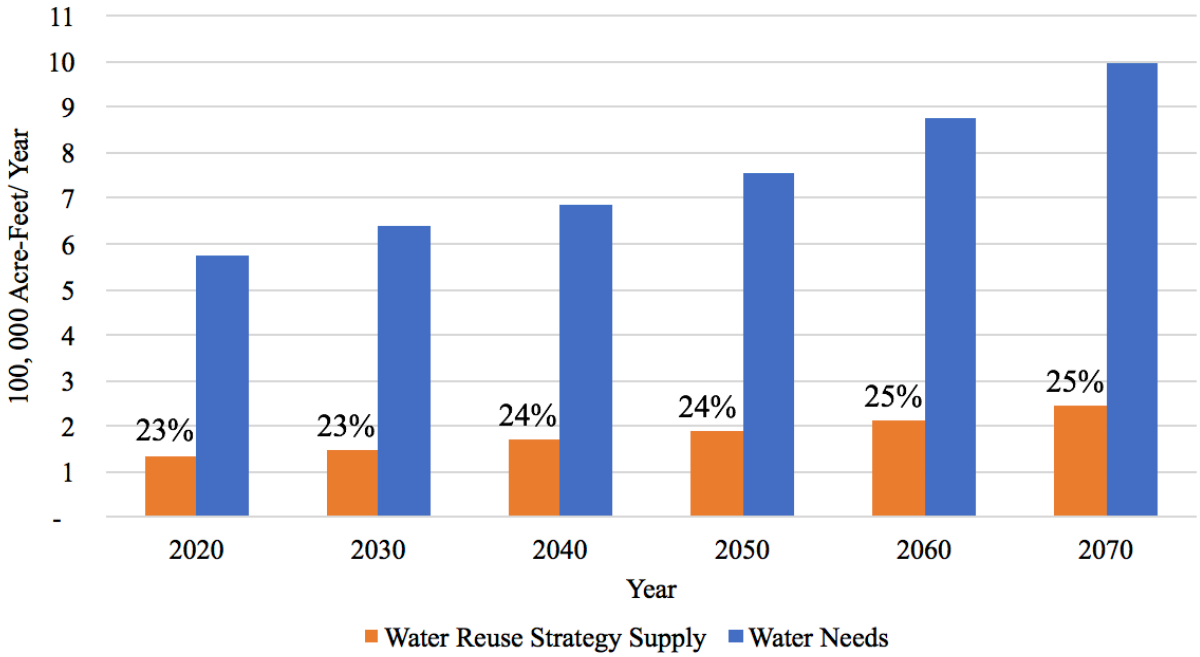

Figure 3. Projected water reuse strategy supplies and water needs for the San Antonio Region by decade. Water reuse strategy supplies will be able to supply 24% of the average water needs in the San Antonio Region. Adapted from TWDB 2017 State Water Plan data, courtesy of TWDB.

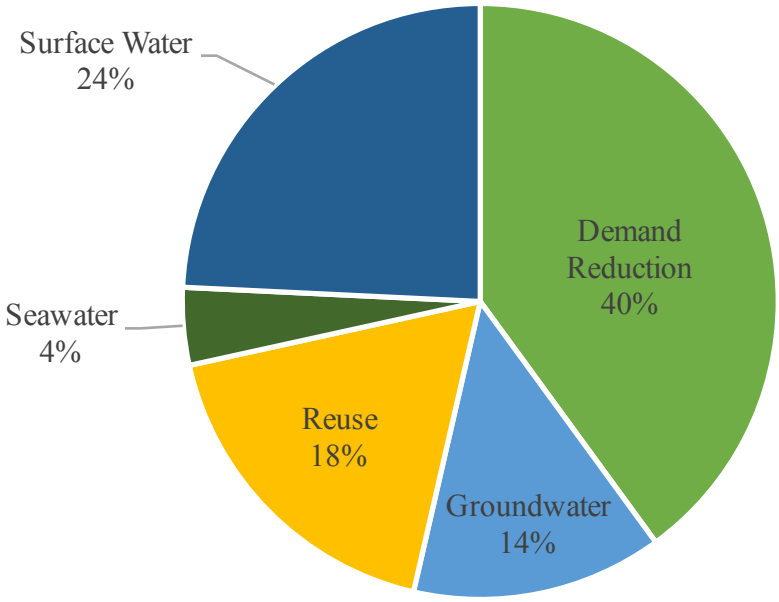

Figure 4. Projected water sources for strategy supplies in 2070 for the San Antonio Region. Eighteen percent of strategy supplies from 2070 will be sourced from water reuse. Adapted from TWDB 2017 State Water Plan, courtesy of TWDB.

5. WATER PLANNING IN TEXAS

Water management in the United States has developed over the past few decades, with federal water policy dating to mid- 1900s, and state policy and agency development beginning in the 1970's. The first federal water policy was enacted in 1948, the Federal Water Pollution Control Act, and the Environmental Protection Agency was created in 1970. Since then, many federal water policies have been changed and added. Furthermore, state and local water management agencies have been developed to help manage these water levels. The Texas Commission on Environmental Quality (TCEQ) is the state's primary water regulatory agency, began development in the 1960's, becoming what it is today in 2002. The development of Texas' primary state water planning agency, the Texas Water Development Board (TWDB), traces back to the 1970's. Over the span of these fifteen years, countless water agency additions and reformations occurred until, in 1985, a single state planning agency was created: the Texas Water Development Board. Little research exits on the degree of coordination and communication between these water agencies regarding water policies, whether at the local, state, or federal level.

5.1 Texas Water Development Board Planning Process: A Bottom-Up Approach

The Texas Water Development Board, created in 1957, has evolved over time. Among many responsibilities, a primary current responsibility is to support the development of regional water plans, and to incorporate these into a state water plan: TWDB is responsible for the development, management, and conservation of the state's water resources.

5.1.1 History of Texas Water Development Board

TWDB was developed as a result of the severe drought in Texas between 1954 and 1956. The state legislature, in 1965, restructured the state water agencies and passed the duty of water resource planning to TWDB. In 1977, the three Texas water agencies then existing, TWDB, the

Texas Water Rights Commission (formerly Texas Commission on Environmental Quality), and the Water Quality Board, were combined into the Texas Department of Water Resources. In 1985, TWDB was given the responsibility of long-term planning and water project financing. In 1997, the 75th Texas Legislature passed Senate Bill (1), changing the water planning process in Texas. The bill charged local entities with preparing regional water plans and TWDB with incorporating these plans into a comprehensive state plan.

5.1.2 Texas Water Development Board's State Water Plan and Regional Planning

The Texas Water Development Board prepares a comprehensive state water plan every five years. The 2017 plan provides water management strategies for addressing the water needs of a growing population. The purpose is to plan for Texas to have enough water to sustain cities, rural communities, farms, homes, businesses, while also preserving the state's natural ecosystems (TWDB, 2017).

TWDB has sixteen regional planning groups, each responsible for planning for the short- and long-term water supply needs. TWDB endorses water management strategies to address these needs for the individual regions. Under the direction of TWDB and every five years, each region submits its own five-year plan to TWDB. These regional plans are then compiled by TWDB into one Texas state plan. The majority of the San Antonio Region is in the jurisdiction of TWDB's Region L planning group, though a portion of the region falls into the jurisdiction of the Region K planning group. Thus, plans submitted from both Region L and Region K are meant to address the specific water needs for the entire San Antonio Region.

5.2 Texas Water Development Board's Water Supply Strategies

Chapter eight of the 2017 Texas State Water Plan outlines the water management strategies for the planning regions. A water management strategy is a plan to meet a water need or potential

shortage for a water user group (TWDB 2017). In the state planning process, each planning group evaluates feasible water management strategies to plan for the future water needs of the region. After evaluation, each group then recommends a final set of strategies and reports these to TWDB. The recommended strategies depend on need, location, cost, and available water sources. If implemented, all of the recommended water management strategies would provide 8.5 million acre-feet per year of additional water supply in 2070 (see Figure 5); for this purpose, reuse, groundwater, seawater, surface water and demand management (mostly in the form of water conservation) are "supply strategies". Reuse has the potential to supply 14.2% of strategies in Texas by 2070.

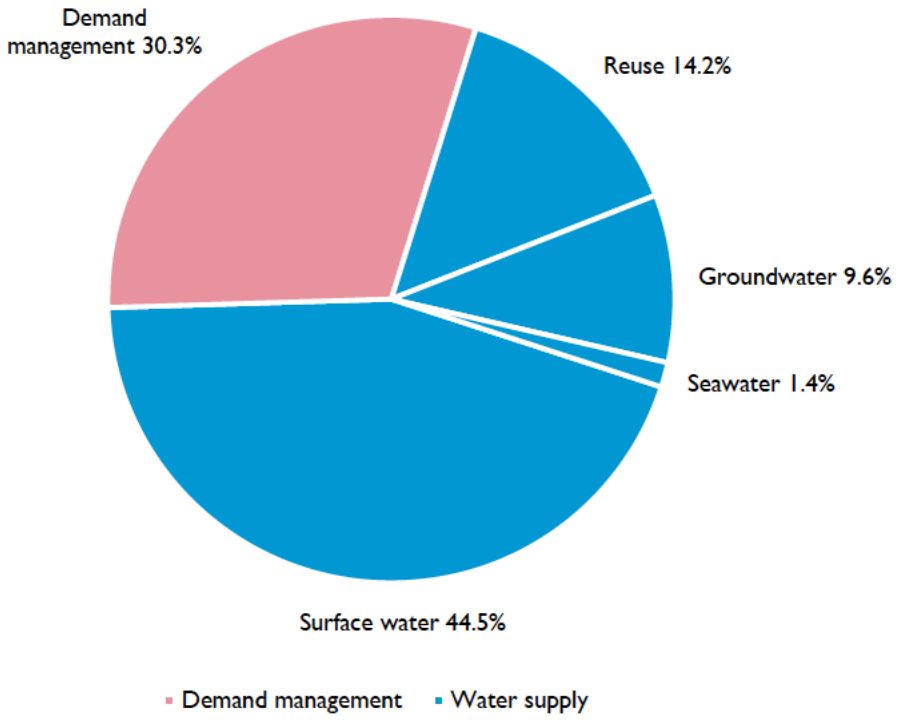

Figure 5. Share of recommended water management strategies by water resource for Texas in 2070. Reprinted from TWDB's 2017 State Water Plan, courtesy of TWDB (TWDB 2017).

6. METHODOLOGY

6.1 Questionnaire

A questionnaire was developed for the *Water Management in the San Antonio Region* project targeted public officials and other identified individuals in institutions or agencies that have some type of legal authority for making water management and policy decisions affecting water availability, and water quality in the region. While the larger project included 23 questions in the questionnaire, for the purposes of this research, three questions were used to analyze governance factors impacting increased water reuse efforts from agencies (these specific questions are discussed in the hypotheses section). Appendix A provides detailed background information and survey methodology about the questionnaire.

6.1.1 Identified Water Governance Institutions and Agencies

The first step in the research process was to identify key water management and policy agencies responsible for water in the San Antonio Region. In order to identify these agencies, it was important to first define the boundaries of the San Antonio Region. The *Water Management in the San Antonio Region* study determined that most of the applicable organizations had jurisdiction within the TWDB's Region L boundary, including organizations that seemed relevant to water management in the San Antonio Region that were outside of the boundary (further discussed in Appendix A in **"**Identified Water Governance Institutions and Organizations"). For the purposes of this research, questionnaire responses from institutions and agencies whose jurisdictions either fit entirely within or have a portion within Region L and Region K boundaries were included in the study results. Defining a list of organizations involved in water governance and management required that specific judgements to be made: see

Appendix A for a description of these guiding principles and a complete initial list of organizations used in this survey "Water Governance Organizations in the San Antonio Region."

6.1.2 People in Water Governance and Institutions and Agencies

Once the relevant agencies were identified, individuals within these agencies were identified to be surveyed. Instead of choosing individuals to "represent" each organization, this project identified each and every person within the organization whose position would be relevant. In total, 289 individual people were identified using a variety of web-based sources, and by placing calls to many of the agencies. A database containing the names and contact information for these people was created. This database was used to prepare personalized mail merge files containing cover letters and mailing envelopes.

6.1.3 IRB Processes and Review

An IRB approval process was required as the research contains field research involving human subjects. Appendix A offers a full description of the IRB process and review; Appendix C includes the "outcome letter" showing the judgement for the project to meet the exemption criteria for full IRB review. A certification of this outcome was provided on October 17, 2017, and included in the footer of both the on line and the paper versions of the questionnaire

6.1.4 The Survey Process

The database containing the names and contact information of the potential respondents was used to prepare personalized cover letters and mailing envelopes. A sample of this initial cover letter is in Appendix D. Each letter was addressed, by name, to the specific person designated as a potential respondent and signed by Professor Kent Portney. Within the contents of the envelope was a paper copy of the questionnaire to be completed (see Appendix B). The cover letter indicated an option to each respondent to complete the questionnaire on line. A version of the

questionnaire was prepared in Qualtrics software under the Texas A&M institutional license; the URL to this questionnaire was shortened to https://u.tamu.edu/water. For a complete, detailed description of the survey process, refer to Appendix A "The Survey Process." Appendix A also includes a description of incentives for participation.

6.1.5 Timeline of Key Events

A detailed timeline of key events for preparing and mailing the questionnaires, as well as the follow up process can be found in Appendix A. While the appendix indicates November 29th as the date for data set completion for the *Water Management in the San Antonio Region* study, 21 additional responses were received during approximately two months following this date and making the actual completion date of this questionnaire data on January 31st, 2018.

6.1.6 Response Rate

While the original timeline describes the initial response rates for *Water Management in the San Antonio Region* study using the November 29th data completion date, for the purposes of this report, response rates were recalculated using the January 31st data completion date and Region K and Region L boundary criteria (as described in the proceeding section). The calculated response rate includes 101 completed questionnaires received. Since 289 questionnaires were mailed, the raw response rate was calculated as 101/289 = 34.9%. However, the denominator for this calculation does not accurately reflect the size of the actual population of people surveyed. As a result of the mailings, it was determined that some people on the original list were not available to be included for one reason or another. For example, 21 questionnaires were returned by the U.S. Postal Service as "undeliverable." Additionally, 4 people had left their respective positions, and 3 were on long-term leave from their position. It was also discovered that one of the private water service providers had lost its certification, and

all of the people (4) who had been sent questionnaires were ineligible to participate in the survey. Based on these results, an adjusted response rate was calculated as 101 / (289 – 21 – 4 – 3 -4) = 101 / 257 = 39.3%.

A more accurate estimated response rate would also consider agencies included in the survey but having nothing to do with the San Antonio Region. In those situations where an agency's jurisdiction boundary did not fit within or reach an area within Region K and Region L planning areas, the respondents were considered to be ineligible as part of the survey population. A total of 23 people meeting these criteria were mailed questionnaires and should not have been. Thus, a third adjusted response rate was calculated as 101 / (257 – 23) = 101 / 234 = 43.2%.

6.2 Boundary

For the purposes of this study the San Antonio Region is characterized as the combined area of Texas Water Development Board's planning regions K and L. While the initial questionnaire was sent to organizations possibly outside of the San Antonio Region (see Appendix A "The Survey Process"**)**, for the purposes of this study, responses were included from those surveyed if their area of jurisdiction fit within or extended into the Texas Water Development Board's Region K or Region L boundaries. Figure 6 shows all of the TWDB's regional planning areas for the state of Texas. The combined areas of Region K and L define the boundary of the San Antonio Region for this research. Web based research was used to verify whether an agency fit within the planning boundary of either Region K or L, based on the usage of address' from the created database. The specific criteria for a respondent's questionnaire to be considered within the San Antonio Region boundary are listed below:

- Jurisdiction of organization must be within or extend into any part of TWDB Region K or Region L boundary.

- If the organization responded “No”, “Not in the San Antonio Region,” or “Not Sure” to Q1: “Do you currently work for an agency or department that deals with water issues in the San Antonio Region?” but their area of jurisdiction fit within or extended into the Region K or Region L boundary, then their responses were included.
- If the organization responded “Yes,” to Q1, then their area of jurisdiction was verified if it fit within or extend into the Region K or Region L boundary for inclusion.

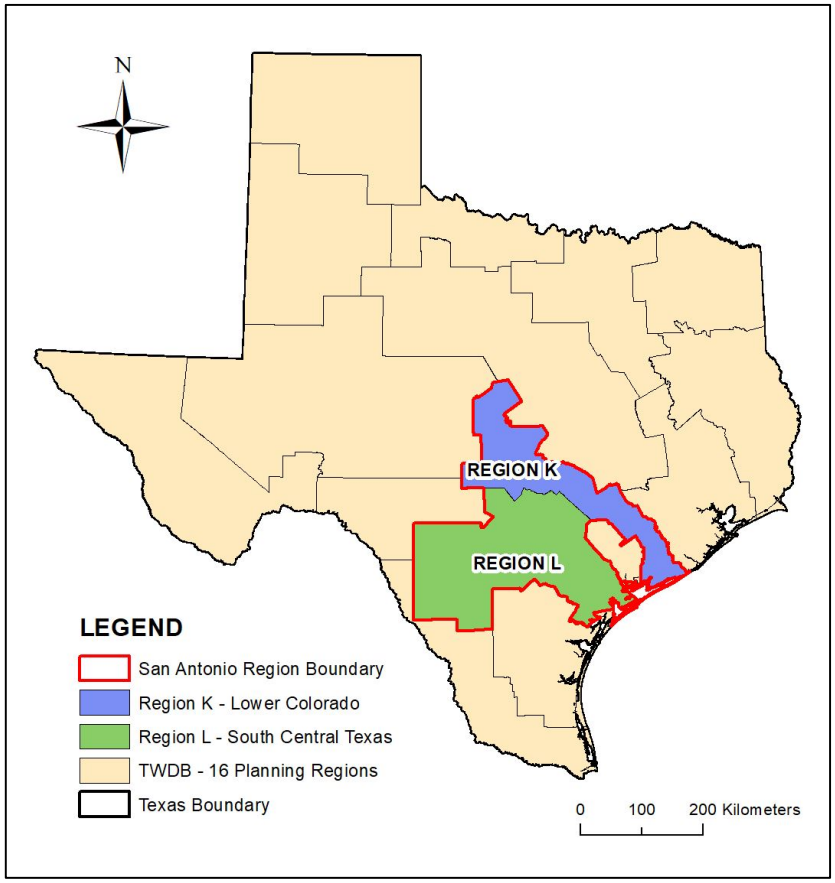

Figure 6. Texas Water Development Board’s regional planning areas. Region K and L combined define the boundary for the San Antonio Region. Adapted from Regional Water Planning Areas, data courtesy of TWDB.

6.3 Statistical Analysis

This study examines the effects of four independent variables upon the dependent variable: agency efforts to increase water reuse. STATA statistical software was used to calculate two-way table of frequencies between each hypotheses' independent variable and the dependent variable in order to identify if an increase in the independent variable of the hypothesis also increased level of agencies efforts to reuse water. To test for statistical significance among all of the variables, seven regression analysis models were run, also using STATA. This section describes the questions in the survey used to test each of four hypotheses and how the data was coded. At the end is a description of the seven regression analysis models that were computed using STATA.

Question 19 (Q19) in the questionnaire addresses the dependent variable of agencies' efforts to increase water reuse and was utilized as the dependent variable for this study. Respondents were able to identify their agencies' percent level of efforts to increase water reuse. The question reads as follows:

> *Q19. What percentage of the activities of your organization, agency, or department involves **efforts to increase water reuse** in the San Antonio Region?*
>
> ◯ *0-10%* ◯ *11-20%* ◯ *21-30%* ◯ *31-50%* ◯ *51-75%* ◯ *76-100%*

6.3.1 Hypothesis 1: How Increased Familiarity with TWDB's Water Supply Strategies Impacts Water Reuse Efforts

For testing Hypothesis 1, in determining whether a higher familiarity level with the TWDB's water supply strategies in their 2017 State Water Plan correlates to agency efforts to increase water reuse, two-way frequency tables were calculated using responses to Question 19

and Question 16 (Q16) shown below. Respondents selected their level of familiarity using a Likert scale of 1-5, 1 for "Not at all familiar" and 5 for "Extremely familiar."

Q16. How familiar are you with the Texas Water Development Board's ***water supply strategies*** *for the San Antonio Region in the 2017 State Water Plan?*

Not at all familiar (1)	*Slightly familiar (2)*	*Moderately familiar (3)*	*Very familiar (4)*	*Extremely familiar (5)*
○	○	○	○	○

6.3.2 Hypothesis 2: How Increased Communication with TWDB Impacts Water Reuse Efforts

For testing Hypothesis 2, in determining whether the frequency of communication with the TWDB correlates to an agencies' efforts to increase water reuse, responses to Q19 were cross-tabulated with responses to Q9 below.

Q9. Over the last year, as part of your job, how often have you communicated with any of these organizations, or decision makers from these organizations, ***about water issues affecting the San Antonio Region****?*

TWDB's office in Austin, TWDB's Region K office, and TWDB's Region L office were listed agencies for respondents to select their frequency of communication with (see question 9 e, f, g in Appendix B). Available responses regarding frequency of communication were: (1) Once a week or more, (2) Monthly, (3) Once every 3 months, (4) Once a year, (5) Not at all. In order to calculate the level of frequency in communication with TWDB as a single agency, an average of the respondent's level of frequency in communication with each TWDB office (Austin, Region L, and Region K) was used. Once averaged, the final value for frequency of communication with

TWDB was rounded to the nearest whole number in order to fit within the frequency bins of (1) Once a week or more, (2) Monthly, (3) Once every 3 months, (4) Once a year, or (5) Not at all.

6.3.3 Hypothesis 3: How Local Agencies Impact Water Reuse Efforts

For testing Hypothesis 3, in determining whether a local water agency contributes to agencies' increased efforts to reuse water, responses from Q19 were cross-tabulated with coded responses from Question 2 (Q2) below.

Q2 What agency, organization, or department do you work for?

Based on responses, answers to these questions were coded as either 1 for local, 2 for regional, or 3 for state. Agencies categorized as local were those whose jurisdiction expanded to a city limit or smaller. Those categorized as regional, included agencies whose boundary of jurisdiction expanded to at least a county level or larger. Those categorized as state agencies, included those whose jurisdiction / management decisions applies to water anywhere within Texas. A complete list of categorized agencies based on their scale can be found in Appendix H.

6.3.4 Hypothesis 4: How Utility Type Agencies Impact Water Reuse Efforts

In order to determine if utility type agencies impact water reuse efforts, all agencies were first categorized based on the type of water management agency. Responses to Q2 were used to determine individual agency type, identified as one of the following categories: private/company, utility, groundwater, river authority, research/extension, and state regulatory/planning. A complete list of types of agency categorization is in Appendix G.

A dummy variable was created for utility type agencies, and coded as 1 for utility and 0 for non-utility, which in this case represents all other classification types of agencies. For testing Hypothesis 4, in determining whether a utility type agency contributed more to water reuse efforts, responses from Q19 were cross-tabulated with responses from Q2, and coded in their respective

types of agencies. Those who reported their agency was a utility, were coded as 1 for utility or 0 for not utility.

6.3.5 Regression Analysis Models

Seven multiple regression analysis models were computed using STATA statistical software to determine if a statistically significant linear relationship exists between the dependent and independent variables. See table 1 for results of these 7 models of regression analysis.

7. RESULTS AND DISCUSSION

Overall, 69% of water governing agencies in the San Antonio Region use 0-10% of their efforts to increase water reuse, indicating that efforts to increase water reuse among agencies is low. The results of this analysis indicate whether frequency in communication with the TWDB, familiarity with the strategy supplies, scale of an agency or type of agency contributes to an increase in water reuse efforts.

Figure 7 shows the percentage of water governing agencies that indicated their level of effort to increase water reuse. Overall, 69% of water governing agencies in the San Antonio Region use 0-10% of their efforts toward increasing water reuse. Ten percent of the agencies use 11-20% of their efforts to increase water reuse; 6% of agencies use 21-30%, 6% use 31-50%, and 3% of agencies use 76-100% of their efforts to increase water reuse. Overall, the majority of water governing agencies in the San Antonio Region spend 0-10% of their efforts to increase water reuse. Thus, the majority of agency efforts to increase water reuse in the San Antonio Region is low. The remaining 31% spend anywhere from 11% to 100% of their efforts toward increasing water reuse.

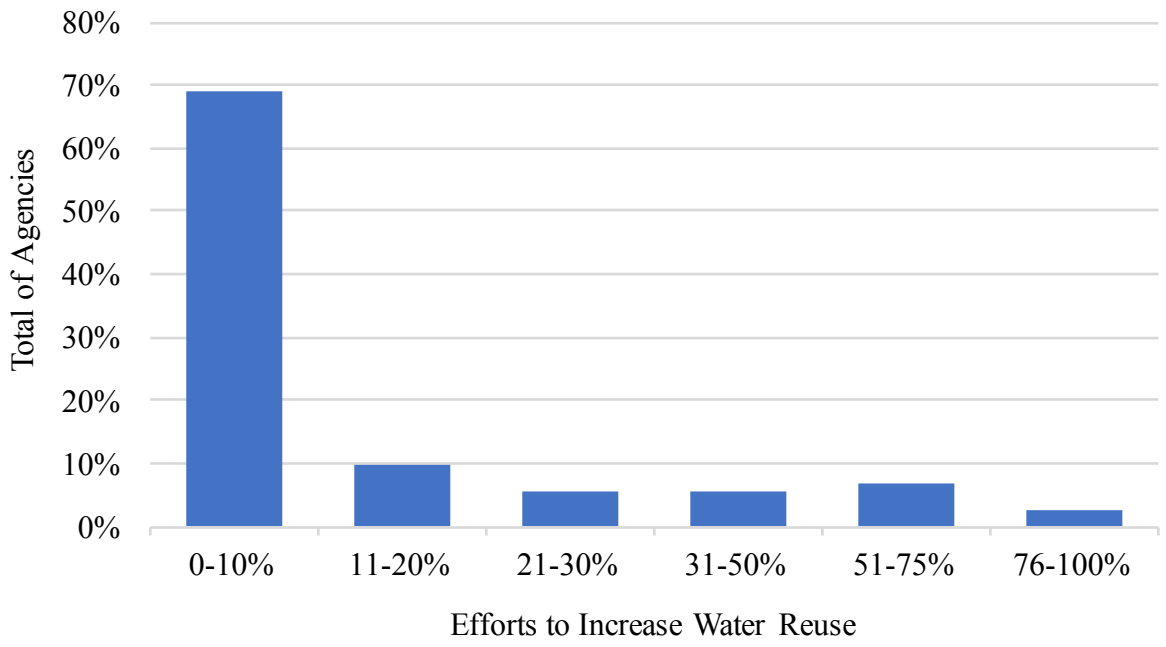

Figure 7. Percent of agencies' efforts to increase water reuse in the San Antonio Region.

7.1 Hypothesis 1

Figure 8 shows the effect of the governing agency's familiarity level with the TWDB's water supply strategies on the agency's efforts to increase water reuse in the San Antonio Region. Figure 8 shows low efforts to increase water reuse by agencies regardless of their level of familiarity with the water strategy supplies in the 2017 State Water Plan. Nearly 70% of agency respondents who indicated they were 'Not Familiar at All,' 'Moderately Familiar,' and 'Very Familiar' with the TWDB strategy supplies; all indicated their agency spends 0-10% of their efforts to increase water reuse. Eighty four percent of agency respondents who indicated they were 'Slightly Familiar' with TWDB's water strategy supplies indicated their agency also spends 0-10% of their efforts to increase water reuse. Twenty percent of respondents who were 'Very Familiar' with the TWDB strategy supplies, indicated 21-30% of their agency's efforts go toward increasing water reuse. Those who were 'Moderately Familiar' ranged in agency efforts all the

way up to 100% to increase water reuse. Nearly 15% of those 'Moderately Familiar' spend 51-75% of their efforts, and 7.7% spend 76-100% of their efforts to increase water reuse. Those who were 'Extremely Familiar' indicated the greatest range in efforts to increase water reuse: 14.3% of those who were extremely familiar indicated 11-20% of their efforts to increase water reuse, 28.6% of them indicated 31-50%, 14.3% indicated 51-75%, and 14.3% indicated 76-100% of their efforts go towards increasing water reuse.

Since the water supply strategies of TWDB in their 2017 State Water Plan are first recommended by user groups to TWDB, then reviewed by TWDB for approval, those who are 'Extremely Familiar' with TWDB's strategy supplies may be those agencies who submitted a water reuse strategy supply to the TWDB. Furthermore, since water strategy supplies are not set up as goals required by TWDB for water governing agencies to meet, this would explain why agencies who ranged from 'Slightly Familiar' to 'Very Familiar' with TWDB's strategy supplies mainly reused 0-10%. Had these water strategy supplies been implemented as goals mandated by TWDB (a top-down approach), then perhaps more agencies would have taken greater efforts to increase water reuse, especially if they had a water reuse target to meet.

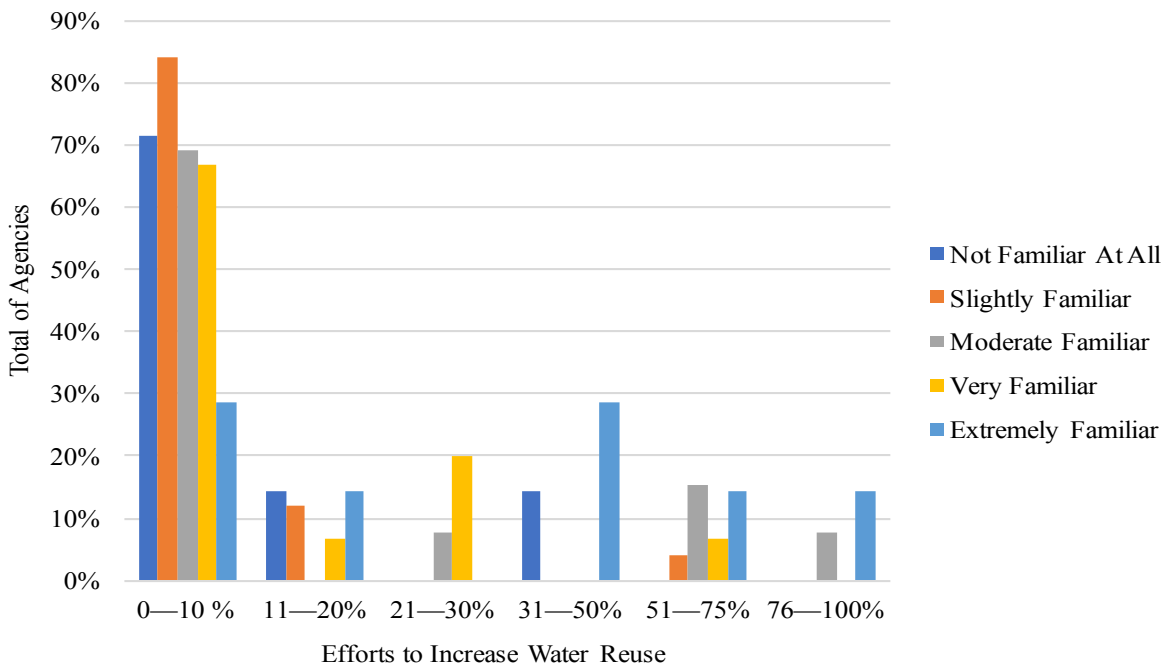

Figure 8. The effect of familiarity with TWDB's water strategy supplies in 2017 Texas State Water Plan on agencies' efforts to increase water reuse in the San Antonio Region.

7.2 Hypothesis 2

Figure 9 shows how water governing agency's frequency of communication with TWDB affects the agency's efforts to increase water reuse. As agencies increase their level of communication with TWDB, their efforts to increase water reuse also increases. Eighty four percent of respondents from agencies who indicated they do not communicate with TWDB, spend 0-10% of their agencies efforts to increase water reuse. The percent of agencies with efforts to increase water reuse at 0-10% decreases as frequency in communication with TWDB increases. Fifty three percent of agencies who communicate with TWDB once a year, spend 0-10% of their efforts to increase water reuse, and those that communicate once every three months, spend 33% of their efforts to increase water reuse. The percent of agencies who spend 11-20% of their efforts to increase water reuse increases from 8% for those that do not communicate at all

with TWDB, to 21% for those that communicate once a year with TWDB. The percent of agencies who spend 21-30% of their efforts to increase water reuse increases from 5% for those that communicate once a year, to 33% for those that communicate once every 3 months. The percent of agencies who spend 31-50% of their efforts to increase water reuse increases from 3% for those that do not communicate at all with TWDB, to 5% for those that communicate once a year, to 17% for those that communicate once every 3 months. The percent of agencies who spend 51-75% of their efforts to increase water reuse increases from 5% for those that do not communicate at all with TWDB, to 11% from those that communicate once a year. Similarly, the percent of agencies who spend 76-100% of their efforts to increase water reuse increases from 5% for those that communicate once a year with TWDB to 17% for those that communicate once every three months.

There was only one respondent who indicated they spoke monthly with TWDB, and none who indicated they spoke once a week or more with TWDB. For the respondent who indicated they spoke monthly with TWDB they also indicated they use 51-75% of their agencies efforts to increase water reuse. In this case, if one respondent indicated reusing 51-75% of water, that means 100% of those who communicate monthly with TWDB reused 51-75%. This one response is not a good enough sample to conclude that a percentage of all agencies who speak monthly with TWDB have efforts 51-75% to increase water reuse. Figure 9 therefore does not include the results for monthly communication with TWDB.

The TWDB provides funding to agencies for their selected strategy supply projects through sources such as the State Water Implementation Fund for Texas (SWIFT). Therefore, agencies supporting water reuse projects may need to communicate more frequently with TWDB in order to secure funding to implement or continue their water reuse projects. As a result, agencies

communicating more frequently with TWDB, may be receiving more funding, with which to begin or continue in their efforts to increase water reuse.

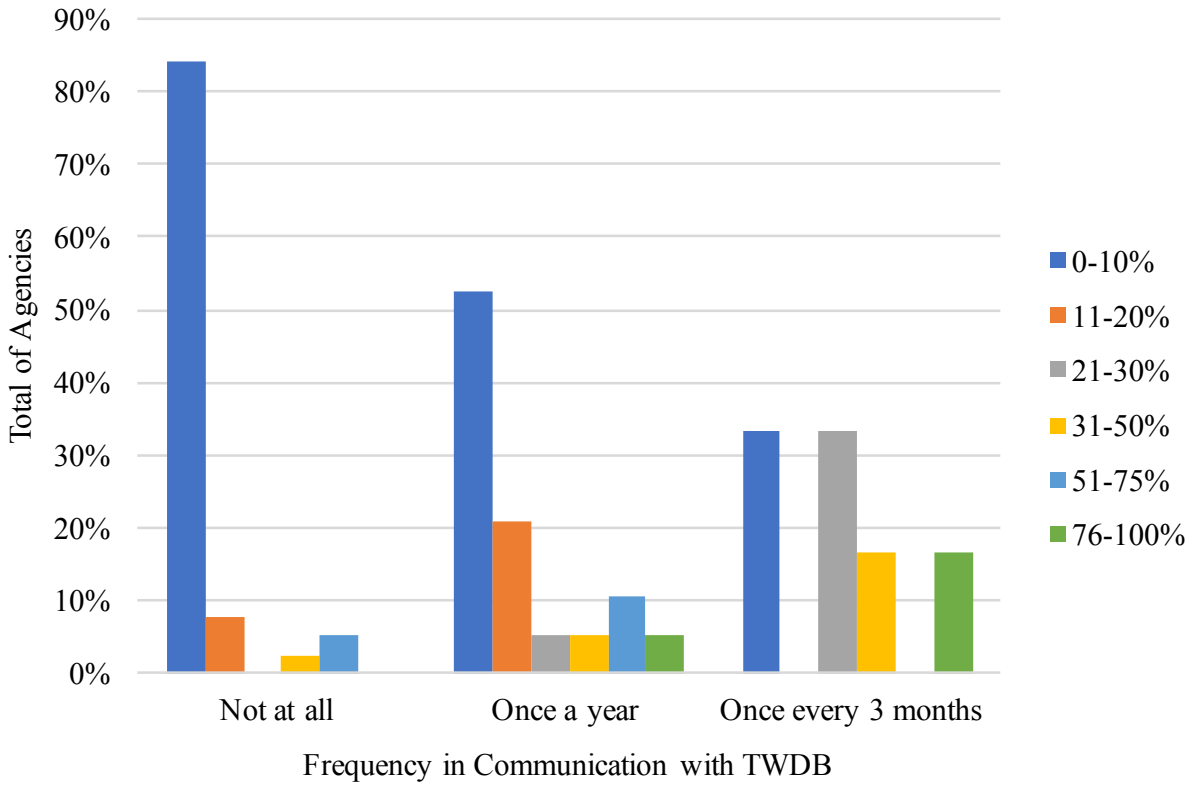

Figure 9. The effect of frequency in communication with the Texas Water Development Board (TWDB) on agencies' efforts to increase water reuse.

7.3 Hypothesis 3

Figure 10 shows the relationship between the scale of the agency and the efforts to increase water reuse in the San Antonio Region. State agencies do not have over 10% of their efforts to increase water reuse. Local and regional level agencies have more efforts to increase water reuse compared to state agencies. There were seven respondents from state agencies all of whom indicated their agencies have 0-10% of efforts to increase water reuse. Nearly 15% of local

agencies and 8% of regional agencies spend 11-20% of their efforts toward increasing water reuse; and nearly 11% of local agencies and 6% of regional agencies spend 51-75% of their efforts to increase water reuse. Four percent of local agencies and 3% of regional agencies spend 76-100% of their efforts to increase water reuse.

One explanation for why water reuse is not happening at the state scale, is because at this scale agencies are usually those who are planning and/or regulating local and regional efforts. State scale agencies are also one's that help fund local and/or regional water projects. Reuse is happening at the local level because local water utilities are often the distributors of reclaimed water.

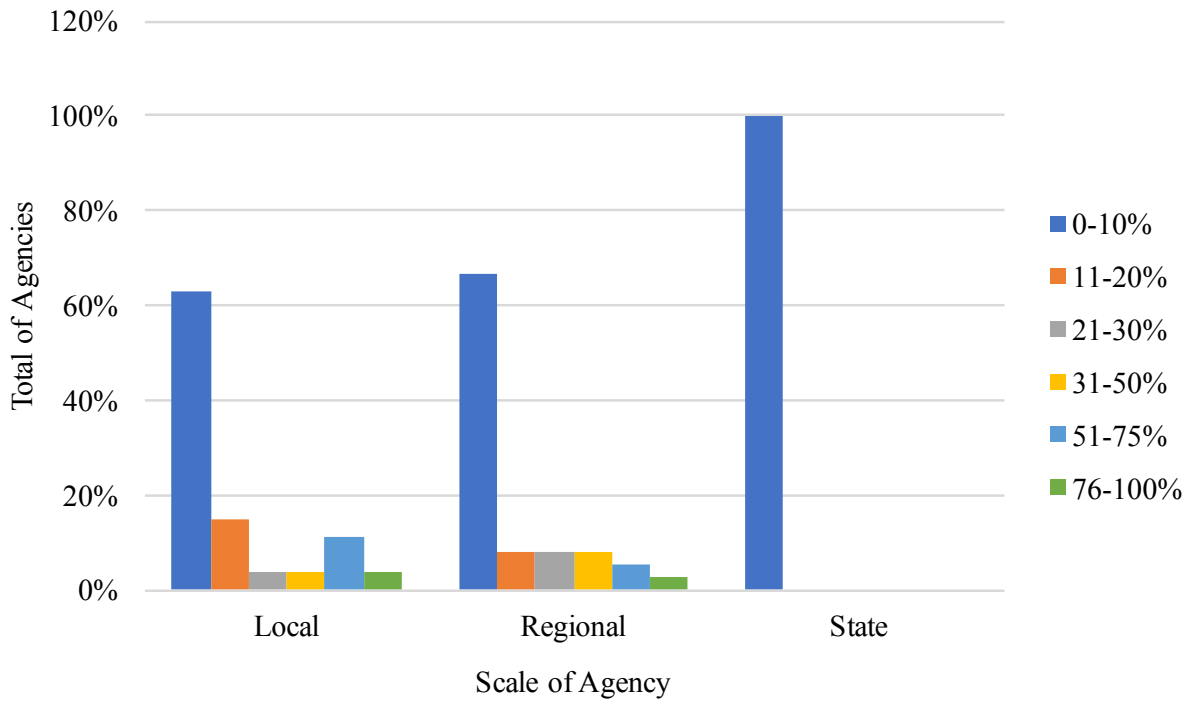

Figure 10. The effect of scale of agency on agencies' efforts to increase water reuse in the San Antonio Region.

7.4 Hypothesis 4

Figure 11 shows the relationship between the type of water governing agency and their efforts to increase water reuse in the San Antonio Region. Utility type agencies show a greater variation of percent of efforts to increase water reuse compared to river authority and groundwater governing agencies. Ranging from the lowest to highest categories of efforts to increase water reuse, nearly 66% of water utilities have 0-10% of efforts to increase water reuse, 14% with 11-20% of efforts, 4% with 21-30% of efforts, 4% with 31-50% of efforts, 10% with 51-75% of efforts, and 4% with 76-100% of efforts to increase water reuse in the San Antonio Region.

While water utilities use a greater variation of percent of efforts, river authorities overall, have a greater percent of agencies with efforts to increase water reuse beyond 0-10%. Nearly 53% of river authorities have 0-10% of effort to increase water reuse, 12% with 11-20% of effort, 6% with 21-30% of effort, 18% with 31-50% of effort, and 12% with 51-75% of effort.

The majority of groundwater agencies have 0-10% of their efforts toward increasing water reuse. Nearly 77% of groundwater agencies have 0-10% of their efforts towards increasing water reuse, 6% with 11-20% of efforts, 12% with 21-30% of efforts, and 6% with 76-100% of their efforts to increase water reuse.

Figure 11 does not include results from respondent's in private companies, research/ extension, and state regulatory/ planning agencies. Results show there were no agencies within the San Antonio Region boundary representing private companies, only two from research/ extension, and five from state regulatory/ planning. All of the respondents from research/ extension and from the state regulatory/ planning indicated their agencies had efforts of 0-10% to increase water reuse in the San Antonio Region. Within these two classifications of types of agencies, results indicate 100% of research/ extension agencies and 100% of state regulatory/planning agencies have 0-10%

of their efforts to increase water reuse. Low numbers of responses in these categories are not significant enough to assume their percent of efforts to increase water reuse results, and have been eliminated from figure 11.

Utilities have a greater range in efforts to increase water reuse, because these types of agencies may be as little as involved in the planning of water reuse projects with the regional planning group, to as involved in water reuse at the distribution line. Another explanation for their range in efforts is not all utilities are set up for water reuse projects. In fact, only one water utility, the San Antonio Water Systems indicated they reuse up to 76-100% of their efforts to increase water reuse.

It is almost expected that research and extension agencies wouldn't be much involved in water reuse as much of the technology supporting water reuse is mostly established. Furthermore, a low amount of effort to increase water by state planning and regulatory agencies would also be expected as these types of agencies are balancing their working efforts toward planning for future water needs through supply of groundwater, surface water, water conservation, water reuse, reservoirs, etc. and in regulating all the many uses of water.

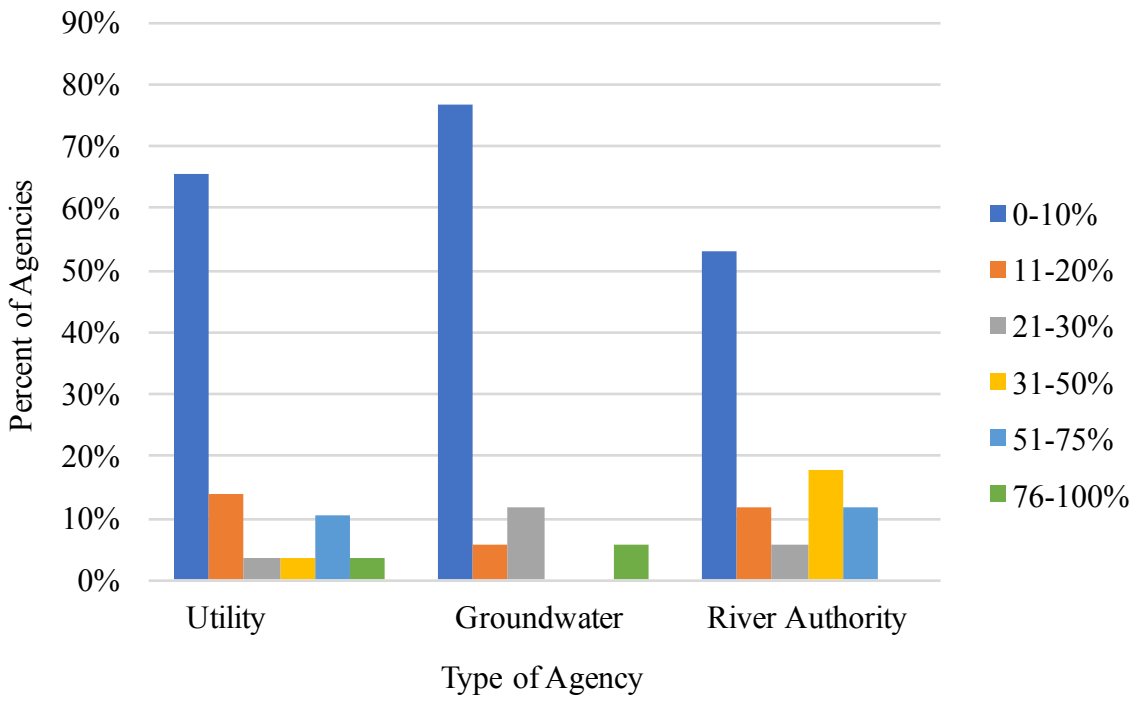

Figure 11. The effect of type of agency on agencies' efforts to increase water reuse in the San Antonio Region.

7.5 Summary Statistics

Table 1 shows seven models of regression analysis on agency efforts to increase water reuse. The table includes the coefficient and standard errors for each model, and indicates whether the coefficient for a variable is statistically significant in increasing water reuse efforts.

Seven regression analysis models were computed using STATA statistical software. In the first of the four regression models three variables remained the same: familiarity with TWDB water strategy supplies, frequency in communication with TWDB, and level of agency. Model 1 includes the impact of a water governing agency being a utility on an agencies efforts to reuse water, model 2 includes the impact of a water governing agency being a groundwater agency on efforts to reuse water, model 3 includes the impact of a water governing agency being a river

authority on efforts to re water reuse efforts, and model 4 includes the impact of a water governing agency being either a utility, groundwater agency and river authority on efforts to increase water reuse. Models 5-7 tests for the differences in scale of agency on efforts to increase water reuse. Model 5 includes the impact of a local on efforts to reuse water, model 6 includes the impact of a regional agency on efforts to reuse, model 7 includes the impact of state agencies on water reuse.

In each model, agency's frequency in communication with TWDB was significant in increasing percent of efforts an agency spends toward increasing water reuse.

7.5.1 Familiarity with strategy supplies

The results of the regression analysis show a slightly positive correlation between familiarity with the water strategy supplies in TWDB 2017 State Water Plan and agencies' efforts to increase water reuse. The correlation coefficient between the two variables is .127 (see Model 4) showing a slightly positive correlation between them. The calculated p-value is .51, larger than .05, showing that the correlation between the two variables is not statistically significant (see Model 4). The correlation coefficient remains slightly positive in all seven models, and the p-value in all models indicates that familiarity with the TWDB's water strategy supplies remains insignificant. Therefore, we cannot reject the null hypothesis that people in agencies who are more familiar with Texas Water Development Board's (TWDB) water supply strategies in the 2017 Texas State Water Plan are not in agencies or organizations with higher efforts to increase water reuse.

7.5.2 Communication with TWDB

The results of the regression analysis show a statistically significant, positive correlation between frequency in communication with the TWDB and an agency's efforts to increase water reuse: the correlation coefficient between the two variables is .852 (see Model 4). The calculated

p-value is .006, smaller than .05, showing that the correlation between the two variables is statistically significant (see Model 4). The correlation coefficient remains positive in all seven models, and the p-value in all seven models remains <.01 indicating that the frequency in communication with the TWDB is statistically significant. Therefore, we can reject the null hypothesis and conclude that people in agencies who communicate more frequently with TWDB do have greater amount of efforts to increase water reuse.

7.5.3 Scale of Agency

The results of the regression analysis show a negative correlation between the scale of agencies and their efforts to increase water reuse. Model 5 does show that local agencies have more efforts to reuse water compared to those that are not local. The correlation coefficient for scale of agency varies in each model. Model 1 shows -.981, model 2 shows -.533, model 3 shows -.666, and model 4 shows -.587. In models 5-7, the significance of each scale of agency is tested. In model 5, the regression tests the level of effort to increase water reuse based on whether or not an agency is local, model 6 tests reuse efforts based on whether or not an agency is regional, and model 7 tests reuse efforts based on whether or not an agency is state. Model 5 shows a positive correlation of .587 on water reuse efforts based on whether or not an agency is local. Model 6 shows a negative correlation on reuse efforts based on whether or not an agency is regional, and model 7 shows a statistically significant negative correlation on water reuse efforts based on whether an agency is a state agency or not.

The results in model 5 best test for the hypothesis that local agencies reuse more water compared to non-local agencies. In model 5, there is a positive correlation of .587 for local agencies. The p-value is .55, larger than .05, indicating that the correlation between efforts to increase reuse and whether an agency is local or not is not statistically significant. We therefore

cannot reject the null hypothesis that people in lower level agencies do not have greater amount of efforts to increase water reuse compared to those in regional, and/or state agencies.

7.5.4 Type of Agency

The first four models of regression analysis best examine the impact of three different types of agencies on increasing water reuse efforts. In the first model the impact of a water utility on efforts to increase water reuse is tested. The correlation coefficient for a water utility type agency on water reuse efforts is -.650, indicating a negative correlation. In the second model, the impact of an agency dealing with groundwater on efforts to increase water reuse is tested. The correlation coefficient between these two variables is -190. In the third model, the impact of an agency being a river authority on efforts to increase water reuse is tested. The correlation coefficient for these two variables is .622, indicating a positive correlation. In the fourth model, where all three types of agencies are considered, the correlation coefficient for water utility becomes positive and is .228; for groundwater types agencies, the correlation coefficient also becomes positive and is .249; and for river authorities the correlation coefficient increases to .842. None of the types of the agencies presented in the four models are statistically significant to increase water reuse.

In testing our original hypothesis if utility agencies have greater efforts to increase water reuse, we can look at model one. Again, the correlation coefficient is -.650, and the p-value is .255, larger than .05, indicating the result is not statistically significant. We therefore, cannot reject the null hypothesis that people working for water utility agencies do not have greater amount of effort to increase water reuse compared to groundwater, river authority, research/extension, and/or state regulatory/planning agencies.

Table 1. Seven regression analysis models of variables that impact agencies' efforts to increase water reuse in the San Antonio Region.

VARIABLES	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Familiarity with TWDB's strategy supplies	0.139	0.189	0.136	0.127	0.127	0.127	0.129
	(0.190)	(0.188)	(0.185)	(0.191)	(0.191)	(0.191)	(0.190)
Frequency in communication with TWDB	0.836**	0.811**	0.841**	0.852**	0.852**	0.852**	0.862**
	(0.296)	(0.298)	(0.292)	(0.300)	(0.300)	(0.300)	(0.297)
Scale of agency	-0.981	-0.533	-0.666*	-0.587			
	(0.507)	(0.285)	(0.278)	(0.975)			
Type of agency: Utility	-0.650			0.228	0.815	1.403*	-0.070
	(0.664)			(1.976)	(1.092)	(0.616)	(0.446)
Type of agency: Groundwater		-0.190		0.249	0.836	1.423	-0.592
		(0.408)		(1.171)	(0.644)	(1.166)	(0.478)
Type of agency: River Authority			0.662	0.842	1.429*	2.016	
			(0.402)	(1.170)	(0.644)	(1.168)	
Scale of agency: Local					0.587		
					(0.975)		
Scale agency: Regional						-0.587	
						(0.975)	
Scale agency: State							-1.430*
							(0.640)
Constant	2.136	1.045	1.166	0.841	-0.920	-0.920	0.484
	(1.250)	(0.605)	(0.594)	(3.054)	(0.720)	(0.720)	(0.599)
Observations	60	60	60	60	60	60	60
R-squared	0.28	0.27	0.3	0.3	0.3	0.3	0.3
Adj R-squared	0.23	0.22	0.25	0.23	0.23	0.23	0.23
F	5.37	5.12	5.97	3.86	3.86	3.86	4.61

Note: Standard errors in parentheses, *** p<0.001, ** p<0.01, * p<0.05

8. CONCLUSION

With a rapidly growing population and high demands for water, the region of San Antonio needs new sources from which to secure water. While water reuse has the potential to supply nearly 24% of water needs in the San Antonio Region, the impact of securing this type of water, and coordinating water governing agencies to do so should not be undermined. As most of the literature on water reuse has thus far focused on the technological, economic and social aspects, this research begins to add to the limited literature of water reuse governance, in efforts to understand key governance-related factors that contribute to agencies coordinating over the shared water reuse goal in Texas.

This research tested four hypotheses regarding the impact of agency efforts to increase water reuse in the San Antonio Region. The impacts of frequency of communication with TWDB, familiarity with the TWDB water strategy supplies in their 2017 Texas State Water Plan, type of water governing agencies, and scale of water governing agencies were all variables tested to see their impact on agencies efforts to increase water reuse in the San Antonio Region. Results from a questionnaire sent to water governing agencies in the San Antonio Region show nearly 70% of agencies in the San Antonio Region have efforts to increase water reuse by only 0-10%. Results from testing the indicated hypotheses will help water mangers identify key governance-related factors that contribute to increased water reuse by water governing agencies.

While cross tabulations of efforts to increase water reuse with familiarity of TWDB water strategy supplies, scale of agency, and type of agency show some patterns of efforts to increase water reuse by agencies, communication with the Texas Water Development Board (TWDB) was the only statistically significant variable contributing to agencies' efforts to increase water reuse

in the San Antonio Region.

Respondents indicating they were 'Extremely Familiar' with the TWDB water strategy supplies showed a greater range of efforts to increase water reuse. Additionally, a lower percent of respondents represented those who were 'Extremely Familiar' and who had indicated they spend 0-10% of their efforts to increase reuse, compared to a nearly 70% of agencies reusing 0-10% that indicated a lower than 'Extremely Familiar' with the strategy supplies. While a positive correlation exists between familiarity with TWDB's water strategy supplies and efforts to increase water reuse, results indicate this factor is not statistically significant to assume that increased familiarity with the strategy supplies increases water reuse.

Water reuse is confirmed to occur at local and regional scales, rather than state scale. There is a positive correlation between water reuse on the local scale and efforts to increase water reuse. However, results indicate that this relationship is not statistically significant to assume increased water reuse efforts. Additional patterns show, water utilities have more efforts to increase water reuse compared to private companies, research / extension and state regulatory and planning, but that they have less efforts to increase water reuse compared to river authorities. Responses from private companies, research / extension, and state regulatory and planning agencies were low, and indicated limited efforts to increase water reuse all at 0-10%.

Increased communication with TWDB increases agency efforts to reuse water. This is the only variable tested that is sufficiently statistically significant to assume its impact to increase water reuse efforts by agencies. Results of the questionnaire show that 58% of water governing agencies in the San Antonio Region do not communicate with TWDB at all. While the region is struggling to secure water, there is a level of expectation that there would be at least some level of communication among water governing agencies and the state planning agency, especially as

water in the region is scarcely needing to be planned to meet the needs. This result showing a lack of communication, also indicates there is large potential for agencies to bridge this gap in communication. While there are many factors to consider regarding why agencies are not communicating with TWDB, these are not within the scope of this research, results here indicate that an increase in frequency of communication with the state planning agency, specifically for local agencies, will increase an agency's efforts to reuse water.

Water strategy supplies proposed to the TWDB indicate the water reuse has the potential to supply up to 24% on average of water needs of the San Antonio Region. While this research was able to identify that a greater frequency in communication with the state water planning agency was able to increase water reuse efforts amongst water governing agencies within the San Antonio Region, further research is necessary to understand in greater detail the communication occurring between local, regional and state water governing agencies as they work to secure more water supplies for their region. It is important to identify the aspects of communication between agencies that contribute to the increase of water reuse, as well as any water supply strategies: are these agencies communicating specifically about the state water plan; what type of data sharing occurs; are they communicating about sources of funding for water supply projects? These are all questions that need to be addressed in order to better understand the coordination between scales of water governing agencies with the goal of securing water for the future.

Thus, while we have the scientific know-how and the technology to mass produce reusable water, this study points to the importance of the social sciences in helping determine sustainable water management solutions. The lack of agency communication is identified as a bottle neck to expanding water reuse in the region. Although communication appears a seemingly simplistic matter, the findings of this study further point to the significance of greater

communication in expanding water reuse and, ultimately, the actual supply of water to the San Antonio Region. While “hard” science provides a basis for water management solutions, the critical question becomes: what is value of the technologic approaches if those governing the technologies do not communicate or collaborate with the potential consumers of the water produced by the technologies? Social science is a viable asset to water management and science: assessing the levels of communication within and between agencies is as important as that science which assesses levels of toxicity, volumetric groundwater flows in aquifers, or rates of water uptake in plants.

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APPENDIX A

SURVEY METHODOLOGY

The survey for the *Water Management in the San Antonio Region* project targeted public officials and others who work in institutions or organizations that are thought to have legal authority for making water management and policy decisions that affect water availability, quality, or use in a geographic area we loosely refer to as the "San Antonio Region." Although this project was intended to contribute to a larger "water-energy-food nexus initiative," its focus is clearly on the water portion of this nexus in that the target survey subjects are all expected to be part of water governance in the San Antonio Region. The nexus aspects of this project are captured in the questionnaire, where each water governance respondent was asked to report on contacts with organizations in the region involved in energy and food governance. This Appendix provides detailed background information about this survey.

Identified Water Governance Institutions and Organizations

As a first step in the research process, an effort was made to identify the key policy and management organizations affecting water in the San Antonio Region. In order to accomplish this, a definition of the San Antonio Region needed to be developed. An effort was made to conduct this survey in a way that would be provide significant information relevant to the Texas A&M-wide water-energy-food nexus case study in the San Antonio area. This larger project has tended to focus on a specific geographic area defined by the Texas Water Development Board, as an administrative convenience, referred to as "Planning Area L." The assessment conducted for this survey project determined that most of the relevant organizations had geographic jurisdiction within Region L, but that there were other organizations with possible relevance to water management in San Antonio that were completely or partially outside of Region L. So, in compiling the list of organizations eligible to be surveyed, a concerted effort was made to err on the side of including those whose geographic coverage might be relevant. The results of the survey, as discussed below, suggest that some of these organizations need not have been included.

Defining the list of organizations also required making judgments about which organizations are, in fact, involved in "water governance and management." There is no universally understood or agreed upon set of criteria to use in making these judgments. Our foundational guiding principle is that organizations included in the survey would have to have some explicit legal authority or responsibility for making decisions that affect surface or groundwater in the San Antonio Region. Some of the organizations have clear-cut authority for making decisions, such as the officially recognized "groundwater conservation districts" and river authorities. Other organizations represent administrative mechanisms to perform various management and planning functions. These include groundwater management area offices, the groundwater management and priority area offices, and Texas Water Development Board's regional planning offices. Of course, a number of state agencies such as the Texas Commission on Environmental Quality, the Texas Water Development Board, and the Texas Water Resources Institute have explicit responsibilities. The complete initial list of organizations assembled for this survey includes:

Water Governance Organizations in the San Antonio Region

Groundwater governance

Groundwater conservations districts (GCDs)

- Bandera County River Authority and GCD
- Barton Springs/Edwards Aquifer and GCD
- Blanco-Pedernales GCD
- Comal Trinity GCD
- Cow Creek GCD
- Evergreen GCD
- Gonzales County Underground Water
- Hays Trinity GCD
- Headwaters GCD
- Kinney County GCD
- McMullen GCD
- Medina County GCD
- Pecan Valley GCD
- Plum Creek GCD
- Post Oak Savannah GCD
- Trinity-Glen Rose GCD
- Uvalde County Underground Water

Groundwater Management Areas

- Texas Groundwater Management Area #9 TWDB
- Texas Groundwater Management Area #10 TWDB
- Hill Country Priority
- Trinity Aquifer Priority

Edwards Aquifer Authority

Texas Irrigation Districts

Texas Groundwater Protection Committee

Groundwater-related Nonprofit Organizations

- Edwards Aquifer Association
- Texas Association Watershed Sponsors (TAWS)
- Texas Alliance of Groundwater Districts

Water service providers

San Antonio Water System (SAWS)
Live Oak Municipal Utility
Canyon Regional Water Authority
Other municipal providers

Surface water governance

River authorities

- Bandera County
- Brazos River Authority
- Central Colorado River Authority
- Guadalupe-Blanco River Authority
- Lavaca-Navidad River Authority
- Lower Colorado River Authority
- Nueces River Authority
- Trinity River Authority
- Trinity River Vision Authority
- San Antonio River Authority
- Upper Colorado River Authority
- Upper Guadalupe River Authority

Ground and surface water governance

Texas Commission on Environmental Quality

- South Texas Watermaster

Texas Water Development Board
Regional Planning Areas

- Region K (Lower Colorado)
- Region L (South Central)

Texas State Soil and Water Conservation Board (Region 2)
Texas Water Resources Institute (TAMU)
Texas Soil and Water Conservation Districts

- Alamo SWCD #330
- Comal-Guadalupe SWCD #306
- Wilson County SWCD #301

Texas State Public Utility Commission
Texas General Land Office
County and municipal elected officials

Storm Water Control Districts (TCEQ)

Freshwater Supply District (TCEQ)

Drainage District (TCEQ)

Subsidence Districts

- Fort Bend Subsidence District
- Harris-Galveston Subsidence District

People in Water Governance Institutions and Organizations

Once the relevant organizations were identified, an effort was made to identify individual people to be surveyed. Instead of selecting a single person to "represent" each organization, this project elected to identify each and every person within these organizations whose position would be relevant. In all, 289 individual people were identified using a variety of web-based sources, and by placing calls to many of the organizations. A database containing the names of, and contact information for, these people was created, and this database was used to prepare personalized mail merge files containing cover letters and mailing envelopes, as detailed below.

IRB Process and Review

As with all field research involving human subjects, this project submitted an application for IRB approval. The questionnaire, a description of the process to be used, and all supporting documents were submitted for review on October 9, 2017. As reflected in the "outcome letter," shown below, this project was judged to meet the criteria for exemption from full IRB review, and certification was provided on October 17, 2017. This certification was added as a footer to the questionnaires in both paper and online form.

The Survey Process

The database containing the names and contact information for the potential respondents was used to prepare a personalized cover letter and mailing envelope. This cover letter, prepared on official letter head with the seal of the Institute for Science, Technology and Public Policy, provided the requisite information about the survey, contact information for people who would be able to answer any questions. A sample of this initial letter is provided below. Each letter was addressed, by name, to the specific person designated as a potential respondent, and was signed by Professor Kent Portney.

This initial cover letter was placed in an initial mailing with a self-addressed postpaid return envelope, a separate self-addressed postpaid postcard, a paper questionnaire, and a single $1 bill (as referenced in the cover letter). A total of 289 envelopes made up the initial mailing.

As indicated in the cover letter, each prospective respondent was offered the opportunity to complete the questionnaire on line. A version of the questionnaire was prepared in Qualtrics software under the Texas A&M institutional license, and the URL to this questionnaire was shortened to https://u.tamu.edu/water.

IRB requirements preclude using any sort of explicit system for attaching identifying information to completed questionnaires. Indeed, we promised respondents anonymity. So as an alternative, the initial mailing included a postpaid postcard that could be returned after the questionnaire was completed. This postcard was used to identify those who responded, and to define the pool of people eligible to be entered into a drawing to win a gift card, as discussed in the "incentives" section below. For those who complete the questionnaire online, the final question provided respondents with an opportunity to identify themselves and to be eligible for the gift card drawing. The information provided in this final

question was saved in a separate file from the questionnaire results so that the identifying information would not be connected to the questionnaire responses.

After 10 days had elapsed, an effort was made to identify those who had not yet completed a questionnaire. This was done identifying those respondents who returned postcards or provided information in the online questionnaire, and removing them from the database of all possible respondents. A few additional recipients of mailed questionnaires returned those questionnaires with notes of refusal, and these people were also removed from the database. Those who remained in the database were emailed a reminder to complete the questionnaire, and this email message included a link to the online version.

After another five days, this process was repeated, and a second email message was sent. After approximately two more weeks, a decision was made to assemble and mail a replacement questionnaire. The package mailed to those who likely did not respond to the first mailing was identical to the first except that the envelope did not contain a $1 bill. A total of 254 replacement questionnaires were mailed.

Incentives for Participation

As suggested above, the survey made use of two mechanisms to try to create an incentive for participation. First, each initial outgoing mailing contained a $1 bill. Although including currency may seem trivial, research has shown that including the money can have a significant effect on the response rate. Specifically, it helps to create a sense of obligation to respond for some people. Second, the project provided the opportunity for those who completed questionnaires and who were willing to identify themselves, either through the postpaid post card or through the final question on the online questionnaire, to become eligible for a drawing to receive one of three $75.00 Amazon.com gift cards. Of the 81 respondents who are included in this report's analysis, 37 returned postcards with identifying information and 16 provided contact information in the online questionnaire, for a total of 53 people eligible for the drawing. Thus, the chance of being selected was 3 of 53, or 6%.

Responses and Response Rate Calculations

For the purposes of this report, 81 completed questionnaires were received. Since 289 initial questionnaires were mailed, the raw or nominal response rate would be calculated as 81/289 = 28%. However, the denominator for this calculation does not an accurately reflect the size of the actual population of people surveyed. As a result of the mailings, it was determined that some people on the original list were not available to be included for one reason or another. For example, 21 questionnaires were returned by the U.S. Postal Service as "undeliverable." Additionally, 4 people had left their respective positions, and 3 people were on long-term leave from their positions. We also discovered that one of the private water service providers had lost its certification, and all 4 of the people there who had been sent questionnaires were not eligible to participate in the survey. Based on these results, an adjusted response rate is calculated as 81 / (289 – 21 – 4 – 3 -4) = 81 / 257 = 31.5%.

A more accurate estimated response rate needs to take into consideration that some of the people (and organizations) included in the survey probably should not have been surveyed because their water governance decisions truly don't have any connection to the San Antonio Region, as described above. In those situations where 1) there was a priori reason to believe an organization probably did not have any connection to the San Antonio Region, and 2) respondents reported that they indeed have no connection to the San Antonio Region, those respondents were considered to be not part of the eligible survey population. By our count, a total of 25 people meeting these criteria were mailed questionnaires and should not have been. Thus, a third adjusted response rate would be calculated as 81 / (257 – 25) = 81 / 232 = 35%.

Potential Response Bias

In the absence of full response, there is the possibility of some type of response bias being reflected among the third of people who did respond. While analysis of the potential for response bias will continue, an initial effort was made to determine whether some types of organizations were over or under represented in the final sample. Here we examined several categories of types of organizations whose people were surveyed. We provide an assessment of the number of people who were surveyed, what proportion of the total they represent, and how the sample respondents compared.

Category of organization	Number of people surveyed	Percentage of the total surveyed	Number of respondents	Percentage of the total respondents	% Under or over represented
Groundwater conservation districts	81	28.0%	20	24.8%	- 3.2
River authorities	46	16.0%	13	16.2%	+ 0.2
State agencies (including regional offices)	26	9.0%	15	18.5%	+ 9.5
Private municipal water service providers	30	10.4%	9	11.1%	+ 0.7
All others	106	36.6%	27	33.4%	- 3.2
Totals	289	100.0%	81	100.0%	-----

These results suggest that there is only one category of organization whose respondents appear to be over-represented in the sample – state agencies. These agencies include the Texas Commission on Environmental Quality (TCEQ), the Texas Water Development Board (TWDB) and people from its regional offices, and the Texas Water Resources Institute (TWRI). Although people from these organizations make up a relatively small portion of the people surveyed (9.0% of the total) and of the people who responded (18.5%), clearly they are over-represented (by about 7 or 8 people) in the final sample.

Timelines and Key Events

Draft questionnaire completed	October 6 (Friday)
All other written materials completed (cover letter, postcard, etc.)	October 9 (Monday)
Mailing list completed	October 9 (Monday)
IRB application submitted	October 9 (Monday)
Printing/stuffing envelopes	October 12-13 (Thursday-Friday)
Initial questionnaire mailing	October 13 (Friday)
Follow-up email #1	October 23 (Monday)
Follow-up email #2	October 30 (Monday)
Second (replacement) questionnaire mail	November 13 (Monday)
Data set completed	November 29 (Wednesday)

The Survey Questionnaire

The survey instrument was developed as a collaborative venture involving the students in the Bush School's Water Policy and Management course during the fall semester of 2017. Each student was asked to contribute questions that would be used in a final research paper. The questionnaire was prepared on paper for distribution via U.S. Postal Service. A parallel question was developed in Qualtrics software under the Bush School's license agreement. These questionnaires were nearly identical. A copy of the questionnaire in included below.

APPENDIX B

WATER MANAGEMENT IN THE SAN ANTONIO REGION QUESTIONNAIRE

Water Management in the San Antonio Region

Thank you for taking a few minutes to answer questions about water management and activities in the San Antonio Region. As noted in our cover letter, your answers will be held in the strictest confidence. If you would prefer to answer the questions online with a computer or cell phone, please go to:

https://u.tamu.edu/water

Q1. Do you currently work for an agency or department that deals with **water issues in the San Antonio Region**?

◯ Yes ◯ No ◯ Not in the San Antonio Region ◯ Not sure

Q1a. If you answered "Yes" above, about what percentage of your time in a typical week do you currently spend working on **water issues of any sort**?

◯ 0-10% ◯ 11-20% ◯ 21-30% ◯ 31-50% ◯ 51-75% ◯ 76-100%

Q2. What agency or department do you work for?

Q3. What position do you currently hold in this department or agency?

Q4. Is your work full-time, part-time, or is it purely voluntary?

◯ Full-time ◯ Part-time ◯ Voluntary

Q5. About how many years have you spent in this current position?

◯ Less than a year ◯ 1-2 years ◯ 3-4 years ◯ 5 years or more

Q6. About how many years have you spent working for this department or agency?

◯ Less than a year ◯ 1-2 years ◯ 3-4 years ◯ 5 years or more

Q7. About how many years have you worked in any water-related field?

◯ Less than a year ◯ 1-2 years ◯ 3-4 years ◯ 5 years or more

Q8. Does any agency or department, including your own, conduct any type of **program performance review** of your agency? If so, how often?

◯ No program performance review ◯ Every other year ◯ Once a year ◯ Twice a year

Q9. Over the last year, as part of your job, how often have you communicated with any of these organizations, or decision makers from these organizations, **about water issues affecting the San Antonio Region**?

	Once a week or more (1)	Monthly (2)	Once every 3 months (3)	Once a year (4)	Not at all (5)	This is my own organiz-ation (6)
a. Edwards Aquifer Authority	○	○	○	○	○	○
b. Any Irrigation District	○	○	○	○	○	○
c. A TCEQ Office in Austin	○	○	○	○	○	○
d. Any TCEQ Freshwater Supply District	○	○	○	○	○	○
e. Texas Water Development Board in Austin	○	○	○	○	○	○
f. Texas Water Development Board Region K Office	○	○	○	○	○	○
g. Texas Water Development Board Region L Office	○	○	○	○	○	○
h. San Antonio Water System (SAWS)	○	○	○	○	○	○
i. Live Oak Municipal Utility	○	○	○	○	○	○
j. Canyon Regional Water Authority	○	○	○	○	○	○
k. Any Stormwater Management or Control District	○	○	○	○	○	○
l. Texas Water Resources Institute	○	○	○	○	○	○
m. Texas State Public Utility Commission	○	○	○	○	○	○
n. Texas General Land Office	○	○	○	○	○	○
o. Texas State Soil and Water Conservation Board, Region 2 Office	○	○	○	○	○	○
p. South Texas Watermaster	○	○	○	○	○	○
q. Edwards Aquifer Association	○	○	○	○	○	○
r. Texas Alliance of Groundwater Districts	○	○	○	○	○	○
s. Any Drainage District	○	○	○	○	○	○
t. Bexar County Heritage & Parks Department	○	○	○	○	○	○

Q10. Over the last year, as part of your job, how often have you communicated with any of these specific organizations, or decision makers from these organizations, **about water issues affecting the San Antonio Region**?

	Once a week or more (1)	Monthly (2)	Once every 3 months (3)	Once a year (4)	Not at all (5)	This is my own organization (6)
a. Bandera County River Authority & Groundwater Conservation District	○	○	○	○	○	○
b. Barton Springs/Edwards Aquifer & Groundwater Conservation District	○	○	○	○	○	○
c. Blanco-Pedernales Groundwater Conservation District	○	○	○	○	○	○
d. Comal Trinity Groundwater Conservation District	○	○	○	○	○	○
e. Cow Creek Groundwater Conservation District	○	○	○	○	○	○
f. Evergreen Groundwater Conservation District	○	○	○	○	○	○
g. Gonzales County Underground Water Conservation District	○	○	○	○	○	○
h. Hays Trinity Groundwater Conservation District	○	○	○	○	○	○
i. Headwaters Groundwater Conservation District	○	○	○	○	○	○
j. Kinney County Groundwater Conservation District	○	○	○	○	○	○
k. McMullen Groundwater Conservation District	○	○	○	○	○	○
l. Medina County Groundwater Conservation District	○	○	○	○	○	○
m. Pecan Valley Groundwater Conservation District	○	○	○	○	○	○
n. Plum Creek Groundwater Conservation District	○	○	○	○	○	○
o. Post Oak Savannah Groundwater Conservation District	○	○	○	○	○	○
p. Uvalde County Underground Water Conservation District	○	○	○	○	○	○
q. Alamo Soil & Water Conservation District #330	○	○	○	○	○	○
r. Comal-Guadalupe Soil & Water Conservation District #306	○	○	○	○	○	○
s. Wilson County Soil & Water Conservation District #301	○	○	○	○	○	○

Q11. Over the last year, as part of your job, how often have you communicated with any of these specific organizations, or decision makers from these organizations, **about water issues affecting the San Antonio Region**?

	Once a week or more (1)	Monthly (2)	Once every 3 months (3)	Once a year (4)	Not at all (5)	This is my own organiza-tion (6)
a. Brazos River Authority	○	○	○	○	○	○
b. Central Colorado River Authority	○	○	○	○	○	○
c. Guadalupe-Blanco River Authority	○	○	○	○	○	○
d. Lavaca-Navidad River Authority	○	○	○	○	○	○
e. Lower Colorado River Authority	○	○	○	○	○	○
f. Nueces River Authority	○	○	○	○	○	○
g. Trinity River Authority	○	○	○	○	○	○
h. Trinity River Vision Authority	○	○	○	○	○	○
i. San Antonio River Authority	○	○	○	○	○	○
j. Upper Colorado River Authority	○	○	○	○	○	○
k. Upper Guadalupe River Authority	○	○	○	○	○	○
l. Groundwater Management Area #9 Office	○	○	○	○	○	○
m. Groundwater Management Area #10 Office	○	○	○	○	○	○
n. Hill Country Priority Area Office	○	○	○	○	○	○
o. Trinity Aquifer Priority Area Office	○	○	○	○	○	○
p. Ozarka Spring Water Company	○	○	○	○	○	○
q. ExxonMobil	○	○	○	○	○	○
r. Shell Oil	○	○	○	○	○	○
s. Office of Texas House Speaker Joe Strauss	○	○	○	○	○	○
t. Joint Base San Antonio	○	○	○	○	○	○
u. Valero	○	○	○	○	○	○
v. Any Professional Hydrologist or Geologist	○	○	○	○	○	○

w. Office of State Representative Lyle Larson	◯	◯	◯	◯	◯	◯
x. Office of Texas State Senator Carlos Uresti	◯	◯	◯	◯	◯	◯

Q12. Over the last year, as part of your job, have you personally participated in any kind of **stakeholder forum or cooperative planning effort** with organizations or agencies other than your own?

◯ Yes ◯ No ◯ Not sure

Q12a. If you participated in any stakeholder forums or planning efforts over the last year, please provide the **names or types** of up to three of these. About how many times did you participate in each type of forum or planning effort over the last year?

	Once (1)	Twice (2)	Three times (3)	More than three times (4)
1. Name or type of forum or organization #1_____	◯	◯	◯	◯
2. Name or type of forum or organization #2_____	◯	◯	◯	◯
3. Name or type of forum or organization #3 _____	◯	◯	◯	◯

Q12b. Thinking about the three forums or organizations you listed, did any of these discuss or otherwise address issues of water used for extracting or producing **energy or electricity**?

◯ Yes ◯ No ◯ Not sure

Q13. Overall, how concerned are you about **future water availability** in the San Antonio Region?

0 Not Concerned at all	1	2	3	4	5	6	7	8	9	10 Extremely Concerned
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Q14. How important do you think **water conservation** is in the San Antonio Region today?

◯ Very Important ◯ Moderately Important ◯ Not Very Important

Q15. Over the last year, as part of your job, about how often have you communicated with organizations, or decision makers from these organizations, **about any issues affecting the San Antonio Region**?

	Once a week or more (1)	Monthly (2)	Once every 3 months (3)	Once a year (4)	Not at all (5)
a. City Public Service (CPS) Energy	◯	◯	◯	◯	◯
b. Duke Energy	◯	◯	◯	◯	◯
c. Marathon Oil	◯	◯	◯	◯	◯
d. Pioneer Natural Resources/Reliance Joint Venture	◯	◯	◯	◯	◯
e. EOG Resources	◯	◯	◯	◯	◯
f. San Antonio City Office of Sustainability	◯	◯	◯	◯	◯
g. Texas Railroad Commission	◯	◯	◯	◯	◯
h. Texas Comptroller, Office of Energy Conservation	◯	◯	◯	◯	◯
i. Texas Public Utility Commission	◯	◯	◯	◯	◯
j. Texas Farm Bureau	◯	◯	◯	◯	◯
k. San Antonio Mayor's Office	◯	◯	◯	◯	◯

l. San Antonio City Manager's Office	◯	◯	◯	◯	◯
m. Bexar County Commissioners or County Manager	◯	◯	◯	◯	◯
n. San Antonio Metro Health District	◯	◯	◯	◯	◯
o. San Antonio Parks & Recreation Department	◯	◯	◯	◯	◯
p. San Antonio Food Policy Council	◯	◯	◯	◯	◯
q. San Antonio Food Bank	◯	◯	◯	◯	◯
r. H.E.B.	◯	◯	◯	◯	◯
s. Kroger	◯	◯	◯	◯	◯
t. NatureSweet Company	◯	◯	◯	◯	◯
u. Sysco Central Texas, Inc.	◯	◯	◯	◯	◯
v. Labatt Food Services	◯	◯	◯	◯	◯
w. Del Norte Foods, Inc.	◯	◯	◯	◯	◯
x. Cargill Food Distributors	◯	◯	◯	◯	◯
y. Blue Wing Solar, Inc.	◯	◯	◯	◯	◯
z. San Antonio Greenspace Alliance	◯	◯	◯	◯	◯
aa. GE Power and Water	◯	◯	◯	◯	◯
bb. Halliburton	◯	◯	◯	◯	◯
cc. Association for Electric Companies of Texas	◯	◯	◯	◯	◯

Q16. How familiar are you with the Texas Water Development Board's **water supply strategies** for the San Antonio Region in the 2017 State Water Plan?

Not at all familiar (1)	Slightly familiar (2)	Moderately familiar (3)	Very familiar (4)	Extremely familiar (5)
○	○	○	○	○

Q17. Please indicate **how much potential** you think each strategy listed below has for managing water to help the San Antonio Region meet its water needs over the next 50 years?

	Very low potential (1)	Low potential (2)	Moderate potential (3)	High potential (4)	Very high potential (5)
a. Conservation of Irrigation Water	○	○	○	○	○
b. Build a New Reservoir	○	○	○	○	○
c. Municipal Water Conservation	○	○	○	○	○
d. Indirect Water Reuse	○	○	○	○	○
e. Direct Water Reuse	○	○	○	○	○
f. Drought Management	○	○	○	○	○
g. Aquifer Storage and Recovery	○	○	○	○	○
h. Seawater Desalination	○	○	○	○	○
i. Groundwater Desalination	○	○	○	○	○
j. Direct Potable Water Reuse	○	○	○	○	○

We have a small number of questions about you, your job and the organization, agency, or department you work for.

Q18. About what percentage of your time in a typical week do you spend **working directly on activities** that help your organization achieve its primary mission?

○ 0-10% ○ 11-20% ○ 21-30% ○ 31-50% ○ 51-75% ○ 76-100%

Q19. What percentage of the activities of your organization, agency, or department involves **efforts to increase water reuse** in the San Antonio Region?

○ 0-10% ○ 11-20% ○ 21-30% ○ 31-50% ○ 51-75% ○ 76-100%

Q20. What is your gender? ○ Male ○ Female

Q21. Please select all of the categories that best describe your background.

White (1)	Black or African American (2)	American Indian or Alaska Native (3)	Asian (4)	Latino (5)	Native Hawaiian or Pacific Islander (6)	Other (7)
◯	◯	◯	◯	◯	◯	◯

◯ Less than a high school diploma (e.g. GED)
◯ Some college, no degree
◯ Bachelor's degree (e.g. BA, BS)
◯ Professional degree
◯ High school diploma or equivalent
◯ Associates degree (e.g. AA, AS)
◯ Master's degree
◯ Doctorate degree

Q22. What is the highest level of schooling you have completed to date?

Q23. Is there **any other information** that you can share with us about water-related issues that you have been involved in over the last year or so? If so, please provide a brief description or assessment below.

Again, thanks for taking the time to answer these questions. When completed, please return this questionnaire in the self-addressed stamped envelope and return the postcard separately to:

Prof. Kent Portney, Director
Institute for Science, Technology and Public Policy
Texas A&M University
TAMU 4350
College Station, Texas 77843-4350

APPENDIX C

IRB APPROVAL LETTER

DIVISION OF RESEARCH
EXEMPTION DETERMINATION
October 16, 2017

Type of Review:	Initial Review Submission Form
Title:	Water Management in the San Antonio Region
Investigator:	Kent E. Portney
IRB ID:	IRB2017-0726M
Reference Number:	066134
Funding:	None
Documents Reviewed:	Online Information.Sheet_9OCT2017 Cover Letter. Information Sheet_9OCT2017 Return Postcard for Respondents_9OCT2017 Email FollowUp_9OCT2017 WEF.Nexus_S.A._Questionnaire_9OCT2017
Risk Level of Study:	Not Greater than Minimal Risk under 45 CFR 46 / 21 CFR 56

Dear Kent E. Portney:

The HRPP determined on that this research meets the criteria for Exemption in accordance with 45 CFR 46.101(b) under Category 2: Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior unless, the information is obtained in an identifiable manner and any disclosure of the subjects responses outside of research could reasonably place the subject at risk. Category 3: Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior, if (i) the human subjects are elected or appointed public officials or candidates for public office or (ii) federal statute(s) require(s) that the confidentiality of the subjects identifiable information will be maintained throughout the research and thereafter.

Your exemption is good for five (5) years from the Approval Start Date. At that time, you must contact the IRB with your intent to close the study or request a new determination. If you have any questions, please contact the IRB Administrative Office at 1-979-458-4067, toll free at 1-855-795-8636.

Sincerely,
IRB Administration

1186 TAMU, College Station, TX 77843-1186, 750 Agronomy Road, Suite 2701 | Tel. 979.458.1467 Fax. 979.862.3176
http://rcb.tamu

APPENDIX D

SAMPLE INITIAL COVER LETTER

Mr. xxxx
Address
City, TX

October 17, 2017

Dear Mr. xxxx:

The Institute for Science, Technology, and Public Policy and students in the Water Policy and Management course at Texas A&M University are developing an understanding of how water in the San Antonio Region is managed. Based on your position, we are asking you to help us with this research study, *Water Management in the San Antonio Region*. We have enclosed a questionnaire that will give us some basic information about the roles and responsibilities of water management officials, the interconnections among their organizations and with other entities in the region, and their general sense of water availability, conservation, and supply strategies. If you would prefer to answer the questions online using a computer or your cell phone, please go to **https://u.tamu.edu/water**. Your response to this questionnaire, or any question on it, is voluntary and your answers will be kept confidential.

Please fill out this questionnaire as best you can from the perspective of your position. Your answers are very important to us, and it should only take about 8-12 minutes to complete. We are asking people in a number of different water-related agencies and positions to fill out our questionnaire. Some questions may not readily pertain to your job. Please answer only those questions that do apply to you.

As a very small token of our appreciation, we include a $1 bill. You may also choose to enter a random drawing to win one of four $75.00 gift cards to Amazon.com. To enter, please fill out and return the post-paid postcard or provide your contact information as requested on the last page of the online version. Your contact information will be used only for selecting a winner in the random drawing and will not be shared with anyone. Your name or contact information will not be connected with the questionnaire you return to us.

This research has been reviewed and approved by the Texas A&M Institutional Review Board (IRB). You may talk to them at 1-979-458-4067, toll free at 1-855-795-8636, or by email at **irb@tamu.edu**. If you have any questions, concerns, or would like us to share the survey results with you, please do not hesitate to contact me at (979) 458-8031 or **kportney@tamu.edu**. Please understand that by completing the questionnaire, you are giving permission for us to use your responses for research purposes.

Thank you in advance for all your help.
Sincerely,

Kent E. Portney, Professor and Director
Institute for Science, Technology and Public Policy
Texas A&M University
4350 TAMU
College Station, TX 77843-4350

IRB NUMBER: IRB2017-0726M
IRB APPROVAL DATE: 10/17/2017
IRB EXPIRATION DATE: 10/15/2022

APPENDIX E

SAMPLE SECOND MAILING COVER LETTER

Mr. xxxx
Address

November 10, 2017

Dear Mr. xxxx:

About two weeks ago, I contacted you to ask for help with a research study called *Water Management in the San Antonio Region*. This is a project of the Institute for Science, Technology, and Public Policy and students in the Water Policy and Management course at Texas A&M University. I apologize if you have already responded. I am following up to make sure that everyone who is eligible to participate has every chance to provide their answers to the enclosed questionnaire. If you would prefer to answer the questions online using a computer or your cell phone, please go to **https://u.tamu.edu/water**. Your response to this questionnaire, or any question on it, is voluntary and your answers will be kept confidential.

Please fill out this questionnaire as best you can from the perspective of your position. Your answers are very important to us, and it should only take about 8-12 minutes to complete. We are asking people in a number of different water-related agencies and positions to fill out our questionnaire. Some questions may not readily pertain to your job. Please answer only those questions that do apply to you.

As a token of our appreciation, we offer you the opportunity to enter a random drawing to win one of four $75.00 gift cards to Amazon.com. We have received assurance that this amount does not in any way raise ethics issues for Texas government employees. To enter the drawing, please fill out and return the post-paid postcard or provide your contact information as requested on the last page of the online version. Your contact information will be used only for selecting a winner in the random drawing and will not be shared with anyone. Your name or contact information will not be connected with the questionnaire you return to us.

This research has been reviewed and approved by the Texas A&M Institutional Review Board (IRB). You may talk to them at 1-979-458-4067, toll free at 1-855-795-8636, or by email at **irb@tamu.edu**. If you have any questions, concerns, or would like us to share the survey results with you, please do not hesitate to contact me at (979) 458-8031 or **kportney@tamu.edu**. Please understand that by completing the questionnaire, you are giving permission for us to use your responses for research purposes.

Thank you in advance for all your help.

Sincerely,

Kent E. Portney, Professor and Director
Institute for Science, Technology and Public Policy
Texas A&M University
4350 TAMU
College Station, TX 77843-4350

IRB NUMBER: IRB2017-0726M

IRB APPROVAL DATE: 10/17/2017

IRB EXPIRATION DATE: 10/15/2022

APPENDIX F

SAMPLE SELF-ADDRESSED POSTPAID RETURN POSTCARD

Return to:

Professor Kent Portney
Institute for Science, Technology and Public Policy
Texas A&M University
TAMU 4350
College Station, TX 77843-4350

I have completed the *Water Management in San Antonio* questionnaire:

☐ On paper, and mailed it under separate cover

☐ Online

☐ Please enter me in the drawing for a $75.00 gift card to Amazon.com

Email address (for raffle notification only):

Name_____
Address 1 _____
Address 2 _____
City and State _____
Zip Code _____

Please return this postcard separately. Thanks for your help!

APPENDIX G

TYPE OF AGENCY CATEGORIZATION AND LIST

PRIVATE / COMPANY

NA

UTILITY

- Bexar County Water Control and Improvement District #10
- Cancan Water Supply Corp
- City of Cibolo, TX
- City of Converse, TX
- City of Fair Oaks Ranch, TX (2)
- City of Floresville, TX
- City of Hondo, TX
- City of Jourdanton, TX
- City of Leon Valley, TX
- City of Natalia, TX
- City of Nixon, TX
- City of Pleasanton, TX
- City of Poteet, TX (2)
- City of Shavano Park, TX
- Cypress Cover Water System
- East Medina County Special Utility District
- Enchanted Oaks Water Supply Corp
- KT Water Development Corp
- Medina County Water Control and Improvement District #2
- SAWS (6)
- Sunko Water Supply Corp
- US Air Force (2)
- Westhaven Water Association

RIVER AUTHORITY

- Brazos River Authority (2)
- Guadalupe-Blanco River Authority
- Lavaca-Navidad River Authority
- Nueces River Authority (3)
- San Antonio River Authority (10)
- Upper Guadalupe River Authority

STATE REGULATORY & PLANNING

- TCEQ (4)
- TWDB (3)

RESEARCH & EXTENSION

- TWRI (2)
- TAMU AgriLife Research & Extension Service

GROUNDWATER

- Barton Springs/Edwards Aquifer Conservation District (2)
- Blanco-Pedernales GCD (2)
- Cow Creek GCD
- Gonzales County UGWCSD #1 (2)
- Plum Creek GCD (2)
- Trinity Glen Rose GCD (3)
- Uvalde County UWC District

APPENDIX H

SCALE OF AGENCY

LOCAL

- City of Cibolo, TX
- City of Leon Valley, TX
- SAWS (6)
- City of Poteet, TX (2)
- Cypress Cover Water System
- City of Floresville, TX
- East Medina County Special Utility District
- Enchanted Oaks Water Supply Corp
- Westhaven Water Association
- City of Natalia, TX
- City of Jourdanton, TX
- City of Fair Oaks Ranch, TX (2)
- Sunko Water Supply Corp
- City of Shavano Park, TX
- City of Hondo, TX
- KT Water Development Corp
- City of Nixon, TX
- US Air Force (2)
- Cancan Water Supply Corp
- Bexar County Water Control and Improvement District #10
- City of Converse, TX

STATE

- TWRI (2)
- TAMU AgriLife Research & Extension Service
- TCEQ (4)
- TWDB (3)

REGIONAL

- Gonzales County UGWCSD #1 (2)
- Uvalde County UWC District
- Plum Creek GCD
- Plum Creek GCD
- Trinity Glen Rose GCD (3)
- Barton Springs/Edwards Aquifer Conservation District (2)
- Cow Creek GCD
- Blanco-Pedernales GCD (3)
- Evergreen Underground Water and Conservation District (3)
- Pecan Valley GCD (2)
- Nueces River Authority (3)
- San Antonio River Authority (10)
- Guadalupe-Blanco River Authority
- Lavaca-Navidad River Authority
- Brazos River Authority (2)
- Upper Guadalupe Rivery Authority
- City of Pleasanton, TX
- Medina County Water Control and Improvement District #2