Gauging Water Conservation efforts of Central Texas Municipalities against Best Management Practices set forth by the Texas Water Development Board

By

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Applied Research Project

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About the Author

Yvonne K. Spell is a graduate student in the Master of Public Administration Program (MPA) program at Texas State University-San Marcos. She earned a Bachelor of Science in Business Administration and a Bachelor of Business Administration in Human Resources from Tarleton State University-Central Texas in 2007. She started her municipal career with the City of Harker Heights in 2010 as the Public Works Administrative Assistant, and is now working as the Customer Relations Supervisor. Lifelong interest in environmental conservation lead to the topic of choice for her research project, and she hopes to continue working to ensure water will be present for future generations.

Abstract

Texas drought has been a contentious issue in the state since the middle of the 20th century. As Texas population continues to experience tremendous growth, serious consideration should be given to future water supply for the state. A bottom up approach from municipalities would be a broad range approach to combat this issue. The purpose of this study is to compare efforts of 5 municipalities in the Austin region against Best Management Practices (BMP) created by the Texas Water Development Board. Water Conservation Plans from the cities of Cedar Park, Georgetown, Leander, Pflugerville and Temple were all judged against the Best Management Practices. The methodology used was comparative document analysis. Two cities showed full or partial presence of the BMPs in about 60% of the elements, one city showed 51%, and the remaining two cities both showed around 40%. All of the cities presented well written, detailed Water Conservation Plans; the plans varied from 7 pages to 64 pages in length. The results found that this is a solid start for future water conservation efforts on behalf of the municipalities. Continued evaluation, based on future water modeling, should assist in overcoming the predicted future water supply shortage for the state.

Keywords: water conservation, Best Management Practices, municipal, drought

Chapter I

Introduction

"When the well's dry, we know the worth of water."

When Benjamin Franklin wrote these words in Poor Richards Almanac in 1746, it may have been a philosophical reference to other losses, but these words ring true and appropriate for the current state of water supply. (Franklin, 1746) For the state of Texas in the 21st century, there is undoubtedly any public policy issue more pressing than that of future water supply for the ever-increasing population.

Figure 1.1 Texas Living Waters Project image

Explosive population growth in the State of Texas, coupled with a devastating decrease in rainfall events (Gholson, Boellstorff, Cummings, Wagner, and Dozier, 2019) have prompted a scramble to plan for future water supply. As both El Paso (Tennyson, 2007) and San Antonio (Davis, Harrah, & Timmerman, 2015), have learned, it is no longer safe to assume that water will always be present. Both cities have faced a severely dwindling supply of water and have embraced innovative practices to ensure that future populations would have sufficient supply. Texas is no stranger to drought, the longest and most severe to date occurring from 1949 – 1957. Drought events have occurred on a regular basis since the drought of record, although none as severe or long lasting.

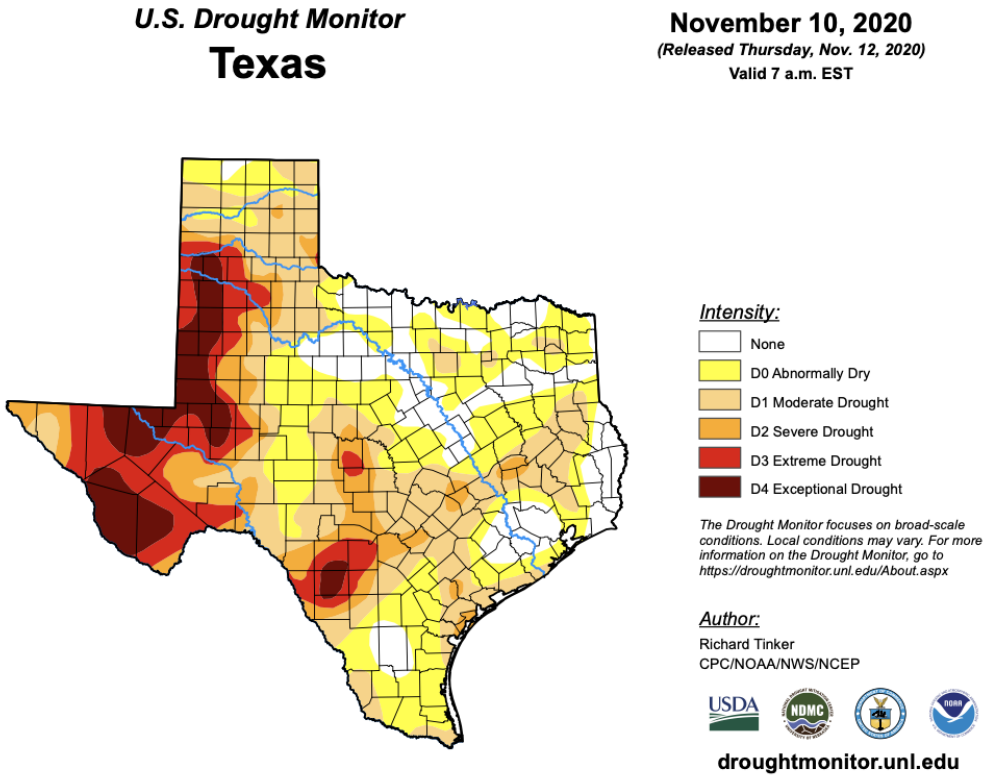

Figure 1.2 State of Drought as of 11/10/2020

Citizens of the City of El Paso were forced to come to terms with their inadequate water supply in the early 1990's when the aquifer they regularly pumped water from began to run dry. With a concerted effort by the city and residents, a 50-year water resource management plan was implemented to combat a bleak future predicting lack of water, litigation between neighboring states and Mexico, and crumbling infrastructure (Tennyson & Parker, 2007). The remainder of the state could benefit immensely from adopting practices implemented by the City of El Paso to guarantee that water resources will be adequate for future growth. San Antonio met with a similar situation, and also had to re-think water supply and control. San Antonio Water Supply (SAWS) now pumps brackish water from an aquifer, desalinating the water before supplying to customers (Davis, et al, 2015).

Cyclical drought conditions in Texas have prompted statewide concerns over water supply issues. A number of local reservoirs and aquifers have been depleted of their supply due to the excessive water demand. As Texas continues to experience explosive population growth, water supply for municipal users has become a priority. It should be noted that drought conversely results in increased water usage, as landscape irrigation usually increases as residents combat the lack of natural rainfall. When Texas experienced detrimental drought in the 1950's, it became apparent that regulatory bodies should be created to enforce water restrictions. The following table shows the percentage of the state experiencing drought since 2000, with each level of drought being represented by a darker shade of color.

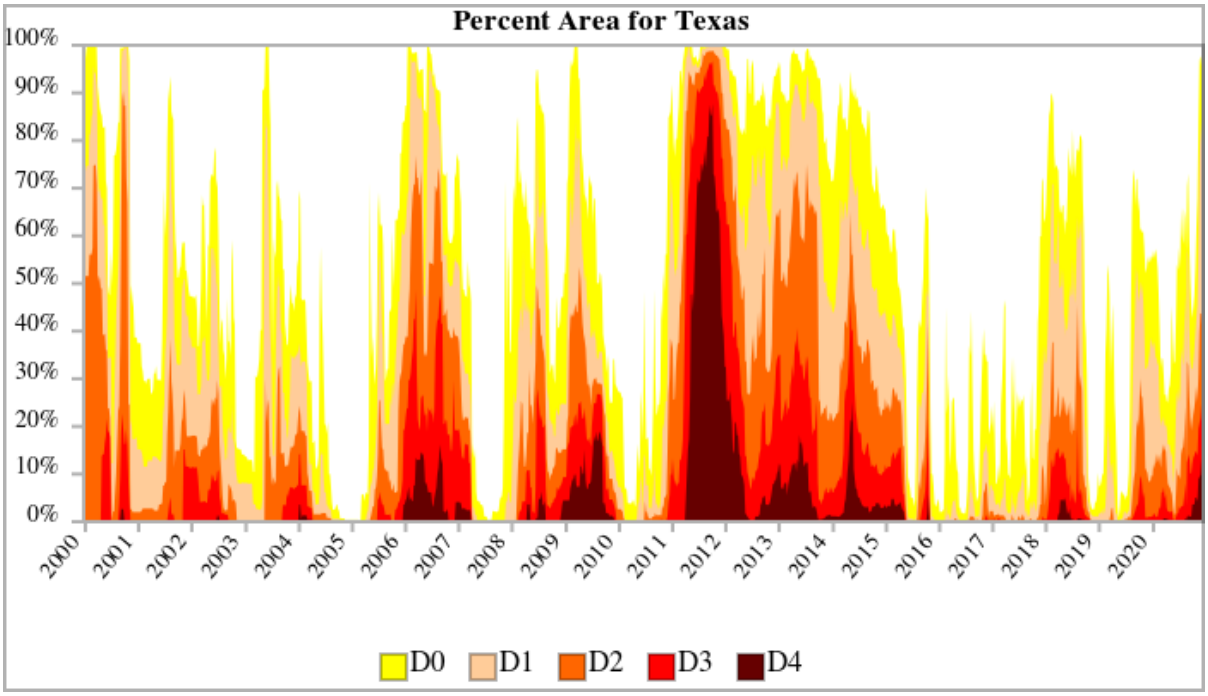

Figure 1.3 History of Texas Drought, www.drought.gov

D0 – Abnormally Dry

D1 – Moderate Drought

D2 – Severe Drought

D3 – Extreme Drought

D4 – Exceptional Drought

The Texas Water Development Board (TWDB) was created in 1957 in response to this catastrophic drought. The TWDB offers assistance in water planning, data collection and dissemination, and financial assistance for water projects. Recurrent drought conditions are common in Texas, and in 2011, the state experienced record losses in irrigated agriculture and power production due to water shortages (Roach, 2013). How water is allocated based on user rights continues to be a contentious issue between irrigators, municipalities, power production companies, and industrial users.

Surface water (lakes, reservoirs, and rivers) in the State of Texas is a state held resource. Water users may apply for a surface water rights permit with the Texas Commission on Environmental Quality (TCEQ), and must submit a Water Conservation Plan (WCP) to TCEQ every 5 years if they are allocated more than 1,000 acre-feet (an acre foot of water is defined as a sheet of water, one acre in area and one foot in depth) for non-irrigation use, or 10,000 acre-feet for irrigation use (TWDB website). The TCEQ has mandatory requirements for Water Conservation Plans, while the Texas Water Development Board has recommendations in the form of Best Management Practices (BMP) on what the WCP should include based on the user category (municipality, irrigator, wholesale water suppliers, etc.).

Texas has adopted a bottom up program of water conservation measures. Local cities/districts/counties report to their respective Regional Water Planning Group their water usage, expected water availability, and water conservation measure for future years. There are currently 16 Regional Water Planning Groups (RWPG) in the state of Texas, encompassing 15 River Basins. These groups were implemented by Senate Bill One in 1997 legislation to plan for future water supply and demand due to projected growth in population.

Managed water flow in these river basins range from more than 6 million acre-feet to just under 200,000 acre-feet. As we see continued growth of our state population, we also need to consider how water will be supplied to future generations. Educational outreach with the general public to teach conservation, paired with municipal, agricultural and industrial efforts to decrease water use and finding solutions for future water supplies are the solution to this burgeoning problem.

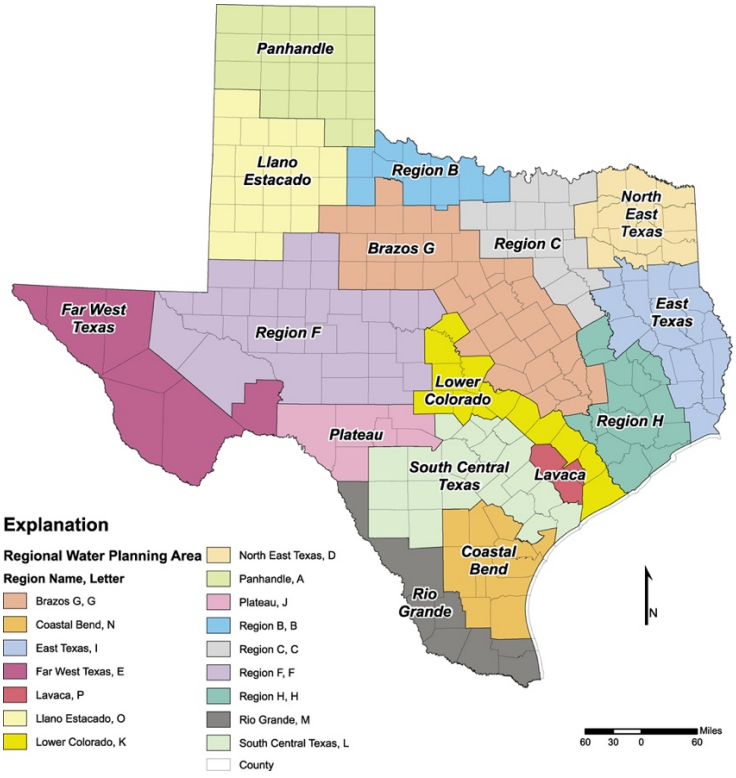

Figure 1.4 Map of Regional Water Planning Groups, Texas Water Development Board

Research Purpose

The purpose of the applied research project is to gauge the Water Conservation Plans of Central Texas Municipalities against the Best Management Practices of the Texas Water Development Board. Continued oversight of water conservation in Texas is necessary to ensure there will be adequate water supply for future populations. This applied research will gauge the contents of Central Texas Municipalities water conservation plans, utilizing content analysis.

The Texas Water Development Board issues voluntary Best Management Practices for municipalities for efficiency measures. Specifically, each BMP will be measured against the content of the water conservation program adopted by the respective municipality. The researcher will also apply learnings from prior theses and Applied Research Projects conducted on the subject of water conservation in Central Texas. The BMPs issued by the TWDB are strictly voluntary, and it is expected that the Water Conservation Plans will not be 100% compliant with the recommendations. The lack of inclusion of the Best Management Practices could be due to varying reasons, i.e. lack of revenues for implementation of BMP or not being an effective conservation measure for the particular city to implement.

Chapter II: Literature Review

Components of an effective Water Conservation Plan

Chapter Purpose

The purpose of this chapter is to discuss the components of an effective water conservation program that will ensure appropriate and effective measures are adopted to guarantee adequate future water supply. Water Conservation Programs utilized by municipalities in Texas were assessed to determine compliance with Best Management Practices recommended by the Texas Water Development Board.

Introducing a model Water Conservation Program

Elements of a successful Water Conservation Program based on ideal categories are found in Table 2.1. The Best Management Practice categories listed below were referenced directly from the Texas Water Development Board recommendations for municipalities. Conservation measures range from passive efforts (replacement of deteriorating infrastructure causing waste of water, to progressive rate structures, landscaping incentives, custom conservation rebates, etc.).

Table 2.1 Conceptual Framework

Title: Gauging Water Conservation efforts of Municipalities against Best Management Practices set forth by the Texas Water Development Board **Purpose:** Adequate future water supply depends upon appropriate planning at city, county and regional levels. The State of Texas utilizes a bottom to top system when compiling data for water conservation studies. Municipalities, water improvement districts and other large water users report information to the river authorities, who then supply a Water Conservation Plan to the state government for a State Water Plan to be compiled. This study will compare the Best Management Practices recommended by the TWDB against the information included in the Water Conservation Plans supplied by Municipalities.	
Ideal Category	**Supporting Literature**
1. Conservation Analysis and Planning	Blount (2011); Edwards (2019); Green (2008); Pincetl (2019)
1a. Conservation Coordinator	
1b. Cost-Effective Analysis	
1c. Water Survey for Single-Family & Multi-Family Customers	
1d. Customer Characterization	
2. Financial Category	Blount (2011); Chesnutt (2019)
2a. Water Conservation Pricing	
2b. Wholesale Agency Assistance Programs	
3. System Operations	Baird (2011); Cairns (2018); Leauber (2020)
3a. Metering of All New Connections and Retrofit of Existing Connections	
3b. System Water Audit and Water Loss Control	
4. Landscaping Conservation Recommendations	Contreras (2008); Green (2008); Petrosillo (2019); Warner (2016);
4a. Athletic Field Conservation	
4b. Golf Course Conservation	
4c. Landscape Irrigation Conservation and Incentives	
4d. Park Conservation	
4e. Residential Landscape Irrigation Evaluations	
4f. Outdoor Watering Schedule	
5. Education and Public Awareness	Amahmid (2019); Sanchez (2020); Stelzer (2014)
5a. Public Information	
5b. School Education	
5c. Public Outreach and Education	
5d. Partnership with Nonprofit Organizations	

6. Rebate, Retrofit, and Incentive Programs	Lee (2013); Lee (2013); Pincetl (2019);
6a. Conservation Programs for Industrial, Commercial, and Institutional Accounts	
6b. Residential Clothes Washer Incentive Program	
6c. Residential Toilet Replacement Program	
6d. Showerhead, Aerator, and Toilet Flapper Retrofit Program	
6e. Water Wise Landscape Design and Conversion Programs	
6f. Custom Conservation Rebates	
6g. Plumbing Assistance for Economically Disadvantaged Customers	
7. Conservation Technology	Algarni (2018); Fleming (1969); Glick (2011);
7a. New Construction Graywater	
7b. Rainwater Harvesting and Condensate Reuse	
7c. Water Reuse	
8. Technical Assistance & Outreach	Olsen (1987);
8a. Prohibition on Wasting Water	
8b. Conservation Ordinance Planning and Development	
8c. Enforcement of Irrigation Standards	

Conservation Analysis and Planning

An effective and well-planned conservation program does not just happen overnight. Essential elements must be analyzed to determine what best conservation measures best fit each municipality. Establishing a goal for water use reduction by means of conservation needs to be the first step, followed by formulating plans to achieve those numbers through various conservation measures, then finally implementation of the policy. Reduced per capita and household water consumption are critical to meet the water demands of projected population growth, and minimize the necessity of acquiring additional water supply, treatment and system expansion costs (Blount, p. 4).

1a. Conservation Coordinator

While a Conservation Coordinator is required for retail public water utilities with at least 3,300 service connections, TWDB has listed suggested functions of the position as part of a programs BMPs. Designation of a qualified Conservation Coordinator would guarantee a vested interest in compliance with BMPs recommended by the TWDB. This position should also be responsible for collecting data from residential and commercial connections, and disseminating the correct data to state agencies. Utility water conservation (water efficiency) coordinators have several points of interface with customer service and finance departments and depend on CS (customer service) and finance staff for before- and after-billing data to document reductions in water use from water conservation programs (Green, 62).

1b. Cost-Effectiveness Analysis

The extent and breadth of the program should be reflective of what can reasonably be afforded by the municipality. To invest revenues into a program that will return no cost savings would prove to be uneconomical. The expenses expected to be spent on the program should be compared against the "costs of conserved water" or the expenses that would be associated with exploring a new source of water supply. Users have many potential conservation options, but they will first undertake the cheapest measure… (Edwards, 436). By lowering the volume of water consumed a municipality can expect to have a decrease in revenues, but will also benefit from reduced costs in the following areas: water rights and permits, treatment, transportation and storage, and reduction in wastewater treatment related costs (most likely the biggest cost savings).

1c. Water Survey for Single-Family and Multi-Family Customers

By conducting a survey of households with irrigation systems, and older houses with inefficient water fixtures, the municipality can determine whether there is sufficient need for assistance in households with older fixtures, or lack of knowledge on common practices to conserve water in the household (benefits are twofold: both the municipality and the residence will result in lower water use, in effect saving money from decrease in consumption). Water surveys should be conducted with both single family and multi-family users, with the highest volume of water consumers being the first to be surveyed.

1e. Customer Characterization

When conducting a water use survey, analysis should be conducted to learn how water is used in varying service areas, what trends are present in neighborhoods depending upon lot size, age of residence, and common knowledge or lack of water use knowledge of the residents. By utilizing a customer characterization, a municipality can prioritize BMP selection. Not all BMPs will be applicable in all municipalities, potentially causing superfluous costs. For example, conducting an irrigation survey in an area that will mostly have xeriscaping installed would not yield a cost savings. The households in this area will not be using irrigation systems to water their yards. Likewise, for residences that use less than 20,000 gallons of water per month, due to low volume of water use for irrigation, savings will likely not be very much.

Financial Category

2a. Water Conservation Pricing

To encourage lower water consumption, a tiered pricing schedule should be adopted that will result in lower water usage. This BMP can be applied to both water consumption and sewer treatment pricing. In order for the tiered pricing structure to be successful, water users should be

educated on the pricing structure so they will be knowledgeable on the volume of their water usage. Municipalities should include public involvement when developing the price structure to assure the goals of the BMP will be attained. The Los Angeles Department of Water and Power implemented tiered water rates in their price structure in 1992, with impressive reductions in consumption (Chesnutt, 25-26). The increase in population did not result in a proportionate increase in water usage, providing substantial data to support tiered rates being a successful BMP when striving for reduced consumption.

Volumetric water charge	*Gallons Used*	*Per 1,000 Gallons*
for usage above 0 Gallons	0 to 2,000	$2.50
	2,001 to 6,000	$3.00
	6,001 to 10,000	$3.25
	10,000 to 15,000	$4.50
	Over 15,000	$5.50

Figure 2.1 Sample of tiered water rates, Sonterra Municipal Utility District

2b. Wholesale Agency Assistant Programs

Some municipalities are also considered a Wholesale Municipal Water User Group, depending upon to whom they sell potable water. This BMP is designed to offer aid to wholesale utility customers, who then sell water to customers. Financing for this type of program can be built into the pricing structure as a specific fund to benefit the wholesale water users. As discussed previously, a tiered rate structure should also be built in the pricing for the wholesale water user.

System Operations

3a. Metering of All New Connections and Retrofit of Existing Connections

A clear aim of water metering is that people use water conservatively in the home (Cairns, 413). It is assumed that all water connections would be metered, but it can be possible that an older Municipal Water User Group may have connections that are not metered, thus resulting in water consumption that is not accounted for. Meters should be appropriately sized for the volume of water to be used; incorrectly sized meters can result in either miscalculation of water usage, or malfunction of the meter installed causing water leaks. Meters do not have an infinite life span and should be changed out regularly according to manufacturer specifications to avoid inaccurate tracking of water usage. Recommendations are also made that multi-family residences have a meter for each unit, to more accurately track usage.

Figure 2.2 Image of water meter, Neptune brand

3b. System Water Audit and Water Loss Control

Water Audits are required to be conducted annually for any public water utility with more than 3,300 connections by Texas Water Code Section 16.0121(b). Water system audits and water loss programs are valuable methods of tracking all water usage for a municipality. There are listings of indicators in a water audit and water loss control program that should be included; a few of them are real loss, apparent loss, and unavoidable annual real loss. Real loss is water loss

from leaks and system water pressure that is too high. This type of loss is not beneficial to any part. Apparent loss is from data errors, or inaccurate meters. Revenue is not generated from these types of loss. Unavoidable annual real loss is the lowest level of real loss (in theory) that could exist in a system even with all potential water leak control measures in place, without considering the cost effectiveness of the water leak control measures.

As aging infrastructure fails across the nation, audits and water loss control can help to limit the loss of revenue for municipalities (Baird, 23). A rational approach to introducing water loss control would be to divide the metered area into districts and conduct analysis on current and historical flow in these areas. By comparing historical use to current use, coupled with any new metered connections and the expected demand or usage from the new connections, underground or previously undetected leaks are easier to identify and repair before there is substantial water loss (Leauber, 12).

Landscaping Conservation Recommendations

4a. Athletic Field Conservation

Many municipalities will operate athletic fields as part of their services offered to residents. Athletic fields use copious amounts of water to maintain the fields, and should only be irrigated in areas where essential. Determining the square footage of area to be maintained will establish how much water should be utilized for the field.

4b. Golf Course Conservation

There has been a recognized strong relation between water use and golf courses, which can assume a positive or negative connotation depending on the landscape context (Petrosillo, 2216). Golf courses maintained by municipalities would be an ideal area in which to reuse water. Again, square footage of areas needing to be maintained should be determined in order to not use

excessive water on recreational services. Irrigating should be done in a manner so as not to exceed the amount of water that can be absorbed by the ground, otherwise runoff will occur and water will not be conserved as needed.

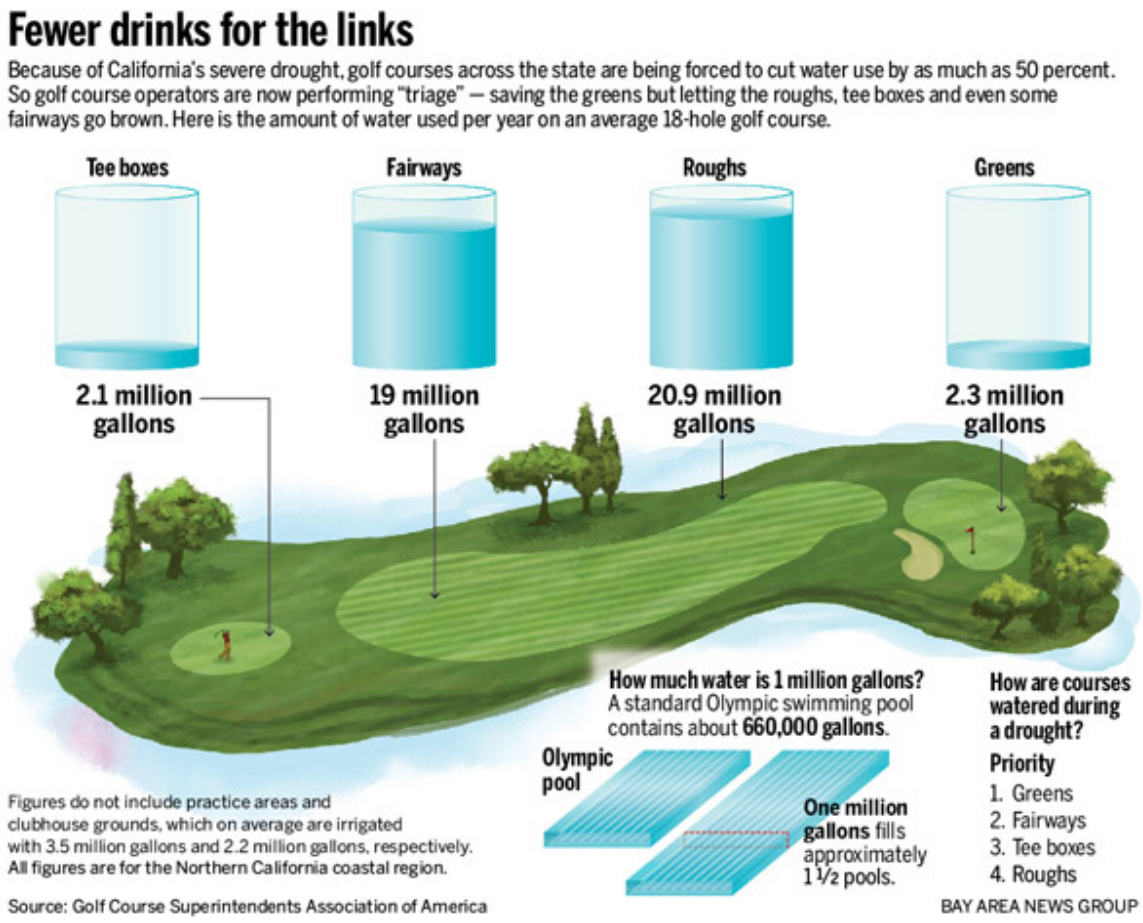

Figure 2.3 How many gallons needed to water golf course annually

4c. Landscape Irrigation Conservation and Incentives

Culture in the United States (US) places a high value on green lawns and lush residential landscapes (Warner, 240). The emphasis on green yards leads to high irrigation water use, an unnecessary use of a precious resource. The landscape irrigation conservation and incentives BMP should be utilized with municipalities that have a large percentage of residences with automated landscape irrigation systems. According to TWDB, if the ratio of summer usage (high irrigation season) is more than 1.6 to the winter usage (low irrigation season), this BMP will

most likely prove beneficial to adopt as part of the water conservation program. Runoff due to overwatering and evaporation from irrigating during the hotter times of the day results in wasted water resources and leads to damaged municipal infrastructure, leading to increased costs to maintain streets and drainage features.

Figure 2.4 Image of lawn before and after xeriscaping

4d. Park Conservation

Municipalities that manage parks or pools should have specific measures in place as to not overuse water in these specific locations. Use of native species of plants and xeriscaping the park can result in significantly reduced volumes of water required to maintain the aesthetic features of public outdoor recreation areas. In an effort to lead by example, municipal parks should utilize native, drought-tolerant plants. The City of San Juan Capistrano in California implemented a measure similar to this when they created demonstration gardens throughout the city that showcased plants native to the area (Contreras, 1).

4e. Residential Landscape Irrigation Evaluations

During summer months, outdoor irrigation systems can use more than 60% of water used per household each day, and much of this water is wasted due to runoff from overwatering, or malfunctions in components of the irrigation system. Municipal staff being available to address concerns regarding high water bills, violations of water schedule (if applicable), and/or over watering concerns would prove to be a valuable asset.

4f. Outdoor Watering Schedule

Many municipalities use outdoor water schedules only as a response to drought, however, having a year-round permanent schedule would have a significant impact on lowering water demands. Extensive public education and training on proper irrigation techniques would prove beneficial in ensuring residences complied with the schedule. Additional education on native species requiring less water and efficient irrigation practices would assist in the success of the schedule, possibly with less resistance from residents.

Education and Public Awareness

5a. Public Information

This BMP would inherently become part of a water conservation program, as residents are typically the largest water user group and benefits would not be realized without decrease in water usage by this group. Changes in customer behavior will not be realized without frequent reminders. The province of Esmeraldas, Ecuador utilized a unique technique of public murals to reach out to residents about the importance of conserving water. The country has a rich history of vibrant artistic expression, and using murals proved to be an efficacious means of educational outreach (Sanchez, 2).

5b. School Education

School related educational programs should be tailored to the appropriate grade level, and should increase in complexity from grade school to high school. Knowledge of water saving habits are often disseminated at home also, and can offer both short term and long-term water savings.

Education programs can be developed to include science, mathematics, social studies and history. "…there is potential for the early education sector to model community education for water conservation. Consequently, increasing attention is being given these days to the education of children and youth on water related topics." (Amahmid, 179).

Activity: Check Your Water Meter

Water utilities, the companies or organizations that provide running water to our homes, keep track of how much water a family uses each month or season with a water meter. Your home's water meter is a device that measures how much water flows into your house. Water meters are usually located outside, either under a metal cover on the sidewalk or in a box outside the house.

See the example of a water meter to the right. The numbers in the boxes show how much water has been used since the last reading. Meters show water use in either gallons or cubic feet (or ccf, a hundred cubic feet). 1 cubic foot of water = 7.48 gallons.

One way to discover if your home has leaks is to check your water meter before and after a two-hour period when no water is being used. Here's how: Check the meter and write down what it says. Then be careful not to flush the toilet, run the faucet, or use any water for at least two hours. At the end of two hours, check the water meter again. If the meter does not read exactly the same, you probably have a leak. Note: If your water meter is in cubic feet, the leak may not register within two hours unless it's a very large leak.

- Where is the water meter located at your house? _____
- What unit of measure does your water meter use? (Circle one) Gallons *or* Cubic Feet

Figure 2.5 Environmental Protection Agency school worksheet sample

5c. Public Outreach and Education

Public outreach and education are necessary for a successful water conservation program. Sharing water conservation tips and strategies with those in the applicable service area will result in lowered water consumption, and realized monetary savings. To achieve the goal of water conservation, education should present an overall picture of available water resources in the community, expected future availability coupled with expected future usage. By quantifying future demand vs. supply, users will have a clear picture of what changes need to be implemented.

5d. Partnership with Nonprofit Organizations

Depending on the metropolitan area, some municipalities will have access to non-profits that can assist with disseminating information to large numbers of water users among varying socioeconomic groups. “Realization is growing that solutions to ongoing and emerging threats to … water resources require collaborative approaches that engage scientists, policy makers, the private sector, and other stakeholders.” (Stezler, 671). Volunteers and employees of the nonprofits are given specialized training, and outreach to communities may occur through speaking engagements, neighborhood events, school projects, etc.

Rebate, Retrofit, and Incentive Programs

6a. Conservation Programs for Industrial, Commercial, and Institutional Accounts

Conservation efforts should not be targeted only to residential users, but all water user groups within a municipality. Industrial, commercial and institutional users can account for vast volumes of water usage, and education on how to decrease usage can greatly benefit them in terms of expenses for water purchasing and sewer costs. A portion of the water conservation program can be specifically developed to target these users for the rapid achievement of conservation goals.

6b. Residential Clothes Washer Incentive Program.

By offering incentives to those who replace older, less efficient units with higher efficiency clothes washing machines, both the business and municipality can expect to experience lower water consumption levels overall. Both residential and commercial water users would benefit from this portion of the water conservation program.

6c. Residential Toilet Replacement Program

Older toilets using high gallons per flush should be replaced with more efficient, low water flush toilets. As estimated by the TWDB, expected gallons saving per flush could be nearly 2 gallons per flush depending upon the age of both replaced unit and the newly installed unit. Municipalities with at least 20% of homes built before 1995 would find conservation savings from implementing this BMP. In a similar study conducted on the Miami-Dade County retro-fit program, results showed toilets had the highest potential in water savings (Lee, 2533).

6d. Showerhead, Aerator, and Toilet Flapper Retrofit Program

Similar to the BMP discussed in the previous section, showerhead, aerator and toilet flapper retrofit programs are small changes that can show significant savings in water usage. These two BMP incentive programs are often offered in conjunction with another, and should be utilized where more than 20% of homes were constructed prior to 1995. A survey conducted of households that participated in a retrofit program offered by Miami-Dade County, Florida indicated that households successfully reduced water consumption, as a result of both the retrofit program and increased education on water consumption (Lee, 686).

6e. Water Wise Landscape Design and Conversion Program

This BMP should be utilized by municipalities that have 20% or more residential customers that use more than 20,000 gallons per month, or use twice as much water in the summer as in the winter. The parameters set forth previously ensure effectiveness of the BMP. If less than 20% of residential customers use less than 20,000 gallons of water per month, there may not be an effective amount of water conservation to be realized. The municipality would offer aid to these water users in converting their existing landscape to a water wise landscape.

This BMP would involve plant selection, and utilize various principles of water wise landscaping. Careful follow up would be necessary to ensure excess irrigation does not waste water. Voluntary conservation actions may not have sufficient public support, especially when program goals conflict with social expectations or the need for change is uncertain (Pincetl, 211). Municipalities wishing to implement this BMP should do so cautiously, as public aesthetic desires typically trend toward lush, green yards that require consistent irrigation. This BMP would not prove beneficial without an immense amount of public outreach and education regarding the sustainable benefits of xeriscaping.

6f. Custom Conservation Rebates

Custom Conservation Rebates would apply to industrial, commercial, and institutional customers only, as they use such large volumes of water. The cost benefits applied to the customer would need to be rebated at the rate the actual cost of water to the municipality. A municipality should create various rebate options for the consumer to choose from, so they may make a choice that will be most beneficial to them.

6g. Plumbing Assistance for Economically Disadvantaged Customers

Benefits for this BMP would be twofold – reduced consumption for the municipality, and reduced bills for the customer. The municipality must first ensure there is sufficient need for this BMP within their service area, otherwise the reduced consumption goals will not be met. The previously mentioned Customer Characterization BMP can assist a municipality in determining if there are a sufficient number of economically disadvantaged households that will meet federal poverty requirements.

Conservation Technology

7a. New Construction Graywater

Graywater is water from washing machines, bathtubs, showers, and handwashing sinks. Because this water does not have to be treated, it can be utilized for irrigation and to water the foundation of residences. This BMP can also be utilized for both single family and multi-family residences. Due to increased usage of low flow showerheads, faucet aerators, and increased washing machine efficiency, the quantity of graywater is declining. Captured greywater can also be utilized for toilets while also putting less demand on water treatment and electrical capacity (Glick, 41). Some municipalities may have adopted strict codes regarding the use of greywater, which could explain the potential lack of compliance with this BMP.

7b. Rainwater Harvesting and Condensate Reuse

This BMP can be utilized by residences, industrial, commercial, and institutional water users. By targeting this specific BMP, municipalities can reduce peak demand usage through extensive customer education. Many larger municipalities will offer rainwater barrel programs to their residents, to assist with the upstart costs and to encourage participation. Condensate reuse can produce additional benefits to a municipality, resulting in both decreased water consumption and decreased costs associated with storm water treatment or wastewater treatment.

Figure 2.6 Examples of barrels for rainwater harvesting

7c. Water Reuse

Documents more than a half-century old have addressed the issue of water reuse and drought in Texas, making recommendations even then that water conservation/reuse is an issue needing to be addressed (Fleming, 1564). Reuse must be approached carefully, due to the restrictive treatment methods required based upon the manner in which the water is meant to be reused. Human contact will need to be limited if used for landscape irrigation, cooling towers, manufacturing process water, and non-contact recreational use.

Technical Assistance & Outreach

8a. Prohibition on Wasting Water

To ensure a successful water conservation program, water users should be offered incentives to encourage compliance with the water conservation program the municipality has adopted. The municipality would enact and enforce adopted ordinances to prohibit water wasting activities such as over watering, sprinkler system leaks, decorative fountains that do not take advantage of water reuse, etc.

Residents who comply with such water conservation efforts will be less inclined to do so if they see neighbors who do not conform to the same standards. Enforcement of an ordinance prohibiting the waste of water may be difficult to achieve, depending upon staffing levels and which department assumes responsibility for patrolling and writing of citations. Municipalities should garner support of their respective court to ensure that violators will have appropriate fines assessed according to the ordinance.

8b. Conservation Ordinance Planning and Development

Ordinances should be planned to reduce long term water usage, not just as a response to drought conditions. In a 1987 study, 61% of respondents indicated they believed water

conservation implementation should be required by city ordinance (Olsen, 62). Extensive customer base education will be necessary to garner the required support from the community in order for the program to be successful without much resistance. Residents and the municipality should work together to determine the goals to be achieved, and then the best manner in which to meet the goals.

Many factors should be considered, such as the age of the existing residences, how many new residences are expected to be constructed, are there both manufacturing and industrial water users in the service area, is a golf course present, are schools present, etc. Determining the makeup of existing water users and expected water users will help determine what attainable goals should be set.

8c. Enforcement of Irrigation Standards

Texas Commission on Environmental Quality has strict design standards for irrigation systems in the state of Texas. By adopting current building codes, and working with city officials, municipalities can ensure the irrigation systems being installed are efficient and will work well for the residential or commercial property. Texas has a strong licensing program for irrigators, and rules set forth by the Texas Administrative Code are most effectively enforced at the local level with education, permits, and ordinances.

Chapter III: Methodology

Chapter Purpose

The intent of this chapter is to describe the techniques used to evaluate the Water Conservation Plans of municipalities against the Best Management Practices set forth by the Texas Water Development Board. Five (5) municipalities in the Austin metropolitan area were chosen based on their population size estimated by the most recent census. Four of the five cities are within a 30-mile radius of Austin, with the furthest being the City of Temple at an estimated 70 miles distance from Austin. The City of Temple was chosen to maintain appropriate population estimates to match the other four cities more centrally located near Austin. The Water Conservation Plans were analyzed to establish which portions of the BMPs were being utilized by each municipality in their respective plan. Additionally, this chapter includes the operationalization table, along with the strengths and weaknesses of the methodology.

Research Setting

Comparative analysis of content was the research method utilized for this research project. Content analysis as defined by Bryman is "an approach to the analysis of documents and texts (which may be printed or visual) that seeks to quantify content in terms of predetermined categories and in a systematic and replicable manner." (Bryman, 2008). Comparative analysis is not intended to prove correlation, but rather to produce evidence of similarities or patterns in the data analyzed. Documents were obtained from each municipal website, or sought out directly from the municipal department responsible for publishing the Water Conservation Plan. As previously mentioned, the municipalities were chosen based on their location in the Austin metropolitan area and their estimated population in the most recent census.

Research Procedure

The City of Austin is the capital of the State of Texas, located slightly southwest from the geographical center of the state. Austin has a population just shy of one million people, with the metropolitan area surpassing two million. As shown in Table 3.1, this research includes municipalities with similar populations, ranging approximately from 62,000 to 79,500. Of the five cities chosen, four are within 30 miles of Austin, with the City of Temple being an outlier at nearly 70 miles.

Table 3.1 Municipal Data

Municipality	**Population**	**Distance from Austin**
Cedar Park	79,462	20.7 miles
Georgetown	79,604	28.2 miles
Leander	62,608	26.7 miles
Pflugerville	65,380	17.8 miles
Temple	78,439	67.8 miles

Data supplied from US Census website 11/14/2020

All of the municipalities chosen are required to submit Water Conservation Plans based upon either their water procurement methods or the quantity of water connections they have (surface water right users or those with more than 3,300 connections). Because the municipalities are similarly populated and geographically located near each other, it would be reasonable to expect their water conservation efforts are also similarly structured.

The intent of choosing similarly structured water conservation plans was to give a brief snapshot into conservation measures from a region of Texas that is not in an extreme climate condition. West Texas has extreme drought conditions, while East Texas typically has sufficient amounts of rainfall each year to sustain water usage. The Central Texas area was chosen due to its moderate annual rainfall, and high temperature range.

The Water Conservation Plans were found on each municipal website and downloaded, with the exception of the City of Pflugerville. The water conservation plan for this city was adopted by city ordinance, and thus was difficult to find utilizing normal search methods. The author sought out the appropriate municipal department to request a copy of the plan be emailed directly to her for the purposes of the project. The analyzed plans ranged from 7 pages in length (City of Cedar Park) to 64 pages (City of Georgetown). The Water Conservation Plans for each city were physically read by the author to determine which components of the BMPs were included.

Strengths of Content Analysis

Content analysis is considered to be a "very transparent research method" (Bryman, 2008). Follow up studies or replications are very easily conducted based on this method of data analysis. As requirements for BMPs change over time, further research could be conducted to indicate continued compliance in the Water Conservation Plans. Content analysis is also a highly flexible research method, as "it can be applied to a wide variety of different kinds of unstructured information (Bryman, 2008).

Weaknesses of Content Analysis

"Documents differ quite widely in regard to their standardization of format" (Bailey, 1987). Because there is not a standard form for creating a water conservation plan, the structure of each document can vary greatly. An inherent weakness of content analysis is the varying interpretation by different readers, leading to a subjective understanding of facts.

Chapter Summary

The methods chapter provided information on data collection, data analysis, and strengths & weaknesses of the content analysis methodology. In addition, the research setting, and operationalization table were also included.

Table 3.2 Operationalization Table

Title: Gauging Water Conservation efforts of Municipalities against Best Management Practices set forth by the Texas Water Development Board **Purpose:** Adequate future water supply depends upon appropriate planning at city, county and regional levels. The State of Texas utilizes a bottom to top system when compiling data for water conservation studies. Municipalities, water improvement districts and other large water users report information to the river authorities, who then supply a Water Conservation Plan to the state government for a State Water Plan to be compiled. This study will compare the Best Management Practices recommended by the TWDB against the information included in the Water Conservation Programs adopted by Municipalities.			
	Research Method	Source of Information	Degree of Evidence
1. Conservation Analysis and Planning			
1a. Conservation Coordinator	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None
1b. Cost-Effective Analysis	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None
1c. Water Survey for Single-Family & Multi-Family Customers	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None
1d. Customer Characterization	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None

	Research Method	Source of Information	Degree of Evidence
2. Financial Category			
2a. Water Conservation Pricing	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None
2b. Wholesale Agency Assistance Programs	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None
3. **System Operations**			
3a. Metering of All New Connections and Retrofit of Existing Connections	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None
3b. System Water Audit and Water Loss Control	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None

	Research Method	Source of Information	Degree of Evidence
4. Landscaping Conservation Recommendations			
4a. Athletic Field Conservation	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None
4b. Golf Course Conservation	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None
4c. Landscape Irrigation Conservation and Incentives	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None
4d. Park Conservation	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None
4e. Residential Landscape Irrigation Evaluations	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None
4f. Outdoor Watering Schedule	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None

	Research Method	Source of Information	Degree of Evidence
5. Education and Public Awareness			
5a. Public Information	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None
5b. School Education	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None
5c. Public Outreach and Education	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None
5d. Partnership with Nonprofit Organizations	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None

	Research Method	Source of Information	Degree of Evidence
6. Rebate, Retrofit, and Incentive Programs			
6a. Conservation Programs for Industrial, Commercial, and Institutional Accounts	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None
6b. Residential Clothes Washer Incentive Program	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None
6c. Residential Toilet Replacement Program	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None
6d. Showerhead, Aerator, and Toilet Flapper Retrofit Program	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None
6e. Water Wise Landscape Design and Conversion Programs	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None
6f. Custom Conservation Rebates	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None
6g. Plumbing Assistance for Economically Disadvantaged Customers	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None
7. Conservation Technology			
7a. New Construction Graywater	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None
7b. Rainwater Harvesting and Condensate Reuse	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None
7c. Water Reuse	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None

	Research Method	Source of Information	Degree of Evidence
8. Technical Assistance & Outreach			
8a. Prohibition on Wasting Water	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None
8b. Conservation Ordinance Planning & Development	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None
8c. Enforcement of Irrigation Standards	Document Analysis	Municipal Water Conservation Plans	Full/ Partial/ None

Chapter IV: Results

Chapter Purpose

This chapter presents the findings of the analysis of municipal Water Conservation Plans in Central Texas. The analysis judged the content of each plan against the Best Management Practices created by the Texas Water Development Board. Objective review of the plans was conducted to determine which components of the BMPs were included in each WCP. The findings are divided into the following sections to match the categories created by the TWDB: Conservation Analysis and Planning, Financial Category, System Operations, Landscaping Conservation Recommendations, Education and Public Awareness, Rebate/Retrofit and Incentive Programs, Conservation Technology, Technical Assistance and Outreach.

Conservation Analysis and Planning

Table 4.1 Conservation Analysis and Planning

	Full Evidence	Partial Evidence	No Evidence
1a. Conservation Coordinator	Cedar Park, Georgetown, Leander, Pflugerville (80%)	Temple (20%)	
1b. Cost-Effective Analysis			Cedar Park, Georgetown, Leander, Pflugerville, Temple (100%)
1c. Water Survey for Single-Family & Multi-Family Customers			Cedar Park, Georgetown, Leander, Pflugerville, Temple (100%)
1d. Customer Characterization	Cedar Park, Georgetown, Temple (60%)	Leander, Pflugerville (40%)	

Results pertaining to conservation analysis and planning are discussed in this section. Of the 5 municipalities observed, 80% indicated full evidence of a Conservation Coordinator position within their plan, with 20% having partial evidence. Conservation Coordinators are a vital component of a successful Water Conservation Plan for cities; having a dedicated member on staff helps to ensure realization of planning efforts. Two municipalities explicitly used the precise term, 2 others referred to a position functioning in this capacity, and 1 municipality made vague reference to a title responsible for the plan.

None of the studied plans made mention of a Cost-Effective Analysis. It may be practical to assume that there was some level of cost-effective study done prior to implementing any water conservation plans; otherwise, a municipality may not have sufficient revenue to account for the increased expenses. Georgetown's plan indicated they would conduct a cost-effective analysis in 2019. It can be expected that their next published Water Conservation Plan will include this component.

None of the cities had included a Water Survey for Single-Family & Multi-Family Customers. Again, Georgetown indicated this element would be completed in 2020 and should be included in their next publication. Water surveys offer a view of typical water fixtures in older homes and water usage in households with an irrigation system. Because many of these cities have experienced recent population growth, it can be assumed that many households would have water conservation fixtures already in place per local adopted building codes.

Of the plans studied, 60% made mention of customer characterization (Cedar Park, Georgetown, Temple), while 40% did not have this element present (Leander, Pflugerville). Utilizing customer characterization to determine which areas of the city would benefit most from water surveys and custom water conservation suggestions would prove most valuable. Areas that have mostly xeriscaping in place of traditional lawns would most likely not see benefits from irrigation conservation tips.

Financial Category

Table 4.2 Financial Category

	Full Evidence	Partial Evidence	No Evidence
2a. Water Conservation Pricing	Cedar Park, Georgetown, Pflugerville (60%)	Leander (20%)	Temple (20%)
2b. Wholesale Agency Assistance Programs	Pflugerville (20%)		Cedar Park, Georgetown, Leander, Temple (80%)

Financial components of an effective water conservation plan are discussed in this section. Water conservation pricing is a tiered pricing plan in place to encourage using a reduced amount of water. The more water that is consumed, the more the customer will be charged at increasingly higher rates. Cedar Park, Georgetown and Pflugerville (60%) had full evidence of a tiered price plan, Leander (20%) had partial evidence, and Temple (20%) had no evidence. It is worth noting that of the 3 cities that had full evidence, these are more closely geographically located to Austin and surrounding cities that may be more proactive in water conservation policies. Pflugerville was the only city to specifically mention assistance for wholesale agencies (20%), with the remaining cities (80%) making no indication of this component. Many of the cities may not have wholesale agencies purchasing water from them, which would rationalize why evidence of this element is so low.

System Operations

Table 4.3 System Operations

	Full Evidence	Partial Evidence	No Evidence
3a. Metering of All New Connections and Retrofit of Existing Connections	Cedar Park, Georgetown, Leander, Pflugerville, Temple (100%)		
3b. System Water Audit and Water Loss Control	Cedar Park, Georgetown, Leander, Pflugerville, Temple 100%)		

All of the municipalities studied had full evidence of both Metering of All New Connections and Retrofit of Existing Connections, and System Water Audit and Water Loss Control. Effective and correct metering of water consumed is a crucial portion of developing a water conservation plan, but also predicting revenues for a city. Ad valorem taxes (property taxes) and utility fees are the typically the highest revenue generators for municipalities. Conversely, with water conservation measures there would also be a reduction in utility revenues that each municipality would need to account for. Water meters should be changed out according to manufacturer standards, typically after a specified amount of time used or a specific number of metered gallons. Water meters that are used past these guidelines typically do not correctly track water usage, leading to incorrect data being collected. To supplement the effectiveness of a water meter program, a Water Audit and Water Loss Control component can also expose potential losses, resulting in water savings. These elements are similar to a financial statement, without which it would be difficult to determine where loss of revenue is occurring.

Landscaping Conservation Recommendations

Table 4.4 Landscaping Conservation Recommendations

	Full Evidence	Partial Evidence	No Evidence
4a. Athletic Field Conservation	Cedar Park, Georgetown, Pflugerville (60%)		Leander, Temple (40%)
4b. Golf Course Conservation	Cedar Park, Georgetown, Leander (60%)	Temple (20%)	Pflugerville (20%)
4c. Landscape Irrigation Conservation and Incentives	Georgetown, Pflugerville (40%)		Cedar Park, Leander, Temple (60%)
4d. Park Conservation	Cedar Park, Georgetown, Temple (60%)		Leander, Pflugerville (40%)
4e. Residential Landscape Irrigation Evaluations	Georgetown, Pflugerville (40%)		Cedar Park, Leander, Temple (60%)
4f. Outdoor Watering Schedule	Georgetown, Pflugerville (40%)	Cedar Park, Leander (40%)	Temple (20%)

Three out of the five cities observed (Cedar Park, Georgetown, Pflugerville) indicated they had some type of Athletic Field Conservation component in place, with Leander and Temple showing no indication of this component. Similarly, 60% also showed indication of Golf Course Conservation (Cedar Park, Georgetown, Leander), with the remaining two cities either

showing limited evidence (Temple) or giving no indication of the practice (Pflugerville). These two practices are similar in nature, both being large expanses of grass needing excessive amounts of water to keep conditions suitable for use.

Landscape Irrigation Conservation and Incentives had 40% of cities with full evidence from Georgetown and Pflugerville, with the remaining three cities showing no evidence. This element has the potential to have the most profound effect on water conservation efforts as the climate in Central Texas does not naturally have an abundance of rainfall, and residences use copious amounts of water for lawn and landscape irrigation.

Park Conservation showed 60% of cities with full evidence (Cedar Park, Georgetown, Temple), and 40% with no evidence (Leander, Pflugerville). Dependent upon how parks were planned and developed, there may be limited need for water conservation in the two cities that had no evidence. Xeriscaping, native grasses, and plants could have been utilized when parks were being developed to decrease future dependence upon irrigation. Residential Landscape Irrigation Evaluations had 40% with full evidence (Georgetown, Pflugerville) and 60% with no evidence of being present (Cedar Park, Leander, Temple). Again, this element should be utilized to the fullest capacity to assist in decreasing the amount of water used solely for irrigation purposes.

Outdoor watering schedules were fully present in 40% of the plans (Georgetown and Pflugerville). Cedar Park and Leander had limited evidence of this component, and Temple made no mention at all. Watering schedules may be specifically outlined in the city code of ordinances, Drought Contingency Plan (another separate document required by TWDB and TCEQ separate from the Water Conservation Plan), or on the city website/social media accounts. Lack of

mention in the Water Conservation Plan specifically does not indicate there is not an outdoor watering schedule in place.

Education and Public Awareness

Table 4.5 Education and Public Awareness

	Full Evidence	Partial Evidence	No Evidence
5a. Public Information	Cedar Park, Georgetown, Leander, Pflugerville, Temple (100%)		
5b. School Education	Georgetown, Temple (40%)		Cedar Park, Leander, Pflugerville (60%)
5c. Public Outreach and Education	Cedar Park, Georgetown, Leander, Pflugerville, Temple (100%)		
5d. Partnership with Nonprofit Organizations		Georgetown, Temple (40%)	Cedar Park, Leander, Pflugerville (60%)

All of the plans studied made mention of both Public Education and Public Outreach and Education. Educating residents on water saving tips and smart water use is a vital component of a water conservation plan. It would be impossible to measure any success in water conservation without properly educating those who consume the highest amounts of water.

School Education showed 40% of full evidence (Georgetown, Temple), and 60% with no indication of evidence (Cedar Park, Leander, Pflugerville). Reaching out to school districts to

assist with disseminating water habits is a component that most municipalities should embrace. It is much easier to teach good habits from the start versus trying to re-learn habits at an older age.

Georgetown and Temple both had limited evidence of partnership with nonprofit organizations, and Cedar Park, Leander and Pflugerville all had no indication of this element in their Water Conservation Plans. Nonprofit organizations often have resources (grants, funding, larger audiences, etc.) that municipalities may not have access to and should be looked at as a means to expand the outreach for water conservation.

Rebate, Retrofit, and Incentive Programs

Table 4.6 Rebate, Retrofit and Incentive Programs

	Full Evidence	Partial Evidence	No Evidence
6a. Conservation Programs for Industrial, Commercial, and Institutional Accounts			Cedar Park, Georgetown, Leander, Pflugerville, Temple (100%)
6b. Residential Clothes Washer Incentive Program			Cedar Park, Georgetown, Leander, Pflugerville, Temple (100%)
6c. Residential Toilet Replacement Program			Cedar Park, Georgetown, Leander, Pflugerville, Temple (100%)
6d. Showerhead, Aerator, and Toilet Flapper Retrofit Program	Cedar Park, Pflugerville (40%)		Georgetown, Leander, Temple (60%)
6e. Water Wise Landscape Design and Conversion Programs	Pflugerville (20%)		Cedar Park, Georgetown, Leander, Temple (80%)
6f. Custom Conservation Rebates		Cedar Park (20%)	Georgetown, Leander, Pflugerville, Temple (80%)
6g. Plumbing Assistance for Economically Disadvantaged Customers			Cedar Park, Georgetown, Leander, Pflugerville, Temple (100%)

The first three components showed no evidence of being present in any of the Water Conservation Plans studied (Conservation Programs for Industrial, Commercial, and Institutional Accounts, Residential Clothes Washer Incentive Program, Residential Toilet Replacement Program). Industrial, Commercial and Institutional water user groups are some of the largest single water users in a municipality. Without using a cost-effective analysis (discussed in the first section of Chapter IV) to determine how to offset lost revenues from conservation programs in place for these user groups, it would be difficult to put in place a plan that would be both effective and advantageous to the municipality.

As discussed previously, many of these cities have experienced population growth only recently. It would not be expected that toilet or clothes washer replacement programs would be utilized very much as recent building codes call for efficient toilets to be used in new construction. Additionally, the Environmental Protection Agency (EPA) has federal guidelines in place for water usage in both toilets and clothes washing machines.

Both Cedar Park and Pflugerville had full evidence of a program to retrofit showerheads, aerators, and toilet flappers, while Georgetown, Leander and Temple had no evidence of this component in their plans. Again, this may be due to the majority of residential construction in these areas being so recent and not many residences being present that would need to take advantage of this resource. Pflugerville was the only city to have full evidence of a water wise landscape design and conversion program, with the remaining cities having no evidence of this element. Only 20% of cities reviewed (Cedar Park) had evidence of custom conservation rebates; the remaining 80% had no evidence of this component being present. None of the cities had a program in place to assist economically disadvantaged customers with plumbing.

Conservation Technology

Table 4.7 Conservation Technology

	Full Evidence	Partial Evidence	No Evidence
7a. New Construction Graywater			Cedar Park, Georgetown, Leander, Pflugerville, Temple (100%)
7b. Rainwater Harvesting and Condensate Reuse	Georgetown, Pflugerville (40%)		Cedar Park, Leander, Temple (60%)
7c. Water Reuse	Cedar Park, Georgetown, Leander Pflugerville, Temple (100%)		

None of the cities reviewed had evidence of requiring new construction greywater to be reused. Rainwater harvesting and condensate reuse was fully present in 40% of plans studied (Georgetown and Pflugerville) with the remaining 60% (Cedar Park, Leander, Temple) showing no evidence of being present. All of the plans reviewed showed full evidence of having components for water reuse.

Technical Assistance and Outreach

Table 4.8 Technical Assistance and Outreach

	Full Evidence	Partial Evidence	No Evidence
8a. Prohibition on Wasting Water	Cedar Park, Georgetown, Leander, Pflugerville (80%)		Temple (20%)
8b. Conservation Ordinance Planning & Development	Cedar Park, Georgetown, Leander, Pflugerville, Temple (100%)		
8c. Enforcement of Irrigation Standards		Georgetown (20%)	Cedar Park, Leander, Pflugerville, Temple (80%)

80% of the observed plans had full evidence of Prohibition of Wasting Water (Cedar Park, Georgetown, Leander, Pflugerville), with Temple having no evidence of the component being present. All of the plans had full evidence of Conservation Ordinance Planning & Development, inherently due to the nature of creating a Water Conservation Plan. Only Georgetown had partial evidence of Enforcement of Irrigation Standards, with the remaining cities (80%) having no indication of this element being present.

Chapter Summary

The results chapter provided a detailed review of the data, indicating which elements of the Best Management Plans were present in each cities' Water Conservation Plan. The results were broken down into percentages (shown in the tables), and then described further below the respective table. There was strong evidence present to indicate that the municipalities have embraced conservation measures and put thought into their plans to combat predicted future water shortages. There was recognized areas that could be improved upon in a few of the plans, while some of them provided more than adequate information, and one plan exceeded expectations in the amount of information included in their plan. The next chapter will discuss the implications of the results, how future research on this topic could be expanded upon, and what more can be done to ensure adequate water supply.

Chapter V: Conclusion

Chapter Purpose

The purpose of this final chapter is to examine and discuss the impact of the findings from comparing the Water Conservation Plans of five municipalities in the Austin metropolitan area against Best Management Practices created by the Texas Water Development Board. Chapter V components include: discussing the contributions of this research, a compilation of the key findings, offering recommendations to the municipalities for improvement, limitations of the research, and suggesting directions for expansion of the research in the future.

Research Contributions

One of the largest contributions of this research would be to the municipalities who wish to improve their water conservation efforts. By assessing where there is lack of participation, they would able to learn where the most effective improvement could be. Municipalities should implement intense efforts now in the areas that were lacking to conserve water for future growth. In addition, once they have implemented more of the elements, it would be sensible to analyze the amount of water savings they acquired, to determine the effectiveness of the added water conservation measures. Future policy changes from this research could be amendments to what components of a Water Conservation Plan are considered to be truly effective, resulting in more stringent application of the respective element.

Principal Findings

The results of comparison showed that, in general, the five municipalities had evidence of compliance with the Best Management Practices. The City of Georgetown had the most comprehensive plan, addressing nearly all of the suggested elements with either being presently included, or plans to introduce them at a later date. The plan for Pflugerville had similar results,

having close to the same percentages that the City of Georgetown had. The City of Pflugerville had the shortest plan in terms of pages, and it should be noted that Pflugerville's plan was in the form of an adopted ordinance, while the other four cities had a separate document constructed as their Water Conservation Plan. Cedar Park had fewer of the elements present than Georgetown and Pflugerville, yet more than Leander and Temple. Likewise, Leander and Temple's plans were also similarly constructed and showed the lowest number of elements included.

Table 5.1 Summary of Findings

	Full Evidence			**Partial Evidence**			**No Evidence**	
Municipality	Total Number of Elements	Percentage		Total Number of Elements	Percentage		Total Number of Elements	Percentage
Georgetown	18	58.06%		2	6.45%		11	35.48%
Cedar Park	14	45.16%		2	6.45%		15	48.39%
Leander	9	29.03%		3	9.68%		19	61.29%
Pflugerville	17	54.84%		1	3.23%		13	41.94%
Temple	9	29.03%		3	9.68%		19	61.29%

Areas for Improvement

Each municipality differs in areas that could be improved, i.e. there is not one central element that all five of the plans were lacking (with the exception of the retrofit programs as discussed previously). While all plans had some element of Conservation Analysis and Planning, none had conducted a water survey for customers. A water survey could prove to be an effective tool for customizing water (and fiscal) saving tips for water users. Neighborhoods that consistently use more water for irrigation could benefit from tips about native plants and grasses to decrease water usage, while also being informed about disadvantages from over-watering (ineffective water use, higher utility bills, damage to personal property and public property from excessive water use, etc.).

Neither Leander nor Temple had full evidence of water conservation pricing, which is a valuable component of municipal water conservation. Fiscal incentives to conserve water would probably be the most effective for municipalities, although analysis would need to be conducted to determine appropriate pricing to counteract the loss of revenue from lower water sales. The analysis of plans indicated a strong presence of water conservation or reuse on behalf of the municipalities in athletic fields and golf courses, yet less than half of the plans studied showed full evidence of an outdoor watering schedule. Using irrigation systems to water landscaping in the hottest part of the day leads to evaporation and an ineffective use of water. By limiting the times and days that an area can water, a municipality could expect to see decreased water use during warmer times of the year, when surface water evaporation is at the highest and lake levels decrease.

None of the municipalities indicated full evidence of partnering with nonprofit organizations. This element could prove to be a very successful tool for public outreach and education. If utilized well, the burden on the municipality could prove to be minimal while yielding effective results. Only one plan (City of Pflugerville) indicated the presence of water wise landscape design and conversion programs. This element, combined with the water survey previously mentioned, could have fantastic results in terms of decreasing water usage. Traditional subdivision lawns consist of grasses that require high watering, versus native grasses that are drought tolerant. A municipality could consult with a landscape engineer to provide advice on what plants or grasses could be best utilized for a particular area based on soil type, topography, and sun/shade hours in the day. Implementation of using new construction graywater would also prove beneficial to both the municipality and the resident. By using greywater to water foundations (to prevent cracking) or using it for a drip field for gardens (both

ornamental and vegetable/fruit), both the resident and municipality would see decreased water usage.

Limitations of Research

While the Water Conservation Plans should reflect all of the measures each municipality has in place, it can be expected that there are elements that are not included in the plan, yet being practiced by each municipality. By limiting the research to only the Water Conservation Plan, it is plausible that there are Best Management Practices in place, yet not specifically referenced in the plan. For example, a municipality may require condensate or greywater reuse in new construction by ordinance, which may not reflect in the Water Conservation Plan.

Discrepancies such as this would lead to more stringent research of each municipality to gain a more precise view of their comprehensive water conservation measures. Another limitation is the subjective interpretation of the reader. An intended inclusion of a particular BMP on the municipalities part could be misinterpreted by the reader, resulting in lack of consideration when analyzing the plan. The City of Georgetown included a table listing each of the elements, whether they were included or not, and a future date to be included if they were not currently part of the plan. Transparency of this sort leads to a simple understanding of their intent.

Future Research

Future research could involve the study of all municipalities in a particular county, or specific water region. It would be advantageous to have data from all users of one singular water source (i.e. Lake Georgetown, or Brazos River) to determine what efforts are being put forth as a large group to combat water loss, or excessive water use. Conversely, a study could be conducted to compare conservation efforts of municipalities from varying areas of the state. A study of

efforts in the arid region of West Texas compared to the wetter regions of East Texas could be another approach to understanding conservation measures as a whole in the State of Texas. Another option would be to revisit this same study in 5-10 years to determine what improvements have been made. Water conservation measures are continuously being updated to reflect the changing population, changing water availability and fluctuating water models. Continued diligence in water conservation research coupled with fluid measures to combat excessive use of water will provide the truest picture of what elements are most successful, and which need to be improved upon.

Chapter Summary

Chapter V discussed the impact of the findings from the results chapter, and gave suggestions as to what improvements could be made in the water conservation plans. Contributions to research and principal findings were briefly deliberated. The majority of the chapter focused on areas for improvement. This particular area was concentrated on due to the importance of continued progress in water conservation. It would be irresponsible for a municipality to adopt a plan and never update or expand conservation efforts based on water supply and future water models. Limitations of research and future research were also provided at the closing of the chapter.

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