TOWN OF HIGHLAND PARK, TEXAS: AN ASSESSMENT OF WATER USE AND CONSERVATION POTENTIAL

by

Jaime P. Murata

A directed research report submitted to the Geography Department of
Texas State University in partial fulfillment
of the requirements for the degree of
Master of Applied Geography
with a specialization in Resource and Environmental Studies

August 2019

Committee Members:

Dr. Timothy T. Loftus

Dr. Ronald R. Hagelman

Contents

Acknowledgements

I am so thankful to everyone involved in the process of obtaining my graduate degree and I am especially appreciative of the opportunity to work with my advisor, Dr. Tim Loftus and the Town of Highland Park for this, my directed research project. I am especially appreciative of Dr. Tim Loftus' wise collaboration and guidance, his kind support and constant encouragement, and for imparting his extensive water conservation knowledge to me. I would also like to show my gratitude to the Town of Highland Park executive staff: Mr. Bill Lindley, Town Administrator; Mr. Steven Alexander, Director of Administrative Services & Chief Financial Officer; and Ms. Kathleen Stewart, Director of Town Services for their support, coordination, and the opportunity to work with them on this project. I owe many thanks to other Town staff that we communicated with and numerous others in Texas and elsewhere that helped me achieve the project goals. Thank you also to my committee member, Dr. Ron Hagelman of the Department of Geography, for pushing me to apply my new skills and knowledge in real-world big-picture ways. For funding support to complete this project, I would like to acknowledge and thank the Town of Highland Park, The Meadows Foundation, and the Meadows Center for Water and the Environment, Texas State University through Dr. Tim Loftus.

Finally, I would like to thank my husband, Michael, for his endless support and encouragement throughout graduate school and to my parents for their push to further pursue water and environmental education to follow my dreams.

Table of Figures

Table of Tables

Introduction

The Town of Highland Park, Texas would like to take steps towards improving their water use conservation as a demonstration of community leadership. To do this, they have partnered with the Texas State University team (TSU) – Dr. Tim Loftus and the author as graduate research assistant – in a nine-month project to delve into the town's potential for reducing water use. The purpose of this research is three-fold:

1. Gather information about Best Management Practices (BMPs) applied to city- and town-owned properties for the purpose of conserving water from the following cities in Texas: Alamo Heights, Irving, Southlake, The Woodlands, West University Place, Westlake, and Westover Hills. Similar information was also gathered from Cary, North Carolina, Santa Fe, New Mexico, and Scottsdale, Arizona;
2. Develop a water use conservation program scenario that promises to reduce water use in Highland Park and will have the additional potential to improve the town's score as determined by the Texas Living Waters Project, Texas Water Conservation Scorecard (2016). The conservation program scenario will be developed with application of a water conservation planning tool;
3. Analyze WaterSmart-derived monthly water-use data to create new information that enables the Town of Highland Park to better understand recent water use and target water-use conservation.

Background

As population rapidly grows in Texas and climate change creates uncertainty and greater variability with droughts, floods, and their impacts on water-supply sources, water conservation is becoming a necessary practice in pursuit of more sustainable use of water. Moreover, our influences over water sources have a larger impact than just the immediate environment and populations served. The THP and its source of water – Lake Grapevine – are part of the Trinity River Basin which supports other small communities of Texas and feeds the fragile ecosystems that make up the estuaries and bays of the Texas coast (Figure 1). The THP can demonstrate leadership and fulfill an obligation to conserve water within their river basin to support other towns and ecosystems that lie downstream in their shared watershed.

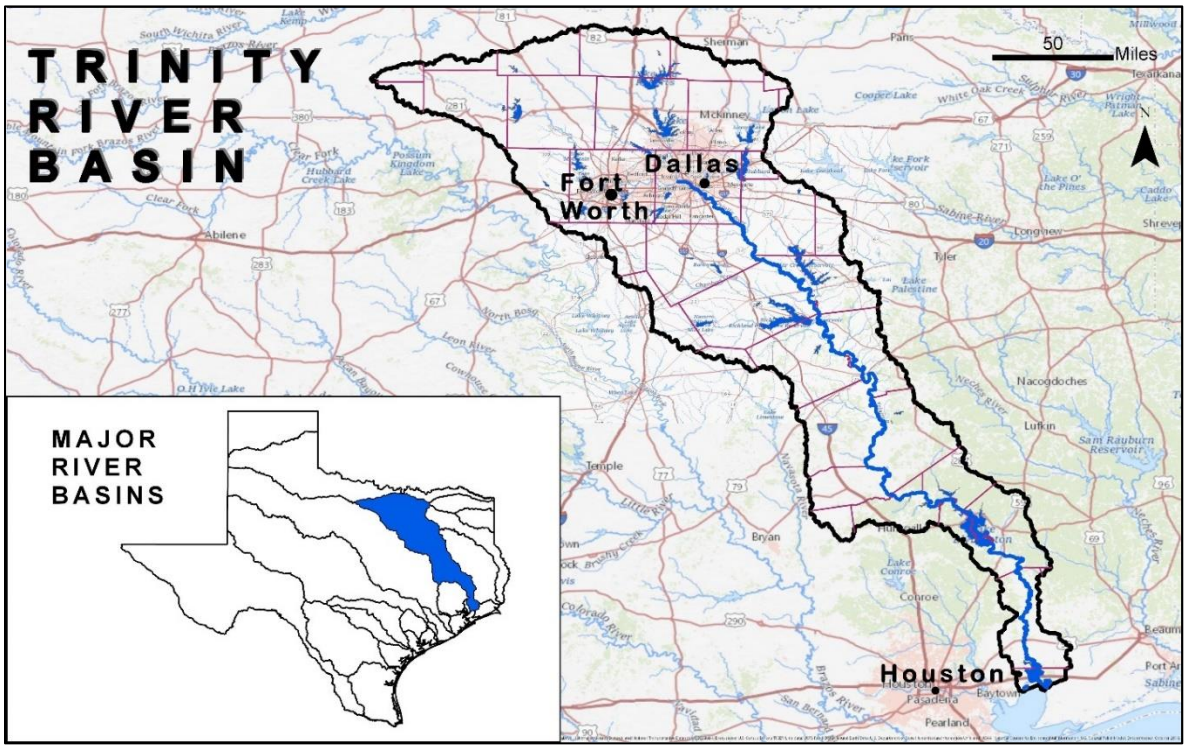

Figure 1. The Trinity River Basin reaches from north of Dallas to Galveston Bay

The Town of Highland Park (THP) is a compact 2.26 square mile town located 3 miles north of the center of Dallas (Figure 1; THP 2018). Its population was 8,564 as of the 2010 census with an increased estimate of 9,220 in 2017. A very affluent town, the THP's estimated median annual household income from 2013-2017 was $200,208 which is 3.5 times more than Texas' median household income of $57,051 (USCB 2018 American FactFinder; USCB 2018 Quick Facts).

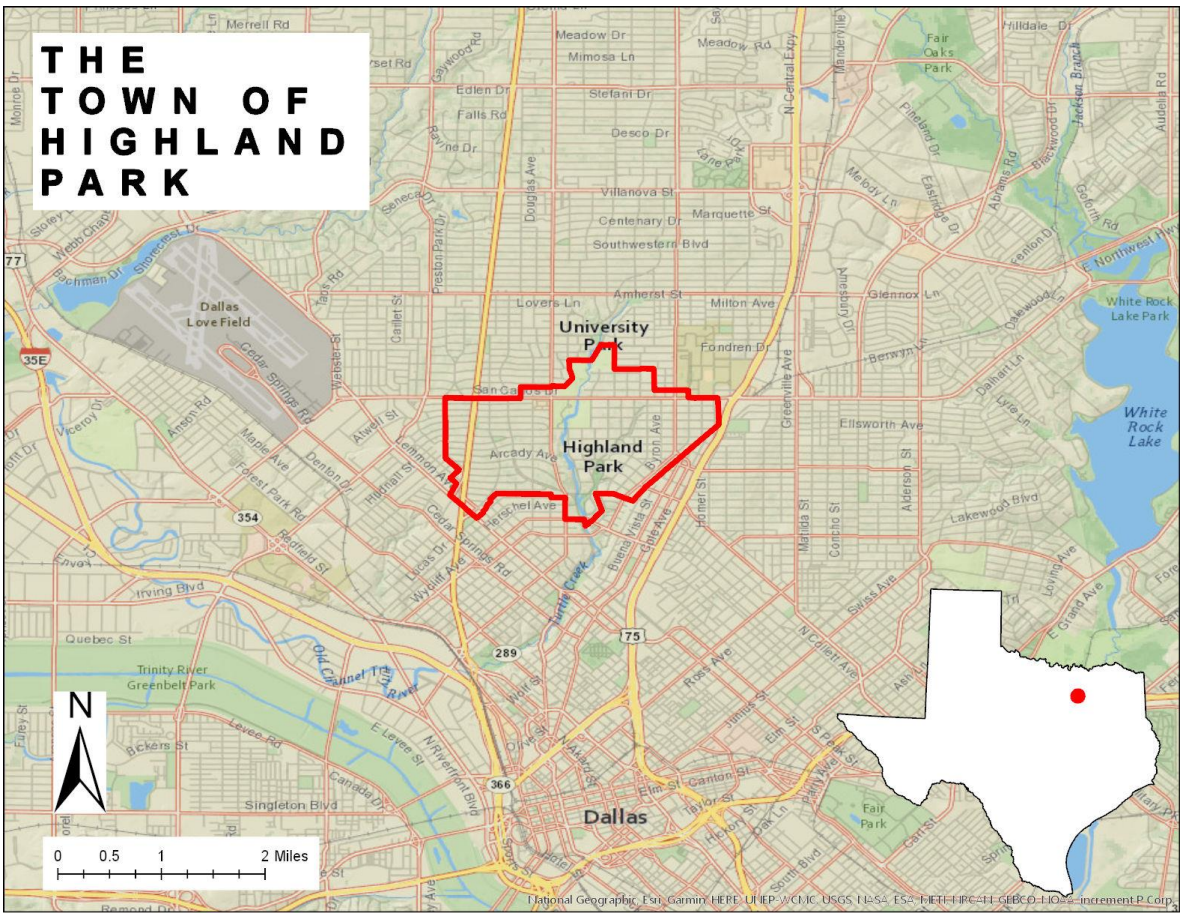

Figure 2. The Town of Highland Park, Texas

The THP acquires its water from the Dallas County Park Cities Municipal Utility District (the District). The District holds senior water rights in Grapevine Lake which is the sole source of supply for the THP (Maier 2014). The town's water use of 282 total gallons per capita daily (GPCD) and 325 residential GPCD[1] is very high compared to Texas' average single-family residential GPCD of 94 (Hermitte and Mace 2012; Loftus and Smith 2018). Affluent homes, as in the THP, tend to use more water than average both indoor and outdoor due to the general higher consumption of goods and services like hot tubs, fountains, and multiple-head showers (Vickers 2001).

The Town of Highland Park's garden-like atmosphere and high affluence has created a pattern of high-water use, especially outdoors for the upkeep of residential landscaping. In the

[1] From the Town of Highland Park's 2017 Water Conservation Plan Annual Report submitted to the Texas Water Development Board.

THP, Hermitte and Mace (2012) determined that 45 percent of total residential water use was due to outdoor use, while the average in Texas for outdoor use was found to be 31 percent. More current water use data, analyzed for the period January 2016 through April 2019 and discussed below, indicates a much higher percentage of outdoor water use in Highland Park relative to total water use.

Because the town has senior water rights to a reliable water source and they have less financial incentive to save water due to their relative wealth, encouraging a water use decrease can prove difficult. Inspiring water conservation, though, for various reasons such as an obligation to downstream communities in their watershed or to demonstrate leadership in environmental stewardship to other Texas communities may be the key to helping this high-water using community reduce their water footprint.

Literature Review

Water Use Reduction Potential

One way to save water is to improve appliance efficiency in which a new fixture provides the same service as a previous or current model but uses less water to do so. Water efficiency has improved in recent years in the U.S., especially through indoor fixtures. The Energy Policy Act of 1992 (Public Law 102-486; effective Jan. 1, 1994) improved water efficiency in homes by establishing federal standards for maximum flow rates for toilets, showerheads, and faucets. Residential water use has also decreased with the help of the Environmental Protection Agency's (EPA) voluntary WaterSense Program, which certifies products that use 20 percent less water than federal minimum rates while keeping or improving their quality of performance (NCSL 2015). Since its launch in June of 2006, through the end of 2018, WaterSense has helped save 3.4 trillion gallons of water and $84.2 billion in water and energy bills (USEPA 2019).

In Texas, water-use efficiency standards preceded federal standards. One year before the Energy Policy Act (EPAct) of 1992 was signed into law, the 72nd Texas Legislature passed the Water Saving Performance Standards for Plumbing Fixtures Act of 1992 (HB 2176 / SB 587), introducing rate requirements of high-efficiency fixtures that were mirrored by the federal EPAct. In 2009, the 81st Texas Legislature further strengthened their efficiency standards to surpass the federal EPAct standards (HB 2667; Loftus and Smith 2018).

Water conservation in Texas is implemented through the Texas Water Code Chapter 11 and through Title 30 Texas Administrative Code Chapter 288 that require certain entities to develop, submit, and implement Water Conservation Plans (WCP) every five years – submitted to the Texas Commission on Environmental Quality (TCEQ). A WCP requires each entity to set water reduction targets and select strategies to reach those goals. Such strategies include best management practices that can reduce water consumption by lessening water loss, improving water efficiency, and recycling or reusing water. These entities, such as municipal, industrial, agricultural, and mining water users are then required to submit updated annual reports of their plans to the Texas Water Development Board (TWDB) (TCEQ 2019). A Water Conservation Plan Annual Report (WCPAR) confirms the effectiveness of the WCP by ensuring its implementation through evaluation of program successes and needs (TWDB 2019).

The TWDB provides assistance in developing WCPs, offers conservation education, and has begun public outreach programs such as the "Water IQ: Know your water" website that educates Texans on water conservation and supports existing local conservation efforts. The TWDB takes part in and supports the Water Conservation Advisory Council which is made up of twenty-three members representing entities and interest groups for the purpose of establishing a forum to continue development of water conservation resources, progress, and expertise to benefit Texas (Save Texas Water 2019). Another collaboration of Texas conservation groups is the Texas Living Waters Project which works to push utilities to better conserve by creating a Water Conservation Scorecard. This Scorecard uses WCPs, water loss audits, and utility websites to appoint an annual score for 305 utilities, allowing the tracking of their conservation initiatives. This helps serve as a benchmark to encourage performance improvement and strengthening of water conservation goals (Walker 2019).

A pivotal study, *Residential End Uses of Water* (Mayer and DeOreo 1999) and its more recent update, *Version 2* (DeOreo et al. 2016), delved into water conservation research through

indoor water use which had not been previously pursued to that extent. These reports concluded that indoor water use per household has dropped in the US and Canada by 22 percent between their 1999 and 2016 studies. This 22 percent drop in household water use equals a reduction from 177 to 138 average gallons per household daily of indoor water use. In terms of individual water use, a 15 percent decrease occurred from the 1999 study to the 2016 study, from 69.3 GPCD to 58.6 GPCD. While the average number of people per household has slightly decreased, the reduction in water use is mostly due to improved water efficiency of clothes washers and toilets (DeOreo et al. 2016).

A more recent study similarly calculated the potential of water-use conservation, specifically in Planning Regions C and K of Texas, in *Estimating the Potential of Urban Water-use Conservation in Texas: A Pilot Study of Two Planning Regions* (Loftus and Smith 2018). That study determined that given fully efficient indoor technology implementation in 2014, water use would have decreased by 44 percent, from 61.9 to 35 GPCD. Likewise the *Residential End Uses of Water, Version 2* study suggests that in the case of 100 percent occurrence of higher efficiency household fixtures, indoor household water use would drop by 35 percent to reach indoor GPCDs lower than 40 in the U.S. and Canada.

Efficiency, however, differs from conservation as the latter conveys a more comprehensive suite of activities. Improving water efficiency means using less water to accomplish a task without any change in behavior related to that task. For example, a high-efficiency clothes washer continues to perform the function of cleaning clothes while using less water to do so. Water conservation furthers this idea by including all programs, policies, and practices with the goal of reducing water use. Conservation translates to using only the water we need in an effort to beneficially reduce water loss, waste, or use. Turning off the faucet while brushing teeth or replacing turf grass with native plants that require less water are examples of reducing water waste through conservation. Conservation programs strategically combine conservation incentives and measures. Incentive increases customer awareness of the need to save water through means of education, finances, and regulations. Conservation measures are the actual practices that reduce demand through hardware measures like installation of WaterSense-labeled fixtures or behavioral changes like watering lawns less frequently (Vickers 2001). DeOreo predicts that the implementation of mild to aggressive landscape conservation programs could decrease outdoor water use by an additional 20 to 50 percent (DeOreo et al. 2016).

The Future of Water Conservation in Texas

The rapid growth of Texas' population – expected to increase more than 70 percent from 29.5 million in year 2020 to 51 million by year 2070 – will require significant growth of the municipal water sector to serve the rising residential sector (TWDB 2016). Municipal water users will face the greatest increase in water needs from 2020 to 2070, going from 11 percent of total state water needs to 38 percent (TWDB 2016). Significant increases in water demand of over 30 percent growth from 2020 to 2070 are projected for seven of the sixteen regions in Texas. In region C, which includes the THP, the percent change of projected water demand is by far the highest, with an expected 71 percent increase in demand from 1.7 million acre-feet in 2020 to 2.9 million acre-feet by 2070 (TWDB 2016). In the case of another drought of record in Texas without the implementation of any recommended municipal water management strategies, Region C's potential water shortage would reach 125,037 acre-feet per year in 2020 and thirty-four percent, or 17.2 million of all Texans would have less than half of their needed municipal water supplies in 2070 (TWDB 2016).

Water conservation can be used toward helping to ensure water security for the state's population. The Texas State Water Plan recommends 5,500 water management strategies to provide 8.5 million acre-feet of additional water supplies to the state in year 2070. Of these water management strategies, conservation strategies are recommended for half (1,300/2,600) of the water user groups, which if implemented would account for 28 percent (2.3 million acre-feet per year) of all the recommended water management strategy volumes in year 2070 (TWDB 2016).

Higher water savings potentials are estimated by Loftus and Smith (2018) for Texas Regions C and K. Implementation of fully-efficient indoor fixtures in these two regions (one to which the THP belongs) could save over 214,000 acre-feet of water which far exceeds the almost 87,000 acre-feet expected from municipal conservation in 2020 by the regional plans (Loftus and Smith 2018). Their study suggests that more robust conservation practices including indoor efficient fixture replacements would be more effective than the anticipated conservation measures planned for these two regions as documented in the State Water Plan.

In regard to outdoor water use savings potential for the same two planning regions, Loftus and Smith (2018) estimate that by implementing a one-day per week watering restriction, Regions C and K could have saved from about 45,500 to 76,000 acre-feet of water in year 2014. Given both indoor and outdoor estimated water conservation potential, this study calculated that combined water savings could account for 52 to 58 percent of anticipated shortages in these regions.

With a price tag of $63 billion to implement all the plan's water management strategies, relatively inexpensive conservation is ideal. The least expensive recommended water management strategy types in 2070 are irrigation conservation and "other conservation", which entail changes to irrigation methods and equipment and savings associated with steam-electric, manufacturing, and mining conservation activities. Municipal conservation as suggested by the plan includes activities such as high-efficiency plumbing fixture installation, conservation pricing structures, and landscape irrigation restrictions. Collectively, these activities are set to save 204,000 acre-feet per year in 2020 and 811,000 acre-feet per year by 2070, statewide.

Charging water customers for the "full cost" of water service will help to achieve the goal of encouraging water resource conservation. Full cost includes prices that sufficiently cover revenue requirements for the utility's operation and maintenance, cover adequate supply costs, reflect environmental damage and impacts, and promote water conservation through a pricing signal (CMAP 2012). Conservation pricing can be done through rate structures, varying rates by customer class, billing frequency, and peak pricing (CMAP 2010). Rate structures can include cost-of-service requirements for the utility as well as pricing signals for customers and environmental costs to cover the impacts of water use.

The top four conservation rates structures are uniform rates, inverted block rates, seasonal rates, and marginal cost rates (Vickers 2001). In one study, *Regional Water Demand Scenarios for Northeastern Illinois: 2005-2050,* three water-demand scenarios evaluated how several factors and variable assumptions about them affect water demand in the 11-county regional planning area of northeastern Illinois into year 2050. In the Less Resource Intensive (LRI) scenario, the largest impacts on water demand in the public supply sector came from increasing future prices of water by 2.5 percent per year above inflation rates and increased conservation

trends. Results revealed that the price of water is a statistically significant variable in water use demand – as water rates increase, demand decreases (Dziegielewski and Chowdhury 2008).

In their 2018 study, Loftus and Smith calculated the average monthly consumption for Texas at 8,000 gallons per single-family residential household. This is based on 2.84 persons per household (USCB 2017) and a 94 GPCD (single-family residential) derived from Mace and Hermitte (2012). The study focused on the top 27 of 106 water service providers of Region C and Region K, which account for about 85 percent of 2014 system input volume in both regions. Since only one of the 27 was located in Region K, 26 utilities were from planning Region C, of which the THP is a part of. The calculated average monthly bill for the top 27 water service providers was $41.67[2]. The water bill includes fixed or minimum charges, meter size charges, and volumetric rates (Loftus and Smith 2018).

Advanced Metering Infrastructure

Advanced Metering Infrastructure (AMI) is a technology that provides interval meter data to water utilities and its customers. Interval water use data can be collected from customers every hour or more frequently and is transmitted through a communication network to a central collection point either daily or more often (Moore 2008). AMI systems consist of at least three components to fully function. First, the smart meter collects the interval water use measurements. Communications networks are then used to transmit large volumes of data from the meter to the utility. Finally, a meter data management system (MDMS) stores and analyzes the interval data, offering standard interfaces with information or control systems like billing systems and customer information systems (Moore 2008, USDOI 2016). The previous one-way Automatic Metering Reading (AMR) meters required either a daily or monthly reading through a hand-held device or a drive-by vehicle and resulted in monthly billing statements (Roche 2008). A suspected leak used to mean sending workers across the suspected area to search for the leak, while AMI now allows the accurate pinpointing of leaks (Rafter 2012).

By using these data and information effectively, municipalities are able to save water through improved maintenance and infrastructure repair. AMI allows them to pinpoint serious leaks through quicker alerts and more accurate location identification which means faster and more accurately targeted maintenance responses to such problems as a water main break rather than searching the whole system (Rafter 2012).

AMI's advantages to consumers can even further lower water consumption. Both customers and water utilities can fully benefit from direct two-way communication regarding their water use in terms of utility customer service and helping consumers understand their household water use. WaterSmart is such a software that acts as a middleman between consumers and utilities by enabling customer engagement and providing an analytics platform (WaterSmart Software 2019). Hourly and daily water use data enables customers to identify leaks or system damages, but also to their own water use patterns (Rafter 2012). Access to their real-time water use information can encourage behavioral changes to minimize waste of water.

Conservation Planning Tools

Conservation planning tools use software to help planners and decision makers such as utility managers and urban planners to gain new insights, visualizations, and interpretations of

[2] This average monthly rate was calculated from rates prevailing in 2017 or earlier.

their data. These advanced tools may come in many forms such as frameworks, models, or through Geographic Information Systems (APA 2011). As utility water loss recovery has become more important, a water loss audit methodology (AWWA 2016) and complementary software - the American Water Works Association (AWWA) Free Water Audit Software – enable utilities to better account for their water through billing and distribution to prevent nonrevenue water loss (Loftus and Smith 2018).

The Alliance for Water Efficiency (AWE) released their Water Conservation Tracking Tool (Tracking Tool) in 2009, free of charge to AWE members. Now in its Version 3.0, it is used by nearly 400 water utility users. The Tracking Tool is a Microsoft Excel-based model designed to help water utility managers develop and plan a water conservation program by using data collected from the utility system. The result shows potential water savings and benefit-cost accounting for a selection of pre-determined conservation activities. The AWE Tracking Tool helps develop long-range conservation plans, compare saving potentials, costs, and benefits between conservation measures and over time, and assess revenue requirement changes to the utility (AWE 2019).

The Texas Water Development Board's Municipal Conservation Planning Tool (TWDB Tool) was created with the help of AWE and its subcontractors in 2018. The TWDB Tool has the same purpose and similar, but not identical functionality as the AWE's Tracking Tool and allows for a more streamlined user experience as it comes with preloaded data for each Texas water utility (TWDB 2018). The study presented by the author used elements of both the AWE Tracking Tool and the TWDB Tool proving the value of conservation programs based on benefit-cost ratios and determining associated revenue requirement changes.

Methodology and Results

Goal #1. City Comparisons Report

Ten cities were selected or approved by the THP executive staff for investigation of their Best Management Practices (BMPs) related to municipal properties (Table 1; Appendix A). Six Texas cities of similar affluence to the THP were chosen by THP staff, while the remaining four were selected by the TSU team for their known water conservation leadership. A list of interview questions was then developed by the TSU team to determine how each city minimizes watering of their properties and how water conservation is promoted to the public and to local school districts. These five questions were posed by the TSU team in telephone interviews with each city[3]. Additional research using the information available on municipal websites was then conducted on the cities' water rates/structures, outdoor-watering ordinances, and public awareness efforts.

[3] A majority of interviewees could not answer the question, "how many acres or parcels of land are managed by the city?" and the question/responses, therefore, were omitted from this summary.

Table 1. Peer cities from Texas and elsewhere for limited comparison of water-use practices.

1	City of Alamo Heights, TX
2	City of Irving, TX
3	City of Southlake, TX
4	City of West University Place, TX
5	Town of Westlake, TX
6	Town of Westover Hills, TX
7	The Woodlands CDP, TX
8	Town of Cary, NC
9	City of Santa Fe, NM
10	City of Scottsdale, AZ

City Property Management

The following results include responses to two interview questions: "Do you manage any of these [city] properties as best practices or demonstration projects for your residents in terms of minimizing water use?" and "How often do you specify native or regionally-appropriate plants for purposes of minimizing watering requirements?" Of the water conservation strategies implemented by the ten cities for their own property management, seven use native or regionally-appropriate plants. As for irrigation, four do not (or barely) irrigate, four irrigate with reused water or captured rainwater, and two use artificial turf for sports fields. Put another way, very little potable water is applied to peer-city-managed landscapes. Also, seasonal time-of-day watering schedules are used by Irving, Santa Fe, and West University Place. West University Place also utilizes rain sensors to prevent overwatering.

Coordination between City and local ISD

In response to the question, "Thinking about promoting water conservation, what level of coordination occurs between the public works department and the local school district?", the interviewees provided answers in the following results. Five of the eight cities with public schools encourage water conservation through education by participating in career fairs at local schools or hosting conservation-related annual events for school-aged children. Other cities' efforts include classroom presentations and field trips. Santa Fe, New Mexico provides an outstanding example by hosting an Annual Children's Water Conservation Poster Contest, a Passport Program to 14 classes with a field trip of the water system and the city's water recycling, a Water Fiesta for all 4th graders in the city, and by taking part in Project WET (Water Education for Teachers) to help teachers incorporate water education in elementary and middle school curricula.

Water Consumption: GPCDs

The last interview question was "What is your city's current total GPCD (gallons per capita daily) and current residential GPCD?" It was discovered that the THP's residential and total GPCDs are higher than seven of the nine cities that have available GPCD data (Figure 3). The town with the lowest GPCD is the Town of Cary, North Carolina with a 46 residential GPCD and an 83 total GPCD in year 2018. Most cities studied have lower GPCDs than the THP with both Westlake and Westover Hills exceeding the THP's GPCDs.

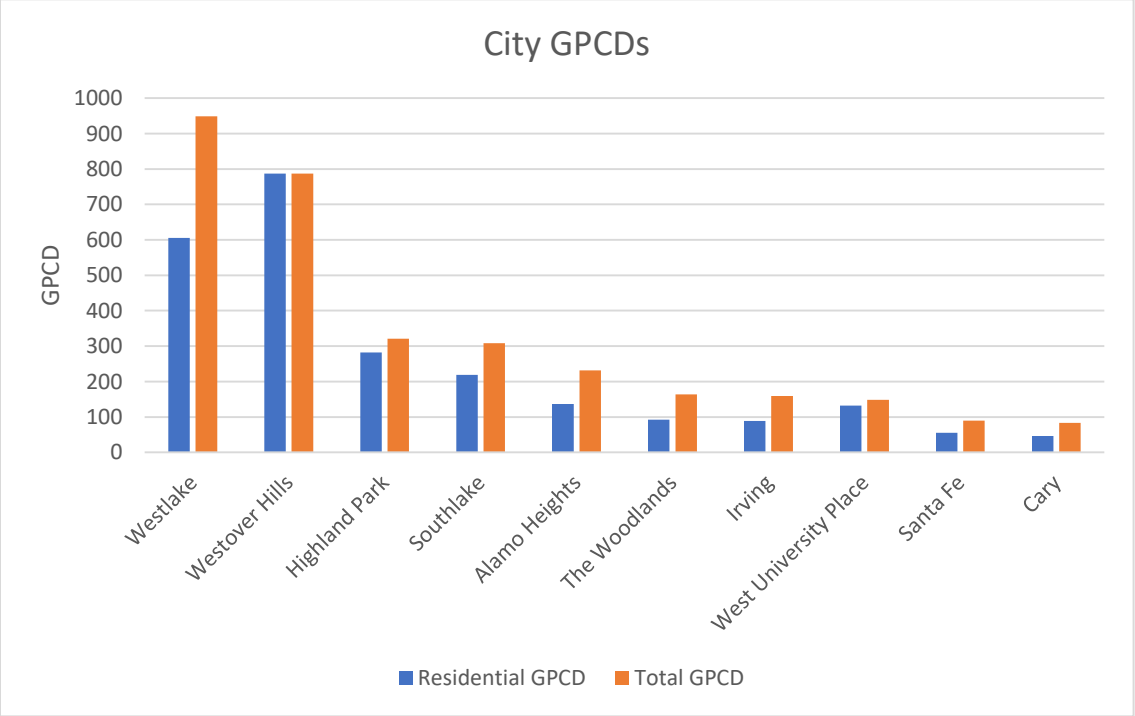

Figure 3. Comparison of total and residential water consumption: gallons per capita per day (GPCDs).[4,5]

Public Awareness/Campaign

To promote public awareness, a water-conservation campaign that features a memorable slogan along with substantive information and guidance, is a good start and four of the cities have taken this initiative. All ten cities and the THP use their city's website to promote water conservation with aspects from landscaping tips, blogs, educational videos, and links to other water-wise resources. The City of Irving has success passing out the Texas A&M AgriLife Extension's Top 100 Plants for North Texas Deck of Cards at events to promote water efficient landscapes. They also have a City Green Advisory Board to advise the City Council on "green" initiatives. Southlake, The Woodlands, and Scottsdale, Arizona advocate conservation through their demonstration gardens. The Woodlands and Cary, North Carolina encourage residential leadership through neighborhood competitions and block leader programs.

[4] Scottsdale, AZ was omitted from Figure 1 because insufficient data were supplied for determining their GPCDs.
[5] While the 2017 Water Use Surveys were used to calculate GPCD, different population estimates can be found elsewhere and thus, the population and related GPCDs are best considered provisional.

Outdoor-Watering Restrictions

Seven out of 10 of the cities have time-of-day watering restrictions, like the THP, but The Woodlands has exceeded these by forbidding watering from 6am to 8pm, year-round. While the THP's time restriction is only seasonal, five of the cities implement a time-of-day ordinance that is year-round to maintain a continuous water-conservation mindset. The THP currently matches the number-of-watering-days restriction of 5 of 10 cities by limiting watering to two days per week. Yet research conducted elsewhere shows that it is common for homeowners to irrigate their residential landscapes much more than necessary.[6] The WaterMyYard.org web-based resource, for example, indicates that for the week of June 17 to Sunday, June 23, 2019 at the address – 4700 Drexel Drive, Highland Park, Texas – zero inches of water is needed and thus, recommends "No watering required!" In other words, based on recent weather, no outdoor watering is necessary for this seven-day period. Watering requirements are updated weekly.

Water Rates/Rate Structures

The THP's water rates come out relatively average compared to the 10 cities studied. Their base charge of $17.41 is much less than the potential shown in Westlake's base charge of $50.40. High rates within the first tier of a multitiered water-rate structure is a strategy to promote conservation from the start which Southlake exemplifies with a first-tier rate of $40.58/1,000 gallons up to 2,000 gallons.[7] Higher prices in the second tier to encourage conservation with discretionary water use is another strategy applied by Santa Fe where the charge is $21.72/1,000 gallons for usage above 7,000 gallons of use during the drier months of the year.[8] While the THP's four tiers is the most common number of tiers in this comparison (7 of 10 cities), the size of the tiers is equally important for incentivizing conservation.

All but one of the nine cities that have tiered water-rate structures have a smaller or narrower first tier range than the THP which is 0-12,000 gallons. The cost for a residential ratepayer to use 8,000 gallons in one month[9] in the THP is $61.25, but four cities in our comparison have a higher price for that amount of consumption (Figure 4). Three of these four cities are located in Texas with similar affluence to the THP, while the five cities that have lower water-bill charges than the THP are mostly in wetter climates where scarcity potential is lower. Southlake has the highest cost for 8,000 gallons consumption at $108.34.[10] Each of the cities selected for comparison will be discussed in further detail below accompanied by a matrix of condensed results (e-Appendix G).

---

[6] See, for example, the Texas Water Journal, Vol. 6, No. 1 (2015), "Residential outdoor water use in one East Texas community) by T.R. Pannkuk and L.A. Wolfskill.

[7] Alternate strategies, depending on the socio-economic demographics of a municipality, keep the first-tier rate relatively low in order to make essential water use, affordable.

[8] Santa Fe, New Mexico has two seasonal water rates/rate structures: May-August (not-so-dry season) and September-April (dry season).

[9] Average monthly consumption of 8,000 gallons is presented in Loftus and Smith (2018) and is based on 2.84 persons per household in Texas (USCB 2017) and 94 gallons per capita per day consumption (single-family residential, statewide average) derived from Hermitte and Mace (2012).

[10] While not one of the cities evaluated, the City of Austin, known for its water conservation program, has a rate structure that places monthly water usage above 11,000 gallons in a fourth tier priced at $12.70/1,000 gallons. Low-income residents that participate in the Community Assistance Program will pay $11.51/1,000 gallons for usage above 11,000 gallons. Austin Water's water-rate structure features five price tiers. For more information, see https://www.austintexas.gov/sites/default/files/files/Water/Rates/ResidentialPublicRates_2019.pdf

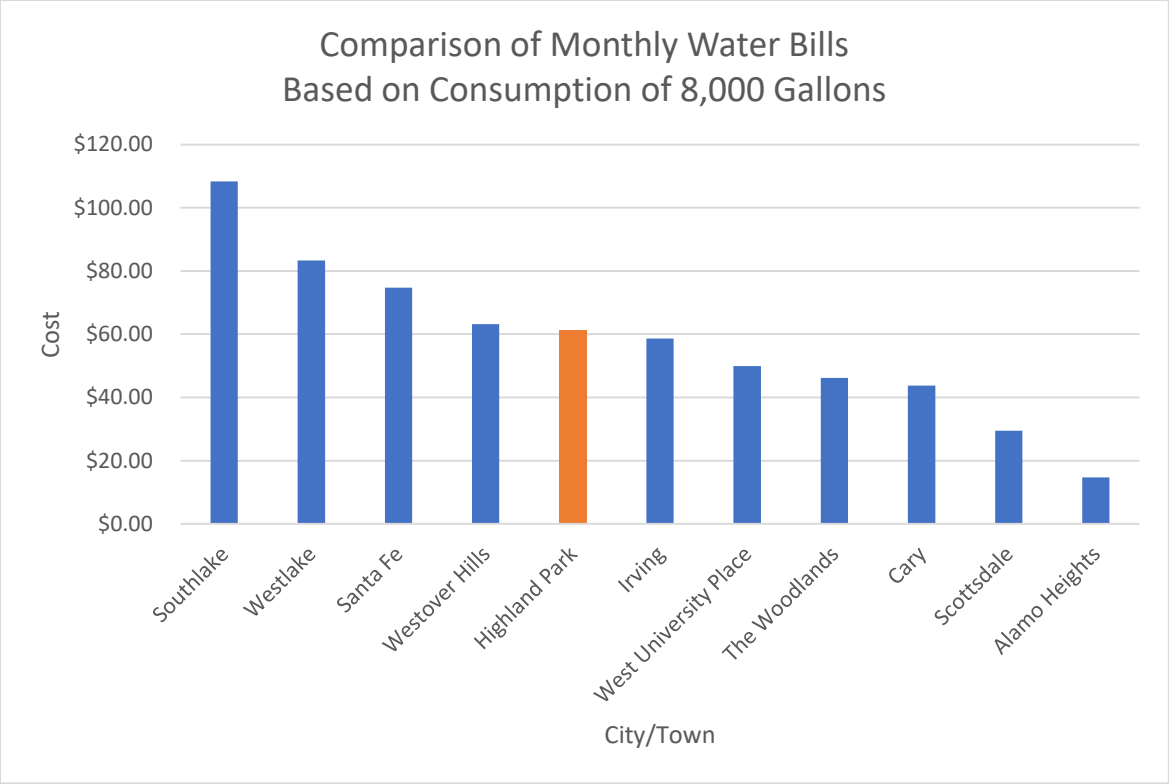

Figure 4. Comparison of residential water bills based on average monthly consumption.[11]

[11] The City of Santa Fe, New Mexico has two seasonal water rates where the higher rate applies during the longer dry season. The water bill featured here is an average of the two rates.

1. City of Alamo Heights, TX

a. Rate structure & outdoor watering ordinance:

The City of Alamo Heights is situated entirely within the City of San Antonio. Alamo Heights has a median annual household income of $110,980 and a population of 8,413[12]. Precipitation in this region is nearly 35 inches annually[13]. Of all ten cities examined in this report, Alamo Heights has the lowest water rates, a disincentive for conservation (Table 2). An average monthly bill for 8,000 gallons, including a minimal base charge of $3.00, is just $18.56[14]. Uniquely, the city charges its residents a Water Conservation Fee of $0.1369 / 1,000 gallons that funds conservation programs and other initiatives as part of the upcoming City's Water Conservation Plan (Alamo Heights, Texas 2018). Their year-round, time-of-day outdoor watering restriction allows irrigation from 8pm to 10am daily to reduce evaporative losses. Watering with a handheld hose, soaker hose, drip irrigation system or bucket is allowed at any time.

Table 2. Alamo Heights' water rate structure.

Tier/Other:	*Single-Family Rate Cost Per 100 Cubic Feet:*	*Multi-Family Rate Cost Per 100 Cubic Feet:*
Base charge (5/8" meter)	$3.00/month	$3.00/month
<500cf / <3,740g	$0.83	$0.83
501-1,000cf / 3,748-7,481g	$1.13	$1.13
1,001-2,300cf / 7,488-17,205g	$1.63	$1.63
2,300+ / 17,205g+	$2.7631	$1.63
Water Conservation Fee	$0.1024 per 100 cf / 0.1369 per 1,000 g	$0.1024 per 100 cf / 0.1369 per 1,000 g
Edwards Aquifer Authority Fee	$0.3309 per 100 cf / .4423 per 1,000 g	$0.3309 per 100 cf / .4423 per 1,000 g

b. Public awareness programs/campaign, city property management, coordination with town/local ISD:

To promote public awareness, Alamo Heights distributes annual promotional material to encourage conservation. They also list conservation tips on the city website. They support water conservation by leaving most of their city property as natural habitat or by using native plants. Of the 64 acres of common property maintained by the city, only three are irrigated. Alamo Heights' only coordination with the local school district is to provide promotional material encouraging conservation[15].

[12] (United States Census Bureau 2017) This reference is used for the population of each city in this report.
[13] (NOAA 2010) This reference is used for the average annual rainfall of each city in this report.
[14] New rates effective March 1, 2019 now result in a monthly water bill of $19.26, an increase of 3.77 percent from the rates originally used.
[15] Email interview with Pat Sullivan, Director of Public Works, City of Alamo Heights on 12/04/18

2. City of Irving, TX

a. Rate structure & outdoor watering ordinance:

The City of Irving is located northwest of Dallas with a population of 240,373 and a median annual income of 54,868. Annual precipitation is 36 inches. Although Irving's rate structure does not include a base charge, the first of the four tiers has a particularly high rate that could act as a base charge (Table 3). The cost for an 8,000 gallon per month water bill is $58.61. They do include a slight conservation signal for the top tier of water use with a small increase in rates during the summer months. Year-round, Irving has a two-day watering schedule determined by property address. The City also has seasonal time-of-day restrictions that do not allow irrigation between 10am and 6pm from April through October. Use of soaker hoses and hand-held hoses, however, is permitted during the restricted time period (Irving, Texas 2018).

Table 3. Irving's water rate structure.

Tier:	*Cost Per 1,000 Gallons:*
Base charge	N/A
0-3,000	$11.67 (includes 5/8" or 3/4" meter charge)
3,000-10,000	$4.72
10,000-20,000	$5.09
20,000+	$5.44 (from Oct. – May) OR $5.98 (from June – Sept.)

b. Public awareness programs/campaign, city property management, coordination with town/local ISD:

Irving has many active public awareness programs in place. Their "Think Green, Be Green" website offers everyday tips on how to be more environmentally minded with educational videos, water conservation tips, a link to Irving's "green classes," and rainwater harvesting instructions (Irving's Think Green Be Green 2018). The Think Green, Be Green website links to related water conservation webpages such as "North Central Texas Smartscape," the "Water, Use it Wisely" website, and TCEQ's "What You Should Know About Watering Your Yard." The website also presents "Irving's Garden for Wildlife Program" page. This program routes from a partnership with the National Wildlife Federation (NWF) to promote the NWF certified Wildlife Habitat Program that educates residents on easy ways they can support pollinators in outdoor spaces. They are using this program to work towards a nationally-recognized city that has signed the Mayors' Monarch Pledge.

Irving's city website also has a water conservation page with seasonal water conservation tips and other helpful resources that allow residents to contact the Water Conservation Coordinator, request a residential water audit, view the Water Management Plan, and access Irving's "Native Plant Guide" (Irving Texas 2018). As a part of their outreach efforts, the City of Irving will conduct a Water Conservation Program Lecture to all residents, homeowners' associations, and civic groups upon request. They also offer a courtesy residential irrigation system checkup to investigate a home's irrigation system and detect any leaks. Another public outreach program in Irving is WaterMyYard. In 2014 the city partnered with Texas A&M AgriLife Extension by installing weather stations that give watering recommendations for this region through the watermyyard.org program. As residents sign up, they receive weekly

customized emails with their watering recommendations based on the previous week's weather conditions (City of Irving Water Utilities 2014). The city also uses the Texas A&M AgriLife Extension's Top 100 Plants for North Texas Deck of Cards which feature the region's top one-hundred plants with the necessary water and care requirements to help locals produce a water efficient garden at their homes (Texas A&M 2018). These cards are popular with Master Gardeners and are passed out at events and irrigation checks to help residents choose water efficient plants based on their desires[16]. The city promotes these native and adapted drought tolerant species and conservation landscaping tips in articles locally. Winter conservation such as no irrigation at night or to dormant grass is promoted to the City's Green Advisory Board which advises the City Council on "green" initiatives. Irving has participated in Save Dallas Water's public outreach program of the Annual WaterWise Landscape Tour, which is a free self-guided tour for locals to see first-hand the feasibility and beauty of drought-tolerant gardens of participating homes and public gardens with a Master Gardener located at each station for assistance (Dallas Water Utilities 2018).

Irving has two methods to conserve water with its city-managed property. The city uses time-of-day scheduling for water conservation purposes. During the warmer months of April to October they do not water during the day. During the cooler months of November to March, they water during the day. Water reuse is a method of city property management in Las Colinas, a 12,000-acre, master-planned development within the City of Irving that includes four golf courses, luxury hotels, exclusive residential areas, and office buildings. One of the development's major features is extensive waterways, lakes and landscaped areas, but Dallas County Utility and Reclamation District (DCURD) provides them with non-potable reclaimed water. Thus, water is reused for irrigation of these areas and as evaporation make-up water (City of Irving Water Utilities 2014).

Irving has been coordinating with local school districts since 2008 to enable high school students to receive training and certification for two TCEQ occupational licenses: Wastewater Treatment Plant & Collection System Operators or Water Systems Operators. In 2008 the city made a deal with TCEQ to hold passed test grades until the students were of age to collect their licenses. In this program the City Water Utility trains the students and the school pays for them to take the license test. Also taught is job outreach and opportunities for the students in this field. The City Water Utility additionally participates in career fairs to teach about water conservation and job opportunities[2].

[16] Phone interview with Donna Starling, Water Programs Manager, City of Irving on 12/06/18

3. City of Southlake, TX

a. Rate structure & outdoor watering ordinance:

The City of Southlake is a suburb of Dallas/Fort Worth with a population of 31,824 and a median annual household income of $189,432. Annual precipitation in the area is nearly 38 inches. Southlake's rates and rate structure are unique in multiple ways, beginning with the fact that there are only two residential meter sizes - 1" and 2" - both of which are much larger than the average ⅝ or ¾ inch size (see Table 4). The 5 tiers send a conservation signal, especially the small size of the first tier at 0-2,000 gallons. The first tier is a relatively higher cost to account for no base charge. For the average water user of 8,000 gallons with a 1" meter, a month of water will cost $108.34[17] which sends an above average conservation signal. Southlake's watering restrictions also send a conservation signal with year-round time-of-day restrictions that prohibit irrigation between 10am and 6pm. They also designate two-day designated lawn irrigation determined by property address. Hand watering, drip irrigation, and soaker hoses, though, are allowed at any time (Southlake Water Utilities 2018).

Table 4. Southlake's water rate structure.

Tier: (1" meter)	*Cost Per 1,000 Gallons:*
Base charge	N/A
0-2,000	$40.58
2,001-10,000	$4.53
10,001-25,000	$5.21
25,001-40,000	$5.99
40,000+	$6.89

b. Public awareness programs/campaign, city property management, coordination with town/local ISD:

Southlake has a plethora of public awareness programs to promote water conservation in their city. There are demonstration gardens at the Bob Jones Nature Center and Bicentennial Part, both of which are maintained by the Tarrant County Master Gardeners on behalf of the city[18]. The Southlake Water Utilities' slogan is "Water Smart, Southlake" for which they have a water conservation webpage and a weekly blog/newsletter that gives best practices to be water-wise indoors and outdoors. The webpage also promotes their free water conservation program called W.I.S.E. Guys Program which is a personalized irrigation evaluation to help residents' irrigation systems run more efficiently. By upgrading the city's meters in year 2016, Southlake is able to use the service called "Eye on Water" that allows residents to track their hourly water use and detect leaks which promotes conservation-inducing habits. Their campaign name to advocate for use of this service is "Wired for Water" and its slogan is "When it comes to your water, be a know it all" (Southlake Water Utilities 2018).

As far as city property management in Southlake, two of the 16 parks are supplemented with well water in addition to city water. However, of the 29 parcels managed by the city which

[17] New rates effective October 1, 2018 now result in a monthly water bill of $113.10, an increase of 4.39 percent from the rates originally used.
[18] Email communication with Ashley Carlisle, Environmental Coordinator, City of Southlake on 12/12/18.

include the parks, municipal buildings, 5 roundabouts, and Bob Jones Nature Center, the majority do not require a large amount of watering due to their use of native-plant landscaping.

While the City does not have a partnership with local school districts, they do participate in an event called Science Night each year. At this event the City creates a display or experiment to demonstrate an aspect of sustainability.

4. City of West University Place, TX

a. Rate structure & outdoor watering ordinance:

The City of West University Place is a city mostly surrounded by Houston with a population of 15,608 and a median household income of $220,868. Average rainfall of the area is 57 inches, annually. West University Park's water rates do not send a strong conservation signal as the average water user's monthly bill for 8,000 gallons is $49.94 which includes a low base charge of $10.89. The 4 tiers, however, do promote some conservation with each tier's price increase (see Table 5). The city does not have any outdoor watering restrictions until drought stage III. Stages I and II have voluntary watering restrictions (City of West University Place 2014).

Table 5. West University Place's water rate structure.

Tier:	*Cost Per 1,000 Gallons:*
Base charge (5/8" or 3/4" meter)	$10.89/month
0-3,000	$4.30
3,001-9,000	$5.23
9,001-15,000	$6.22
15,001+	$7.41

b. Public awareness programs/campaign, city property management, coordination with town/local ISD:

West University Place does not take part in any public awareness campaigns or programs, but they do have a minimal water conservation webpage with links to their Water Conservation Plan and Drought Contingency Plan (City of University Place 2018). To manage their city property efficiently, all of the city's irrigation systems are equipped with rain sensors to prevent overwatering and have set seasonal schedules to optimize the best times to water. The city utilizes native plants as a part of their standard operating procedures, with their newest park that opened in October featuring many native plants. Regarding coordination with the local school district, the Public Works Department provides funding for educational programs presented at the Elementary School Level that are a part of the local subsidence district[19].

[19] Email communications with Patrick Walters, Operations Superintendent and Susan White, Parks and Recreation Department Director, Town of West University Place on 12/04/18.

5. Town of Westlake, TX

a. Rate structure & outdoor watering ordinance:

The Town of Westlake is an affluent suburb of Fort Worth with a population of 1,483 and a median annual household income of over $250,000. Precipitation in this region is 40 inches, annually. Their city water rates send a strong conservation signal as the average 8,000 gallon-user would pay a monthly bill of $83.28 which includes the high base charge of $50.40. The rate structure has 4 tiers, but the first tier of 0-20,000 gallons is very large and does not promote conservation (see Table 6). The city has water-wise, year-round time-of-day outdoor watering restrictions with no watering allowed between 10am and 6pm. They also have a designated two-day schedule determined by property address. Handheld and soaker hose and drip irrigation are allowed any day and at any time.

Table 6. Westlake's water rate structure (The Town of Westlake 2018).

Tier:	*Cost Per 1,000 Gallons:*
Base charge (3/4" meter)	$50.40/month
0-20,000	$4.11
20,001-40,000	$5.39
40,001-400,000	$6.65
40,000+	$8.60

b. Public awareness programs/campaign, city property management, coordination with town/local ISD:

To encourage water conservation awareness, the city has a water conservation webpage with links to Texas Smartscape, LCRA WaterSmart Tools & Resources, EPA's WaterSense Landscaping Tips, Water - Use It Wisely, and Take Care of Texas (The Town of Westlake 2018). Westlake uses the "Eye on Water" program to encourage public awareness of real-time water use. The city also recommends regionally-appropriate plants during the plan review process of new city property and home-owned properties. Although there are no school districts in Westlake, there is one municipally-owned charter school for which complete coordination with the city is allowed, so conservation is integrated into the school's curriculum. Additionally, the Parks director and Facility Manager are head of the charter school's campus landscaping[20].

[20] Phone interview with Dianna Orender, Public Works Assistant, Town of Westlake on 12/12/18.

6. Town of Westover Hills, TX

a. Rate structure & outdoor watering ordinance:

The Town of Westover Hills is an affluent suburb of Fort Worth with a population of only 694 and median annual income of $165,625. Annual average precipitation of this area is 34 inches. While its water rates have a base charge of $26.00 the flat rate structure does not send any kind of conservation signal (see Table 7). The average 8,000 gallon per month household will spend $63.20. Their time-of-day outdoor watering restriction does help to promote conservation by not allowing irrigation between 10am and 6pm, year-round, and on a designated two-day schedule that is determined by property address. Handheld hose, drip irrigation, soaker hose or tree bubblers are only allowed up to 2 hours on any day.

Table 7. Westover Hills' water rate structure (Town of Westover Hills 2018).

Tier:	*Cost Per 1,000 Gallons*
Base charge (any meter size)	$26.00/month
Volume charge	$4.65

b. Public awareness programs/campaign, city property management, coordination with town/local ISD:

The town encourages water conservation through public awareness on their website's "Water Conservation" page. This webpage has water conservation tips and a link to their Water Conservation Plan (Town of Westover Hills 2018). Of the 5 acres of property managed by the town, none are irrigated and they use native plants for all town medians. Since there are no schools in Westover Hills, they are not able to take part in school education coordination[21].

[21] Phone interview with Tim Chambers, Public Works Director, Town of Westover Hills on 12/05/18

7. The Woodlands CDP, TX

a. Rate structure & outdoor watering ordinance:

The Woodlands is a master planned community and a census-designated place (CDP) in the Houston metropolitan area. Its population is just over 100,000 and its median household income is $109,605. The annual precipitation of this region is 50.48 inches, annually. The Woodlands does not have water rates with an especially strong conservation signal relative to six of the other ten communities since the average bill of 8,000 gallons is $46.02 per month including a minimal base charge of just $5.00. Their rate structure is more conducive to conservation with 4 tiers and a small range for the first tier of 1,000 to 3,000 gallons (Table 8). The rest of the tiered structure, however, features wide tiers and relatively low rates, both of which do very little to incentivize conservation. Irrigation is metered separately and has seasonal pricing to encourage water conservation during summer months. They also encourage conservation with The Woodlands' outdoor watering time restriction between 6am and 8pm, year-round. There is also a designated two-day watering schedule determined by property address.

Table 8. The Woodlands' water rate structure (WJPA 2018).

Tier:	*Cost per 1,000 gallons:*
Base charge (any meter size)	$5.00/month
1,000-3,000	$1.70
4,000-15,000	$2.80
16,000-30,000	$4.45
31,000+	$5.80
Surface Water Conversion Fee	$2.74/1,000g

b. Public awareness programs/campaign, city property management, & coordination with town/local ISD:

The Woodlands CDP supports several public awareness campaigns and programs. The Water-Wise Village Challenge uses the slogan "Take the pledge to conserve water!". It is a competition between villages, or communities, within the Woodlands to pledge to turn off sprinkler systems in the winter with a prize to the village with the most participating residents. The Woodlands Township Environmental Services Department also offers free events, classes and seminars on how to incorporate conservation habits into daily routines. A water conservation presentation can be requested of the Environmental Services Department. Their Water Conservation webpage includes links to "Water Use Calculator" and "Water, Use it Wisely" (The Woodlands Township 2018).

Property management by The Woodlands is a showplace for water conservation. They have three demonstration gardens to educate about native plants and species. There is also a 2,500-gallon demonstration rainwater harvesting tank and other rainwater harvesting being done at sports fields with signage for kids' education. Local Boy Scouts' troops have installed smaller rainwater harvesting systems in parks for park watering and general cleanup. Of the 200 parks

managed by The Woodlands, each uses drip irrigation and 850,000 square feet of sports fields have been replaced with artificial turf at a cost of $5 million[22].

The Woodlands Joint Powers Agency (WJPA), the central management agency for the ten Municipal Utility Districts that serve The Woodlands, coordinates with schools by providing talks in the schools. They spend a full eight-hour day teaching about water conservation during each class period of the school day. WJPA is present at every event in the area and sets up a table in the schools on Earth Day. They are currently in the process of planning on setting up further programs in the schools.

[22] Phone interview with Bob Dailey, Water Awareness and Public Education Coordinator, The Woodlands Joint Powers Agency and Chris Nunes, Director of Parks and Recreation, The Woodlands CDP on 12/06/18.

8. Town of Cary, NC

a. Rate structure & outdoor watering ordinance:

Cary is a large town in North Carolina, west of Raleigh, with a population of 165,904 and a median annual household income of $97,755. The annual precipitation in this region is 46.29 inches. The cost of an average 8,000 gallon water bill is $43.71[23]. The rate structure has 4 tiers which helps to send a conservation signal, but the base charge of $3.25 is low and the first tier of 0-5,000 gallons is a relatively wide range (see Table 9). Cary's outdoor watering restrictions do not have time-of-day restrictions, but they do have an alternate day watering schedule determined by property address and they fine irrigators for runoff. They also require annual testing of every water-user's backflow prevention device. Drip irrigation and hand watering are allowed any time (Town of Cary 2018).

Table 9. Cary's water rate structure.

Tier:	*Cost Per 1,000 Gallons:*
Base charge (5/8" or 3/4" meter)	$3.25/month
0-5,000	$4.84
5,001-8,000	$5.42
8,001-23,000	$6.85
23,000+	$12.94

b. Public awareness programs/campaign, city property management, & coordination with town/local ISD:

The town holds several public awareness campaigns to promote water conservation. They hold an annual irrigation campaign each spring to highlight seasonal tips for watering efficiency and remind residents of the watering restrictions. Every March they host Fix a Leak Week campaign to encourage testing for household leaks. The Block Leader Program is also available for citizens to become more involved in the Town's environmental programs (Town of Cary 2018). Of the 155 acres managed by the city, the general turf of parks, town facilities, or medians is not irrigated[24]. Only athletic fields and one park are irrigated, and some of these irrigation systems are fed by pond water or reclaimed water. Two town parks have replaced turf with artificial turf on their soccer fields. Many facilities' plant beds are only hand watered using reclaimed water. The Town's Outreach Supervisor of the Water Resources Department provides classroom instruction for all grades of elementary and secondary schools on age-appropriate water resources topics and provides training to teachers on how to do these lessons themselves. Water and wastewater facility tours are also provided for students[25].

[23] New rates effective July 1, 2019 now result in a monthly water bill of $44.61, an increase of 2.06 percent from the rates originally used.
[24] Email communication with Scott Hecht, Public Works Department Director, Town of Cary on 12/11/18.
[25] Phone interview with Jeff Adkins, Water Resources Manager, Town of Cary on 12/05/18.

9. City of Santa Fe, NM

a. Rate structure & outdoor watering ordinance:

Santa Fe is the state capital of New Mexico with a population of 83,776 and median household income of $53,922. Their annual precipitation of only 13.5 inches may be a factor in their innovative water conservation efforts that have received national recognition. The city also encourages efficient water use with its seasonal time-of-day outdoor watering restrictions. No watering is allowed between 10am and 6pm from May 1 to October 31 (City of Santa Fe 2018). Santa Fe's water rates and rate structure send a strong conservation signal with an average 8,000-gallon user paying $66.90 from May to August and paying $82.56 from September to April. While featuring just two tiers and a relatively wide first tier at that, water use beyond the first tier is costly and thus, highly reflective of the value of both water and water-use conservation. The base charge of $18.42 is substantial compared to most other cities. The seasonality of the rate structure is conducive to water conservation in the winter months (Table 10).

Table 10. Santa Fe's water rate structure.

Sept. – Apr:	
Tier:	*Cost Per 1,000 Gallons:*
Base Charge (5/8" or 3/4" meter)	$18.42/month
0-7,000	$6.06
7,000+	$21.72
May – August:	
Tier:	*Cost Per 1,000 Gallons:*
Base Charge (5/8" or 3/4" meter)	$18.42/month
0-10,000	$6.06
10,000+	$21.72

b. Public awareness programs/campaign, city property management, & coordination with town/local ISD:

The city's campaign is called "Save Water Santa Fe" which has its own website full of resources to encourage conservation such as educational videos, local water news, and rebate incentives, such as rain barrels, moisture sensors, and landscape greywater recycling systems. The "Eye on Water" program is also encouraged and utilized by the city for residents to track their water use in real time. The Save Water Santa Fe Radio Show is a weekly radio show and live stream hosted by Christine Chavez, the City's Water Conservation Manager, who talks about water conservation. The city also partakes in general outreach through community events and fairs, like Earth Day (Save Water Santa Fe 2018).

Municipal properties are managed to conserve water by following a seasonal watering schedule. They have recently further lowered the winter watering times to 3 times each week for one hour each watering day. All sports fields and golf courses are required to use artificial turf.

To help residents become more water-wise, the city requires that homeowners' landscapes cannot be more than 75 percent of warm season grasses[26].

Santa Fe is active in school education and coordination to teach students about conservation. Each year, the Water Conservation Office hosts a Water Fiesta for all 4th grade students in the city with local speakers and some high school presenters teaching about water-related concepts and values through hands-on learning activities. During Water Fiesta, the Passport Program is offered by the city to up to 14 of these classes to go on a field trip of Santa Fe's water system with additional presentations and activities. The Water Conservation Office also creates an annual Children's Water Conservation Poster Contest to students in 1st to 6th grade with a theme and prizes (Save Water Santa Fe 2018). The winning artwork from each poster contest is then made into a highly-requested "Conservation Calendar". The city takes part in the international campaign, Project WET (Water Education for Teachers), by hosting workshops to help teachers incorporate hands-on learning activities into elementary and middle school curricula (Project WET 2018).

[26] Phone interview with Patricio Pacheco, Water Conservation Education & Compliance Specialist, City of Santa Fe on 12/11/18.

10. City of Scottsdale, AZ

a. Rate structure & outdoor watering ordinance:

Scottsdale, Arizona adjoins Phoenix with a population of 250,000 and a median household income of $80,306. Their annual precipitation is only 10.27 inches, but the city has been awarded the Sustainable Water Utility Management Award, the top municipal water agency recognition (Sherbert 2018). The city's water rate structure does not send much of a conservation signal with low rates and an average water bill for 8,000 gallons at only $29.50, despite five tiers of water pricing. (Table 11). No watering restrictions are imposed in the city until drought stage 2 is reached (City of Scottsdale 2018).

Table 11. Scottsdale's water rate structure.

Tier:	*Cost Per 1,000 Gallons:*
Base Charge (5/8" meter)	$12.40/month
0-5,000	$1.65
5,001-12,000	$2.95
12,001-30,000	$3.75
30,001-65,000	$4.85
65,000+	$5.70

b. Public awareness programs/campaign, city property management, coordination with town/local ISD:

As a partner in the Arizona-originated and internationally-known campaign, "Water, Use it Wisely", Scottsdale is a strong supporter of water-conservation awareness. The Water Resources Department has a page on the city website with local water news, irrigation efficiency checklists and water-wise landscaping tips, and rebates - including grass removal (City of Scottsdale 2018). The city offers a number of free water conservation publications that can be mailed directly to residents. Scottsdale Water also offers some facility tours and water efficiency workshops.

To manage its city property and promote city water conservation, reclaimed water is used to irrigate the majority of their many golf courses. Depending on each HOA, homeowners may be required to landscape from the Arizona plant list that all commercial properties are required to use. Depending on the amount of property owned, the city does not allow portions of it to be watered by the owner and natural areas are not allowed to be watered. Located in a city park is a 5.5-acre demonstration garden called The Scottsdale Xeriscape Garden that showcases 200 species of regionally-appropriate plants to grow public awareness of the beauty of saving water. Further efforts being pursued by the city include the use of GIS to create water budgets for commercial properties and conducting a pilot study for smart metering[27].

For school district coordination, free interactive presentations can be requested from Scottsdale Water for grades 2 through 6, free booklets are available for all students, and the Parks and Recreation department has extensive school programs that the Water Resources department contributes to with water conservation material. The schools' water is allocated by

[27] Phone interview with Elisa Klein, Conservation Coordinator, City of Scottsdale on 12/18/18.

Scottsdale Water if they have more than 10 acres of turf. The city ordinances also specify that schools may have only 15 percent of their property in turfgrass (Scottsdale, Arizona, Municipal Code article VII, sec. 49-245).

Goal #2. Conservation Tracking Tool

The following is a summary of output from an application of the AWE's Tracking Tool that was developed to help its members plan their water conservation program. This MS-Excel-based model evaluates water savings, costs, and benefits of potential water conservation programs. For this project component, the AWE Tracking Tool was used, but some of the predefined measures found in the TWDB Tool was used too, with its Texas utility preloaded data and tools. The Tracking Tool was chosen because it allowed for more specific and recent input data than the TWDB Tool, such as the input option of water loss and the results including utility water rate requirements. The AWE Tracking Tool also allows for planned activity over 35 years by one-year increments while the TWDB's Tool is less specific with 10-year increments over 50 years. For the conservation-program scenario found in the accompanying MS-Excel-based model, Texas State chose for the THP to implement annual conservation measures through 2040.

The conservation-program scenario presented is based on indoor water-use conservation measures only. Outdoor-landscape measures require data on average lot size, average landscape area, and average turf area. An inquiry was made of the THP to learn if such data were available, for example, for three to four different lot-size categories of houses ranging from the smallest lots to the estate homes. These outdoor related data are currently under development by the Town of Highland Park (THP) staff. Once these data are made available, another scenario can be developed to reflect savings, costs, and benefits associated with implementation of outdoor-landscape measures, but this will occur beyond the scope of this directed research project.

If the conservation measures that are featured in the scenario prepared for the THP are implemented, the annual water savings achieved by year 2035 will supplant eight percent of the forecast-baseline demand, equaling annual savings of 113 million gallons MG/346 acre-feet. These savings have the potential to reduce the forecast-baseline total demand from 1,403 MG/4,305 acre-feet to 1,290 MG/3,959 acre-feet per year. The water savings achievement will lower the THP's GPCD from the baseline of 413 to 380 for a reduction of 33 GPCD by year 2035.

Table 12 lists the measures included in the conservation-program scenario. The most effective measures, in terms of water savings, are the toilet rebates as this fixture uses the most water of all indoor fixtures and appliances. Table 12 breaks down water savings that are attributable to measure implementation versus those savings that will eventually occur due to a combination of natural replacement rates and current fixture standards.

Table 12. AWE Tracking Tool conservation measures and associated water savings.

Conservation Measure:	Lifetime Water Savings (MG)			"Lifetime" end year	Avg. Annual Water Savings (MG)		
	Gross savings	Utility savings	Attributable to National Standards		Gross savings	Utility savings	Attributable to National Standards
Res HE Toilet Rebates, SF	**1510**	816	694	2076	**26**	14	12
Res HE Toilet Rebates, MF	**1618**	876	742	2076	**28**	15	13
Res LF Showerhead Distribution, SF	**413**	73	340	2076	7	1	6
Res LF Showerhead Distribution, MF	**190**	34	157	2076	**3**	1	3
Home Water Reports	**5**	5	-	2040	**0**	0	-
CII Dishwasher Rebates	**298**	298	-	2059	**7**	7	-
CII Kitchen Food Steamer Rebates	**210**	210	-	2049	**7**	7	-
CII Cooling Tower Conductivity Controller Rebates	**38**	38	-	2029	4	4	-
CII Valve-Type HE Toilet Rebates	**358**	198	160	2076	**6**	3	3
CII Pre-Rinse Spray Valve Replacements	**204**	39	165	2076	**4**	1	3
Commercial General Rebate	*81*	*41*	*41*	*2038*	*4*	*2*	*2*

The Tracking Tool estimates the Net Present Value (conservation program savings and resultant avoided water costs minus the costs of program implementation) to be $1,789,717 for the program scenario with a benefit-cost ratio of 2.4 after full execution of the program. The conservation measures with the highest benefit-cost ratios are the Residential Showerhead Distributions (first single-family, then multi-family) followed by Residential HE Toilet rebates (first multi-family, then single-family).

One conservation measure to mention that is not included in the program scenario for the THP is “Commercial General Rebate.” The Commercial General Rebate represents an alternate

approach to implementing conservation measures in the commercial/institutional/industry (CII) water-use sector. This measure works differently than the other CII measures because here the THP would set an allotted annual budget over several years for the program first and then provide cash rebates for the installation of water efficient equipment whatever that might be. The rebate amount is set to $1.68 per one gallon per day of water savings. The potential savings for this measure can be found below Table 12. It does not produce as strong of water savings compared to most other CII measures, but its benefit-cost ratio is high at 3.1 if $5,000 is budgeted annually for five years. This budget was chosen arbitrarily by Texas State. A sensitivity analysis will reveal the effects of different budget amounts. The decision of its implementation and budget is left up to the THP.

While the THP plans to increase water rates by 4.75 percent every other year, or approximately 2.3 percent per year, rates will need to increase by a little more than that to support the costs of implementing the conservation-program scenario. Assuming a two percent annual rate of inflation, a 4.75 nominal rate of biannual increase covers inflation and leaves a 7/10ths of one percent real increase in water rates over two years in time. Thus, an additional increase as noted on the Utility Revenues and Rates tab of the Tracking Tool seems reasonable. By year 2035, for example, the retail water rate per thousand gallons necessary will need to be 5.4 percent higher than the rate scheduled for that year or $7.58 per thousand gallons rather than the $7.20 it is currently set to reach. Implied, of course, is the fact that conservation program implementation requires financial resources that can either be budgeted annually or debt-financed. In either case, recovering the costs of conservation is ideally achieved by developing and explaining thoughtfully prepared water rates and a rate structure that incentivizes conservation behavior.

Regarding the Texas Living Waters Project and their Texas Water Conservation Scorecard, one category of the scorecard is a 10-point ranking for the number of State Municipal conservation measures that a water service provider checks on their most recent Water Conservation Plan Annual Report (WCPAR). The Town of Highland Park's most recent grade can be improved by implementing the conservation-program scenario developed for this project. The ten conservation measures featured in the program scenario, however, are not each individually enumerated in the TWDB WCPAR. Three additional BMPs can be checked on the WCPAR, nonetheless (Table 13).

Table 13. AWE Tracking Tool measures that match on the WCPAR BMP list.

Water Conservation Plan Annual Report BMP List	Tracking Tool Conservation-Program Scenario Measures
Conservation Programs for ICI	• CII Cooling Tower Conductivity Controller Rebates • CII Dishwasher Rebates • CII Kitchen Food Steamer Rebates • CII Valve-Type HE Toilet Rebates • CII Kitchen Pre-Rinse Spray Valve Replacements
Showerhead, Aerator, and Toilet Flapper Retrofit	• Residential LF Showerhead Distribution, SF • Residential LF Showerhead Distribution, MF
Residential Toilet Replacement Programs	• Residential HE Toilet Rebates, SF • Residential HE Toilet Rebates, MF
No correlated measure	• Home Water Reports

In a similar fashion, the eight Best Management Practices (BMPs) checked in the THP's 2017 WCPAR are not among the measures found in either the AWE Tracking Tool resource library or the TWDB Tool pre-defined measures. There is one exception to that statement: the AWE Tracking Tool will accommodate a water loss control program as a conservation measure. In any event, the only BMP checked by the THP in the 2017 WCPAR that is associated with an estimated volume of gallons saved – metering new connections and retrofitting existing connections – can be added as a user defined measure in either tool. The Texas State Team has not included this measure due to additional information needs from the THP. It can be added in the future and by doing so can serve as a validity check for the volume of savings estimated by the THP in their 2017 WCPAR.

As just suggested, the availability and use of the new TWDB Tool has created somewhat of a mismatch between the predefined conservation measures for which savings/costs can be quantified and the BMPs listed in the WCPAR. This matter has been raised at the most recent meeting of the Water Conservation Advisory Council[28]. The matter of creating a better

[28] Tim Loftus is a member of the Texas Water Development Board's Water Conservation Advisory Council representing Higher Education.

"handshake" between the tool measures and the BMP checklist will be pursued with the hope that appropriate changes can be made in time for the next WCPAR submissions by May 2020.

The AWE Tracking Tool and newer TWDB Tool are valuable tools for exploring the efficacy of various conservation measures. Five additional measures (four residential and one CII) were originally included in the program scenario, but ultimately dropped from the scenario presented in the accompanying MS-Excel-based file once it became clear that the benefit-cost ratio was less than one for each of them. As a result, the overall program scenario benefit-cost ratio improved to the current 2.4; strong evidence in support of implementing a more robust conservation program.[29]

Ultimately, and regardless of the exact matching of BMPs between the scorecard and those indicated by the THP on their WCPAR, the strong resulting benefit-cost ratio of the conservation program scenario developed here, implies that implementation of the modeled program will be highly effective in reducing water and cost effective too. Focusing on the Texas Living Waters Project scorecard which relies on a selection of classifications thought to determine utility conservation activity is less important than actual water savings achieved through implementation of proven best water management practices.

[29] Here it is assumed that the THP Conservation Coordinator can manage program implementation if given the financial resources to do so.

Goal #3. WaterSmart-Derived Data Analysis

In general, the THP wishes to build on current water-use conservation efforts and by doing so, reduce relatively high per capita water use. A recent investment in automatic meter infrastructure and complementary WaterSmart software positions the THP with state-of-the-art technology to better understand real-time water use, change through time, and potential trends that might emerge among their five meter-class accounts. Information from data analysis will help inform efforts to communicate with ratepayers, tailor conservation measures, and develop and manage a robust water-conservation program.

For the Town of Highland Park Texas, monthly water-use data collected since January 2016 through April 2019 is analyzed for year-over-year trends by each of the 12 months in the calendar year (e-Appendix B). The results of analyses begin here with the 2,338 Irrigation Only accounts[30]. This type of analysis results in 28,056 "account months" (2,388 x 12) that either feature an increasing or decreasing trend in water use or no trend across the three to four years studied depending on the month. [31] Appendix C features a spreadsheet of the results. Here, we summarize key findings

Irrigation Only (IO) accounts have used the majority of water in the Town of Highland Park during the 40-month period of review: 58 percent (1771.4 of 3046.4 MG) (Appendix D). Water use by IO accounts fell below 50 percent of total monthly water use in the THP in just 12 of the 40 months in the dataset. The months of January and February in each of the four years studied account for eight of these 12 months. During the months of June through September of each of the three years for which there are data (i.e., 2016-2018), monthly IO water use ranges from 60-71 percent of total water use (except for June of 2016 when IO water use accounted for 52 percent of total water use).

When comparing monthly water use on a year-over-year basis, the majority of IO account months, over 70 percent, do not exhibit either an increasing or decreasing water-use trend during the period of analysis. For these accounts, the net change through time (i.e., across years) in water use for each of the 12 calendar months sums to a decrease of 7.37 million gallons (MG), 0.42 percent of the total water use by IO accounts over the 40-month period.[32]

Among those IO accounts that exhibit a usage trend, a greater number exhibit an increasing trend in monthly water use than those with a decreasing trend, year-over-year: 3,156 increasing account months versus 2,693 decreasing account months for a net change in monthly water use of +78.2 MG for increasing accounts and a net change in water use of -60.4 MG for account months that show a downward trend in water use. The net effect is a cumulative increase in use of 17.8 MG over the period analyzed. This translates to a one percent increase in water use over 40 months among IO accounts reporting some degree of monthly change.

[30] Monthly data are missing for a number of IO accounts.

[31] Here, a trend requires a minimum of three data points where an increase or decrease in water use is consistent from the first data point to the second point and on to the third data point at a minimum. For example, from Jan. 2016 to Jan 2019 there are four water-use data points. If there is an increase (or decrease) in water use each year after 2016, then there is an increasing (or decreasing) trend for the month of January, year-over year.

[32] 245,742 GPD X 30 = 7,372,260 gallons expressed on a monthly basis. Divide this product by 1,771,440,000 gallons of cumulative water use by IO accounts during the 40-month period of analysis and one arrives at 0.00416 or 0.42 percent.

Given that there are several factors that affect water use (e.g., temperature, precipitation, ET rate, water rates/rate structure, irrigation-controller sophistication, level of conservation program effort, ratepayer awareness, etc.) it is not possible to fully explain the water-use trends (or lack thereof) by Irrigation Only accounts given the single variable analyzed (i.e., monthly water use). Looking at year-over-year change per each of the 12 months in the year, narrows the degree of weather variability that will affect an entire year's worth of data in a simple year-to-year comparison. That said and as of April 2019, there is no apparent factor at work in the Town of Highland Park that is having the effect of reducing overall monthly water-use among IO accounts since January 1, 2016.

The Single-Family Residential (SFR) meter class uses the second greatest amount of water in the THP – 33.5 percent of total water use – and features 3,076 accounts (Appendix D). A subset of SFR accounts capture both indoor and outdoor water (i.e., they do not have an additional meter for irrigation-only use.) For what immediately follows, SFR accounts will capture a combination of those accounts that meter just indoor use (i.e., they have an additional outdoor-use meter) and those that meter both indoor and outdoor use with one meter.

Considering trends in monthly SFR water use over a 40-month period as done above for IO accounts, the majority of SFR account months – over 74 percent – do not exhibit an upward or downward trend in monthly use, year-over year (Appendix C). The number of account months with increasing monthly water use are nearly the same as those with decreasing water use. While the sum of monthly water use changes among all SFR accounts reporting change – those with increasing and decreasing trends and those with no apparent trend - indicates an overall net decrease of 11.9 MG, this amount of water-use change represents a small percentage of water use during 40 months among SFR accounts: 1.2 percent. Thus, we conclude that with this type of year-over-year monthly trend analysis, there is little at work other than perhaps passive conservation[33] to have affected a significant change or trend in water use among SFR accounts during the 40 months studied.

Together, IO and SFR meter-class accounts have used over 91 percent of the water sold by the Town of Highland Park during the 40-month period of analysis. The other three meter classes – commercial, multi-family residential, and municipal – collectively account for less than nine percent of total water use (Appendix D). Water conservation program efforts, therefore, should prioritize IO and SFR accounts with the former type offering the largest opportunity to reduce consumption of water and thus, achieve conservation goals once they are established.

Another dataset offered on the WaterSmart dashboard is a listing of accounts that are repeatedly in the highest tier of the water rate structure by using over 60,000 gallons per month for one to twelve months in the last year (e-Appendix E). A review of this dataset reveals that for the past 12 months, IO accounts constituted a large majority of water use in the THP as indicated above. Of the 589 accounts that are repeatedly in the highest tier, 492 are IO accounts. These IO accounts represent over 83 percent of the accounts that are in the highest water-use tier. Five of these IO accounts have consistently remained in the highest tier for 11 consecutive months. The average water use of these five accounts for those 11 months totals >120,000 gallons / month). The average water use of the IO accounts repeatedly in the highest tier is 99,540 gallons/month.

[33] Passive conservation is the result of efficiency improvements (e.g., fixture upgrades) and typically not attributed to behavior change.

The SFR accounts repeatedly in the highest tier use an average of 85,000 gallons/month. This information can be used to target those ratepayers for conservation outreach (e-Appendix E).

Four municipal accounts are also among the highest water-use tier: Town Hall & Fire Department (11 months), two accounts in the Davis Park swimming pool (6 and 4 months), and the Highland Park Town Services Center (1 month). While it was noted above that the municipal meter class is among a small minority of total water users relative to all five meter-class accounts, this information suggests that some of the municipal accounts use a disproportionately high amount of water, nonetheless.

Another dataset in WaterSmart is "Consumption by Rate Tier" that, for each month from April 2017 to April 2019, gives the percentage of accounts (separated by meter class) that are in each of the 4 tiers (e-Appendix F). For the purpose of analyzing a complete year of 12 months, year 2018 is used for this analysis. On average in year 2018, 6.5 percent of IO accounts reach tier 4 of the THP water rate structure. The tier 4 IO accounts use an average 12.7 percent of total water used each month by all IO accounts. During the peak months of water use (May-September), the percent of IO accounts that reaches tier 4 nearly doubles to 12.8 percent, using an average of 21.6 percent of total water consumed by all IO accounts. Targeting these highest users for water-use conservation has the potential to offer the largest payback in terms of water-use reduction.

In 2018, nearly 14 percent of SFR accounts reached tier 2 which is 12,000 to 30,000 gallons per month. This group accounted for nearly 16 percent of total SFR consumption per month. During summer months (May-September), SFR accounts that reached tier 2 increased to almost 18 percent, making up 21.2 percent of total SFR consumption per summer month. The amount of increased water use among highest-tier users during the summer isn't as dramatic as with IO accounts, but this information can be used to target highest-use accounts with special conservation efforts.

Conclusions

Comparisons of the conservation-oriented management practices of similar cities can inform and help to motivate the THP construct new conservation goals in the interest of becoming a leader in the region and state of Texas. City property can serve as an example of the town's shared goal to use less water with native landscaping and irrigation with reuse water. Leadership in school education can be improved by adopting some practices demonstrated by cities such as offering water-use classroom lectures, field trip opportunities, and participating in career fairs. Considering some of the competitive GPCDs held by cities in the comparison may act as an inspiration to Highland Park to set lower total and residential GPCD goals for the town.

To inspire residents to share in a common goal and motivation to conserve water, public awareness strategies that were learned of in the comparison can be implemented like an in-depth educational water conservation website, neighborhood competitions, and demonstration gardens. Stricter outdoor watering restrictions should be enforced in the THP such as year-round time-of-day restrictions and use of the WaterMyYard resource to set proper location-based watering requirements. Finally, the city comparison presents higher water rates and a smaller first tier than the THP's which should inform, if not influence future rate increases and a rethinking of tier intervals in order to better capture the high value placed on water.

From a financial perspective, implementing an indoor water-use conservation program in the THP has been justified. Developing a conservation plan based on outdoor water-use measures should prove to make economic sense for Highland Park too. To help enlist community buy-in, a watershed-based appeal for stewardship of a shared resource has additionally been made. Going forward, the leaders and residents of Highland Park must also build a shared vision for their community's water future - one that is inextricably tied to consideration of a growing number of fellow Texans. What follows are six recommendations that were presented to the THP by Loftus and Murata (2019) as a result of this work:

In order to benefit fully from the promise of a water conservation program, the Town of Highland Park should hire a new conservation coordinator whose focus will be to develop and manage a new water conservation program. Without a manager whose sole focus is development and management of a water conservation program, one that employs available tools, takes full advantage of data generated by the THP's new meters and WaterSmart software, and fully supported and resourced by the Town Council and executive staff, measurable progress with conserving water will be elusive. Conservation-planning tool output offers an excellent guide for choosing measures for implementation. A new conservation coordinator can be a part-time, full-time, or full-time-shared (e.g., with University Park?) staff member.

The THP should phase out use of potable water on their town-owned properties by making a commitment to showcasing native and regionally-appropriate (i.e., drought tolerant) plants and using either rainwater or reclaimed water when watering is necessary. The THP must lead by example for ratepayers and school-aged children alike and use their town-managed landscapes as demonstration projects and key components of a conservation awareness and outreach campaign. Attractive (flowering) plants and landscapes that meet the abovementioned

criteria are available and in use in many places. Ample resources are available to the THP within the Dallas-Ft. Worth region (and Texas State University) to help achieve such a new goal.

Current Highland Park water rates and the tiered-rate structure should be reimagined to both pay for and incentivize water-use conservation. Conservation planning tool results indicate how a conservation program can be paid for by adjustments to scheduled rate increases. Adding outdoor-watering measures and a new conservation coordinator will lead to additional costs that can be fully or partially offset by higher water rates and a new tier-based rate structure. The THP's first tier is too wide and should be narrowed such that use of 12,000 gallons per month invokes a third or fourth water-rate tier. Any future cost-of-service study should include covering the costs of a new conservation coordinator and a robust conservation program of both indoor- and outdoor-focused measures.

The THP must actively engage with the Highland Park Independent School District and other willing collaborators in order to ensure that K-12 school-aged residents adopt a water conservation ethic to carry forward in life. Collaboration with like-minded entities will take some effort and require a commitment on the part of the THP. A new conservation coordinator can be the staff person for leading this effort and achieving this goal. But it will take all staff and elected officials to ensure that THP policies and practices lead by example. Lack of action on the part of the THP will dilute the momentum that this project has created.

The THP should invest in data development about average lot size, landscaped area per lot, and turf grass per lot. These new data will inform a conservation program of outdoor watering measures and help with development of outdoor water budgets if the THP wants to pursue such a way to price water. In any event, these new data are necessary to examine potential benefit-cost ratios and the net present value of investing in measures to reduce outdoor-water use.

Reducing outdoor watering should be emphasized in a new water-conservation program. Outdoor water use is the single largest user of water in the THP. Any real progress with reducing overall water use in the THP must come from reductions in outdoor watering and primarily from IO meter-class accounts. Beyond steps such as making time-of-day watering hours a year-round feature of the town ordinance, narrowing the time-of-day outdoor-watering window(s), and needed adjustments to water rates and the THP rate structure, more creative efforts will be necessary and could include incentives to convert part of residential landscapes to native and regionally-adapted plantscapes. The THP should consider participating in the WaterMyYard program and incentivizing alternatives to timer-based controllers or even those that claim to be rain-sensitive. The new conservation coordinator can take full advantage of the THP's investment in smart meters and advanced software to target messaging, high-users, and experiment with other tactics to effect measurable change.

References

Alamo Heights, Texas. 2018. Utility Application and Billing. https://www.alamoheightstx.gov/services/residential/utility-application-and-billing/ (accessed December 20, 2018).

Alliance for Water Efficiency (AWE). 2019. AWE Water Conservation Tracking Tool. http://www.allianceforwaterefficiency.org/Tracking-Tool.aspx (accessed July 29, 2019).

American Planning Association (APA). 2011. Conservation Planning Tools Assessment. https://www.planning.org/nationalcenters/green/forestservice/ (accessed July 29, 2019).

American Water Works Association. 2016. Manual of water supply practices – M36: water audits and loss control programs. 4th edition. Denver (Colorado): American Water Works Association. 405 p.

City of Irving Water Utilities. 2014. City of Irving Water Management Plan. Ordinance No. 7524, Irving, TX.

City of Santa Fe. 2018. Water Conservation. https://www.santafenm.gov/water_conservation (accessed December 20, 2018).

City of Scottsdale. 2018. Water Resources. https://www.scottsdaleaz.gov/water (accessed December 20, 2018).

City of University Place. 2018. Water Conservation. https://www.westutx.gov/345/Water-Conservation (accessed December 20, 2018).

City of West University Place. 2014. Water Conservation and Drought Contingency Plan. Ordinance No. 1996, City of West University Place, TX.

Chicago Metropolitan Agency for Planning (CMAP). 2010. Water 2050: Northeastern Illinois Regional Water Supply/Demand Plan. Chicago Metropolitan Agency for Planning, Chicago, IL. https://www.cmap.illinois.gov/documents/10180/14452/NE+IL+Regional+Water+Supply+Demand+Plan.pdf/26911cec-866e-4253-8d99-ef39c5653757 (accessed July 30, 2019)

Chicago Metropolitan Agency for Planning (CMAP). 2012. Full-Cost Water Pricing Guidebook for Sustainable Community Water Systems. Chicago Metropolitan Agency for Planning, Chicago, IL.

Dallas Water Utilities. 2018. Save Dallas Water. https://savedallaswater.com/the-24th-annual-city-of-dallas/ (accessed December 20, 2018.

Dziegielewski, B. and F. Chowdhury. 2008. Regional Water Demand Scenarios for Northeastern Illinois: 2005 – 2050. Chicago Metropolitan Agency for Planning, Chicago, IL. https://www.cmap.illinois.gov/documents/10180/14452/NE+IL+Regional+Water+Demand+Scenarios+to+2050+project+completion+report.pdf/c67c0773-5986-4fae-b5a8-324bf23e84b4 (accessed July 30, 2019)

DeOreo, W., P. Mayer, B. Dziegielewski, and J. Kiefer. 2016. Residential End Uses of Water, Version 2: Executive Report and PDF Report #4309b. Water Research Foundation, Denver, CO.

Hermitte, S., R. Mace. 2012. The Grass is Always Greener…Outdoor Residential Water Use in Texas. Technical Note 12-01, Texas Water Development Board, Austin, TX.

Irving, Texas. 2018. Water Rates. https://www.cityofirving.org/367/Water-Rates (accessed December 20, 2018).
Irving's Think Green Be Green. 2018. Think Green…Be Green. https://www.cityofirving.org/570/Think-Green-Be-Green (accessed December 20, 2018).
Loftus, T. and J. Murata. 2019. Town of Highland Park, Texas: Assessment of Water Use and Conservation Potential. 2019-04. The Meadows Center for Water and the Environment, San Marcos, TX. https://gato-docs.its.txstate.edu/jcr:687b6509-ef8a-4b37-bb96-90c4a47c84b6 (accessed July 30, 2019)
Loftus, T. and L. Smith. 2018. Estimating the Potential of Urban Water-Use Conservation in Texas: A Pilot Study of Two Planning Regions. The Meadows Center for Water and the Environment, San Marcos, TX. https://gato-docs.its.txstate.edu/jcr:a5aaeff7-3822-4c54-a5f6-fb1b6ff0e138 (accessed July 30, 2019)
Maier, N. 2014. Town of Highland Park Water Conservation Plan. Consulting Engineers Inc, Dallas, Texas.
Mayer P. and W. DeOreo 1999. Residential End Uses of Water. American Water Works Association Research Foundation, Denver, CO.
Moore, S. and D. Hughes. 2008. Advanced Metering Infrastructure: Lifeblood for Water Utilities. *Journal: American Water Works Association* 100 (4): 64-68. doi: 10.1002/j.1551-8833.2008.tb09605.x.
National Conference of State Legislatures. 2015. Water-Efficient Plumbing Standards. http://www.ncsl.org/research/environment-and-natural-resources/water-efficient-plumbing-fixtures635433474.aspx. (accessed July 17, 2019).
National Oceanic and Atmospheric Administration (NOAA). 2010. Climate Data Online. https://www.ncdc.noaa.gov/cdo-web/ (accessed December 20, 2018).
Project WET. 2018. Project WET Water Education for Teachers. https://www.projectwet.org/what-we-do (accessed December 20, 2018).
Rafter, D. 2012. AMI—The All-Purpose Tool. *Water Efficiency*. March/April 2002, pp. 11-15.
Roche J. 2008. AMR vs AMI. Electric Light & Power. https://www.elp.com/articles/powergrid_international/print/volume-13/issue-10/features/amr-vs-ami.html (accessed July 24, 2019).
Save Texas Water. 2019. Water Conservation Advisory Council: About Us. https://savetexaswater.org/about/index.html (accessed July 24, 2019).
Save Water Santa Fe. 2018. Save Water Santa Fe. https://savewatersantafe.com/ (accessed December 20, 2018).
Sherbert, N. 2018. Scottsdale Water receives nation's top utility management award. https://www.scottsdaleaz.gov/news/Scottsdale-Water-receives-nations-top-utility-management-award_s4_p27295 (accessed December 20, 2018).
Southlake Water Utilities. 2018. Water Smart, Outside. https://www.cityofsouthlake.com/289/Water-Smart-Outside (accessed December 20, 2018).
Texas A&M. 2018. Top 100 Plants for North Texas Deck of Cards. https://secure.touchnet.com/C21490_ustores/web/classic/product_detail.jsp?PRODUCTID=8966 (accessed December 20, 2018).

Texas Commission on Environmental Quality (TCEQ). 2019. Water Conservation Plans and Water Conservation Implementation Reports. https://www.tceq.texas.gov/permitting/water_rights/wr_technical-resources/conserve.html#moreinformation (accessed July 24, 2019).
Texas Water Development Board (TWDB). 2016. Water for Texas: 2017 State Water Plan. http://www.twdb.texas.gov/waterplanning/swp/2017/index.asp (accessed July 15, 2019).
Texas Water Development Board (TWDB). 2018. Municipal Water Conservation Planning Tool User Guide, Version 1. Texas Water Development Board, Austin, TX.
Texas Water Development Board (TWDB). 2019. Water Conservation. https://www.twdb.texas.gov/conservation/ (accessed July 24, 2019).
The Town of Westlake. 2018. Water Conservation. https://www.westlake-tx.org/399/Water-Conservation (accessed December 20, 2018).
The Woodlands Township. 2018. Water Conservation. https://www.thewoodlandstownship-tx.gov/931/Water-Conservation (accessed December 20, 2018).
Town of Cary. 2018. Water Conservation. https://www.townofcary.org/services-publications/water-sewer/sewer/water-conservation (accessed December 20, 2018).
Town of Highland Park (THP). 2017. Texas water Development Board Water Use Survey. Survey number 0389241, Town of Highland Park, TX.
Town of Highland Park (THP). 2018. About Us: Quick Facts. https://www.hptx.org/index.aspx?nid=310 (accessed August 20, 2018).
Town of Westover Hills. 2018. Water Conservation Plan. http://www.westoverhills.us/?page_id=234 (accessed December 20, 2018).
United States Census Bureau (USCB). 2017. American FactFinder: Community Facts. https://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml (accessed July 15, 2019).
United States Census Bureau (USCB). 2018. Quick Facts. https://www.census.gov/quickfacts/fact/table/highlandparktowntexas,TX,US/PST045218 (accessed July 26, 2019).
United States Department of Energy (USDOE. 2016. Advanced Metering Infrastructure and Customer Systems: Results from the Smart Grid Investment Grant Program. Department of Energy: Office of Electricity Delivery and Energy Reliability, Washington DC. https://www.energy.gov/sites/prod/files/2016/12/f34/AMI%20Summary%20Report_09-26-16.pdf (accessed July 30, 2019).
United States Environmental Protection Agency (USEPA). 2019. WaterSense Accomplishments and History. https://www.epa.gov/watersense/accomplishments-and-history (accessed July 24, 2019).
Vickers, A. 2001. *Handbook of Water Use and Conservation.* Amherst, MA: Water Plow Press.
Walker, J. 2019. What's in your water conservation scorecard? https://texaslivingwaters.org/conservation-scorecard-2019/ (accessed July 24, 2019).
WaterSmart Software. 2019. About Us. https://www.watersmart.com/about-watersmart/ (accessed July 18, 2019).

WJPA. 2018. Rates. https://www.wjpa.org/information/rates (accessed December 20, 2018).

Appendices

Appendix A – Peer Cities, Contact Information

City	Name	Title	Contact Info
1. Alamo Heights, TX	Pat Sullivan	Director of Public Works	(210)882-1506; psullivan@alamoheightstx.gov
2. Irving, TX	Donna Starling	Water Programs Manager	(972)721-2431; dstarling@cityofirving.org
3. Southlake, TX	Ashley Carlisle	Environmental Coordinator	(817)748-8638; acarlisle@ci.southlake.tx.us
4. West University Place, TX	Susan White Patrick Walters	Parks and Rec Director Operations Superintendent	(713)662-5894; SWhite@westutx.gov (713)662-5858; pwalters@westutx.gov
5. Westlake, TX	Jarrod Greenwood Dianna Orender	Director of Public Works Public Works Assistant	(817)490-5717 jgreenwood@westlake-tx.org (817)490-5732; customerservice@westlake-tx.org
6. Westover Hills, TX	Tim Chambers	Public Works Director	(817) 737-8442; t.chambers@westoverhills.us
7. The Woodlands, TX	Bob Dailey Jason Williams Chris Nunes	Water awareness and public education coordinator for the WJPA Operations and Maintenance Manager Director of Parks and Recreation	(281) 367-1271; bdailey@wjpa.org (281)367-9511; jwilliams@sjra.net (281)210-3800; cell (936) 672-3907
8. Cary, NC	Scott Hecht Jeff Adkins	Public Works Department Director Water Resources Manager	(919) 469-4093; scott.hecht@townofcary.org (919) 462-2066; jeff.adkins@townofcary.org
9. Santa Fe, NM	Patricio Pacheco	Water Conservation Education & Compliance Specialist	(505) 955-4221; pmpacheco@santafenm.gov
10. Scottsdale, AZ	No correspondence		

e-Appendix B – Reading Detail by Account
View online at http://bit.ly/HighlandParkReport-e-AppendixB

This appendix is available to Town of Highland Park executive staff only

Appendix C – Account Months

THP Water Use Trends

	Irrigation-only Trend*	*Total Irrigation-Only Accounts = 2,338														
		Water	**% of**	**GPD** change	**Water**	**% of**	**GPD** Change	Bounce in	**% of**	**GPD** Change	**No change**	**% of**	**No-data**	**% of**	**Total**	**TOTALS**
	January-1	33	1.85%	29,247	67	3.76%	-44,010	1569	87.95%	70,126	115	6.45%	554	31.05%	1,784.00	2,338.00
Jan-Mar: 2016-2019 data(4 data p	February-2	31	1.73%	21,670	93	5.19%	-67,568	1564	87.33%	-139,496	103	5.75%	547	30.54%	1,791.00	2,338.00
	March-3	16	0.89%	11,631	171	9.48%	-126,854	1521	84.36%	-290,795	95	5.27%	535	29.67%	1,803.00	2,338.00
	April-4	206	11.41%	106,734	321	17.77%	-208,706	1201	66.50%	-85,009	78	4.32%	532	29.46%	1,806.00	2,338.00
	May-5	551	30.32%	346,486	104	5.72%	-59,294	1111	61.14%	147,258	51	2.81%	521	28.67%	1,817.00	2,338.00
	June-6	894	48.69%	828,630	51	2.78%	-30,381	848	46.19%	258,363	43	2.34%	502	27.34%	1,836.00	2,338.00
Apr-Dec: 2016-2018 data(3 data p	July-7	470	25.27%	532,572	73	3.92%	-48,196	1275	68.55%	387,648	42	2.26%	478	25.70%	1,860.00	2,338.00
	August-8	205	10.92%	197,989	183	9.74%	-141,959	1454	77.42%	70,890	36	1.92%	460	24.49%	1,878.00	2,338.00
	September-9	394	20.85%	330,376	186	9.84%	-156,773	1267	67.04%	106,219	43	2.28%	448	23.70%	1,890.00	2,338.00
	October-10	146	7.68%	88,795	482	25.36%	-404,484	1234	64.91%	-224,177	39	2.05%	437	22.99%	1,901.00	2,338.00
	November-11	66	3.45%	34,348	657	34.38%	-533,182	1138	59.55%	-407,874	50	2.62%	427	22.34%	1,911.00	2,338.00
	December-12	144	7.50%	78,426	305	15.88%	-192,264	1393	72.51%	-138,895	79	4.11%	417	21.71%	1,921.00	2,338.00
	Average		14.21%			11.99%			70.29%			3.51%				100.00%
	Sum (of accounts)	3156			2,693			15,575			774		5,858		22,198.00	28,056
Percent accounts of total (accounts over 40 months period)		11.25%			9.60%			55.51%			2.76%		20.88%		79.12%	100.00%
	Sum (of GPD)			**2,606,904**			**-2,013,671**			**-245,742**						**347,491**
	Total Change (gallons)			**78,207,120**			**-60,410,130**			**-7,372,260**						**10,424,730**

	SFR Trend**	**Total SFR Accounts = 3,076														
		Water INCREASE accounts	**% of accounts**	**GPD change (of "increases")**	**Water DECREASE accounts**	**% of accounts**	**GPD** Change (of "decreases")	**Bounce in trend/ AKA no trend accounts**	**% of accounts**	**GPD** Change (of "no trends")	**No change** accounts (same every year)	**% of accounts**	**No-data accounts (-)**	**% of accounts**	**Total accounts** (with data)	**TOTALS**
	January-1	46	2.00%	17,249	73	3.17%	-35,148	2126	92.27%	-50,652	59	2.56%	772	33.51%	2304	3076
Jan-Mar: 2016-2019 data(4 data p	February-2	35	1.51%	13,868	84	3.63%	-41,155	2133	92.14%	-47,456	63	2.72%	761	32.87%	2315	3076
	March-3	59	2.54%	26,840	93	4.00%	-38,185	2158	92.86%	-88,259	14	0.60%	752	32.36%	2324	3076
	April-4	215	9.20%	51,793	281	12.03%	-74,059	1680	71.92%	-24,081	160	6.85%	740	31.68%	2336	3076
	May-5	456	19.41%	120,103	117	4.98%	-37,000	1646	70.07%	44,227	130	5.53%	727	30.95%	2349	3076
	June-6	484	20.40%	166,950	154	6.49%	-43,157	1615	68.09%	58,903	119	5.02%	704	29.68%	2372	3076
	July-7	371	15.46%	131,903	212	8.83%	-58,171	1698	70.75%	43,309	119	4.96%	676	28.17%	2400	3076
Apr-Dec: 2016-2018 data(3 data p	August-8	206	8.51%	74,348	331	13.67%	-111,974	1764	72.86%	-35,490	120	4.96%	655	27.05%	2421	3076
	September-9	299	12.22%	87,670	253	10.34%	-79,768	1736	70.94%	-12,939	159	6.50%	629	25.70%	2447	3076
	October-10	202	8.21%	51,894	371	15.08%	-143,722	1708	69.40%	-63,867	180	7.31%	615	24.99%	2461	3076
	November-11	156	6.31%	34,436	470	19.01%	-166,588	1704	68.90%	-100,833	143	5.78%	603	24.38%	2473	3076
	December-12	229	9.20%	52,031	300	12.05%	-97,608	1773	71.23%	-23,311	187	7.51%	587	23.58%	2489	3076
	Average		9.58%			9.44%			75.95%			5.03%		28.74%		100.00%
	Sum (of accounts)	2758			2,739			21,741			1,453		8,221		28,691	36,912
Percent accounts of total (accounts over 40 months period)		7.47%			7.42%			59%			3.94%		22%		77.73%	100.00%
	Sum (of GPD)			**829,085**			**-926,535**			**-300,449**						**-397,899**
	Total Change (gallons)			**24,872,550**			**-27,796,050**			**-9,013,470**						**-11,936,970**

Appendix D – Monthly Water Use by Meter Class

Monthly Water Use by Sector: January 2016 - April 2019 (MG)

Period	*SFR Accts*	*% SFR Accts*	*Irrigation Accts*	*% Irrigation*	*Commercial*	*% Commercial*	*MFR Accts*	*% MFR Accts*	*Municipal*	*% Municipal*	*All Accounts*
Jan-16	23.2	52.0	16.5	37.0%	2.5	5.6%	2.3	5.2%	0.1	0.2%	44.6
Feb-16	24.7	44.7	25.3	45.8%	2.7	4.9%	2.4	4.3%	0.1	0.2%	55.2
Mar-16	22.1	40.2	28.2	51.3%	2.5	4.5%	2.1	3.8%	0.1	0.2%	55
Apr-16	25.8	36.0	40.4	56.4%	3	4.2%	2.3	3.2%	0.2	0.3%	71.6
May-16	21.5	37.3	30.2	52.3%	3.5	6.1%	2.2	3.8%	0.2	0.3%	57.7
Jun-16	26.2	37.8	36.1	52.1%	4.2	6.1%	2.6	3.8%	0.3	0.4%	69.3
Jul-16	27.5	28.9	60.7	63.7%	4.1	4.3%	2.6	2.7%	0.5	0.5%	95.3
Aug-16	36.7	26.0	96.4	68.2%	4.7	3.3%	3.1	2.2%	0.5	0.4%	141.4
Sep-16	29.2	27.4	69.4	65.2%	4.1	3.9%	3.1	2.9%	0.6	0.6%	106.4
Oct-16	28.6	29.6	61.5	63.7%	3.3	3.4%	2.8	2.9%	0.3	0.3%	96.5
Nov-16	29.1	33.1	51.7	58.8%	4.1	4.7%	2.7	3.1%	0.3	0.3%	87.9
Dec-16	23.7	40.0	29.9	50.5%	3.1	5.2%	2.2	3.7%	0.2	0.3%	59.2
Jan-17	24.9	46.7	22.9	43.0%	3	5.6%	2.3	4.3%	0.2	0.4%	53.3
Feb-17	25.1	42.9	27.6	47.2%	3.3	5.6%	2.4	4.1%	0.1	0.2%	58.5
Mar-17	21.7	38.8	28.8	51.5%	3.1	5.5%	2.1	3.8%	0.1	0.2%	55.9
Apr-17	23.6	34.9	38.07	56.3%	3.4	5.0%	2.3	3.4%	0.3	0.4%	67.6
May-17	26.1	34.5	43.13	57.1%	3.7	4.9%	2.4	3.2%	0.3	0.4%	75.6
Jun-17	27.6	31.9	51.75	59.9%	3.7	4.3%	2.6	3.0%	0.7	0.8%	86.4
Jul-17	26.2	28.9	57.36	63.2%	3.7	4.1%	2.7	3.0%	0.7	0.8%	90.7
Aug-17	28.8	27.1	70.22	66.2%	3.6	3.4%	2.8	2.6%	0.7	0.7%	106.1
Sep-17	30.2	27.1	73.13	65.7%	4.7	4.2%	2.8	2.5%	0.5	0.4%	111.3
Oct-17	27.9	28.2	63.77	64.5%	4.3	4.3%	2.6	2.6%	0.4	0.4%	98.9
Nov-17	27.4	31.1	54.44	61.7%	3.5	4.0%	2.7	3.1%	0.2	0.2%	88.2
Dec-17	25.1	34.6	41.67	57.5%	2.9	4.0%	2.6	3.6%	0.2	0.3%	72.5
Jan-18	24.3	48.7	19.84	39.8%	3.1	6.2%	2.4	4.8%	0.1	0.2%	49.9
Feb-18	23.5	45.5	21.89	42.4%	3.4	6.6%	2.6	5.0%	0.1	0.2%	51.6
Mar-18	18.6	45.1	17.38	42.2%	2.9	7.0%	2.2	5.3%	0.1	0.2%	41.2
Apr-18	23.7	37.4	33.59	53.1%	3.1	4.9%	2.6	4.1%	0.2	0.3%	63.3
May-18	25.8	33.2	45.51	58.6%	3.5	4.5%	2.5	3.2%	0.3	0.4%	77.6
Jun-18	32.3	27.9	74.99	64.8%	4.4	3.8%	3.4	2.9%	0.5	0.4%	115.7
Jul-18	31.7	24.2	91.79	70.2%	3.8	2.9%	2.8	2.1%	0.7	0.5%	130.8
Aug-18	33.6	23.3	102.5	71.2%	4.3	3.0%	2.9	2.0%	0.7	0.5%	144
Sep-18	29.2	24.9	80.98	69.1%	3.7	3.2%	2.7	2.3%	0.5	0.4%	117.2
Oct-18	23.2	32.0	43.35	59.8%	3.1	4.3%	2.4	3.3%	0.4	0.6%	72.5
Nov-18	20.6	44.4	19.78	42.6%	3.4	7.3%	2.4	5.2%	0.2	0.4%	46.4
Dec-18	20.9	43.5	21.25	44.3%	3.6	7.5%	2.1	4.4%	0.1	0.2%	48
Jan-19	20.0	47.7	16.05	38.3%	3.7	8.8%	2.1	5.0%	0.1	0.2%	41.9
Feb-19	21.4	46.0	18.47	39.7%	4.1	8.8%	2.4	5.2%	0.2	0.4%	46.5
Mar-19	17.5	47.6	14.01	38.1%	3.2	8.7%	2	5.4%	0.1	0.3%	36.8
Apr-19	21.2	36.6	30.92	53.4%	3.3	5.7%	2.3	4.0%	0.3	0.5%	57.9
Total	1020.4	33.50	1771.44	58.15%	141.3	4.64%	100.5	3.30%	12.4	0.41%	3046.4

e-Appendix E – Accounts Repeatedly in Highest Water Use Tier
View online at http://bit.ly/HighlandParkReport-e-AppendixE

This appendix is available to Town of Highland Park executive staff only

e-Appendix F – Water Consumption by Rate Tier
View online at http://bit.ly/HighlandParkReport-e-AppendixF

e-Appendix G – City Comparisons Matrix
http://bit.ly/HighlandParkReport-e-AppendixG.