WATER CONSERVATION IN CENTRAL TEXAS: SUSTAINABLE WATER SAVINGS AND FUTURE APPLICATIONS

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ABSTRACT

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The population in Central Texas is expected to increase over 100% between 2010 and 2060 significantly increasing municipal water demands, which may be further complicated by climate change and drought (Texas Water Development Board 2007). In order to address potential shortages, municipal water conservation is expected to contribute 145,277 acre-feet of water supplies per year in Central Texas (TWDB 2006). The economic and per unit water savings of specific conservation measures are not well documented and few studies have been published that include empirical findings concerning the effectiveness of conservation programs on water demand reductions (WCASA 2006). The majority of studies that do contain information on conservation savings do not provide methodologies, models or standardized values transferable to Central Texas municipalities. Currently, there is no published record of existing conservation measures in Central Texas; even less is known about the water savings resulting from the use of such measures. Accurately assessing the progress toward the significant water reductions mandated by the 2007 State Water Plan makes it imperative that we know: (i) what measures are in place; (ii) how much water they are saving; and (iii) the costs of such measures, as well as the potential water savings from implementing additional water conservation best management practices recommended in the State Water Plan. Water conservation measures in place for more than 30 municipal water providers were examined for Bastrop, Caldwell, Hays, Travis and Williamson counties, which comprise portions of Texas Regional Planning Groups G, K and L. Collected data and information for many water providers in the study area were cataloged and categorized into a database. Several municipal water demand reduction best management practices were examined for potential savings applications for Central Texas water providers, including plumbing fixture, rain barrel, and rain catchment system rebates and watering restrictions. Estimations of conservation savings necessary to meet projected water savings over the fifty year planning horizon were calculated equally over each decade and model outputs show that plumbing retrofit, rebate and replacement programs were among the most efficient measures for reducing water use. Outdoor watering restrictions were also found to be very effective conserving water. Based on study results, collected case studies and relevant information, recommendations for best management practices and related regulations were provided.

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CHAPTER ONE

AN INTRODUCTION TO MUNICIPAL WATER CONSERVATION IN CENTRAL TEXAS

Water supply and management issues are becoming increasingly important as the demand on existing supplies continues to grow. Increasing populations in many areas, combined with increasing demand for water for recreation, scenic value, and fish and wildlife habitat, have resulted in conflicts throughout the country, especially in the arid West.

- Congressional Research Service report for Congress, "Water Resource Issues in the 107th Congress" by Betsy Cody and H. Steven Hughes, January 16, 2001.

Texas Water Needs Now and Into the Future

Central Texas' water resources are increasingly utilized for water extraction, as demands for satisfying substantial population growth, urbanization and industrialization continue to grow. The population of Central Texas is expected to more than double between 2010 and 2060 and increased water demands may be further complicated by climate change and drought (Texas Water Development Board 2007). Our increasing knowledge of necessary instream flow requirements may further decrease the quantity of water available for human uses. Further, projections of available water supplies suggest a decrease of more than 18%, due primarily to drought and siltation accumulation in Texas reservoirs (TWDB 2006). These increasing water demands and supply shortages across the state will result in a deficit of nearly 9 million acre-feet equivalent to more than one-third of the projected total water demands in 2060 (TWDB 2007). According to recent Texas Water Development Board estimates, if similar deficits continues and drought persists, up to 85% of the population's water demands may not be met, with water shortages costing the state over $9 billion dollars by the end of 2010, and potentially rising to $98.4 billion by 2060 (TWDB 2007).

Future percentages of water allocated to municipal water use are predicted increase by at least 10% (4.6 million acre-feet), accounting for 35% of the state's total water needs (i.e., from 25% in 2000 to 35% in 2050), driven primarily by rapid population growth (TWDB 2007; U.S. Department of Interior 2006; WRA 2003). Interestingly, although Texas' population is expected to double over the next fifty years, the quantity of water needed for municipal supply is expected to increase by only 27%, due partly to decreasing agricultural water allocations, with the majority of the savings expected in the form of water conservation. Municipal water conservation is expected to contribute approximately 30% of Texas's total water savings, as suggested in the 2007 State Water Plan (TWDB 2007).

The U.S. Department of Interior strongly recommends implementation of appropriate conservation practices to help alleviate water shortages, based on study findings which identified 6 locations in Texas where existing water supplies are projected to be inadequate to meet the water demands of people, farms, and the environment as soon as 2025 (U.S. Department of the Interior 2006).

Such hydrologic realities support the notion that the long-term sustainability of the state's human and ecological water resources depend at least partly on identification, analysis, expansion and adoption of water conservation techniques for reducing the necessary quantity of water provided by traditional water treatment and delivery systems. There are examples whereby water providers in other semi-arid and arid parts of the country have successfully alleviated seasonal water demand fluctuations, ultimately reducing overall and per capita water consumption, through implementation of conservation and water recycling programs (Howe 2005; Loaucuga and Renehan 1997; Western Resource Advocates 2003). Reduced cumulative water demands and consumption were realized in some of these examples, despite rapidly increasing populations (Loaucuga and Renehan 1997; Michelsen et al. 1998; Michelsen et al. 1999; Morrison Institute 1999). Such water savings may eliminate, or at least postpone, the need to implement costly water supply upgrades (e.g., reservoir development; expanded infrastructure and construction of additional pipelines). Water supply requirements based on reduced demand levels can allow utilities to more readily employ conservation-based management (Ward 2007). Conservation methods commonly used to reduce per capita and overall water consumption include non-price related methods and pricing mechanisms. The former measures include education programs, distribution of public information, appliance retrofits and replacement programs/incentives, rainwater catchment and graywater systems, and water use ordinances (Campbell and Johnson 1999; Michelsen et al. 1998; Water Conservation Alliance of Southern Arizona 2006). Common conservation pricing strategies include marginal cost-pricing structures, multi-tiered pricing (also known as increasing block rates) and peak load pricing. Marginal cost prices increase per water use increment, so that customers using more water pay more for each additional increment consumed (Chambouleyron, 2004; Johansson et al. 2002). Multi-tiered pricing, a form of marginal-cost pricing (also known as inclining or increasing block rates), establishes incremental prices sufficiently high to offset financial losses realized from pricing basic water use increments below their average cost (Agthe and Billings 1997; Nieswiadomy 1990; Renzetti 1992; Ward 2007). Peak load pricing is the practice of increasing prices during peak demand periods, typically during summer months, to encourage reduced water consumption for non-essential uses (Bakker et al. 2003).

Reduced per capita and household water consumption is critical to meet the water demands of projected population growth, and minimize the necessity of acquiring additional water supply, treatment and system expansion costs. Estimated water savings resulting from combinations of non-price and price conservation practices can be incorporated into capital investment and operating decisions and may prevent or postpone fixed capital and variable operating costs, such as infrastructure development and unnecessary water purchases (Chesnutt and Beecher 2004; Loucks 2000; Ward 2007).

Recent assessments of water providers in the Western United States indicated water consumption accounting and monitoring were severely limited and, therefore, inadequate for calculating the effects of implemented conservation measures. Few surveyed providers had attempted to assess the cost-effectiveness of their conservation programs, due mostly to lack of information for calculating water and cost savings (Western Resource Advocates 2003). Detailed benefit/cost analyses are often conducted to justify traditional structural water supply improvements, however, this level of analysis for water use efficiency measures is extremely limited, even non-existent, for many providers (Michelsen et al. 1998; Western Resource Advocates 2003).

Although the Texas Water Development Board recommends best management practices and water conservation measures (*Water Conservation Best Management Practices Guide – TWDB Report 362)*, very few measures are mandatory (TWDB 2005, TWDB 2006). For example, local river authorities require wholesale water purchasers to include method for monitoring the effectiveness of conservation measures in the purchaser's water conservation plan. However, most submitted plans neither report nor utilize functional methodologies. Further, as in other parts of the country, few water providers have assessed reduced water use or cost-effectiveness associated with implemented water conservation measures. In fact, many water providers may not have the ability to perform such assessments. Few studies have been published that include empirical findings concerning the effectiveness of non-price conservation programs on water demand reductions. Several studies contain information on conservation savings, but do not provide methodologies, models or standardized values transferable to Central Texas municipalities. Further, many discrepancies exist in the literature concerning water conservation and pricing, and earlier econometric studies did not demonstrate that non-price conservation measures were significantly effective (Hamilton 1983; Michelsen et al. 1998; Ward 2007). It is difficult to identify the effectiveness of specific measures within conservation programs in studies lacking long-term, intensive data collection for relatively stable populations (Hamilton 1983; Michelsen et al. 1998; WCASA 2006). Such information and data scarcity obviously make estimation of the efficiency and cost- savings attributable to non-price conservation measures difficult, at best (Michelsen et al. 1999). Climate change implications and instream flow requirements further complicate the situation (Gerston et al. 2002; Gleick 1998, 2000; Lind 1997 TWDB 2006; Ward 2007).

Increasing municipal, agricultural and industrial water use must be effectively managed to meet increasing population growth, urban and industrial needs, while at the same time ensuring environmental and ecological water needs (Dyballa 1999; Gleick 2000). Accordingly, institutional policy emphasis is changing from developing new water supplies toward incorporating ecological values in water policy, as well as increased focus on economically-efficient water allocations (Loaiciga and Renehan 1997; Ward 2007). According to Dzurik (2003), this trend means that a crucial challenge in water policy and planning is the valuation of water as a limited and scarce resource.

Central Texas Water Conservation Study

Water Planning Regions G, K, and L in Texas expect to save 349,460 acre-feet through implementation of water conservation practices (not including water reuse) by 2060. A substantial portion of these water savings and a large percent of overall water demands will come from the Central Texas area (TWDB 2006). Noting that water providers and policy makers Central Texas must now face the challenge of identifying impacts and tradeoffs of current water use management decisions well into the future (Loucks, 2000; Ward 2007), economic concepts (e.g., growth projections; valuation and structured pricing models) can be useful tools in management schemes targeting improved water supply quantity and reliability (Tsur et al. 2004; Ward 2007).

Against this background, the purpose of this study is several-fold, including: (1) identifying and assessing the extent that water conservation methods are being used in the 5 counties that encompass the 3 Central Texas regional planning groups; and (2) estimating the current and potential future volumes of water to be saved by using such techniques.

As stated above, there is no published record of existing conservation measures in Central Texas; even less is known about the water savings resulting from the use of such measures. Accurately assessing the progress toward the significant water reductions mandated by the 2007 and future State Water Plans make it imperative that we know: (i) what measures are in place; (ii) how much water they are saving; and (iii) the costs of such measures, as well as the potential water savings from implementing additional water conservation best management practices recommended in the State Water Plan.

Study goals included: (1) identifying major water conservation programs and measures practiced by selected municipalities and private water providers in Bastrop, Caldwell, Hays, Travis and Williamson Counties; (2) identifying and revising models for assessing the effectiveness of identified water conservation programs and evaluating their utility; and (3) determining the potential savings of implementing additional water conservation programs and activities.

Currently, the majority of water providers in the West and Southwest, and specifically in Texas, have not achieved significant potential water conservation savings, or optimized the efficiency of their existing facilities and delivery systems, despite reduced water supplies and persistent drought (WRA 2003; Michelsen et al. 1998). Adoption of cost-efficient conservation measures and best management practices could reduce water supply stress and alleviate future water deficits. The results of this study can be used not only to develop policy guidelines and water-provider management tools for Central Texas, but could also be expanded for use in other areas in Texas and the United States. The legislature-mandated Texas Water Conservation Advisory Council is currently undertaking a state-wide study to determine conservation measures utilized by water providers, as well as the efficacy and cost of these programs. The results of this thesis project will be submitted to the council.

Best Management Water Conservation Practices

Although municipal water conservation measures are well described in the literature, the economic and per unit water savings of specific conservation measures are not so well documented (WCASA 2006). Some programs describe water use reductions, but are not able to provide total water savings and cost ratio data (Hamilton 1983; Michelsen et al. 1999; United States Environmental Protection Agency 2002; Urban Water Conservation Council 2000; WRA 2003). In fact, assessment of the efficacy of water conservation measures is seldom done after they are implemented, with any calculations of monetary or water savings being done prior to adopting a measure, often only for the purpose of attempting to rationalize implementation of a measure in the first place (WCASA 2006).

<u>Demand Side Measures</u>

Demand-side or end-use water conservation measures include practices that lower total water use or demand, through installation of new technology (e.g., ultra low-flow toilets) or behavior changes (e.g., education; distribution of public information; pricing strategies). Several conservation programs have demonstrated that significant decreases in per capita and household water use are feasible when demand-side conservation measures are implemented (Vickers 2001; WRA 2003; WSACA 2006).

Decreased per capita water use can translate to saving available water as a means of augmenting existing supplies, allowing for postponing and downsizing of new supply development, even when facing population increases. Based on water conservation planning undertaken in the 1990s, for example, the Massachusetts Water Resources Authority (MWRA) achieved a 25% reduction in Boston's system-wide water needs, allowing cancellation of plans for a new dam project, and saving more than $500 million in capital expenditures. (Vickers 2001). Over the last one-and-a-half decades, New York City conservation programs have conserved more than 250 million gallons per day (New York City 1997). The water savings realized from the city's aggressive low-flow toilet rebate program and other municipal conservation practices resulted in termination of a planned $1 billion expansion of a wastewater treatment facility. Seattle's comprehensive water conservation program includes tiered water pricing, customer rebates, and water-related ordinances, which have successfully reduced total water consumption by nearly 30% over the past decade (Seattle Public Utilities 1998, 2006).

Although these examples provide useful benchmarks for potential water demand reductions in Central Texas, our semi-arid region exhibits much higher water use for outdoor purposes. Most documented water conservation savings studies have realized water savings primarily from reduced indoor water use. In addition to similar potential indoor conservation savings, greater water per capita water reductions in Central Texas can be anticipated from outdoor water savings practices (WCASA 2006; WRA 2003).

Non-pricing Related Conservation Methods

In areas experiencing high population growth (e.g., arid Southwest), and where residential use comprises a substantial share of total municipal water use, conservation programs for reducing residential water use are increasingly being implemented (Michelsen et al. 1998, Vickers 2001). Many programs consist of non-price conservation measures, including education programs, distribution of public information, appliance retrofits and replacement programs/incentives, and water use ordinances (Campbell and Johnson 1999; Michelsen et al. 1998). Few studies, however, include empirical findings concerning the effectiveness of water demand reductions via non-price conservation programs. Earlier econometric studies did not demonstrate these types of conservation measures were significantly effective (Hamilton 1983; Michelsen et al. 1998; Ward 2007). For studies lacking long-term, intensive data for relatively stable populations, it is difficult to identify the effectiveness of specific conservation program measures (Water Conservation Alliance of Southern Arizona 2006; Michelsen et al. 1998; Hamilton 1983). Accordingly, estimating efficiency and cost savings attributable to non-price conservation measures is difficult, at best (Michelsen et al. 1999).

Household and Multi-family Housing Retrofitting, Replacement and Rebate Programs

Recent studies indicate successful programs for reducing residential water use include installation of water-saving replacement devices. Residential customers receive free or low-cost retrofit devices (e.g., toilet dams; low-flow showerheads;

faucet restrictors). Water appliance rebate programs for water-saving shower heads, low-flow toilets and ultra-efficient washing machines also are effective in lowering household water use (California Urban Water Agency 2001; City of Austin website May 2008; City of San Marcos website May 2008; Michelsen et al. 1999; WSACA 2006). Vickers (2001) offers examples of water use reductions and average household cost savings from this approach. Annual household savings of up to 13,000 gallons, and more than $100 per year, can be realized by replacing high-volume toilets with efficient low-flow models. The average family of four uses about 16,000 gallons annually to wash approximately 400 loads of laundry. High-efficiency washing machines can lower average annual household water usage by as much as 40%, with an annual savings of more than 6,000 gallons. Because toilets, washing machines and faucets account for the highest percentage of water use in a typical home, technological advances in these devices offer the highest potential for water savings.

Although standard flow toilets use an average of 18.5 gallons per person per day, the installation of toilets that utilize only 1.6 gallons per flush reduces per capita daily use by as much as 8.2 gallons (WRA 2003). A recent study calculated per household savings of 10,000 gallons annually by replacing 2 standard toilets with ultra low-flow or high-efficiency toilets (WRA 2003). The long 25 year average lifespan of such toilets means water savings extending far into the future. Because only 1.6 gallons per flush (gpf) toilets or even more efficient models are now available for purchase, such savings can be considered permanent (Vickers 2001).

El Paso Water Utilities (EPWU) distributed over 160,000 low-flow showerheads to customers in 2001. Use of these showerheads resulted in a decreased wastewater volume of about one billion gallons per year. With each showerhead yielding a water savings of 17.2 gallons per day (gpd), and an average of 3.1 people per household in El Paso (according to the 2001 US Census), the per capita water savings would be 5.52 gallons per day (Table 1). A 2002 TWDB/GDS study following adoption of restrictive plumbing standards in 1992 indicated that about 1% of eligible customers per year will replace toilets, showerheads and faucets lost to breakage, remodeling, etc. Thus, approximately 10% of eligible customers have already replaced older toilet models (3.5–7 gallons per flush) with lower flow volume models (1.6 gallon per flush) and lower flow showerheads and faucets between 1992 and 2001. Another recent study anticipates a single family customer participation rate of 50% for SF toilet retrofit or replacement programs. Similar assumptions are made for replacing or retrofitting less efficient showerheads and aerators with low-flow showerheads and aerators, with the stipulation that retrofitting or replacement kits are included in a public information/education program or distribution program (California Urban Water Conservation Council 2005).

A toilet replacement program implemented in the Jordan Valley, UT Water Conservancy District had an average cost of $200 per ULF toilet, including purchase, installation, equipment, mailing and advertising expenses, staff time and participant cost (WRA 2003). Two hundred seventy five toilets were purchased, yielding a water conservation savings of approximately 10.5 gpcd. The entire rebate program conserved 3,794,175 gallons per year, equivalent to nearly 11.65 acre-feet of water at a total cost of $55,000 (approximately $188.94 per year over the 25 year life of the toilets, assuming 3.60 individuals per household. The specific costs for the toilets in this program are summarized in Table 1).

Traditional washing machines have an average water factor of over 13 gallons per cubic foot, using between 35 - 40.9 gallons per normal load, accounting for nearly 22% of total indoor household water use (AWWA 1999; Brown 1984; Vickers 2001). High efficiency machines average 8 gallons per cubic foot, using a maximum of 27 gallons per load, and resulting in energy savings of as much as 50%, as well as an average per load water savings of at least 8 gallons (Consortium of Energy Efficiency 2008; Vickers 2001). Multiple studies suggest 0.37 loads of laundry are washed per capita per day, thereby yielding per capita savings of nearly 3 gallons each day (AWWA 1999; Brown 1984; Vickers 2001). Another study reported savings of 5.6 gallons per person per day (2,044 gallons per person per year) could be realized by replacing a traditional washing machine with a more efficient model (AWWA 1999). San Antonio Water Supply (SAWS) recently implemented a dual-rebate program for replacing high water use washing machines, offering $100 per washer, with the city electric utility matching the $100 for each machine purchased. Even without considering the reduced electricity benefits, an estimated 271 acre-feet of water was conserved in the first year, at a cost of about $600 per acre-foot (SAWS

2006). Federal clothes washer energy standards in 2004 required only trivial increases in water efficiency, increasing to a maximum capacity of 9.5 gallons per cubic foot in 2007 (AWWA 1999; Vickers 2001). Maintaining federal standards for high efficiency washing machines would result in the lifetime of these savings being considered permanent. In fact, the average life of a clothes washer is 10 - 13 years, by which time the market would likely only be offering washing machines utilizing no more than 9.5 gallons per cubic foot capacity (Vickers 2001).

Studies in Texas and California assume at least 2% of eligible customers have already purchased efficient washers over the last 8 years (California Urban Water Conservation Council 2005; TWDB 2002). Another study assumes that if rebates are offered for purchasing high efficiency washing machines, single family participation rates could reach as high as 45% (TWDB 2004). Very little has been documented in the literature, however, about actual washing machine rebate participation rates of single family customers. As an example, only 2,140 out of nearly 300,000 eligible single family customers applied for the SAWS washing machine rebate program in 2008. Nevertheless, because only the highest efficiency washers (tier 3) are accepted, substantial water savings were still realized. With 1,295 customers participating in the first five months of 2009, SAWS projects that 4,200 high-efficiency washing machines will have been rebated by the end of 2009, with an estimated annual water savings of one billion gallons (personal communication, Brandon Leister, SAWS Water Conservation/Wash Right Program Office, June 16, 2009). The city of Austin reported that 4,292 out of 200,000 customers applied for washing machine rebates during the 2007-2008 fiscal year, a rate of only 2.15% (personal communication, Emily Young, Water Conservation Department, City of Austin, June 15, 2009).

Single family and multi-family washing machines' estimated rebate costs include direct costs of $100 for the water utility portion of the incentive/rebate, and indirect costs of $20 for processing, inspection, and marketing, with staff labor being an additional, although variable, cost dependent on the size of the utility and the rebate program. This $120 average cost yields water savings of 30 gpd (based on two loads per day, saving 15 gallons/load) for multi-family washing machine replacements, and between 4.4 - 10.7 gpcd for single family washing machine replacements (AWWA 1999; Vickers 2001). These savings translate into 10,950 gpy for an average of 8 years, and between 1,621 and 3,916 gallons per capita per year for at least 10 years, for multi-family and single family rebates, respectively (Table 1).

Table 1: Summarized metrics from toilet, showerhead and faucet aerators retrofit and rebate studies

Device	Data Source	Savings (GPCD)	Device Life Span (yrs)	Direct Cost/Rebate	Indirect Cost	Installation Costs	Average Cost
LF Shower Head	City Of El Paso, Metro Water Dist of S. CA, Vickers, AWWA	5.50	10				$12-30 See Table 2
LF Shower Head	CA Urban Water Conservation Council	5.50	15	$3.00	$1.00		$ 4.00
SF LF Shower Head	TWDB		15			SF $10-30 MF $0	$ 15.00
Faucet Aerator	CA Urban Water Conservation Council	5.50	15	$3.00	$1.00		
Faucet Aerator	TWDB Vickers	5.50	10			$10-30	$.50-3.00
Ave Faucet Aerator		5.50	12.5	$3.00	$1.00	$ 20.00	$1.75
Toilet Flapper	TWDB Vickers	12.80	5	$3-10			$2-10
Toilet Flapper	Seattle Public Utilities	6.47	20				$ 8.00
Ave Toilet Flapper		9.635	12.5	$ 6.50			$ 6.67
ULF Toilet	City of Jordan Valley, UT Conserv. District		25	$91.00	$37.55	$ 91.00	$ 200.00
ULF Toilet	AWWA TWDB	10.50	25	$60.00	$15-25	$5-20	$ 97.50
ULF Toilet	Vickers	9.7-14.8	25	$75-225		$50-125	
ULF Toilet	WRA Irvine, CA	4.23	10	$ 25.00	$ 9.17		$ 34.17
ULF Toilet	City of San Marcos, TX	9.50					
SF ULF Toilet	Metro Water Dist of S. CA	10.74	25				
Ave ULF Toilet		9.91	25	$95.20	$21.68	$ 58.20	$ 110.56
2nd ULF Toilet	Metro Water Dist of S. CA	6.30	25				
MF ULF Toilet	City of Austin, TX	18.00	25				
SF Washing Machine	TWDB, AWWA	5.31		$100.00	$20.00		$ 120.00
SF Washing Machine	City of Austin, TX, Vickers	5.48-7.48	13	$100.00			
SF Washing Machine	WRA Irvine, CA	8.46	14	$250.00	$ 9.17		$ 259.17
Ave SF Washing Machine		6.68	13.5	$150.00	$14.59		$ 189.59
MF Washing Machine	TWDB, AWWA	15 (2 washes per day = 30 gpd savings)	8	$100.00	$20.00		$ 120.00

Table 2: Costs of distributing low-flow showerhead kits (Vickers 2001)

Kit Distribution Method	Approximate cost per household	Average cost per household
Door-to-door canvas	$13-20	$16.50
Direct installation	$17-30	$23.50
Mass mailing	$10-15	$12.50
Depot Pickup	$8-13	$10.50
Rebate	$15-20	$17.50
Kit requests	$7-12	$9.50

Landscape Irrigation, Conservation and Xeriscaping Rebates and Incentives/Water-Wise Landscape Design and Conversion Programs

Household irrigation is a major water use in the Western United States, with watering of traditional turf grass landscapes and yards being the principal outdoor municipal water use. Average turf grass lawns require 30 - 40 inches (76.2 - 101.6 cm) of water annually, assuming year-round watering in Texas (WRA 2003). Watering lawns can account for more than half of annual household water expenditures (Hurd 2006). Accordingly, a method that promotes household irrigation water-use efficiency is xeriscaping, a multi-step landscape design and maintenance practice using low-water-use, or drought-tolerant, vegetation as the primary element in residential and commercial landscapes, to replace traditional turf grasses (Figure 1). This practice and other low water use landscape designs can significantly decrease outdoor water use, especially in peak months.

The TWDB (2004) Water Conservation Best Management Practices Guide recommends any implemented landscape conversion should achieve a minimum water use reduction of 15%. To estimate the water savings of converting traditional turf grass to more water efficient landscaping, the Best Management Practices Guide provides the following equation:

S = I(h) – I(BMP)
Where: S = water savings (acre-feet/year); I(h) = annual irrigation average prior to implementing BMP; and I(BMP) = annual irrigation after implementing BMP

Figure 1: Example of Residential Xeriscaping (Source: Steve Dodrill, Oregon State University Agricultural Experiment Station, 2008)

A recent study illustrated that converting traditional lawns to "water wise" or xeriscaped landscaping, and improved management of outside watering, resulted in water savings ranging from 35-70% (Hurd 2006). Another study found similar landscape conversions yielded yearly household water savings ranging from 11,387-39,665 gallons (average savings of 21,897 gallons (11.6%; (WRA 2003). Longer-term analyses, however, indicated an 18% decrease in water savings after implementation of landscape conversions (WCASA 2006). Other studies speculate a return to higher water use rates after landscape conservation may be attributable to drought, lack of sprinkler/irrigation maintenance, or reverted consumer behaviors (Faux and Perry 1999; Hurd 2008; Michelsen et al. 1998).

The El Paso Water Utilities (EPWU) offers all residential, commercial, and industrial customers (not applicable to new homes) a landscape/turf replacement rebate program, providing incentives for converting established turf areas to water-efficient landscape designs featuring drought-tolerant plants and water-efficient horticulture practices. A pilot phase was initiated in 2001, offering $0.50/square-foot of turf grass converted to approved landscape. The EPWU increased the rebate to $1.00/ square-foot of converted turf after one year. The utility estimated that 385 participants converted about 29 acres of turf grass during this two-year period, resulting in nearly 23 million gallons of water conserved. During peak use summer months coupled with drought conditions, EPWU data indicated water savings of 150-180 gallons per day per residential household in 2002, attributable to the turf replacement program (City of El Paso Water Utility website May 2008).

In another relevant study, the East Bay Municipal Utility District in northern California compared daily water consumption of single-family detached homes with "water-conserving" landscapes, to water use in homes with traditional turf-oriented landscapes (East Bay Municipal District 2008; Iwata 1994), focusing on 7 developments comprising 548 dwelling units with mature landscapes, either traditional turf grass lawns or low water-use landscaping with specific design criteria. Cost analyses of water, labor inputs, chemical applications (fertilizers;

herbicides) and fuel yielded annual household savings of $75 for low water use landscapes (Iwata 1994). Compared to traditional lawns, water-conserving landscapes required only 75% as much labor, 61% as much fertilizer, 20% as much pesticides, and only 44% as much fuel. The low water use landscapes utilized an average of 54% less water, conserving up to 209 gallons per day over comparable traditional turf grass lawns (East Bay Municipal District 2008; Iwata 1994).

The Southern Nevada Water Authority (SNWA) found its residents irrigated turf grass with an average 73 gallons per square foot per year (117.2 inches), compared to only 17.2 gallons of irrigated water per square foot per year (27.6 inches) for xeric landscaped areas, a savings of 55.8 gallons per square foot. Converting traditional high-water-use turf to low-water-use landscaping resulted in a 74% decrease in outdoor irrigation, ultimately saving 18 billion gallons (55,327 acre-feet) of water each year between 2000 and 2007 (SNWA 2008), with an average of 199,008 gallons (0.61 acre-feet, 752.423 m3) of water saved per rebate participant. Assuming a 10-year life span for low water use water landscaping, SNWA will average a cost of $575/acre-foot of water saved through their landscape conversion rebate program over the lifetime of the landscape (SNWA 2005, 2008). Similar studies in California, Texas and New Mexico indicated up to a 43 % water savings (Table 3).

Table 3: Summarized metrics from turf installation and landscape conversion studies

Practice	Data Source	Initial Savings (G P FT SQ YR)	$ Cost per gallon	1st Year Cost per Sq Ft	Annual Cost per Sq Ft (Staff time)	Initial Cost per Sq Ft (Rebate)	1st Year Cost per AF Water Saved
Synthetic turf installation	WRA Irvine, CA	19.13	$ 0.31	$ 5.85			$ 99,649.22
	WRA Lake Forest, CA	11.97	$ 0.31	$ 3.71			$ 100,973.59
	WRA Tustin, CA	20.53	$ 0.23	$ 4.72			$ 74,924.00
	WRA Newport Beach, CA	25.00	$ 0.15	$ 3.83			$ 49,917.35
Average Synthetic turf installation		**19.16**	**$ 0.25**	**$ 4.53**	**~**	**~**	**$ 81,366.04**
Landscape Conversion/xeriscaping	WRA Las Vegas, NV	55.80	$ 0.04	$ 2.00			$ 11,679.25
	Sovocool, Rosales & S. Nevada Water Authority	54.00	$ 0.02	$ 1.33	$0.02	$1.00	$ 8,025.59
	N. Marin Water Conservation District, CA	33.00	$ 0.02	$ 0.68	$0.02	$0.50	$ 6,714.00
	City of Albuquerque, NM	19.00	$ 0.03	$ 0.55	$0.02	$0.40	$ 9,433.00
	City of El Paso, TX	18.00	$ 0.07	$ 1.33	$0.02	$1.00	$ 24,077.00
Average Landscape Conversion/xeriscaping		**35.96**	**$ 0.04**	**$ 1.18**	**$0.02**	**$0.73**	**$ 11,985.77**

Rainwater Harvesting

The assessment of water conservation by the Texas Water Development Board, and Texas State Soil and Water Conservation Board prepared for the 80th Texas Legislature indicated rainwater harvesting to be an under-utilized source of supplementary urban and suburban water supplies (TSSWCB 2006; TWDB 2006). Rainfall patterns during non-drought years in Central Texas could contribute to a relatively stable supplemental water supply, making rainwater collection and harvesting extremely efficient economically, and requiring relatively little development cost (TWDB 2005b; Vickers 2001). Figure 2 shows a typical 700 gallon collection cistern used to collect and store rainwater. Rain collection systems also tend to be localized, thereby not requiring extensive distribution systems (TWDB 2005b). A TWDB study estimated that utilizing just 10% of the roof area in a large Metropolitan city (e.g., Dallas) could capture 12 billion gallons of rainwater annually. Further calculations indicate 38 billion gallons of supplied water could be conserved annually if rainfall was captured from 10% of the total roof area in Texas (TWDB 2005b).

Rainwater collection and harvesting has proven to be a low-cost supplement to municipal water supplies in Central Texas, being used in a wide variety of settings (e.g., landscape irrigation at Lady Bird Johnson Wildflower Research Center; Wells Branch Municipal Utility District Office; Hays County Extension Office; New Braunfels Municipal Building; Edwards Aquifer Authority Office; Paint Rock High School; Menard Grade School) (TWDB 2005b). Other non-potable rainwater uses in Texas include cooling water for air-conditioning systems (J.J. Pickle Elementary School), and flushing toilets (Austin Resource Center for the Homeless; Lower Colorado River Authority office building).

Water for toilets and washing machines comprises nearly 40% of total in-home water use (Vickers 2001). If collected rainwater could be substituted for these two uses, both water providers and home owners would benefit from a considerable savings of purchased water supplies and total costs. Rainwater utilization also could help reduce maximum water supply capacity of a water supplier, potentially allowing utilities to postpone expansion of water treatment facilities (TWDB 2005b; Vickers 2001).

Figure 2: Seven hundred gallon rain cistern for storing rainwater for the Camp Aldersgate Commons Building, Little Rock, Arkansas (Source: Mark Littrell, Wilcox Group Architects)

A 2001 TWDB (2001) study analyzed the potential results of implementing a rainwater collection/harvesting system rebate program for the City of Austin (TWDB 2001). The city used a model incorporating 50 years of rainfall data, reporting that an average collection system in Central Texas could be expected to top average 21.6 gallons per day (gpd) over the annual cycle. If there is an average of 2.5 members per household, for example, the water savings from implementing a rainwater collection system would be equivalent to 8.64 gpcd in rural Bastrop County. This model assumes collected rainfall would only be utilized for landscape irrigation over a five-day cycle. The City of Austin model also assumes an average roof area of 2,000 square feet, and that 500 gallons every 5 days would satisfy an average household irrigation needs (less would be required for xeric and low water use, native landscaping). (TWDB 2005; TWDB 2006).

An average rainwater collection system was defined as a 1,000 gallon collection tank with a pump, at an estimated cost of $670, for which a rebate of $200 would be offered. The total cost to the water provider would be $250 per participant, including $50 for labor and marketing costs per rebate (TWDB 2005b). Rainwater harvesting systems typically utilize polypropylene collection tanks with a life span of about 15 years. Thus, the water savings over 15 years can be divided by the initial rebate costs to determine the "cost" of each gallon of water saved. For Central Texas, for example, 118,260 gallons of water can be saved over the lifetime of a 1,000 gallon rainwater collection system, at a cost of $0.002 per gallon to the provider, and a cost of $0.004 per gallon to the customer, both substantially less than current costs per gallon (Table 4). The study assumed a 5% participation rate for single family residential customers, based on current market acceptance and demand (TWDB 2005b). This participation rate may have grown substantially over the last 5 years, considering prolonged drought, increased awareness of impending water shortages, and water conservation needs. Further, as technology and building practices become more affordable, both the demand for water collection systems and the participation rates in rebate programs are expected to increase.

Rain barrels provide an option for collecting rainwater on a smaller scale. While the quantity of water conserved is less, so also is the rebate and installation cost (e.g., rain barrels cost approximately $70-100; Vickers 2001; TWDB 2006). Information compiled during the 2002 TWDB/GDS study indicated installation of a 75-gallon rain barrel collecting water from a 500 square foot roof area in Central Texas will provide approximately 2.3 gpd of rainwater for irrigation, to be used in place of tap water. At a cost of $45 ($35 rebate cost plus labor and marketing costs), more than 12,593 gallons will be saved over the 15 life span of 1 rain barrel, at less than one cent per gallon. A similar water savings model developed by the Seattle Public Utilities in 1998 indicated $50 rebates for 50-gallon rain barrels would potentially save 14,600 gallon of water over the lifetime of the rain barrel, with the exact per gallon cost (SPU 1998). Although smaller overall water savings per installation are realized, compared to larger catchment systems, the participation rate for using rain barrels is much higher, averaging 30% in Texas and 20% in Seattle (SPU 1998; TWDB/GDS 2002).

Figure 3: A rain barrel, including spigot and connection to downspout (Source: Lake Co. Illinois Stormwater Management Commission)

Table 4: Summarized metrics and findings from Texas Water Development Board Rainwater Collection Studies

	Initial Savings (GPD)	Device Life Span (yrs)	Lifetime Water Savings	Direct Cost/Rebate	Indirect Cost	Total Cost	Provider Cost per Gallon of Water
(TWDB) 1000 g Collection System	21.6	15	118260	$ 200.00	$ 50.00	$ 250.00	$0.0021
(TWDB) 75 g rain barrel	2.3	15	12592.5	$ 35.00	$ 10.00	$ 45.00	$0.0036
(SPU) 50 g rain barrel	2	20	14600	$ 50.00	$ 2.96	$ 52.96	$0.0036

Public Information, School Education Programs and Employment of Conservation Coordinator

Education programs are the most commonly-utilized demand-side water use efficiency practice in the Southwestern United States. Public education and awareness is fundamental to achieving water conservation goals, with high, though often difficult to measure results for the invested costs (Michelsen 1998; WRA 2003; WSCASA 2006). Public information programs are any combination of distributed printed materials, including water bill inserts, mailed or publically-available literature, public service announcements and advertisements, news articles, xeriscaping seminars and neighborhood demonstration gardens, new homeowner information programs and/or suggested water use rotation schedules (Hamilton 1983; Michelsen 1998). In contrast to public information programs, educational programs focus on classroom presentations and water conservation curricula and activities (although providing the same overall information).

Based on a survey of water use strategies, the success of any water conservation program is contingent upon customer awareness and acceptance, best achievable through effective outreach and education programs (Gerston et al. 2002). Public information programs not only increase awareness of critical water issues and water conservation practices, but also can facilitate public acceptance of financial incentives and regulatory programs. A benchmark survey of water conservation programs conducted by the Austin Planning Environmental and Conservation Services Department indicated public education programs for raising public awareness were in place for 94% of the large utilities surveyed in the United States and Canada (City of Austin Planning Environmental and Conservation Services Department 1999). Mayer and DeOreo (AWWA 1999) reported that public information and education programs were likely to be more effective if a "critical mass" of conservation methods and information were made available (AWWA 1999). Another study reported water providers increasing the number of non-price conservation programs from 5 components to 10 could reduce water demand by an average of 13%. (AWWA 1999; Gerston et al. 2002). Public education programs also were found to be statistically significant in reducing water demands in the Western United States (Nieswiadomy 1992).

The City of Houston's conservation plan projects a 47% reduction in overall water use between 1997 and 2047 due to public education, although they did not publish any calculations related to determining these savings. The city's information campaign includes mass media advertisements, education programs (e.g., *Major*

Rivers; *Learning to be Water Wise and Energy Efficient*), home water audit kits, civic and environmental association presentations, and a T-shirt design contest. Conservation benefits are reported to include current savings in operations and maintenance and savings from deferral or cancellation of capital projects (Gerston et al. 2002; Watson/City of Houston 1997).

An expert panel analyzed potential water savings and associated costs of promoting certain conservation behaviors in the Seattle area in 1998, including decreasing the time faucets are left running, eliminating washing partial loads of clothing, and more responsible management of swimming pool water levels (SPU 1998). The cost per acre-foot cost of water saved is very low, while the daily household conservation savings are substantial (Table 5). The administrative costs represent staff and operating costs, but do not necessarily reflect advertising expenses, nor educational material distribution costs, meaning the actual cost per acre-foot of water saved would be slightly higher.

Table 5: Potential water savings and associated costs of adopted conservation behaviors in Seattle, WA (Seattle Public Utilities 1998, 2006)

Conservation Activity	Gal/ Household/ Day (GPCD)	$ Cost per gallon	$ Per Gal Equip Cost	$ Per Gal Admin Cost	$ Cost per AF Water Saved
Improve Irrigation Scheduling	38.41	$ 0.00010	$ 0.00009	$ 0.00001	32.56
Decrease Toilet Flushes	5.19	$ 0.00005	$ -	$ 0.00005	16.93
Decreased Faucet Use	6.39	$ 0.00004	$ -	$ 0.00004	13.76
Decreased Shower Use	8.88	$ 0.00003	$ -	$ 0.00003	9.89
Reduce Partial Clothes Washer Loads	4.51	$ 0.00006	$ -	$ 0.00006	19.48
Improve Swimming Pool Use	20.59	$ 0.00001	$ -	$ 0.00001	4.27

Water Conservation Pricing

The use of pricing mechanisms that reflect the actual value of water and the cost to provide related services is becoming an increasingly popular method to encourage conservation. Realistic pricing includes costs of current and future infrastructure (including water transfer, storage, treatment, distribution) as well as the costs of purchasing or pumping water. More accurate water pricing is an important tool in planning and economic analysis and should be utilized by water planners and government agencies (Dzurik 2003; Rogers 1986).

Conservation pricing establishes price signals as incentives for reducing water consumption by promoting economically-efficient water use by individual consumers, with total benefits (of water consumption) to exceed costs by the largest degree (Ward 2007). Different conservation pricing methods and their efficacy have been considered. One finding is that, when customers are presented with incremental price structures, individual water use metering increases conservation behaviors (and water savings), compared to group-metered or non-metered water users (Creedy et al. 1998).

Marginal cost pricing sets the price of a unit of water equal to the marginal cost of supplying the last unit of water consumed (Johansson et al. 2002). Thus, marginal cost pricing structures increase the price charged per set increments of water use – as customers use more water, they pay more for each additional increment consumed (Chambouleyron 2004). To ensure basic water demands (e.g., toilets; bathing; drinking; cooking) are met, a set base increment of water is typically priced equivalent to the actual cost of supplying the water. Elective water uses (e.g., lawn watering; car washing; swimming pools) consume greater increments of water, thereby being billed at higher rates than or marginal to the actual cost of the water (Hall 2000). A drawback of the marginal cost method is the risk of pricing water such that an individual's ability to meet basic water needs become too expensive for the individual to pay (Billings and Agthe 1980; Ward 2007). As an illustration of the latter, Tucson, Arizona was until recently the only major US city to adopt marginal cost pricing for municipal water. After only one year of marginal rates, adopted in response to a critical drought, a public recall election over the rates resulted in the entire city council being voted out of office (Ward 2007).

Multi-tiered pricing, a form of marginal cost pricing, utilizes the same components of economic efficiency and sustainability, but also addresses the issue of equity (Nieswiadomy 1990; Renzetti 1992; Ward 2007). Tiered-pricing systems (also known as inclining or increasing block rates) set the incremental prices sufficiently high to offset financial losses realized from pricing basic water use increments below the average cost (Agthe and Billings 1997). By creating revenues from higher water use increments, multi-tiered pricing structures help secure a water provider's financial sustainability, while also promoting equity for basic water use (Agthe and Billings 1997; Ward 2007). Figure 4 illustrates a multi-tiered or inclining block rate pricing structure adopted to decrease overall water consumption without decreasing revenues (Southwest Florida Water Management District 2008). Dalhuisen et al. (2003) examined existing studies of municipal water pricing schemes, determining that increasing block rate pricing structures policies result in increased consumer sensitivity and higher price elasticities.

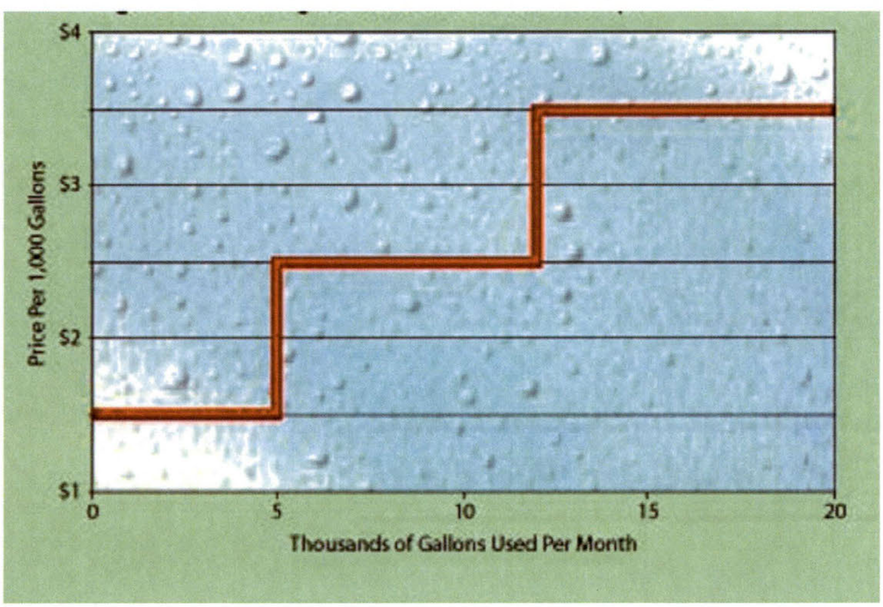

Figure 4: Example of inclining block rate water pricing structure (Southwest Florida Water Management District 2008)

Peak load pricing is increasing water prices during peak demand periods (Bakker et al. 2003). Increased rates in summer and other high demand times can significantly reduce consumer water demands, and increase provider incomes, during these high use and high operating expense periods. This pricing method is an effective, efficient way to promote water conservation, since it is an incentive for reduced water use (and penalizes excessive use) during periods of large water demands (Ward 2007). Peak load pricing can ultimately lower capacity expansion costs over time, by decreasing providers' maximum daily supply loads (Bakker et al. 2003). A recent study by Southwest Florida Management District (SFWMD 2005), for example, found that increasing water prices from $1.20 to $2.00 per thousand gallons achieved a 13% reduction in single-family residential per capita water use, with gpcd consumption reduced from 161 to 140 gallons per day (Figure 5).

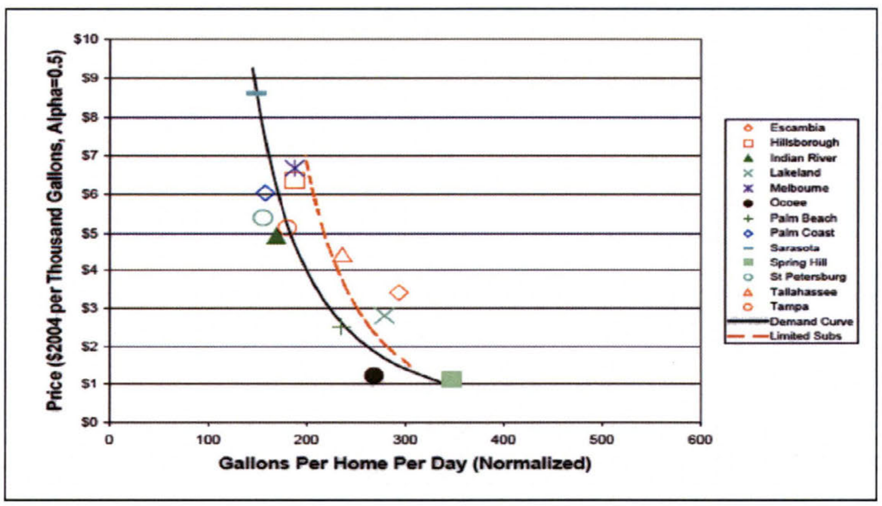

Figure 5: Water demand curve for 13 customer groups in Southwest Florida Management District Water Pricing Study (2005)

The Florida study also determined customers become less sensitive to water price once the costs exceed $6 per thousand gallons (SFWMD 2005). Reduced water use became progressively more difficult beyond the $6 price, with customers seeking reductions in basic water uses (e.g., toilet flushing; showering; washing clothes and dishes). Peak load pricing reduced residential water use between 15 - 22% overall, depending on such factors as house and property size, income and location. The same range of reduction (average of 20%) in residential water use, accompanied by increased revenue, was realized in Greensboro, North Carolina when a declining block and flat rate billing program was replaced with an increasing block rate pricing structure aimed at increasing water conservation (Figure 6; Williams 2008).

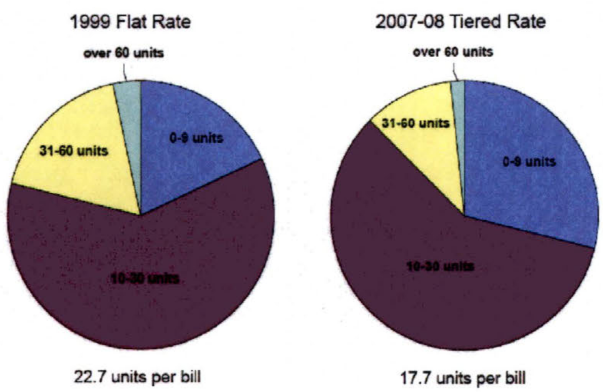

Figure 6: Effects of Replacing Flat Billing Rate with Inclining Block Rate Billing Structure in Greensboro, NC (2008)

The above-noted Southwest Florida Management District Water Pricing Study also surveyed customers about the influence of their water bills on water use behavior. Only 3% of respondents reported calculating the cost savings or reduced price associated with water use decisions. However, 21% of respondents with increasing block rates reported they attempt to reduce certain water uses to stay below specific high-priced water rate blocks (SFWMD 2005). Because demographic characteristics (house and property size; number of household members; income levels; location (suburban vs. rural)) influence a customer's sensitivity to water pricing, the overall effects of conservation pricing also will be specific to each water provider location (TWDB 2004). Elasticity studies across the nation illustrate an average water use reduction of 1 - 3% for every 10% increase in average monthly water bill (Dalhuisen et al. 2003; Nieswiadomy 1990; SFWMD 2005; Williams 2008). The TWDB Best Management Practices Guide (2005) provides guidance for implementing conservation pricing programs in Texas: Historical records of long-term and seasonal customer water consumption patterns must be considered. Based on these patterns, the first price block should encompass typical household water uses deemed necessary for health and sanitary needs. Additional revenue and realized conservation savings from the higher block uses should be associated with discretionary and seasonal outdoor water use. Between the rate blocks, water prices should be increased by at least 25% of the previous block. A 50% increase in price from one block to the next highest block is recommended to maximize water savings and revenues. As an example, if the third block of a four-block rate structure is $5 per 1000 gallons, the fourth block rate should be set at least $7.50 (50% higher) per 1000 gallons.

It is noted that short-term revenue losses represent genuine costs and may be a disincentive for adopting conservation programs, however, over a multiple year period, the costs of implementing a conservation program are mitigated by the benefits in terms of water savings and restored revenue. Long term planning and establishing tiered or block rates to sustain revenue neutrality ensure that water revenues exceed total provider costs (Chesnutt and Beecher 2004).

Supply Side Measures

Efficient supply-side measures can augment existing supplies, increasing the availability of billable, usable water. These additional water supplies can increase revenues, permitting downsizing, or even cancellation, of new water supply development projects for meeting future growth (WRA 2003). Such measures include reducing leakage through auditing, athletic field, golf course, park conservation and conversion, and utilization of graywater and reuse sources.

Leak Audits

It has been stated that the value placed on water is inversely proportional to the magnitude of water loss that a community will accept. Water loss is responsible for unnecessary damage to riparian and aquatic ecosystems, as well as the loss millions of dollars annually from the avoidable construction of water system infrastructure. Each year, an average of 12.5 billion kilowatt hours are also wasted on water that never reaches its destination due to delivery system leaks (Kunkel 2001). As water shortages become prevalent because of drought and/or extensive population growth, environmental and ecological water needs are more carefully scrutinized, and investments in water leak control and prevention become more necessary (Brooks et al. 1982; Freeman III 1993; Ward 2007). Lack of regularly-scheduled water auditing, and inconsistent water loss reporting techniques (including use of non-uniform statistics and "unaccounted for water" percentages for performance comparison) have resulted in a paucity of knowledge about water providers lost water performance. Inconsistent monitoring and reporting make it difficult for utilities to attribute water losses leaks, billing or accounting practices, theft, metering problems, etc., and render water loss minimization strategies ineffective (TWDB/GDS 2005). For municipalities, reducing unaccounted-for water has been identified as significant supply side conservation practice, and loss management, as important to maximize supply-side efficiency. Major strategies in reducing water losses center on improving the accounting methodologies for water use, as well as improved infrastructure management practices (Buchberger and Nadimpalli 2004; TWDB 2005; TWDB/GDS 2005).

Investments in detecting, repairing and preventing leakage can produce the greatest net savings of municipal water particularly in areas of limited water supplies (Buchberger and Nadimpalli 2004). A water delivery system with low leakage rates yields considerable water savings. Further, reduced leakage potentially increases the available water supply for new users and additional use during peak demand periods. One evaluation of municipal water conservation programs found that water savings resulting from audit programs in 8 test studies were as high as 36,490 gallons saved annually, equivalent to an overall water savings of 5% (WCASA 2006).

Based on data contributed from nearly 50% of retail public utilities in Texas (serving over 83% of the state's population), between 212,221-464,219 acre-feet of water is lost to leaks or unmetered usage each year, equating to between 5.6-12.3% of the total water abstracted for human uses (TWDB 2007). The value of "lost" water reported by surveyed water providers was nearly $124,800,000 (2004 dollars). Extrapolated to all public retail utilities in Texas, the estimated total monetary savings approximate $513 million per year (2004 dollars) (TWDB 2007). Using the state's 2004 average municipal daily per capita water consumption rate of 150 gallons, water volumes equivalent to reported losses would provide an annual water supply for between 1.3-2.7 million Texans (TWDB 2007; TWDB/GDS 2005). Statewide water loss and cost totals for a range of water providers in the 2005 study are shown in Table 6.

Table 6: Total Reported Water Losses for Surveyed Texas Water Providers (TWDB 2007)*

	Total Water Losses	Real Losses	Apparent Losses	Revenue Producing Water Lost
Acre-Feet	212,221	102,910	109,310	3,195,153
Gallons	69,152,425,071	33,533,326,410	35,618,772,810	1,041,143,800,203
% Total Water Supplied	5.60	2.70	2.90	~
% of Total Water Lost	~	~	~	8.3 6.7 unknown/balancing adjustment **
Total Annual Value	$ 124,796,012.00	$ 28,005,356.00	$ 96,790,656.00	

* Most utilities reported data for calendar or fiscal year 2005.
** Balancing adjustment is the corrected water input volume minus authorized consumption minus total water loss, and may consist of underestimated real water losses, apparent losses, or authorized consumption. If all provided water is fully utilized, the balancing adjustment is zero. Without further refining a utility's water audit, there is no accurate *ad hoc* method for determining actual water use for water allocated to balancing adjustment.

Real water losses in Table 6 are defined as the actual quantities of water lost, or leaks from the delivery system. These types of loss obviously result in decreased revenues, since water providers must purchase, and perhaps also pay treatment and transport costs for water that ultimately is not available for use. Apparent losses refer to accounting discrepancies for water totals (e.g., metering errors; water totals from unpaid water bills). Although apparent loss volumes and costs are typically smaller than real losses, they still reduce revenue and overall efficiency, and may also lead to inaccurate reporting of consumer water use data skewing future demand models and conservation plans (Kunkel 2001).

Calculations for statewide water losses provided by the TWDB (TWDB 2007, TWDB/GDS 2005) also can be examined on the basis of types of water providers. Relevant water data were provided by 157 municipalities, 42 water districts, 80 water supply corporations and 13 investor-owned utilities, with the majority of water loss rates falling between 5-15% (Table 7).

Table 7: Overview of Water Loss Totals by Water Provider Types (TWDB 2007)

	Municipality		Water District		Water Supply Corp		Investor Owned Utility	
% of Total Water Lost	# of Munic Respondents	% of Munic Respondents	# of WD Respondents	% of WD Respondents	# of WSC Respondents	% of WSC Respondents	# of IOU Respondents	% of IOU Respondents
greater than 25%	12	7.6	1	2.4	10	12.5	1	7.7
25-20 %	14	8.9	2	4.8	10	12.5	1	7.7
20-15 %	25	15.9	4	9.5	16	20	1	7.7
15-10 %	37	23.6	8	19	19	23.8	3	23.1
10-5%	34	21.7	20	47.6	14	17.5	3	23.1
less than 5%	13	8.3	7	16.7	7	8.8	4	30.8
Do not calculate	18	11.5	0	0	3	3.8	0	0
Did not respond	4	2.5	0	0	1	1.3	0	0
Total respondents	[illegible]		[illegible]		[illegible]		[illegible]	

Athletic Field, Golf Course, Park Water Conservation and Conversion

Water providers also are beginning to apply outdoor residential conservation principles to public areas (Vickers 2001; WRA 2003). Minimizing the total water volume allocated to outdoor watering can allow the saved water to be rerouted to municipal sales, thereby not only reducing the water volume used for irrigation, but also increasing available supply and revenues. Converting non-native turf grasses with high water needs to less-water-intensive native grasses in public spaces, parks, athletic fields and golf courses can significantly reduce irrigation water needs. Installing xeriscaping or low-water landscaping in place of traditional turf grass also reduces the water volume required for irrigating public spaces. Replacing traditional residential lawns with native grasses and xeriscaping has reduced water use between 35-70% in some cases (Hurd 2006). Water savings from commercial landscape conservation programs are expected to yield similar irrigation water use reductions, with financial analyses demonstrating such programs to be very cost-effective.

As an example, the city of Colorado Springs adopted a commercial landscaping policy promoting water efficiency, requiring that the irrigated acreage of a commercial property contain less than 50% high-water-use turf. Between 1999 and 2007, approximately 1,650 customers converted traditional turf landscapes to low-water landscapes, saving each approximately 40,500 gallons. An estimated 205 acre-feet of municipal water (66.8 million gallons) were conserved at a cost of just over $1,000,000 for the 9-year period (Colorado Springs Utilities, 2010, 2008; Maddaus Water Management 2003). An estimated 22.8 acre-feet of water are saved annually, for a total cost of $111,000, including staff, administration, and enforcement, with a per acre-foot cost of $4,868.42 and a per gallon cost of only $0.15 (Colorado Springs Utilities, 2010, 2008; Maddaus Water Management 2003).

An alternative water-saving practice is replacing traditional irrigation water with reused or reclaimed water. In the urban and suburban Southwestern United States, less than half the water delivered is actually fully consumed. On a national basis, consumptive use averages only 20% (WRA 2003). The remainder (between 50-80% of initial supply), is typically a product of clothes washing, water from faucets, showers, and baths, subsequently draining to wastewater treatment facilities. If was treated and reused, this quantity of water would be available for use multiple times, such that a gallon of source water could be utilized 2 to 3 times, taking the place of at least 2 new gallons of source water (based on 35-50% consumption rates for Western cities) (WRA 2003).

Utilizing reuse and reclaimed water involves the capture of reusable municipal return flows from such non-potable sources as indicated above (Hydrosphere Resource Consultants, Inc. et al. 1999). Reclaimed or non-potable water reuse represents water that is treated to a secondary level, then being considered safe for irrigating landscapes, parks, and golf courses, and for agricultural irrigation and use in industrial processes. California has been utilizing non-potable reuse water for agricultural irrigation for many years. Its safety standards requiring reused water to "be suitable for full body contact" have become a widely adopted as a standard definition across the country (SAWS 2006; TWDB 2005). Although no standard conservation values have yet been attributed to field, park and golf course conversion or application of reclaimed water for irrigation, reuse is being adopted within several regional planning groups in Texas and is expected to be a major component of water supply portfolios.

Re-use of Graywater

Previous statutes severely restricted residential graywater use in Texas, mainly because of public health concerns. Texas House Bill 2661 introduced comprehensive provisions in 2003 for graywater use in residential and municipal settings. The legislation included a comprehensive classification of graywater, including wastewater from clothes washers, showers, bathtubs, hand-washing lavatories and sinks not used for disposal of hazardous or toxic ingredients. It does not include water from clothes washers used for washing diapers, and sinks used for food preparation, toilets or urinals. House Bill 2661, passed by the 78th Texas Legislature, included a provision permitting the use of up to 400 gallons of untreated graywater per day per private residence for landscape irrigation (TWDB 2005).

Between 22-30 gallons of graywater per capita per day of graywater can be produced for new single-family residences with efficient plumbing fixtures (Green Building Program Sustainable Building Sourcebook 2008; Little 2008). An average household of 2.7 persons could easily create sufficient graywater on a daily basis for both foundation stabilization watering and landscape irrigation. Although it has actually been utilized for years in Texas, little information exists regarding the efficacy and water savings from residential graywater use in Central Texas.

CHAPTER TWO

METHODOLOGY AND DATA COLLECTED

Objectives and Organization of Study and Research Plan

The overarching objectives of this study were to:

(1) Assess the use of current water conservation programs in Central Texas; and

(2) Evaluate the utility and potential monetary savings of implementing additional water conservation programs in Central Texas, based on the following:

• Volume of water conserved/expected to be conserved (using standard methodology for calculating gallons per capita per day of water use recommended by TWDB 2001/2007 and water savings metrics derived from existing literature);

• Meeting goals and targets for per capita water use (recommended by Water Conservation Implementation Task Force 2001/2007);

• Current best management practices used or implemented (*Water Conservation Best Management Practices Guide – TWDB Report 362*);

Study Components

Water conservation measures in place for municipal water providers and users were examined for Bastrop, Caldwell, Hays, Travis and Williamson counties, which comprise portions of Texas Regional Planning Groups G, K and L. Collected data and information for many water providers in the study area were cataloged and categorized into a database. Existing methods for economic valuation of water were combined to assess realized water savings by municipal and other purposes, as well as potential savings for implementing additional conservation measures. Least-cost input conservation program scenarios to maximize water savings, and minimize per capita water use, were explored, as well as methods necessary to achieve future conservation requirements related to increased water use from population growth). A tool box of useful data, journal articles, reports, software applications and programs, websites, surveys and existing models also was compiled during the course of this project.

(1) Municipalities, public and private water providers in Central Texas counties (Bastrop; Caldwell; Hays; Travis; Williamson) and the water conservation best management practices employed:

Water provider lists were collected from the Texas Commission on Environmental Quality, Texas Water Development Board and local river authorities. Selected providers, comprising at least 55% of the total county population served were contacted via phone, e-mail, mail and personal visits to determine the use of conservation measures recommended by the Texas Water Development Board and Texas State Soil and Water Conservation Boards' 2006 Assessment of Water Conservation in Texas, prepared for 80th Texas Legislature, and any other conservation measures being utilized. Data categories and questions from surveys used in a Canadian Water Conservation and Economics Task Group report (Marbek Resource Consultants/Renzetti 2005), and a conservation study of the public water supply sector of the Great Lakes region (Great Lakes Commission 2004), were used to obtain additional conservation information. Water use history and magnitude, water sources, future incorporation plans, and manager-based estimates of water savings from conservation practices were recorded. A list of all providers successfully contacted or used in this study is provided below in Table 8. Other data sources are summarized in Table 9, including local river authorities, Texas Water Development Board (TWDB) and Texas Commission on Environmental Quality (TCEQ).

Table 8: Water provider list and basic demographic information

Provider	Provider type	City	County	# in Household (Individuals per Meter)	GPCD	Area Type
Anderson Mill MUD	private MUD	Austin	Travis, Williamson	n/a	n/a	sub
Andice Water Supply	WSC	Georgetown	Williamson	3.00	147.5	sub
Aquasource Development Inc	private/ WSC	Pflugerville	Williamson	2.82	154	urban
Aqua Water Supply Corporation	IOU	Bastrop +950-square mile area	Bastrop and parts of Lee, Caldwell, Fayette and Williamson	2.51	130	sub
Arroyo Doble Water Supply Inc.	private MUD	Manchaca	Travis	2.98	137.969	sub
Austin, City of	CITY	Austin	Travis	2.40	139	urban
B R R Home Owners Association Inc.	private MUD	San Marcos	Hays	2.69	158.50	sub
Barton Creek WSC	WSC	Austin, Phlugerville	Travis	2.47	154.5	urban
Barton Creek West WSC	WSC	Austin	Travis	3.00	156	sub
Bastrop, City of	CITY	Bastrop	Bastrop	3.00	130	sub
Bastrop County WCID 2	WCID	Bastrop, McDade	Bastrop	3.00	76.1905	rural
Bastrop West Water Systems	WSC	Bastrop	Bastrop	3.00	66.6667	rural
Blessing Mobile Home Park	private MUD	Round Rock	Williamson	3.00	136.5	sub
Block House MUD	mud - gov	Cedar Park	Williamson	3.5	65.4286	sub
Branch Creek Estates	private MUD	Austin	Travis	2.47	156	sub
Briarcliff, Village of	CITY	Briarcliff	Travis	2.47	155.714	sub
Brushy Creek MUD	MUD - private	Round Rock	Williamson	3.02	136.5	sub
Buda, City of	CITY	Buda	Hays	3.00	87.9549	sub
Cedar Park, City of	CITY	Cedar Park	Williamson	2.76	136.5	sub
County Line WSC	WSC/SUD	Uhland	Caldwell	2.94	85	rural
Coupland WSC	WSC	Coupland	Williamson	2.82	149.5	rural
Creedmoor Maha WSC	WSC	Bastrop, Creedmoor	Travis, Bastrop	3.27	90.612	sub/rural

Table 8 Continued: Water provider list and basic demographic information

Provider	Provider type	City	County	# in Household (Individuals per Meter)	GPCD	Area Type
Cypress Ranch WCID #1	WCID	West Cypress Hills/Bee Caves	Travis	2.47	154.5	sub
Dripping Springs, City of	CITY	Dripping Springs	Hays	2.69	158.5	sub
Dripping Springs WSC	WSC	Dripping Springs	Hays	3.06	122.21	sub/rural
Durham Park WSC	WSC	Liberty Hill	Williamson	2.82	136.5	sub
Elgin, City of	CITY	Elgin	Bastrop	3.06	117.01412	sub
Elliot Ranch Water System	private municip	Buda, Hays	Hays	3.46	158.5	sub
Florence, City of	CITY	Florence	Williamson	2.82	147.5	sub/rural
Garfield WSC	WSC	Del Valle	Travis	2.47	149	sub/rural
Georgetown, City of	CITY	Georgetown	Williamson	2.8	160	sub/urban
Gonzales County WSC	WSC	Gonzales	Caldwell	161.50	2.82	rural
Granger, City of	CITY	Granger	Williamson	2.82	147.5	sub/rural
Hays, City of	CITY	Hays	Hays	3	163.9485	sub/rural
Hays County WCID 1	WCID	Austin	Hays	2.69	144	sub/rural
Hays County WCID 2	WCID	Austin	Hays	3.10	144	sub/rural
High Valley WSC	IOU	Austin	Travis	2.47	164	sub
Hornsby Bend Utility Co. Inc.	private municip/ MUD	Webberville	Travis	2.94	154.5	sub

Table 8 Continued: Water provider list and basic demographic information

Provider	Provider type	City	County	# in Household (Individuals per Meter)	GPCD	Area Type
Hutto, City of	CITY	Hutto	Williamson	3.33	88	sub
Inverness Utility Co. Inc	private municip	Austin	Travis	2.47	154.5	sub
J&R Mobile Home Park	private municip	Bastrop	Bastrop	3.00	100	sub
Jonestown WSC	WSC	Jonestown	Travis	3.57	120	sub
K&K Water Co.	private municip	Red Rock	Bastrop, Caldwell	3.00	79.812207	rural
Kelly Lane Utility Co. Inc.	WSC/SUD	Austin	Travis	2.47	156	sub
Kelly Lane WCID 1 Of Travis Co.	WCID	Austin	Travis	3.19	156	sub
Kelly Lane WCID 2 Of Travis Co.	WCID	Austin	Travis	2.47	156	sub
Kyle, City of	CITY	Kyle	Hays	3.19	91.95	sub
Lago Vista, City of	CITY	Lago Vista	Travis	3.13	156	sub
Lakeway MUD	MUD - private	Lakeway	Travis	2.70	66.78 given; 168.01 calculated	urban/sub
Lazy Nine MUD	MUD - private	Austin	Travis	n/a	n/a	not developed
Leander, City of	CITY	Leander	Williamson	3.00	229.21	sub
Liberty Hill WSC	WSC	Liberty Hill	Williamson	2.82	136.5	sub
Lockhart, City of	CITY	Lockhart	Caldwell	4.20	106.87	sub/rural
Lost Creek MUD	MUD - GOV	Austin	Travis	3.19	133.75131	sub
Luling, City of	CITY	Luling	Caldwell	2.82	125	sub/rural
Manor, City of	CITY	Manor	Travis	3.60	70.465337	sub

Table 8 Continued: Water provider list and basic demographic information

Provider	Provider type	City	County	# in Household (Individuals per Meter)	GPCD	Area Type
McMahan WSC	WSC	McMahan, Dale	Caldwell	3.04	161.5	rural
Manville WSC	WSC	Coupland (Manor, Pflugerville, Richland, Cele, New Sweden)	Bastrop, Travis	2.77	79.033215	sub/rural
Martindale WSC	WSC	Martindale	Caldwell	2.82	75.174184	rural/sub
Maxwell WSC	WSC	Maxwell	Caldwell	2.82	161.50	rural
Mid-Tex Utilities, Inc.	private municip	Pflugerville	Travis	2.47	154.50	ave
New Sweden MUD #1,	MUD	Austin, New Sweden	Travis	n/a	n/a	not developed
New Sweden MUD #2	MUD	Austin, New Sweden	Travis	n/a	n/a	not developed
New Sweden MUD #3	MUD	Austin, Phlugerville, New Sweden	Travis	n/a	n/a	not developed
Noack WSC	WSC	Thrall, Coupland	Williamson	2.82	149.5	rural
North Austin MUD #1	MUD	Austin	Williamson (Williamson is majority), Travis	2.82	113.53489	sub/urban
Northeast Travis County Utility District	MUD	Austin	Travis	2.47	154.5	urban
Northridge WSC	WSC	Dripping Springs	Hays	2.69	158.5	sub/rural
Northtown MUD	MUD	Pflugerville	Travis	2.47	154.5	urban

Table 8 Continued: Water provider list and basic demographic information

Provider	Provider type	City	County	# in Household (Individuals per Meter)	GPCD	Area Type
Northwest Austin MUD #1	MUD	Austin	Travis	2.47	156	sub
Pflugerville, City of	CITY	Pflugerville	Travis	2.17	164	urban
Polonia WSC	WSC		Bastrop, Caldwell	2.80	155	rural/sub
Ranch at Cyprus Creek MUD 1	MUD	Cedar Park	Travis	2.47	156	sub
River Place MUD	MUD	Austin	Travis	2.47	156	sub
Round Rock, City of	CITY	Round Rock	Williamson	3.6	97	urban
Round Rock Ranch PUD Utility Co. Inc.	PUD	Round Rock	Williamson	2.82	154	urban/sub
Ruby Ranch WSC	WSC	Buda	Hays	2.69	158.5	sub/rural
San Marcos, City of	CITY	San Marcos	Hays	2.31	122 reported 127.56 calc	urban/ sub
Senna Hills Utility Co.		Austin	Travis	2.47	156	sub
Shady Hollow MUD	MUD	Austin	Travis	3.00	208.9	sub
Slaughter Creek Acres WSC	WSC	Austin	Travis	2.47	156	sub/urban
Smithville, City of	CITY	Smithville	Bastrop	2.51	108.61255	rural/sub
Steiner Utility Co. Inc.	private municip	Austin	Travis	2.47	154.5	urban
Sunset Valley, City of	CITY	Sunset Valley	Travis	2.09	144.6	urban
Taylor, City of	CITY	Taylor	Williamson	3.18	12.69	rural

Table 8 Continued: Water provider list and basic demographic information

Provider	Provider type	City	County	# in Household (Individuals per Meter)	GPCD	Area Type
Thrall, City of	CITY	Thrall	Williamson	3.18	149.5	rural
Travis County MUD 2	MUD	Austin	Travis	2.67	154.5	urban/sub
Travis County MUD 6	MUD	Austin	Travis	2.47	154.5	urban/sub
Travis County MUD 8	MUD	Austin	Travis	2.47	154.5	urban/sub
Travis County MUD 9	MUD	Austin	Travis	2.47	154.5	urban/sub
Travis County MUD 14	MUD	Austin	Travis	2.47	154.5	urban/sub
Travis County WCID 17	WCID	Austin (Lakeway, Beecaves, Steiner Ranch)	Travis	3.00	170	urban
Travis County WCID 20	WCID	Austin	Travis	3.00	156	sub
Travis County WCID Point Venture	WCID	Leander	Travis, Williamson	2.65	154.25	urban
Upper Brushy Creek WCID	WCID	Round Rock	Williamson	2.65	154	urban
Wells Branch MUD	MUD	Austin	Travis	5.49	77.62	sub

Table 8 Continued: Water provider list and basic demographic information

Provider	Provider type	City	County	# in Household (Individuals per Meter)	GPCD	Area Type
West Cypress Hills WCID #1	WCID - PRIVATE	Pflugerville	Williamson	n/a	n/a	not developed
West Travis County MUD #3	MUD owned by LCRA	Austin	Travis	2.47	154.5	urban/sub
West Travis County MUD #5,	MUD owned by LCRA	Austin	Travis	2.47	154.5	urban/sub
Williamson County MUD 9	MUD	Round Rock	Williamson	150.00	3	urban/sub
Williamson-Travis Co MUD #1	MUD	Austin	Travis, Williamson	2.65	154	urban
Williamson-Travis Counties WCID 1-D	WCID	Austin	Travis (primary), Williamson	2.65	154	urban
Williamson-Travis Counties WCID 1-F	WCID - PRIVATE	Austin	Travis (primary), Williamson	2.65	154	urban
Williamson-Travis Counties WCID 1-G	WCID - PRIVATE	Austin	Travis (primary), Williamson	2.65	154	urban
Wimberly WSC	WSC	Wimberley	Hays	3.56	172.9	sub
Windermere Utility Co. Inc.	PUD managed by Southwest Water Co	Austin	Travis	3.37	94.1	sub/urban

Table 9: Data Sources and Types of Information Collected

Survey Data	River Authorities	TWDB	TCEQ & USEPA	US Census Bureau
Existing Conservation Measures	Average Use	Water Sources	Current Water Uses, Practices	Estimates of Future Population
Average Water Use	Water Sources	Number and Type of Customers	Water Sources	Population Growth Rates
Conservation Savings	#, Type Customers	Projected Future Use	Conservation Measures Recommended	
Water Sources	Projected Future Use	Recommended Conservation Measures		
Number and Type of Customers	Recommended Conservation Measures			

Explanation: TWDB, Texas Water Development Board; TCEQ, Texas Commission on Environmental Quality; USEPA, United States Environmental Protection Agency.

(2) Conservation savings and cost values from existing studies in the literature:

Standard savings and cost values of the outlined conservation practices were identified in the literature to create simple economic valuation and water savings models. Valuation and cost savings models for municipal conservation were derived from studies examining water conservation savings, and include Texas Water Development Board models for assessing the effectiveness of conservation techniques (TWDB/GDS 2002) and Western Resources Advocates' Smart Water Report: a comparative study of urban water use efficiency across the southwest (2003). In addition, data collected by AWWA (1999), Michelsen et al. (1999), Vickers (2001), Ward (2007; Ward and Michelsen 2002) and others were used to determine acceptable ranges for municipal and residential standards. These models were applied to collected water provider data to develop estimates of current water savings, as well as identifying potential savings from conservation measures necessary to meet future water demand projections and water reduction targets recommended by Water Conservation Implementation Task Force 2001/2007. Valuation and cost savings methodologies were also applied to determine conservation potentials and costs for specific municipalities chosen to represent typical providers in Central Texas.

Water conservation Best Management Practices Considered:

In 2003, Senate Bill 1094 created the Water Conservation Implementation Task Force (WCITF) for the purpose of recommending water conservation practices. The WCITF board members were selected by the Texas Water Development Board and included representatives from the Texas Commission on Environmental Quality, Texas Department of Agriculture, Texas Parks and Wildlife Department Texas State Soil and Water Conservation Board, regional water planning groups, federal agencies, municipalities, groundwater conservation districts, river authorities, environmental groups, irrigation districts, industries, institutional water users and academia. The broad range of members contributed a wide selection of best management conservation practices for the municipal, agricultural and industrial sectors contained in a special report entitled Texas Water Development Board Report 362: Water Conservation Implementation Task Force Best Management Practices Guide. Conservation practices highlighted in the report used for estimating water conservation savings in this study, as described in greater detail in Chapter 1, include:

1. **Showerhead and Faucet Aerator and Replacement/Retrofit** – Replacement and retrofit programs provide customers with devices to reduce in-home water use. Figures collected in the literature and summarized in Tables 1 and 2 (Chapter 1), along with standardized measurements reported by Vickers (2001), AWWA (1999) and the ECOBA study (WCASA 2003) were used as the values, along with provider data, for estimating water conservation savings and costs among surveyed water providers in Central Texas. Water savings and associated costs were calculated for water providers currently utilizing these conservation practices, as well as for selected providers not employing retrofit programs by multiplying the daily estimated water savings per measure by the number of single family households participating in the replacement/retrofit program (assumed to be 50%). Savings were calculated for one showerhead and two faucets per residence and multiplied by the average number of residents per household. These savings were calculated in gallons and acre-feet over the course of one year and the costs of providing these fixtures was estimated for one year and for the life of the measure;

2. **Residential Ultra-Low Flow Toilet Replacement and Rebate Programs** – Toilet replacement and rebate programs provide municipal water customers with water saving toilets at no cost or for a small fee. Water savings and cost information from Table 1 (Chapter 1), along with standardized measurements reported by AWWA (1999), Vickers (2001), the ECOBA study (WCASA 2003) and provider data were used in calculations of Central Texas water providers' costs and savings from toilet replacement and rebate programs. As with the showerhead and faucet programs, water savings were calculated by multiplying the per toilet per person water savings metric by 50% of the population served (average number of members per metered household) by the water provider. Water savings were divided by the total rebate cost to the provider to determine the cost per water savings unit (gallon and acre-feet) and were divided by the lifetime of the measure to estimate annual cost;

3. **Residential Clothes Washer Incentive Program** – Rebates and discounts are provided to customers for purchasing water conserving washing machines. Water savings and cost measurements in Table 1 (Chapter 1), coupled with information reported by water providers, were used in assessing effects of washing machine rebate programs in Central Texas. Again, current water savings and associated costs were calculated for providers who reported employing rebates, as well as estimated water savings and costs for selected providers without rebate programs. The gallon per capita per day water savings metric was multiplied by the average number of household members in 50% of the single family residences served and costs were calculated per unit of water savings annually and over the life of the washing machine;

4. **Landscape Irrigation Conservation Incentives, ordinances and Water-Wise Landscape Design and Conversion Programs** – Water providers offer incentives or rebates for water saving techniques for residential irrigation, conversion of landscapes and installation of xeriscaping designed to reduce outdoor water use.

Measures and ordinances reported by providers were categorized and compared based on the providers/ averaged GPCD. Table 3 (Chapter 1) provides metrics collected in the literature allow for calculation of the potential amount of water conserved and the associated costs of conservation landscape programs for selected providers in Central Texas by multiplying the per unit water savings and cost metrics per participating household (using .25 acre/10,890ft2/1,011.71m2 as the standard lawn size). However not enough provider data was collected to perform any calculations for existing programs;

5. **Rainwater Harvesting**– Rebates or incentives may be offered for residential or commercial rainwater collection systems and municipalities may install collection systems for public areas such as schools and government offices. Cost and water savings results from rainwater collection studies (2001, 2006) used to estimate conservation impacts in Central Texas are summarized in Table 4 (Chapter 1) and were applied to provider data to estimate current and potential water savings and costs. The standard savings values (in gallons per day) for rain barrels and rainwater collection systems were multiplied by the number (50% participation rate for rain barrels and 10% for collection systems) of households. Per gallon cost (both direct and indirect) was calculated for each unit of water saved per year and over the lifetime of the measure, assuming average rainfall patterns;

6. **Public Information/Education programs and information distributed** – Public information can be distributed in the form of bill inserts, newsletters or through local media and public offices. Public information programs include an educational component designed for the general public and/or school children. Potential water savings and associated costs of adopted conservation behaviors reported in Seattle, Washington are listed in Table 5 (Chapter 1). Due to data and resource constraints, the specific water conservation savings achieved through public education and the distribution of information were not quantified, but rather characterized in terms of aggressiveness (low, medium and high) and compared, by county, provider size and area type (rural, suburban and urban) using per capita water provider use rates as proxies;

7. **Employment of Conservation Coordinator** – Employment of a coordinator to manage and oversee conservation programs, including development of public outreach and marketing strategies for water conservation and coordination of utility conservation programs with management and operations staff is recommended by the TWDB as a best management practice. Per capita water consumption rates for providers with full time, part time and no conservation coordinators were compared using per capita use rates. Employment of a conservation coordinator and corresponding per capita use rates were also examined by county, provider size and area type;

8. **Water Conservation Pricing** – Water conservation pricing includes use of rate structures that discourage the inefficient use or waste of water, e.g. inverted block rates, base rates and excess use rates such as water budget rates, and seasonal rates.

Because many water providers in Central Texas did not provide rate histories, only their current rate structures can be examined. Rate information from each water provider was analyzed on the basis of the TWDB criteria reported in Chapter 1, and categorized into low, medium and high conservation pricing levels. The presence or absence of conservation rates, and their level of aggressiveness, also were compared using per capita water use rates as indicators of effectiveness;

9. **System Water Audits and Leak Reduction Programs** – Audit programs implemented to minimize water loss due to leaks include measuring and monitoring water losses in infrastructure, using a water loss modeling program, conducting regular inspections, metering individual pressure zones. It is not known how figures for Central Texas water providers compare to statewide leak and loss averages. For this study, survey respondents reported whether or not they had an existing leak auditing system, and any specific data regarding the system or program. Per capita water use rates of water providers with, and without, leak monitoring systems were examined for trends;

10. **Athletic Field, Golf Course, Park Conservation and Conversion** – Converting non-native turf grasses with high watering needs to hardier native grasses or Astroturf, and installation of xeriscaping or low water landscaping is encouraged to reduce water demand. Reclaimed or graywater can also be used for irrigation of golf courses, recreation areas, parks and athletic fields. For this study, water providers were asked to report whether their conservation programs included any of these various measures, or if they planned to implement them. This study intended estimate savings from applying these conservation practices to at least 10% of public areas for selected providers in the more in-depth analyses. Water quantities (and associated costs) used to irrigate traditional turf were to be compared with the reduced water needs (and their costs) after implementation of low water and no water lawns in public areas. However no data was reported by providers;

11. **Graywater** – House Bill 2661, passed by the 78th Texas Legislature Regular Session, added a provision that encourages collection graywater from allowable sources for outdoor irrigation and foundation watering. In this study, water providers were asked to report any graywater use. Several providers use graywater for irrigating public spaces; others recommend it for their commercial customers. Only one provider response indicated any ordinance requiring graywater use (only for new residential construction), so it was not possible to categorize graywater use across provider characteristics. Graywater savings were calculated for that provider by multiplying the average gpcd graywater produced daily by the average number of residents per household by the estimated number of new households built per year (based on population growth rate). For the specific providers examined in greater detail, average water savings were calculated for customer graywater use by multiplying the average gpcd graywater produced daily by the average number of residents per household by the number of households participating.

(3) Application of Conservation Metrics to Central Texas Water Providers:

For providers reporting plumbing fixture retrofit, rebate and washing machine incentive programs as well as other conservation program components, current estimated water savings and associated costs were calculated using provider data and metrics obtained from literature and existing studies. The estimated water savings and costs for these measures are reported in Chapters 3 and 4. Aggregate water conserved and the costs per unit of water saved are calculated between 2010 and 2060 for the providers listed below in Table 10. Also, for these providers, the projected water demand based on current trends is compared with the TWDB's projected water use after reductions from conservation savings. Using the metrics described in Chapter 1, the cost of implementing additional conservation measures and the resulting savings are estimated for selected providers in Chapter 4.

Central Texas Data Characteristics

Projected Population Growth and Water Demands for Central Texas

The Texas population is projected to increase at one of the fastest rates in the nation over the next 50 years, more than doubling between 2000 (20,851,790) and 2060 (45,558,282). Similar forecasts apply to Water Planning Regions G, K and L (TWDB 2006). The population growth rates over the next half century for Bastrop, Caldwell, Hays, Travis and Williamson counties in Central Texas are even greater than the projected growth rates for their associated Water Planning groups, further increasing water stresses in Central Texas (see Tables 10, 11 and 12; Figure 8). Population growth projections for major water providers discussed in this study are summarized in Table 10. For some providers, customers are expected to increase by nearly 200% over the next 50 years, drastically increasing residential water supply demands.

As municipal water use demands continue to increase significantly, water demands for some competing water use sectors (agriculture; industry) will stabilize or even decrease in the future. Very little growth in water use in the industrial (manufacturing, mining and steam electric) sector over the next 50 years is projected, coupled with a slight decline in water agricultural water use/availability, and major increases in municipal needs for Regional Planning Groups G, K, L (Figure 9). Municipal water use traditionally comprised only a small portion of the State's total water use, compared to agricultural and industrial uses, which have historically accounted for up to 85% of total water allocation (TWDB 2006; WRA 2003). As water demands for municipal use continue to increase, however, the resulting water shortages will compound impacts from other existing uses. As agricultural water use decreases, recent and future population growth in urban and suburban areas is predicted to be "the straw that threatens to break the camel's back" (WRA 2003). Thus, to meet projected water demands in Central Texas (and elsewhere) into the future, water conservation measures must be adopted in all water sectors, with an emphasis on municipal residential water use. This is particularly the case for water sources in semi-arid regions such as Texas, with the intricacies of municipal water use and management requiring re-evaluation (WRA 2003).

Table 10: Municipal water provider usage and population projections for Central Texas

Bastrop County Municipal Water Providers	Provider Type	Ave Daily Use (MGD)	GPCD	Estimated Population >>>	2010	2020	2030	2040	2050	2060
AQUA WSC	WSC	4.7000	130.00		36138	44618	54593	65914	80250	98194
BASTROP, CITY OF	CITY	1.1240	130.00		4561	5596	6814	8196	9946	12136
BASTROP COUNTY WCID #2	DISTRICT	0.0480	154.50 *		2269	3202	4300	5546	7124	9099
BASTROP WEST WATER SYS	IOU	0.0240	154.50 *		8500	10625	13281	16601	20751	25939
ELGIN, CITY OF	CITY	0.7510	117.00		6411	7348	8450	9701	11285	13267
J&R MOBILE HOME PARK	IOU	0.0066	100.00		66	83	103	129	161	201
K&K WATER CO.	IOU	0.0170	154.50 *		213	266	333	416	520	650
MANVILLE WSC	WSC	0.0822	154.50 *		501	717	971	1259	1624	2080
SMITHVILLE	CITY	0.4830	108.61		4540	5344	6290	7364	8724	10426
				Sample Population Total	63198	77798	95134	115125	140385	171992
				BASTROP Co Total Population	75386	97601	123734	153392	190949	237958
				% of Total Population Represented	83.83%	79.71%	76.89%	75.05%	73.52%	72.28%
Caldwell County Municipal Water Providers	**Provider Type**	**Ave Daily Use (MGD)**	**GPCD**	**Estimated Population >>>**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
COUNTY LINE WSC	WSC/SUD	0.0831	85.00		1262	1939	2565	3193	3824	4434
CREEDMOOR-MAHA WSC	WSC	0.2013	90.61		2217	3015	3717	4423	5130	5815
LOCKHART, CITY OF	CITY	0.3889	100.00		16328	21083	25111	29154	33216	37148
LULING, CITY OF	CITY	0.7630	125.00		6309	7301	7998	8700	9407	10092
MARTINDALE WSC	WSC	0.2050	75.17		1307	1468	1566	1666	1765	1861
				Sample Population Total	27423	34806	40957	47136	53342	59350
				CALDWELL Co Total Population	45958	59722	73500	90900	95103	106575
				% of Total Population Represented	59.67%	58.28%	55.72%	51.85%	56.09%	55.69%
Hays County Municipal Water Providers	**Provider Type**	**Ave Daily Use (MGD)**	**GPCD**	**Estimated Population >>>**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
BUDA, CITY OF	CITY	0.4520	87.96		8042	13971	17341	20728	24797	27997
COUNTY LINE WSC	WSC/SUD	0.3873	85.00		5870	12570	14684	15258	16655	19014
DRIPPING SPRINGS WSC	WSC	0.4520	122.21		2487	3639	4832	6031	7471	8604
ELLIOTT RANCH WATER SYS	IOU	0.1790	331.48		540	675	844	1055	1318	1648
HAYS, CITY OF	CITY	0.0382	163.95		233	291	364	455	569	711
KYLE, CITY OF	CITY	1.9100	149.25 *		21457	31126	33613	35203	39197	41850
SAN MARCOS, CITY OF	CITY	6.8260	122.00		48414	69906	90990	114477	139466	158099
WIMBERLEY WSC	WSC	0.9676	149.25 *		5900	7375	9219	11523	14404	18005
				Sample Population Total	92943	139553	171887	204730	243878	275928
				HAYS County Total Population	166342	242051	302795	363678	436388	493320
				% of Total Population Represented	55.87%	57.65%	56.77%	56.29%	55.89%	55.93%

Table 10 Continued: Municipal water provider usage and population projections for Central Texas

Travis County Municipal Water Providers	Provider Type	Ave Daily Use (MGD)	GPCD	Estimated Population >>>	2010	2020	2030	2040	2050	2060
ARROYO DOBLE WSC	WSC	0.1250	137.97		906	1133	1416	1770	2212	2765
AUSTIN, CITY OF	CITY	127.2900	139.00		770529	946974	1111996	1258580	1409808	1548275
BRIARCLIFF VILLAGE	CITY	0.2180	155.71		1289	1817	2305	2609	2931	3263
ELGIN, CITY OF	CITY	0.2930	117.00		6467	7435	8566	9835	11438	13440
HIGH VALLEY WSC	WSC	0.0328	154.50 *		219	219	219	219	219	219
JONESTOWN WSC	WSC	0.4500	120.00		926	1123	1305	1419	1539	1663
LAGO VISTA, CITY OF	CITY	0.4500	154.50 *		6132	8307	10316	11571	12898	14265
LAKEWAY MUD	MUD/PRIVATE	1.8330	170.00		10789	14519	17965	20117	22394	24738
LAZY NINE MUD	MUD/PRIVATE	0.0000	0.00		0	1800	1800	1800	1800	1800
LOST CREEK MUD	CITY/PRIVATE	1.8180	154.50 *		4372	4372	4372	4372	4372	4372
MANOR, CITY OF	CITY	0.3710	154.50 *		1319	1473	1615	1704	1798	1895
MANVILLE WSC	WSC	2.1299	154.50 *		12987	17931	22498	25350	28367	31474
SUNSET VALLEY, CITY OF	CITY	0.1004	187.72		578	722	903	1129	1411	1763
TRAVIS COUNTY WCID #17	DISTRICT	4.0860	142.00		15838	22283	28236	31954	35887	39936
				Sample Population Total	832351	1030107	1213511	1372428	1537073	1689868
				Travis County Total Population	969955	1185499	1385236	1550538	1722737	1888543
				% of Total Population Represented	85.81%	86.89%	87.60%	88.51%	89.22%	89.48%
Williamson County Municipal Water Providers	**Provider Type**	**Ave Daily Use (MGD)**	**GPCD**	**Estimated Population >>>**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
BLOCK HOUSE MUD	MUD	0.5020	81.21		7669	9586	11983	14979	18723	23404
CEDAR PARK, CITY OF	CITY	2.2000	111.44		75214	94018	117522	146902	183628	229535
GEORGETOWN, CITY OF	CITY	2.5560	160.00		40888	55770	73473	97702	113633	136082
LEANDER, CITY OF	CITY	5.9000	229.00		25740	32175	40219	50273	62842	78552
NORTH AUSTIN MUD #1	MUD	0.8900	113.54		7839	9799	12248	15311	19138	23923
ROUND ROCK, CITY OF	CITY	9.0000	97.00		91151	122140	161290	203443	249285	298426
				Sample Population Total	248501	323488	416735	528610	647249	789922
				Williamson Co Total Population	352811	476833	625189	787039	963542	1153166
				% of Total Population Represented	70.43%	67.84%	66.66%	67.16%	67.17%	68.50%

* In cases where data for GPCD were not reported, or could not be computed, average GPCD values for that water provider's regional planning group (suburban, rural or urban) were used (see Figure 7).

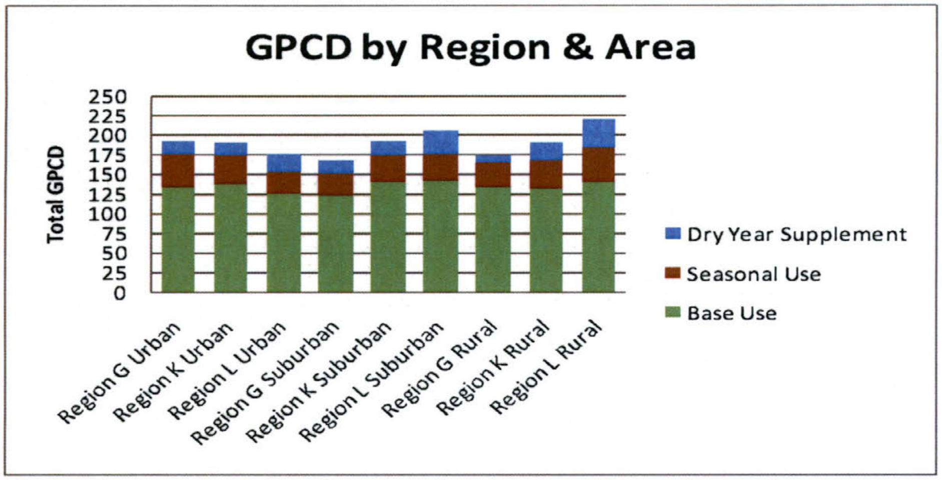

Figure 7: Average annual per capita water use by region and area type (G; Williamson County; K, Travis, Bastrop and Hays Counties; L, Hays and Caldwell Counties) (Source: TWDB/GDS 2002; 2006)

Table 11: Regional water plan region population projections for 2000 – 2060 (Source: Texas Water Development Board, 2006)

Reg.	2000 Census	2010	2020	2030	2040	2050	2060	Increase From 2000 to 2060 (%)
G	1,621,961	1882,896	2,168,682	2,458,075	2,739,717	3,034,798	3,332,100	105
K	1,132,228	1,359,677	1,657,025	1,936,324	2,181,851	2,447,058	2,713,905	140
L	2,042,221	2,460,599	2,892,933	3,292,970	3,644,661	3,984,258	4,297,786	110

Table 12: Regional water plan county population projections for 2000 – 2060 (Source: Texas Water Development Board, 2006)

County	2000 Census	2010	2020	2030	2040	2050	2060	Increase Between 2000 - 2060 (%)
Bastrop	57,733	75,386	97,601	123,734	153,392	190,949	237,958	312
Caldwell	32,194	45,958	59,722	71,459	83,250	95,103	106,575	231
Hays	97,589	166,342	242,051	302,795	363,678	436,388	493,320	406
Travis	812,280	969,955	1,185,499	1,385,236	1,550,538	1,722,737	1,888,543	132
Williamson	249,967	352,811	476,833	625,189	787,039	963,542	1,153,166	361

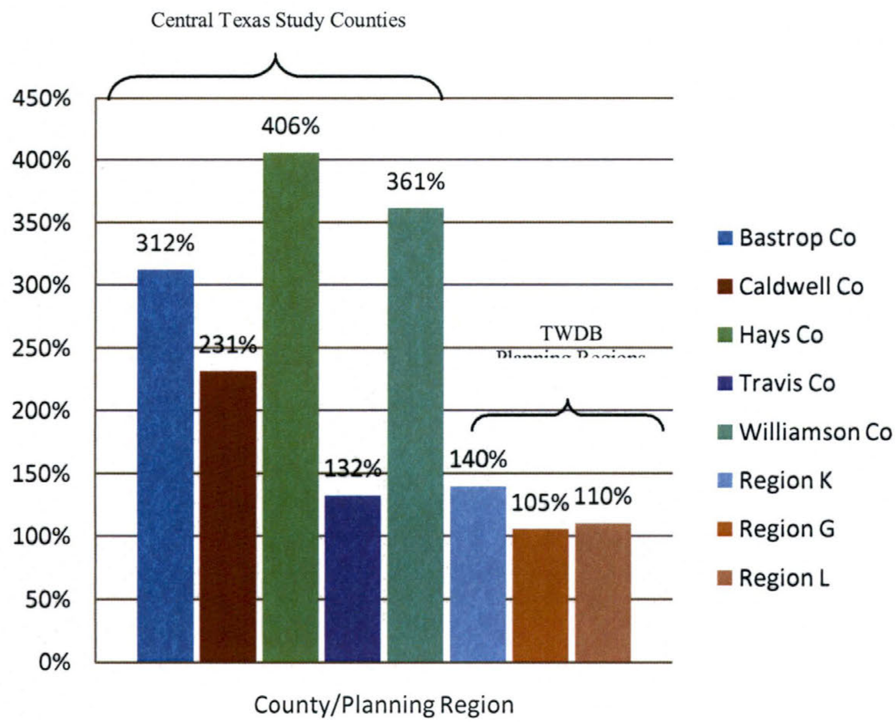

Figure 8: Regional water plan population growth increase, 2000 to 2060 (Source: Texas Water Development Board, 2006)

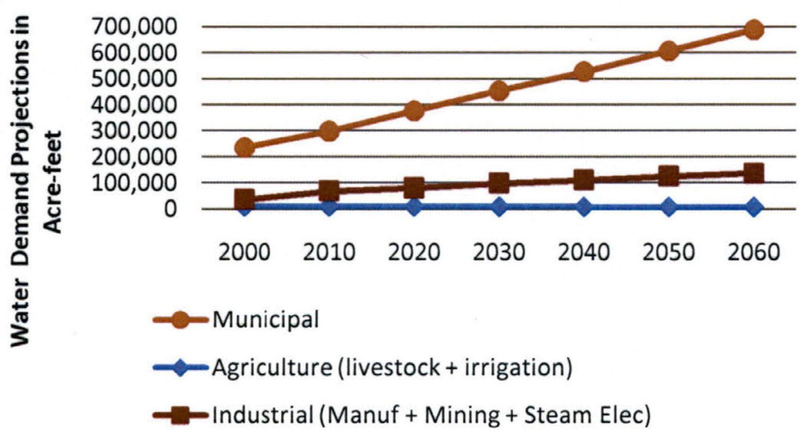

Figure 9: Projected water demands for planning groups G, K and L (Source: Texas Water Development Board 2006)

Total projected water demands for Central Texas (5 county region) for agricultural irrigation, manufacturing, livestock, mining, steam electric and municipal use will increase from nearly 377,000 acre-feet to 833,873 acre-feet between 2009 and 2060. These demands must either be met with new water supplies or, alternatively, conservation of existing water supplies. Municipal water conservation strategies in Texas are expected to provide 617,000 acre-feet per year by 2060 (approximately 7% of total municipal water use), including 145,277 acre-feet per year in Regions G, K and L (TWDB 2006). Irrigation conservation savings are projected to be significantly larger, yielding 1.4 million acre-feet per year by 2060 (about 37% of total forecasted agricultural water demand).

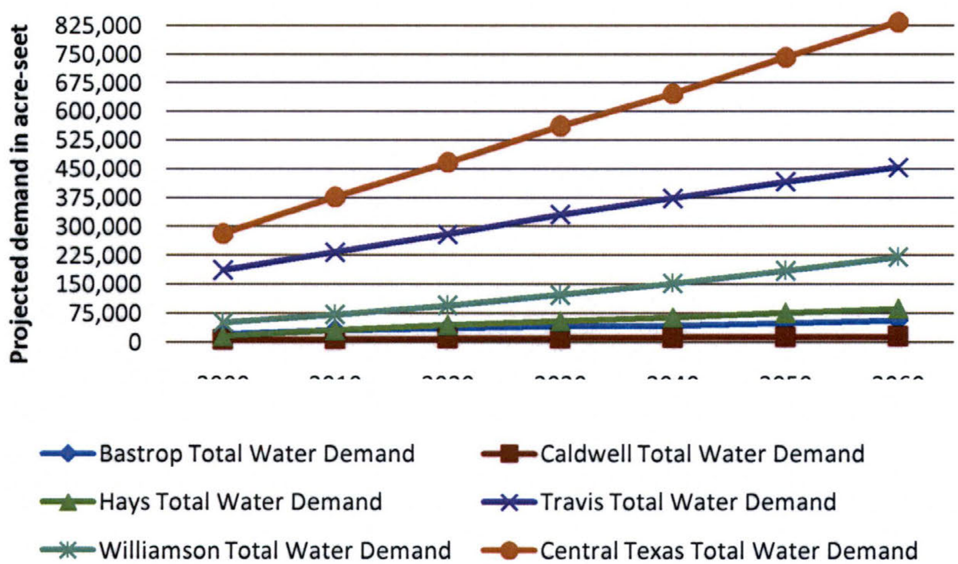

Figure 10: Regional water plan projected total water demand by county, 2000 to 2060 (Source: Texas Water Development Board 2006)

Characteristics of Water Data Sources

State Water Agencies and Legislation

There are 4 legislative categories relating to water supply and distribution:

1. *Public utility acts* - administered by public utility commissions, setting water service standards concerning quantity and quality;

2. *State water supply statutes* - characterized as health and safety standards (analogous to federal enactments);

3. *Environmental statutes* - often relate to federal regulations, environmental impact assessments, or unique environmental occurrences (e.g., endemic species; unusual ecosystems/environments/ habitats;

4. *Water supply agreements* - implemented primarily through local water authorities (Dzurik 2003).

The Texas Water Development Board and Texas Commission on Environmental Quality are responsible for the majority of these categories. The TWDB annually creates a State Water Plan, based on input from the Regional Water Planning Groups, including identification of total water quantity and allocations, critical shortages, water management strategies, and infrastructure development and financing plans. TCEQ mandates and enforces water quality standards, instream uses and environmental protection regulations. Both entities are responsible for source water protection, conservation, drought preparedness and management of water loss.

Texas Water Development Board (TWDB) Water Conservation Regulations

The 78th Texas Legislature passed House Bill 3338 to address the lack of water loss information, requiring retail public utilities providing potable water to “perform and file with the [Texas Water Development Board] a water audit computing the utility's most recent annual system water loss” every five years. Under this authority, the Texas Water Development Board (TWDB) instituted new water audit reporting requirements requiring retail public utilities to: (i) audit system water use at least once every five years and (ii) estimate system water use in standard categories.

TWDB Regional Water Planning Groups

The 75th Texas Legislature enacted Senate Bill 1 (SB 1) in June, 1997, in response to increased awareness of the limitations of existing water supplies to meet increasing water demands from population growth, and supply limitations due to drought and other climate change concerns. Sixteen Regional Water Planning Groups were created with a "bottom up" planning approach to prepare regional water plans for their respective areas. The plans are to identify conservation practices for existing water supplies, ensure future water supply demands, and respond to drought impacts within each planning area (TWDB 2003).

For this study, Central Texas is defined as Bastrop, Caldwell, Hays, Travis and Williamson counties. They fall into 3 water planning regions: G (Brazos Region), K (Lower Colorado Region) and L (South Central Texas Region). Each planning regions is composed of community members from such sectors as state and county government, agriculture, environmental protection and conservation (state level; university faculty; etc), water districts, industry, municipalities, river authorities, utility providers and municipalities.

Water Planning Region G

Known as the Brazos region, Water Planning Region G encompasses all or part of 37 counties, extending from Kent and Knox Counties south and southeast to Grimes and Washington counties (Figure 11). Over 90% of the region is within the Brazos River basin, with Abilene, Bryan, College Station, Killeen, Round Rock, Temple and Waco being the largest cities. The major industries are service, manufacturing and retail trade. Cities in the Central Texas Region include Round Rock, Cedar Park and Leander.

Responding to the TWDB requests for water conservation strategies, the Brazos Planning Group recommended a variety of management practices to alleviate future water supply deficits, potentially creating additional supplies of up to 736,032 acre-feet by 2060, at a projected total cost of approximately $1 billion. Implementing conservation practices are projected to yield water savings of 45,218 acre-feet. The remainder of the water demand will be provided from reuse, acquisition of groundwater, surface water and reservoir construction (TWDB 2006).

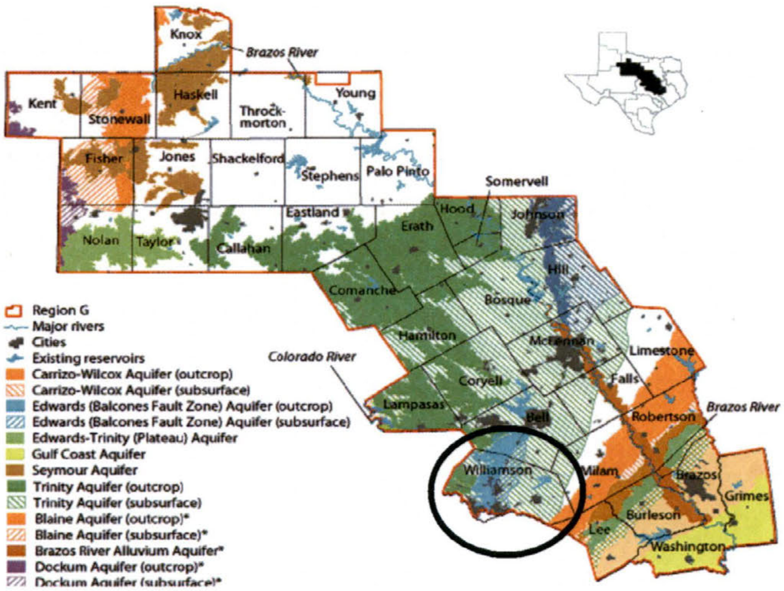

Figure 11: Location of Williamson County in Regional Planning Group G (Source: TWDB 2006)

Water Planning Region K

Referred to as the Lower Colorado Region, Region K extends southeast from Mills and San Saba counties toward the Gulf of Mexico, containing all or part of 13 counties (Figure 12). A major portion of the Hill Country resides within this region, including the towns of Llano, Fredericksburg, Austin and Pflugerville, as well as major coastal communities. Austin, Kyle, Buda and Bastrop are rapidly-growing urban population centers within the Central Texas portion of the planning region. Region K water users include agriculture, government offices, manufacturing (primarily semiconductor and other technological industries), retail and service industries, and urban and suburban municipal centers.

This Planning Group proposed to address future water supply deficits with 4 categories of management strategies, including conservation, groundwater, surface water and water reuse. Implementing Region K's water management strategies is forecasted to cost $358.2 million, providing an additional 861,930 acre-feet by 2060. Although lacking administrative and programmatic costs, a TWDB model estimates the capital costs of conservation will total $2,903,692, providing 194, 315 acre-feet of water ($15 per acre-foot). Although more than $96 million dollars was initially expected to produce 29,568 acre-feet of water for the region through desalination of brackish groundwater, the water savings are now expected to come from additional water re-use and conservation savings in Travis County (TWDB 2006).

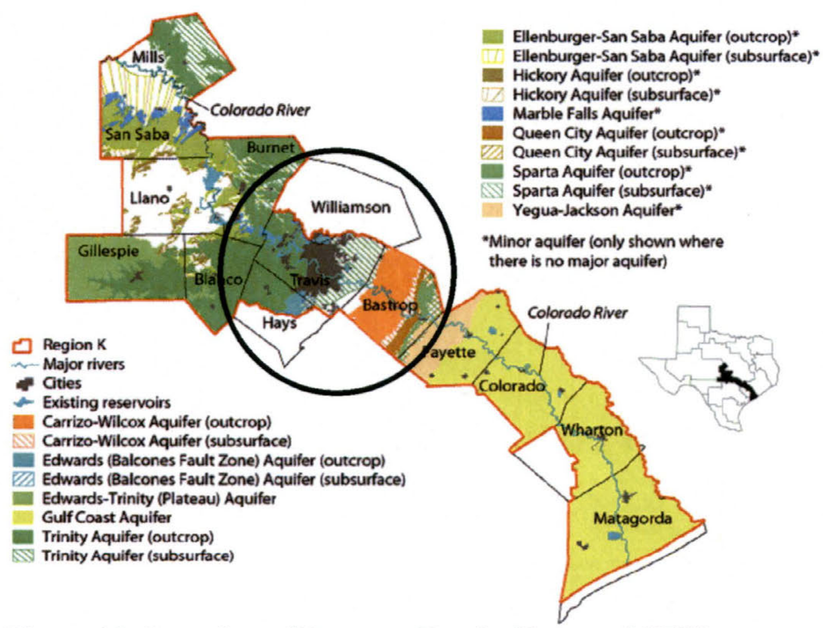

Figure 12: Location of Bastrop, Travis, Hays and Williamson Counties in Regional Planning Group K (Source: TWDB 2006)

Water Planning Region L

Called the South Central Texas region, Regional Planning Group L extends north and westward from the Gulf Coast in Calhoun and Refugio Counties, through South Central Texas to the southern portion of Hays County and down toward Dimmit and

LaSalle Counties. It includes 21 counties, the cities of San Antonio, Victoria, San Marcos, New Braunfels, Lockhart and Luling, 9 significant rivers (including San Antonio, Nueces, Guadalupe, Comal and San Marcos), the Guadalupe Estuary and San Antonio Bay (Figure 13). Comal and San Marcos Springs, the two largest springs in Texas, also are located in the planning region. Tourism, medical, military, service, manufacturing retail trade, and a small level of agriculture, as well as growing population centers, comprise the major water uses.

The Region L Water Planning Group compiled 26 water management strategies to meet the next 50 years of projected water needs, estimated to be 732,779 additional acre-feet at a projected total capital cost of greater than $5.2 billion. Water conservation measures will provide 109,927 acre-feet of projected water savings, although no cost analysis has been performed. The remainder of the projected deficit will be addressed with conjunctive water use (177,177 acre-feet at $14,003 per acre-foot), desalination (89,674 acre-feet at $10,981 per acre-foot), groundwater acquisition (206,111 acre-feet at $3,464 per acre-foot), and surface water supply acquisition (98,214 acre-feet at $8,689 per acre-foot) (TWDB 2006).

Population growth is currently so rapid in this region that future water shortages are imminent, and will cost billions of dollars, if not proactively addressed. Thus, the possibility of importing Carrizo-Wilcox Aquifer water from Gonzales and Wilson counties, potential temporary over-drafting of the Carrizo-Wilcox Aquifer, the revised Lower Guadalupe Water Supply Project, and over-reliance and over-use of the Edwards Aquifer, are major issues requiring immediate attention and planning.

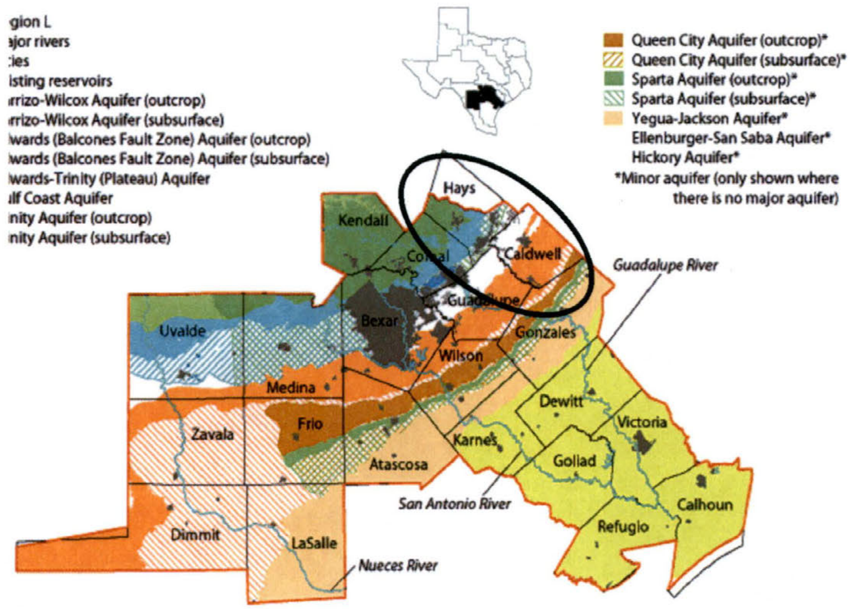

Figure 13: Location of Caldwell and Hays County in Regional Planning Group L (Source: TWDB 2006)

Regional Water Supply Providers:

There are 5 major types of water providers in Texas, as described below:

1. Municipal systems

Most water systems in Central Texas are owned and/or operated by the municipal areas they serve. Water utility operations are typically run by the municipal government, often by the public works or utility departments of the city or municipality. Smaller cities and towns may purchase water from larger neighboring cities, also often utilizing their infrastructure. Elected officials and managers are responsible for financial management and funding of municipal water providers. Larger municipal systems may be managed and operated by distinct, separate utility entities (e.g., large private suppliers or river authorities). Small independently-owned providers usually service their small communities in rural areas (e.g., Arroyo Doble; County Line Water Supply).

2. River Authorities

The Texas Legislature created conservation and reclamation districts for conserving and developing natural resources (e.g., storing, preserving and distributing surface (river) water) for municipal, industrial and commercial water use, irrigation, power, and other beneficial uses. The Lower Colorado River Authority, Brazos River Authority and Guadalupe/Blanco River Authority manage much of the water used for municipal supply in Central Texas, and encourage water purchasers to implement water conservation practices recommended by the State Water Plan.

Lower Colorado River Authority

(Bastrop, Travis, Williamson, and portions of Hays and Caldwell counties)

The Lower Colorado River Authority (LCRA) was created as a conservation and reclamation district in 1934, partly to establish a reliable water supply. LCRA constructed and maintains 6 dams on the lower Colorado River, two in Central Texas, to manage floods and store water supplies for municipal, industrial, agricultural and recreational users throughout a 10-county statutory district that includes Travis and Bastrop counties. LCRA manages water supplies for cities, farmers and industries along a 600-mile stretch of the Texas Colorado River between San Saba and the Gulf Coast, including 10 water systems and treatment facilities in Central Texas, being known throughout Texas as a leader in water conservation education.

Brazos River Authority

(Williamson and a small portion of Bastrop Counties)

The Brazos River Conservation and Reclamation District was created in 1929, just a few years before the LCRA, to conserve, control, and utilize the storm and flood waters of the Brazos River and its tributary streams for beneficial purposes. The BRA began planning reservoir development in 1935, including 13 dams along the Brazos River and its tributaries. By the time it reaches the Gulf of Mexico, the Brazos River basin provides 6.75 billion gallons of water each year for cities, agriculture, industry and mining, with a portion being utilized in Central Texas. The authority currently works to develop and distribute water supplies, provide water and wastewater treatment, monitor water quality, and pursue water conservation through public education programs. The Authority also operates regional wastewater systems for Brushy Creek, and the cities of Hutto, and Georgetown. In addition to the regional plants, the Authority provides potable water to the Sandy Creek Water Treatment Plant in Leander.

Guadalupe-Blanco River Authority

(Hays, Caldwell Counties)

The Guadalupe River Authority was established in 1933, being reauthorized as the Guadalupe-Blanco River Authority (GBRA) two years later to provide stewardship for the water resources in its ten-county district, beginning near the headwaters of the Guadalupe and Blanco Rivers, and ending at San Antonio Bay. Hays, Caldwell and several other surrounding counties fall within GBRA's boundaries. To fulfill GBRA's primary responsibilities of developing, conserving and protecting the water resources of the Guadalupe River Basin, planning and resource development efforts are carefully coordinated within the broader considerations of regional and statewide water needs. It also operates wastewater treatment facilities in Buda, and a wastewater reclamation plant in Lockhart.

3. Districts

Water districts are political sub-divisions formed, in part, as conduits for infrastructure funding and development. They often have characteristics similar to municipalities. These districts commonly serve populations living on the urban and suburban edges of municipalities, essentially serving as distribution systems that purchase water from wholesale suppliers. Examples include Bastrop and Travis County Water Control and Improvement Districts and Municipal Utility Districts (MUDs).

4. Water Supply Corporations

Water Supply Corporations (WSCs) are generally non-profit, member-owned corporations formed to provide water to customers. They are typically located in rural, unincorporated areas often lacking access to municipal or other water supplies. Because of their typically rural settings, WSCs tend to maintain longer distribution lines between connections than urban water systems, and vary significantly in customer numbers and service area. In more suburban areas, homeowner associations often operate as small scale WSCs, an example being Manville WSC.

5. Investor Owned Utilities

Investor-owned utilities (IOUs) are private, for-profit systems, subject to a different set of regulations. Because of their for-profit status, IOUs are believed to more diligently manage water leakage and supply issues. Many investor-owned utilities in Central Texas act as water providers for residential customers, being privately owned in conjunction with mobile home communities.

Calculation Methodology

Because the situation is similar for residential water savings measures in Central Texas, water savings and associated costs were collected from the literature and published studies, and subsequently applied to water provider data in Central Texas to estimate current and potential water use reductions, conservation savings and associated costs. The specific metrics applied to a set of generic equations to determine water savings are as follows:

Average Water Daily Savings = (#SFRMS) x (savings metric x #SFR) X (#MPSFR)

Where:
#SFRMS = Total number of conservation measures implemented per single family residence;
#SFR = Average number of people per single family residence;
#MPSFR = Average number of conservation measures per single family residence;

Total Annual Water Savings = Average annual household water use - ∑ (savings metrics x conservation measures used) x number of metered households (x population growth coefficient).

To estimate the costs of conservation measures, the dollar cost per acre-foot was calculated, and amortized over the lifetime of the measure, using the following equation (adapted from TWDB/GDS 2002):

Total Annual Cost per Measure = [(Direct + Indirect Costs per Measure x 325,851 gallons/acre-foot) / (Savings per Measure [gallons] x 365 days)] amortized at 5 % over the life of the measure.

As financial savings and cost figures were seldom reported in the same measurement units, they were converted to standardized units. Direct and indirect costs were collected from previous studies and averaged for use in this study. The direct costs included actual purchasing costs and rebate amounts, while indirect costs comprised staff and labor costs, overhead and marketing expenses. Residential water savings were calculated in gallons per day (gpd) and, where possible converted to gallons per capita per day (gpcd). The gpcd (SFR refers to a single family residence) was calculated with the following equation:

$$\text{SFR per capita Consumption} = \frac{\text{Retail Water Sold to SFR Accounts}}{\text{Number of SFR Accounts}} \times \frac{1}{\text{Avg. Occup. / SFR Household}}$$

The expected customer participation rates, estimated costs, potential savings, and projected device or savings lifetime and household characteristics were derived from the literature and existing studies. Customer participation rates for water efficiency measures excluded customers that implemented a measure as part of a natural replacement or other factors. Previous analysis indicated that water providers with aggressive public education programs exhibit higher implementation rates (TWDB/GDS 2002; WCASA 2003).

It was assumed in this study that the average lifetime of the conservation device(s) reflected that reported by the manufacturer and that any necessary maintenance was performed by customers. Finally, it was assumed that: (i) each single family residence had two bathrooms and (ii) all residential irrigation was limited to 8 months of the year; For this study, water providers and their customers were classified into one of three population areas (urban; suburban; rural). Cities designated as Metropolitan Statistical Areas (MSA) by the US Census Bureau, or with populations greater than 10,000, were considered urban. Suburban areas were denoted as non-MSA cities located in the same county as the nearest MSA, while rural areas were cities, towns and areas with small populations not located near MSAs.

CHAPTER THREE

INITIAL RESULTS

Introduction

As discussed in several national and southwestern studies introduced in the first chapter (e.g., AWWA, 1999; Vickers, 2001; WRA, 2003), average daily gallon per capita water use rates range between 171 and 200 for standard single family homes (Table 13). Reductions of up to 27 gallons per person per day are achievable when basic conservation features, such as low flow showerheads, faucet aerators, and high efficiency toilets, are in place. For newly-constructed and remodeled homes that utilize high efficiency appliances, additional savings of 14 gallons per person per day can be realized. This chapter provides gallons per capita per day (GPCD) water consumption rates reported by surveyed providers as a means of comparing water provider characteristics and conservation program efficacy. On average, all types and sizes of water providers in Central Texas reported daily water consumption rates below both the state and regional planning group averages. TWDB/GDS (2002, 2005) reports average per capita water consumption rates for planning regions G, K and L of 147.50, 154.50 and 144.00, respectively.

Table 13: Average GPCD values reported in literature

Average Per Capita Water Use (gallons/day)	WRA (2003)	Vickers (2001)	AWWA (1999)
Typical Home	171	200	172
Conserving Home	144		
State of the Art Home	130		

Water Provider Characteristics

Over 120 Central Texas water providers were contacted, with approximately 30% responding. The water provider survey is provided in Appendix D. Thirty respondents provided complete data sets, while 4 provided estimates of water savings from ongoing conservation practices. Several respondents provided partial data sets, while some data were obtained from sources listed in Chapter 2 (Table 9). Based on this information and reported data, water providers (including several who did not respond to the survey) were classified by type, size, area (rural, urban, suburban or general), as well as by county, as discussed in following sections.

Water Provider Type

Providers characterized as city municipalities averaged 134.92 GPCD for 25 water providers ranging from over half a million to only 233 customers. Only 2 providers were classified as investor-owned utilities (IOUs), a large multi-county provider and a small provider servicing an 81 meter housing development, with their GPCD averaging 147. Twenty water providers were considered municipal utility districts (MUDs), with an average per capita volume of 129.47 gallon, with 4 MUDS not yet serving any customers. Water supply corporations (WSCs) averaged 126.91 GPCD among 15 providers, and 4 Water Conservation and Improvement Districts had an average GPCD of 137.42. Several providers reported very low GPCD values that are believed to be inaccurate, and distorting the average GPCD values. When compared with traditionally-accepted GPCD values from the literature (Table 13), all provider categories in Central Texas are lower than the reported per capita rates, and all categories except for the investor-owned utilities, have lower GPCD values for homes actively practicing conservation measures. Both MUDs and WSCs fall below the average per capita water use rates for "state of art" conserving homes, which utilize ultra-efficient plumbing, plumbing fixtures, greywater, outdoor watering restrictions or schedules and native or low-water landscaping (WRA 2003). Table 14 and Figure 14 below shows average per capita use values for each reported provider type.

Table 14: Average GPCD values by categorized water provider type

Water Provider Type	# providers	Ave GPCD
City municipality	25	134.92
IOU	2	147.00
MUD	20	129.47
WSC	15	126.91
WCID	4	137.42

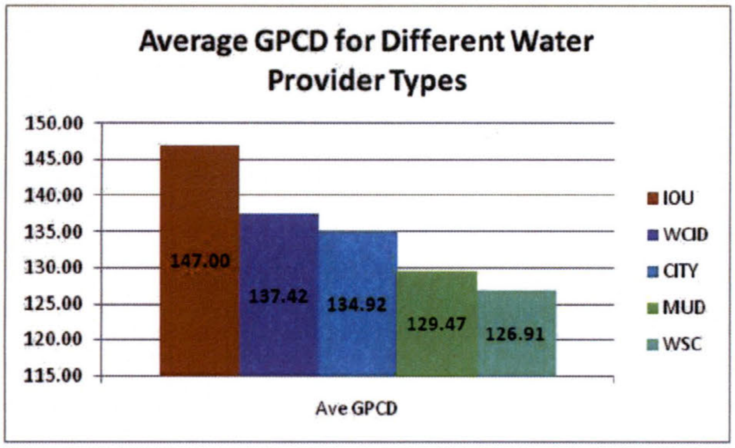

Figure 14: Average GPCD values by categorized water provider type

Water Provider Size

Customer information was collected for 66 water providers which were broken down into small, medium and large classifications, as shown in Tables 15-18 and Figure 15, where small providers serve less than 1400 customers, medium providers serve between 1400 and 9200 individuals and large providers serve more than 9200 customers.

Table 15: Average GPCD values by provider size

Water Provider Size	# providers	Ave GPCD
Small (less than 1400 customers)	26	140.18
Medium (1400 -9200 customers)	22	122.55
Large (more than 9200 customers)	18	132.74

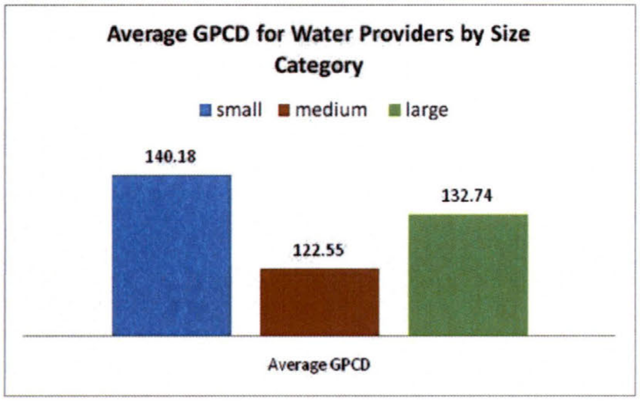

Figure 15: Average GPCD values for identified small, medium and large water providers

As shown in Figure 15, small providers had the highest per capita use on average, with medium providers reporting the lowest GPCD. Because the available data suggest several providers may have underreported their customers' use, these numbers may be skewed. It is not surprising that small providers reported the highest use, since they typically have fewer resources for implementing conservation and leak monitoring programs. As discussed later in this chapter, smaller providers are least likely to have public education programs, which work to reduce per capita use. It is noted that large water providers tend to be in urban centers, and likely to have higher GPCD rates because of larger percentages of affluent or high water use customers (AWWA 1999; Michelsen 1999). This may be the case in Central Texas. Larger municipalities also have larger infrastructure systems with higher potential for leakage, another factor that could increase their GPCD values. An additional consideration that may influence GPCD levels is pricing: it has been shown that strict marginal cost pricing and inverted block pricing or rating (IBR) methods do not always result in the highest conservation practices, even though they are the most commonly used (Loehman 2004). IBR may provide less customer conservation incentives, due to the complexity in determining user savings from review of utility bills (Loehman 2004). It would be useful, in a more in-depth analysis to consider pricing strategies in conjunction with location and other provider characteristics.

Table 16: Water providers categorized by size (small providers service 1,400 customers or less)

Provider	Provider type	City	County	# & type of customers (INDIVIDUALS)	# & type of customers (METERS/ CONNECTIONS)	# in Household (Individuals per Meter)	GPCD
New Sweden MUD #1,	MUD	Austin, New Sweden	Travis	0	0	0	0
New Sweden MUD #2	MUD	Austin, New Sweden	Travis	0	0	0	0
New Sweden MUD #3	MUD	Austin, Phlugerville, New Sweden	Travis	0	0	0	0
Northwest Austin MUD #1	MUD	Austin	Travis	0	0	0	0
Lazy Nine MUD	MUD - private	Austin	Travis	0	1,800	0.00	0.00
West Cypress Hills WCID #1	WCID - PRIVATE	Pflugerville	Williamson	vacant land. no houses. not developed for 5-6 years,	0	0	0
J&R Mobile Home Park	MUD - private	Bastrop	Bastrop	66	22	3.00	100.00
Andice Water Supply	WSC	Georgetown	Williamson	72	24	3.00	147.50
McMahan WSC	WSC	McMahan, Dale	Caldwell	125	41	3.04	161.50
High Valley WSC	IOU	Austin	Travis	200	81	2.47	164.00
K&K Water Co.	MUD - private	Red Rock	Bastrop, Caldwell	213	71	3.00	79.81
Hays, City of	CITY	Hays	Hays	233	88	2.65	163.95
Bastrop West Water Systems	WSC	Bastrop	Bastrop	360	120	3.00	66.67
Blessing Mobile Home Park	MUD - private	Round Rock	Williamson	441	147	3.00	136.50
Maxwell WSC	WSC	Maxwell	Caldwell	500	177	2.82	161.50
Sunset Valley, City of	CITY	Sunset Valley	Travis	535	214 residential 19 commercial	2.50	187.71
Elliot Ranch Water System	MUD - private	Buda, Hays	Hays	540	158	3.42	158.50
Bastrop County WCID 2	WCID	Bastrop, McDade	Bastrop	630	210	3.00	76.19
Thrall, City of	CITY	Thrall	Williamson	710	255	2.78	149.50
Arroyo Doble Water Supply Inc.	MUD - private	Manchaca	Travis	906	304	2.98	137.97
Noack WSC	WSC	Thrall, Coupland	Williamson	945	335	2.82	149.50
Travis County WCID 20	WCID	Austin	Travis	1,047	349	3.00	156.00
Florence, City of	CITY	Florence	Williamson	1,129	400	2.82	147.50
Barton Creek West WSC	WSC	Austin	Travis	1,251	417	3.00	156.00
Granger, City of	CITY	Granger	Williamson	1,363	483	2.82	147.50
Briarcliff, Village of	CITY	Briarcliff	Travis	1,400	704	2.47	155.71

Table 17: Water providers categorized by size (medium providers service between 1,400 and 9,200 customers)

Provider	Provider type	City	County	# & type of customers (INDIVIDUALS)	# & type of customers (METERS/ CONNECTIONS)	# in Household (Individuals per Meter)	GPCD
Dripping Springs, City of	CITY	Dripping Springs	Hays	1,828	680	2.69	158.50
Williamson County MUD 9	MUD	Round Rock	Williamson	2,724	908	3.00	150.88
Martindale WSC	WSC	Martindale	Caldwell	2,727	821	2.82	75.17
Dripping Springs WSC	WSC	Dripping Springs	Hays	3,273	1,071	3.06	122.21
Jonestown WSC	WSC	Jonestown	Travis	3,747	1,048	3.57	120.10
Lost Creek MUD	MUD - GOV	Austin	Travis	4,000	1,252	3.19	133.75
Shady Hollow MUD	MUD	Austin	Travis	4,227	1,409	3.00	208.90
Smithville, City of	CITY	Smithville	Bastrop	4,447	1,772	2.51	108.61
County Line WSC	WSC/SUD	Uhland	Caldwell	4,839	1,647	2.94	85.00
Hornsby Bend Utility Co. Inc.	private municip/ MUD	Webberville	Travis	5,000	1,700	2.94	154.50
Luling, City of	CITY	Luling	Caldwell	5,080	2,184	2.82	125.00
Buda, City of	CITY	Buda	Hays	5,139	1,713	3.00	87.95
Manor, City of	CITY	Manor	Travis	5,265	1,461	3.60	70.47
Wimberly WSC	WSC	Wimberley	Hays	5,900	1,656	3.56	172.88
Lago Vista, City of	CITY	Lago Vista	Travis	6,293	2,011	3.13	156.00
Creedmoor Maha WSC	WSC	Bastrop, Creedmoor	Travis, Bastrop	6,732	2,058	3.27	90.61
Gonzales County WSC	WSC	Gonzales	Caldwell	6,879	2,439	2.82	161.50
Block House MUD	MUD - GOV	Cedar Park	Williamson	7,669	2,191 residential 16 irrigation 0 com/ind/ag	3.50	65.43
North Austin MUD #1	MUD	Austin	Williamson (Williamson is majority), Travis	7,839	2,613	2.82	113.53
Bastrop, City of	CITY	Bastrop	Bastrop	7,936	3,148	3.00	130.00
Elgin, City of	CITY	Elgin	Bastrop	8,922	2,917	3.06	117.01
Hutto, City of	CITY	Hutto	Williamson	9,132	2,892	3.33	88.04

Table 18: Water providers categorized by size (large providers serve more than 9,200 customers)

Provider	Provider type	City	County	# & type of customers (INDIVIDUALS)	# & type of customers (METERS/ CONNECTIONS)	# in Household (Individuals per Meter)	GPCD
Lakeway MUD	MUD - private	Lakeway	Travis	10,910 Build-out pop: 11,655	4,041	2.70	168.01
Manville WSC	WSC	Coupland (Manor, Pflugerville, Richland, Cele, New Sweden)	Bastrop, Travis	12,987 Travis co 501 other 13,488 total	7,038 SF 250 MF 294 COM/INDUST/AG	2.77	79.03
Cedar Park, City of	CITY	Cedar Park	Williamson	75,214	resid 17,239 non-res 1107	3.10	111.44
Brushy Creek MUD	MUD - private	Round Rock	Williamson	14,871	4,957	3.02	136.50
Aqua Water Supply Corporation	IOU	Bastrop +950-square mile area	Bastrop (parts of Lee, Caldwell, Fayette and Williamson)	Residential SF 15,196 Residential MF 844	6,055	2.51	130.00
Windermere Utility Co. Inc.	PUD managed by Southwest Water Co	Austin	Travis	16,299	4,836	3.37	94.12
Lockhart, City of	CITY	Lockhart	Caldwell	16,328	3,889 resid 398 commercial	4.20	106.87
Wells Branch MUD	MUD	Austin	Travis	17,328	2,893	5.99	77.62
Taylor, City of	CITY	Taylor	Williamson	18,120	5,690	3.18	126.93
Kyle, City of	CITY	Kyle	Hays	20,772	6,521	3.19	91.95
Pflugerville, City of	CITY	Pflugerville	Travis	23,389 3,966 wholesale	10,778	2.17	164.44
Travis County WCID 17	WCID	Austin (Lakeway, Beecaves, Steiner Ranch)	Travis	24,000	8,000	3.00	170.00
Leander, City of	CITY	Leander	Williamson	25,740	8,580	3.00	229.22
Georgetown, City of	CITY	Georgetown	Williamson	44,735	15,977	2.80	160.00
San Marcos, City of	CITY	San Marcos	Hays	53,512	8,472.00	2.31	127.56
Barton Creek WSC	WSC	Austin, Phlugerville	Travis	54,000	21,863	2.47	154.50
Round Rock, City of	CITY	Round Rock	Williamson	91,151 12,814 wholesale	28,935	3.15	97.00
Austin, City of	CITY	Austin	Travis	Residential SF 501,480 Residential MF 294,000 Wholesale 54,000	**inside city** residential 174,300 multi fam 5,516 commercial 15,019 industrial 27 golf courses 38 **outside city** residential 10,523 multi fam 273 commercial 699 golf courses 1	2.40	139.00

Water Provider Area Type

Identified providers were classified by service area types, as defined in Chapter 2. Of the 66 water providers, 5 are not yet providing water to customers (categorized as "not developed"), 11 are in rural areas, 2 are in predominantly rural areas with some suburban coverage, and 9 are primarily in suburban areas with some rural coverage. Figure 16 shows twenty seven water providers are classified as suburban, 3 as suburban with some urban customers, 6 as urban, and 3 as principally urban with a small portion of suburban coverage. Over 60% of providers were classified as having at least some suburban and urban coverage, with only 20% of providers based in rural areas, represented in Figures 16-18. Table 19 lists responding providers by type and size, allowing for comparisons.

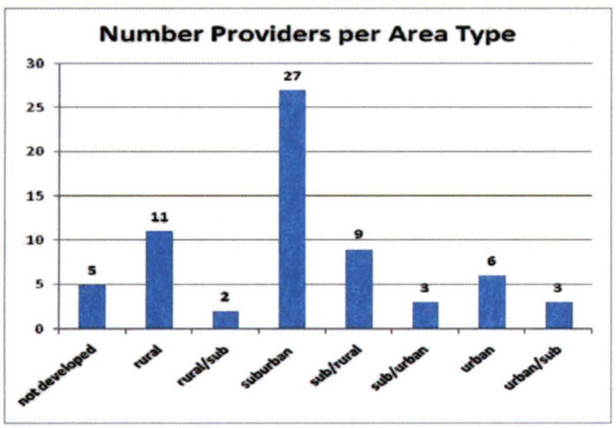

Figure 16: Number of identified water providers per area type

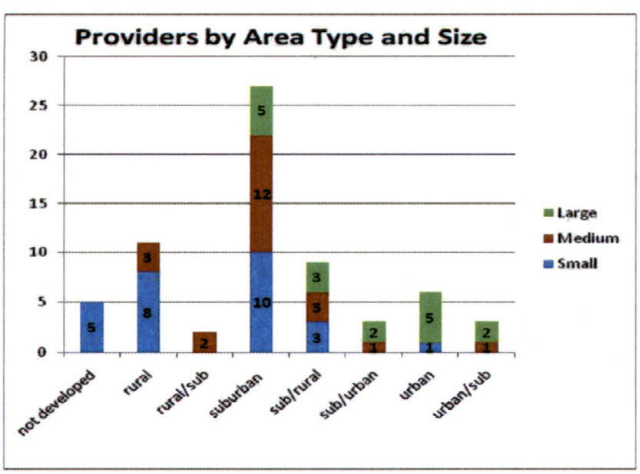

Figure 17: Identified water providers by area type and size

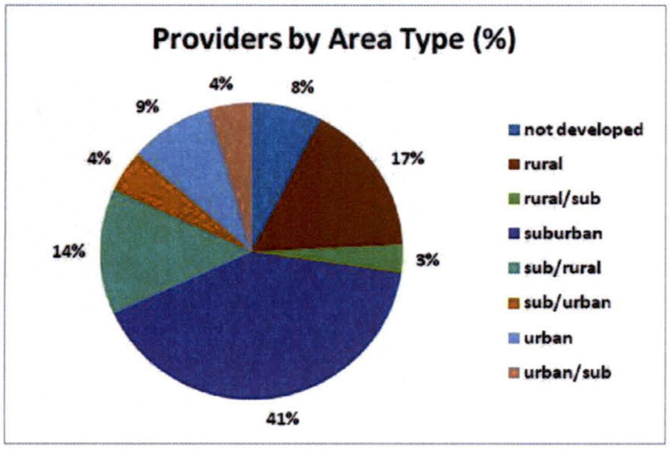

Figure 18: Percentages of identified water providers by area type

As shown in Figure 19, water providers characterized as predominantly rural with some suburban coverage had a 91.89 average GPCD, which was the lowest average value. However, there were only 2 providers in this category (with GPCDs of 75.17 and 108.61), making it difficult to draw any rigorous conclusions based on such limited data. Although suburban/urban providers averaged 122.5 GPCD, again there were data only for 3 providers in this category, (2 large and 1 medium). It would be expected that larger providers within suburban/urban areas would have at least some conservation measures in place, yielding lower water consumption rates. Rural water providers averaged 124.15 GPCD, well below the TWDB rural GPCD estimates for the corresponding regional planning groups (136.5, 161.5 and 149). Providers located in suburban areas averaged 135.41 gallons per person per day, which was less than corresponding planning groups' suburban GPCD totals of 136.5, 158.5 and 158 GPCD. Water providers located in urban settings averaged 144.92 GPCD, comparable to 154, 138.5 and 154.5 GPCD estimates for urban water users in Central Texas planning groups (TWDB/GDS 2002; 2005). Urban water providers with a subset of suburban customers averaged (1 medium, 2 large) 148.82 GPCD, the highest of all area types. As with other provider type categories with little available data, only limited conclusions can be made. Urban and primarily urban water providers tend to have higher per capita use rates for several reasons (often despite aggressive conservation programs), including a larger percentage of affluent, high water use customers and higher leakage rates due to volume and distance of water supplied.

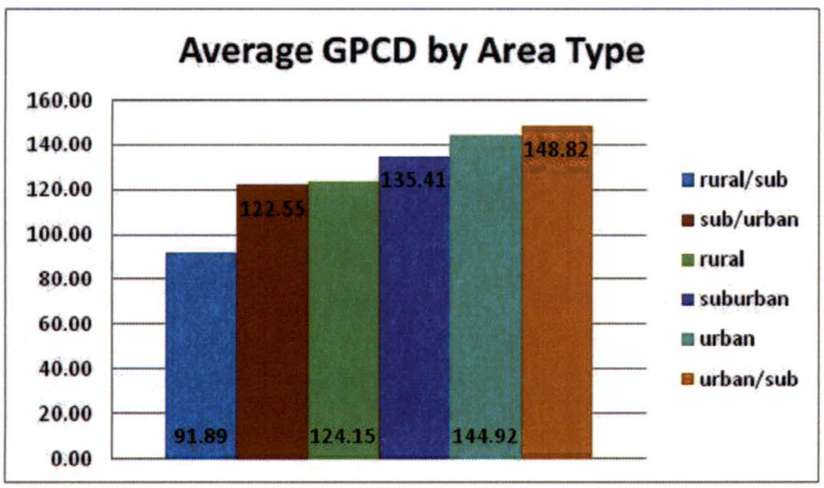

Figure 19: Average GPCD values by water provider area type

Table 19: Water providers characterized by area type and size

Provider	County	Area Type	Provider Size	GPCD
Lazy Nine MUD	Travis	not dvlpd	small	0.00
New Sweden MUD #1,	Travis	not dvlpd	small	0.00
New Sweden MUD #2	Travis	not dvlpd	small	0.00
New Sweden MUD #3	Travis	not dvlpd	small	0.00
West Cypress Hills WCID #1	Williamson	not dvlpd	small	0.00
Andice Water Supply	Williamson	rural	small	147.50
Bastrop County WCID 2	Bastrop	rural	small	76.19
Bastrop West Water Systems	Bastrop	rural	small	66.67
County Line WSC	Caldwell	rural	medium	85.00
Gonzales County WSC	Caldwell	rural	medium	161.50
K&K Water Co.	Bastrop, Caldwell	rural	small	79.81
Maxwell WSC	Caldwell	rural	small	161.50
McMahan WSC	Caldwell	rural	small	161.50
Noack WSC	Williamson	rural	small	149.50
Taylor, City of	Williamson	rural	medium	126.93
Thrall, City of	Williamson	rural	small	149.50
Martindale WSC	Caldwell	rural/ sub	medium	75.17
Smithville, City of	Bastrop	rural/ sub	medium	108.61
Georgetown, City of	Williamson	sub/ urban	large	160.00
North Austin MUD #1	Williamson Travis	sub/ urban	medium	113.53
Windermere Utility Co. Inc.	Travis	sub/ urban	large	94.12

Provider	County	Area Type	Provider Size	GPCD
Austin, City of	Travis	urban	large	139.00
Barton Creek WSC	Travis	urban	large	154.50
Pflugerville, City of	Travis	urban	large	164.44
Round Rock, City of	Williamson	urban	large	97.00
Sunset Valley, City of	Travis	urban	small	144.60
Travis County WCID 17	Travis	urban	large	170.00
Lakeway MUD	Travis	urban/ sub	large	168.01
San Marcos, City of	Hays	urban/ sub	large	127.56
Williamson County MUD 9	Williamson	urban/ sub	medium	150.88
Aqua Water Supply Corporation	Bastrop and others	sub/ rural	large	130.00
Creedmoor Maha WSC	Travis, Bastrop	sub/ rural	medium	90.61
Dripping Springs WSC	Hays	sub/ rural	medium	122.21
Florence, City of	Williamson	sub/ rural	small	147.50
Granger, City of	Williamson	sub/ rural	small	147.50
Hays, City of	Hays	sub/ rural	small	163.95
Lockhart, City of	Caldwell	sub/ rural	large	106.87
Luling, City of	Caldwell	sub/ rural	medium	125.00
Manville WSC	Bastrop, Travis	sub/ rural	large	79.03

Water Providers by County of Service

Based on available data, Bastrop County has the lowest gallons per capita water usage of 98.59 GPCD. However, some suppliers reported unusually low water use rates (or incorrect meter connections) and, if those outliers are removed, Bastrop County's average water usage increases to a more realistic 146.41 GPCD. Caldwell County water providers reported water consumption of 125.22 GPCD, but again with removal of the lowest values, the GPCD grows to 143.27, while Hays County's GPCD of 135.44 increases to 150.60 GPCD. The slight increase in Travis County's reported water use from 143.35 GPCD to 148.48 GPCD may be attributable to the greater number of medium and large water providers, which are likely to have better record keeping and management systems and, therefore, more accurately-reported data, or may be influenced pricing schematics. In addition, providers may have pricing schemes that are not conducive to customer conservation. It has been shown that strict marginal cost pricing and inverted block pricing or rating (IBR) methods do not always result in the highest conservation practices, even though they are the most commonly used (Loehman 2004). IBR may provide less customer conservation incentives, due to the complexity in determining user savings from review of utility bills (Loehman 2004). It would be useful, in a more in-depth analysis to consider pricing strategies in conjunction with location and other provider characteristics.

After removing unrealistic per person water consumption rates, Williamson County's GPCD of 137.03 rises to 145.07. Table 20 below summarizes the GPCD rates for each county with, and without, the low reported values, as well as the corresponding water planning average water use rates reported by the TWDB, which were used as indicators for acceptable GPCD ranges. These values also are presented graphically in Figure 20, while Tables 20-25 show GPCD values by County.

Table 20: Averaged planning group and county GPCD with and without outliers

County	GPCD
Bastrop	98.59
**Bastrop	146.41
Region K Average	154.50
Caldwell	125.22
**Caldwell	143.27
Region L Average	144.00
Hays	135.44
**Hays	150.60
Region K & L Average	149.25
Travis	143.35
**Travis	148.48
Region K Average	154.50
Williamson	137.03
**Williamson	145.07
Region G Average	147.50

** GPCD averages without unusually low reported values.

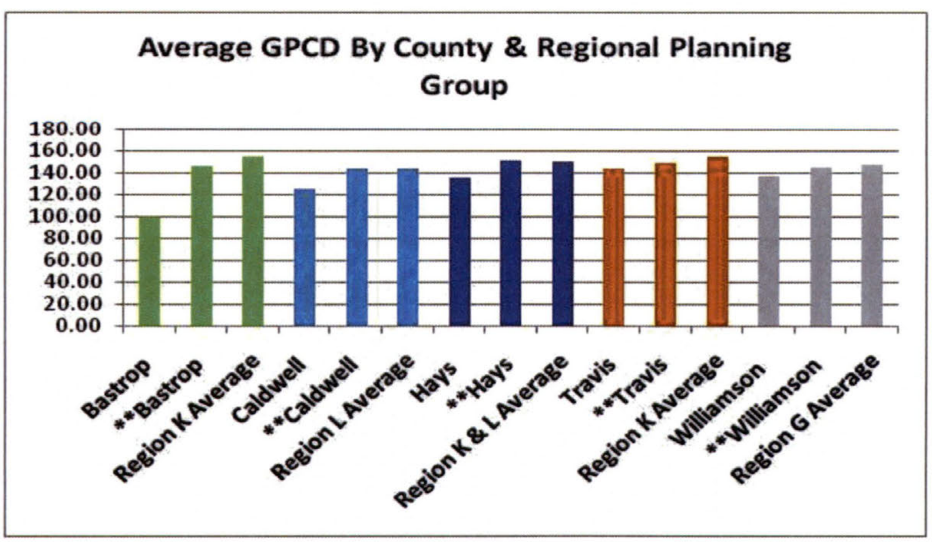

Figure 20: Identified county GPCD with and without outliers, compared with regional planning group averages
** GPCD averages without unusually low reported values

Table 21: Identified water providers categorized by county of service - Bastrop

Provider	Provider type	City	GPCD
Bastrop County WCID 2	WCID	Bastrop, McDade	76.19
Bastrop West Water Systems	WSC	Bastrop	66.67
Bastrop, City of	CITY	Bastrop	130.00
Elgin, City of	CITY	Elgin	117.01
Smithville, City of	CITY	Smithville	108.61
J&R Mobile Home Park	MUD - private	Bastrop	100.00
Aqua Water Supply Corporation	IOU	Bastrop +950-square mile area	130.00
K&K Water Co.	MUD - private	Red Rock	79.81
Manville WSC	WSC	Coupland (Manor, Pflugerville, Richland, Cele, New Sweden)	79.03

Table 22: Identified water providers categorized by county of service - Caldwell

Provider	Provider type	City	GPCD
County Line WSC	WSC/SUD	Uhland	85.00
Gonzales County WSC	WSC	Gonzales	161.50
Lockhart, City of	CITY	Lockhart	106.87
Luling, City of	CITY	Luling	125.00
Martindale WSC	WSC	Martindale	75.17
Maxwell WSC	WSC	Maxwell	161.50
McMahan WSC	WSC	McMahan, Dale	161.50

Table 23: Identified Water Providers Categorized by County of Service - Hays

Provider	Provider type	City	GPCD
Buda, City of	CITY	Buda	87.95
Dripping Springs WSC	WSC	Dripping Springs	122.21
Dripping Springs, City of	CITY	Dripping Springs	158.50
Elliot Ranch Water System	MUD - private	Buda, Hays	158.50
Hays, City of	CITY	Hays	163.95
Kyle, City of	CITY	Kyle	91.95
San Marcos, City of	CITY	San Marcos	127.56
Wimberly WSC	WSC	Wimberley	172.88

Table 24: Identified water providers categorized by county of service - Travis

Provider	Provider type	City	GPCD
Arroyo Doble Water Supply Inc.	MUD - private	Manchaca	137.97
Austin, City of	CITY	Austin	139.00
Barton Creek West WSC	WSC	Austin	156.00
Barton Creek WSC	WSC	Austin, Phlugerville	154.50
Briarcliff, Village of	CITY	Briarcliff	155.71
High Valley WSC	IOU	Austin	164.00
Hornsby Bend Utility Co. Inc.	MUD - private	Webberville	154.50
Jonestown WSC	WSC	Jonestown	120.10
Lago Vista, City of	CITY	Lago Vista	156.00
Lakeway MUD	MUD - private	Lakeway	168.01
Lazy Nine MUD	MUD - private	Austin	0.00
Lost Creek MUD	MUD - GOV	Austin	133.75
Manor, City of	CITY	Manor	70.47
New Sweden MUD #1,	MUD	Austin, New Sweden	156.00
New Sweden MUD #2	MUD	Austin, New Sweden	156.00
New Sweden MUD #3	MUD	Austin, Phlugerville, New Sweden	156.00
Northwest Austin MUD #1	MUD	Austin	156.00
Pflugerville, City of	CITY	Pflugerville	164.44
Shady Hollow MUD	MUD	Austin	208.90
Sunset Valley, City of	CITY	Sunset Valley	144.60
Travis County WCID 17	WCID	Austin (Lakeway, Beecaves, Steiner Ranch)	170.00
Travis County WCID 20	WCID	Austin	156.00
Wells Branch MUD	MUD	Austin	77.62
Windermere Utility Co. Inc.	PUD managed by Southwest Water Co	Austin	94.12
Creedmoor Maha WSC	WSC	Bastrop, Creedmoor	90.61

Table 25: Identified water providers categorized by county of service - Williamson

Provider	Provider type	City	GPCD
Andice Water Supply	WSC	Georgetown	147.50
Blessing Mobile Home Park	MUD - private	Round Rock	136.50
Block House MUD	MUD - GOV	Cedar Park	65.43
Brushy Creek MUD	MUD - private	Round Rock	136.50
Granger, City of	CITY	Granger	147.50
Hutto, City of	CITY	Hutto	88.04
Leander, City of	CITY	Leander	229.22
Taylor, City of	CITY	Taylor	126.93
Thrall, City of	CITY	Thrall	149.50
West Cypress Hills WCID #1	WCID - PRIVATE	Pflugerville	147.50
Williamson County MUD 9	MUD	Round Rock	150.88
Cedar Park, City of	CITY	Cedar Park	111.44 .50
Florence, City of	CITY	Florence	147.50
Georgetown, City of	CITY	Georgetown	160.00
Noack WSC	WSC	Thrall, Coupland	149.50
Round Rock, City of	CITY	Round Rock	97.00
North Austin MUD #1	MUD	Austin	113.53

Water Conservation Measures

Responses from surveyed water providers regarding utilization of conservation measures were categorized by type and level of measures, including demand reduction measures, supply reduction practices and water conservation pricing. For water providers with identifiable customer and meter information, and no conservation measures in place, estimates of water savings and expected costs of implementing conservation practices were calculated, as summarized in Chapter 4. For water demand reduction calculations, customer participation was assumed to be 50%, unless otherwise noted. As with the water provider characteristics above, individual conservation measures are examined, using GPCD water use averages. Although it is difficult to assess the effectiveness of a single measure within a suite of conservation practices, and without knowing water use histories before implementation of conservation practices, comparing GPCD averages to known standards, values from other studies and water use averages among Central Texas providers can provide a general idea of measure efficacy.

Public Education, Websites, Conservation Goals and Savings Estimates

Information was collected from water providers regarding the availability of drought and conservation plans to customers, whether providers operated a website and if published conservation goals were available to customers. If providers could not be contacted or did not respond, the Internet was searched for websites and available information. In addition to email and standard mailed surveys, written requests were made for drought and conservation plans. When possible, drought and conservation plans were requested during visits to water providers' offices. In total, the availability of drought and conservation reports for 66 providers was ascertained with 26 readily-provided drought and conservation plans either via a web page, office visit, phone or mailed request. The majority of these providers fall into the medium and large-sized categories, 38% and 54%, respectively (Figure 21). Forty eight of the same 66 providers were found to have websites, although 9 of those providers' sites contained little or no conservation information (Figure 22). Fifty six percent of the providers operating websites fell into the large size category. As large, and to a lesser extent, medium providers were more likely to have drought and conservation plans available to customers and to maintain websites, it may be concluded that large and medium water providers have more available monetary and personnel resources for distribution of information. This concept is further discussed in the Public Information Programs and Information Distributed section later in the chapter.

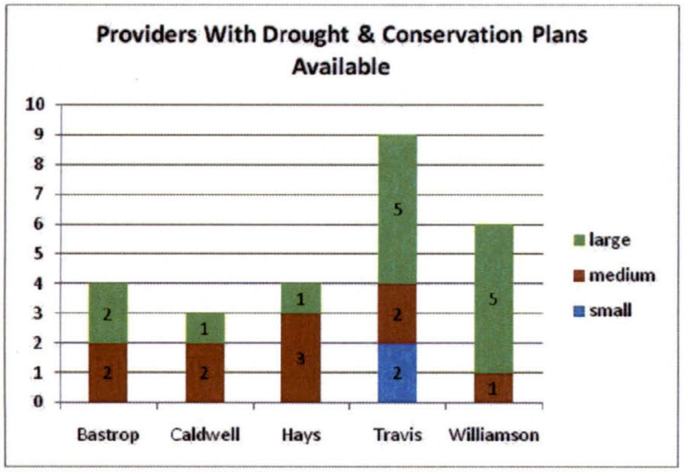

Figure 21: Identified water providers with drought contingency/conservation plans readily available to the public by provider size

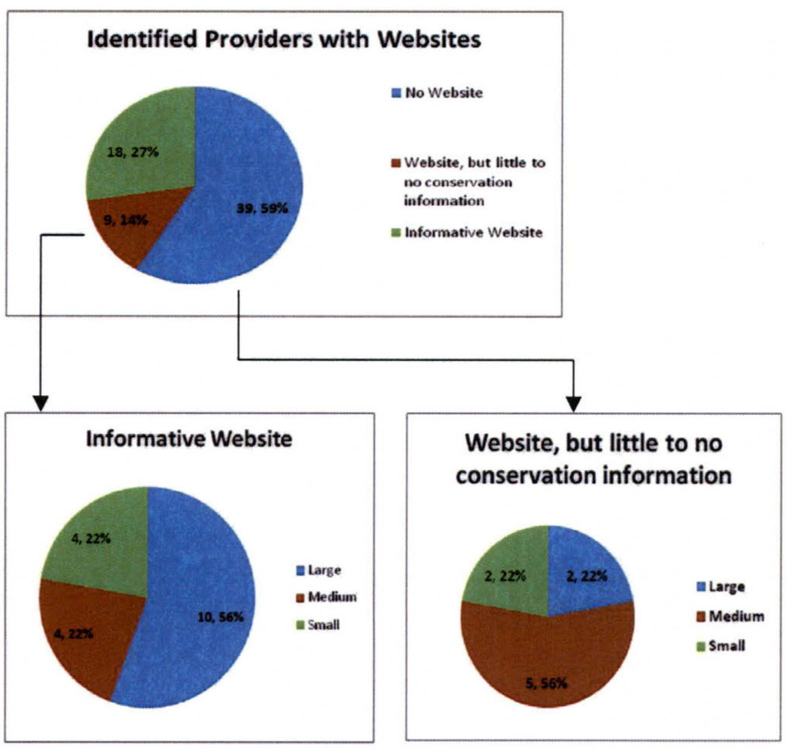

Figure 22: Identified water providers with websites

Statewide and regional planning group water demand reduction goals were discussed in Chapter 1. To determine if these goals could realistically be met through water conservation savings, providers were asked to report conservation savings goals (Table 26, Figure 23). Ten survey respondents (3 medium, 7 large sized providers) reported published water conservation goals. Goals may have been the same as conservation plan goals, but published in newsletters, web sites, etc. All but 1 respondent also had drought contingency plans readily available to customers, and all had conservation plans available and/or distributed to customers. Two water providers in Caldwell County had conservation savings goals available to customers, while Travis County had 3 respondents reporting conservation goals. Williamson County had the highest rate of respondents with conservation goals, while only 1 provider from Hays County and none in Bastrop County reported conservation goals. Hays County had a relatively low response rate in general, and the results of the published goals are not considered representative of the true conservation goals among providers in Hays County. Water providers who reported conservation goals also were examined by provider area type and, due to the small number of respondents, providers with multiple service areas were combined with the area type constituting the majority of the providers' customer base (Figure 24). Water providers classified as suburban/rural, for example, were combined with the rural respondents. Fifty percent of the providers fell into the suburban category, along with 2 rural providers and 3 urban providers. It would be useful to gather conservation goals from all providers in the area and aggregate the conservation savings goals for comparison with TWDB requirements for use reduction. Due to time constraints, however, this activity was not performed.

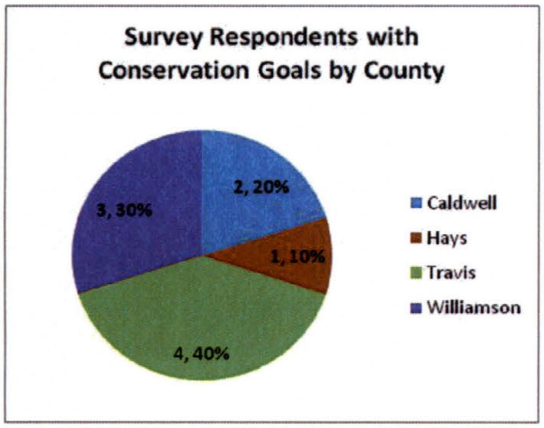

Figure 23: Survey respondents with water conservation goals, reported by county of service

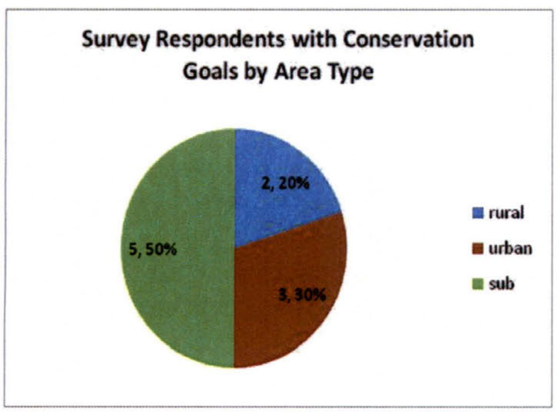

Figure 24: Survey respondents with water conservation goals, reported by area type

Water suppliers were asked to provide an estimate of water or monetary savings from implemented conservation measures. 23 of the 30 providers with complete data sets responded that they did not or were unable to calculate such savings. Only 4 providers offered any per gallon savings and none furnished any monetary savings estimates (Table 26). Reported annual water savings ranged from 365,000 gallons for a small provider in Travis County (High Valley WSC) to over 488 million gallons for the City of Georgetown. Travis County WCID 17 reported 198 million gallons saved annually from reuse practices, but has been unable to quantify savings from conservation practices. The City of Austin estimates conservation savings of 264,173,130 gallons per year. Each of these 4 providers can be categorized as providing water in urban and suburban areas and the specific conservation measures they employ are discussed below.

Table 26: Availability of provider drought contingency/conservation plans; Website; Estimates of conservation savings and goals

Provider	County	Area Type	Provider Size	GPCD	Drought, Conservation plan readily available	Website/ Information available	Estimate of current water savings	Conservation Goals
Aqua Water Supply Corporation	Bastrop and parts of Lee, Caldwell, Fayette and Williamson	sub/rural	large	130.00	yes	yes	unknown	-
Bastrop County WCID 2	Bastrop	rural	small	76.19	no	no	-	-
Bastrop West Water Systems	Bastrop	rural	small	66.70	no	no	-	-
Bastrop, City of	Bastrop	sub	medium	130.00	yes	yes (little information)	unknown	-
Elgin, City of	Bastrop	sub	medium	117.01	yes	yes (little information)	unknown	-
J&R Mobile Home Park	Bastrop	sub	small	100.00	no	no	-	-
K&K Water Co.	Bastrop, Caldwell	rural	small	79.82	no	no	-	-
Manville WSC	Bastrop, Travis	sub/rural	large	79.03	yes	yes	unknown	-
Smithville, City of	Bastrop	rural/sub	medium	108.61	no	no	-	-
County Line WSC	Caldwell	rural	medium	85.00	yes	yes	unknown	reduce per capita use 5% by 2015
Gonzales County WSC	Caldwell	rural	medium	2.82	no	no	-	-
Lockhart, City of	Caldwell	sub/rural	large	106.87	yes	yes	unknown	reduce use by 10% per connection
Luling, City of	Caldwell	sub/rural	medium	125.00	yes	no	unknown	-
Martindale WSC	Caldwell	rural/sub	medium	75.17	no	no	-	-
Maxwell WSC	Caldwell	rural	small	161.50	no	no	-	-
McMahan WSC	Caldwell	rural	small	161.50	no	no	-	-
Buda, City of	Hays	sub	medium	87.95	yes	yes (little information)	unknown	-
Dripping Springs WSC	Hays	sub/rural	medium	122.21	no	no	unknown	-
Dripping Springs, City of	Hays	sub	small	158.50	no	no	unknown	-
Elliot Ranch Water System	Hays	sub	small	158.50	no	yes (little information)	unknown	-
Hays, City of	Hays	sub/rural	small	163.95	no	no	unknown	-
Kyle, City of	Hays	sub	medium	91.95	yes	yes (little information)	-	-
San Marcos, City of	Hays	urban/ sub	large	127.56	yes	yes	unknown	reduce gpcd to 118 by to 2015; to 116 by 2020; to 107 by 2060.
Wimberly WSC	Hays	sub	medium	172.88	yes	no	-	-

Table 26 Continued: Availability of provider drought contingency/conservation plans; Website; Estimates of conservation savings and goals

Provider	County	Area Type	Provider Size	GPCD	Drought, Conservation plan readily available	Website/ Information available	Estimate of current water savings	Conservation Goals
Arroyo Doble Water Supply Inc.	Travis	sub	small	137.97	yes	no	unknown	-
Austin, City of	Travis	urban	large	139.00	yes	yes	264,173, 130 gal saved yr	peak day use reduction of 1%; 25 million gal by 2017
Barton Creek West WSC	Travis	sub	small	156.00	no	no	-	-
Barton Creek WSC	Travis	urban	large	154.50	no	yes (little information)	-	-
Briarcliff, Village of	Travis	sub	small	155.71	no	yes (little information)	unknown	-
High Valley WSC	Travis	sub	small	164.00	no	yes	365,000 gal saved per yr	-
Hornsby Bend Utility Co. Inc.	Travis	sub	medium	154.50	no	no	-	-
Jonestown WSC	Travis	sub	medium	120.10	no	no	unknown	-
Lago Vista, City of	Travis	sub	large	156.00	yes	no	unknown	-
Lakeway MUD	Travis	urban/sub	large	168.01	yes	yes	unknown	reduce system water loss 1% (5 yr), 2% (10 yr); Reduce gpcd 1% (5 yr), 2% (10 yr)
Lazy Nine MUD	Travis	not developed	small	0.00	no	no	none	
Lost Creek MUD	Travis	sub	medium	133.75	no	yes	unknown	reduce peak daily use by 1% per yr, long-term residential use by 5% per yr, water loss by 1% per yr. Conservation Goals: Peak Usage (Kgal/day)
Manor, City of	Travis	sub	medium	70.47	yes	no	unknown	
New Sweden MUD #1,	Travis	not developed	small	156.00	no	no	-	
New Sweden MUD #2	Travis	not developed	small	156.00	no	no	-	
New Sweden MUD #3	Travis	not developed	small	156.00	no	no	-	
Northwest Austin MUD #1	Travis	sub	small	156.00	no	yes	unknown	
Pflugerville, City of	Travis	urban	large	164.44	yes	no	-	

Table 26 Continued: Availability of provider drought contingency/conservation plans; Website; Estimates of conservation savings and goals

Provider	County	Area Type	Provider Size	GPCD	Drought, Conservation plan readily available	Website/ Information available	Estimate of current water savings	Conservation Goals
Shady Hollow MUD	Travis	sub	medium	208.90	no	no	-	
Sunset Valley, City of	Travis	urban	small	144.60	yes	yes	unknown	no specific goals, overall use reduction
Travis County WCID 17	Travis	urban	large	170.00	yes	yes	198,000,000 gal yr saved from resue and raw water use; savings from other conservation measures is unknown	Reduce water loss 10% in 5 (to less than 8%); per capita use to 163 gpd in 5 yr, 161 gpd in 10 yr; Convert 50% athletic fields to artif turf or recycled water in 5 yr, convert 100% within 10 yr
Travis County WCID 20	Travis	sub	medium	156.00	yes	no	-	-
Wells Branch MUD	Travis	sub	large	77.62	no	no	-	-
Windermere Utility Co. Inc.	Travis	sub/urban	large	94.12	no	no	-	-
Creedmoor Maha WSC	Travis, Bastrop	sub/rural	medium	90.61	no	no	-	-
Andice Water Supply	Williamson	general	small	147.50	no	no	-	-
Blessing Mobile Home Park	Williamson	sub	small	136.50	no	no	-	-
Block House MUD	Williamson	sub	medium	65.43	yes	yes (little information)	unknown	Reduce ave daily water use & loss 5% by 2015; per capita water use 0.5% per year thru 2015 which = 2.5% use reduction by 2010 & another 2.5% by 2015; limit unaccounted for water less than 10%
Brushy Creek MUD	Williamson	sub	large	136.50	yes	yes	-	-
Cedar Park, City of	Williamson	sub	large	136.50	yes	yes	unknown	Reduce per capita use by 5% 2015
Florence, City of	Williamson	sub/rural	small	147.50	no	no	-	-
Georgetown, City of	Williamson	sub/urban	large	160.00	yes	yes	488,777,150 gal yr	reduce water loss to 18% in 2010 and 15% in 2015, per capita usage by 1% per year resulting in rolling five-year per capita usage goals of 155 gcd in 2010 and 147 gcd in 2015.

Table 26 Continued: Availability of provider drought contingency/conservation plans; Website; Estimates of conservation savings and goals

Provider	County	Area Type	Provider Size	GPCD	Drought, Conservation plan readily available	Website/ Information available	Estimate of current water savings	Conservation Goals
Granger, City of	Williamson	sub/rural	small	147.50	no	no	-	-
Hutto, City of	Williamson	sub	small	88.04	yes	yes	-	-
Leander, City of	Williamson	sub	large	229.22	yes	yes (little information)	unknown	-
Noack WSC	Williamson	rural	small	149.50	no	no	-	-
North Austin MUD #1	Williamson, Travis	sub/urban	medium	113.50	no	yes	unknown	-
Round Rock, City of	Williamson	urban	large	97.00	yes	yes	unknown	no specific goals, overall use reduction
Taylor, City of	Williamson	rural	medium	126.93	no	no	-	-
Thrall, City of	Williamson	rural	small	149.50	no	no	-	-
West Cypress Hills WCID #1	Williamson	not developed	small	147.50	no	no	-	-
Williamson County MUD 9	Williamson	urban/sub	medium	150.88	no	no	-	-

Plumbing Fixture Replacement/Retrofit/Rebate Programs

Indoor water consumption in single family homes consists primarily of water use for plumbing fixtures such as toilets (26.7%), faucets (15.7%), shower heads (16.8%) and also for clothes washer use (21.7%), typically averaging about 69.3 gallons per person per day. Installation of efficient, water-conserving fixtures and appliances, combined with in-home leak reduction, has been found to reduce per capita consumption by up to 24 GPCD in other arid and semi arid southwestern areas (WRA 2003).

Water providers were asked to report specific information about any retrofit, replacement or rebate programs. The reported information was used to estimate water currently saved by existing programs. As shown in Figure 25, 4 out of 24 respondents reported offering shower/faucet retrofit, rebate or replacement programs; 5 out of 24 offer high efficiency toilet programs and 5 out of 26 offer washing machine rebates. Water use rates of providers with programs in place were compared with those offering no fixture conservation incentives. The savings also were calculated for providers with mandatory or voluntary plumbing and fixture requirements, although the costs were assumed to be zero, and these providers were counted with the respondents reporting no plumbing fixture conservation programs in place.

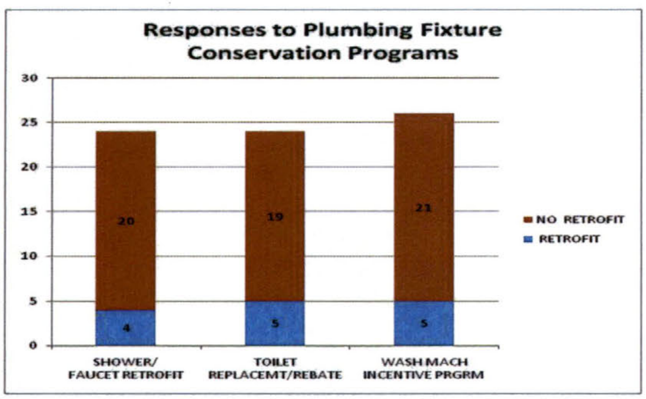

Figure 25: Water providers with plumbing fixture conservation programs

The averaged GPCD water user rates for each program type (shower/faucet, toilet and clothes washer) were lower for water providers with conservation programs in place (Figure 26). Because only 1 conservation measure or program is examined in a suite of measures, the differences in GPCD cannot be attributed solely to water savings from retrofit, rebate and replacement programs. It can be concluded, however, that providers with plumbing fixture programs have lower water use rates, and that those savings are likely compounded by the presence of other conservation programs. Water consumption rates were also examined for water providers with voluntary and mandatory plumbing fixture ordinances (City of Lockhart and City of Georgetown). Lockhart's GPCD water use was much lower than all other plumbing fixture program categories. Without accounting for several other factors, however, including additional conservation measures, leakage rates, provider size and location, it is not possible to draw any meaningful conclusions from this comparison. Georgetown reported a high water use rate, relative to the other water providers responding to this survey question. The city of Georgetown does not offer retrofit, rebate or replacement programs for customers, but does have mandatory requirements for minimum efficiency standards. It is not known what percentage of water customers comply with these regulations and, without knowing water use history, it is not possible to determine if the regulations have reduced GPCD water use, or if the city would benefit from adopting a different type of plumbing conservation program.

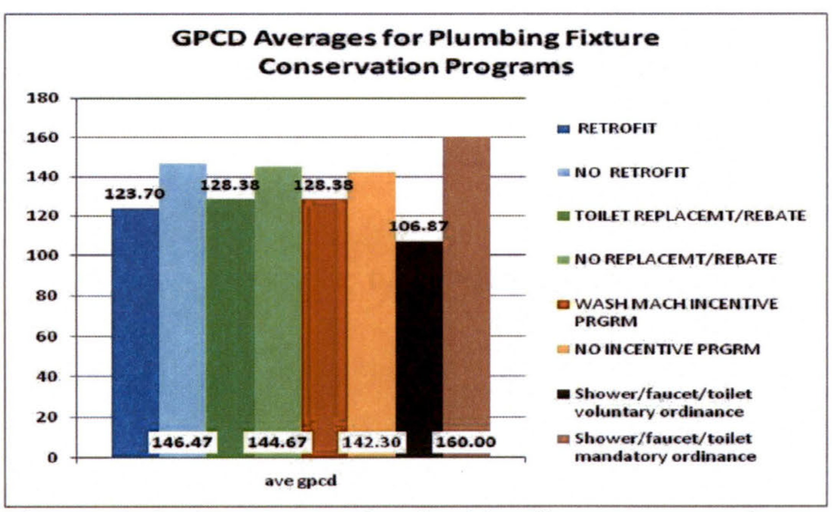

Figure 26: GPCD averages for plumbing fixture conservation programs

Cost and water savings from low flow shower heads and faucet aerators were determined from existing studies, and applied to 50% of each water provider's customers (assuming no growth), as summarized below in Table 27. The annual water savings, not accounting for future rebates or population growth are considerable, ranging from 53.6 million gal/164.5AF (at a per acre-foot cost of $713.67) in Cedar Park to nearly 420 million gal/1289 AF (per acre-foot cost of $921.82) for the City of Austin. The City of Sunset Valley does not have a shower head or faucet replacement/rebate program, but does recommend fixtures to customers that could potentially yield 579,000 gallons in water savings per year (at no cost to the provider, although there are likely some costs associated with providing information). The City of Lockhart has a voluntary ordinance for low flow shower heads and water saving faucet aerators and, if 50% of the households in Lockhart's service area complied, over 16 million gal would be conserved. These values only indicate water savings and amortized costs of 50% of the providers' service population adopting the measure and does not account for any future customer adoption or population growth, which is addressed for selected providers in Table 28. Population growth estimates for the City of Cedar Park were provided by TWDB (2007). An 8% growth rate was assumed for the City of Sunset Valley. Water savings were calculated in 10 year increments, assuming a program adoption rate 50% of the increasing population. Costs were calculated for Cedar Park's program, but because Sunset Valley only encourages and provides information regarding fixtures, no costs were calculated in association with the conservation values, although in all likelihood there are costs connected with promoting efficient fixtures (labor, printing costs, etc).

Table 27: Cost and Water Savings Estimates for Water Providers with Shower/Faucet Retrofit, Rebate Replacement Programs

		Current costs/savings of one shower head per household					Current costs/savings of two faucets per household				
Provider	SHOWER/FAUCET Program	Cost (ave cost $13.63) 50% adoption rate	Total gal savings per day (5.5gpcd)	Annual savings: 100,000 gal, acre-feet	Cost per: 100,000 gal saved AF saved	Cost per yr (12.5 yr @ 5%): 100,000 gal saved, AF saved	Cost (ave cost $1.75) 50% adoption rate	Total gal savings per day (5.5gpcd)	Annual savings: 100,000 gal, acre-feet	Cost per: 100,000 gal saved AF saved	Cost per yr (13.3 yr @ 5%): 100,000 gal saved, AF saved
Austin, City of	Free LF showerheads	$ 1,187,855	1,150,380	4198.89 1288.589 af	$300 $921.82	$32.85 $100.97					
Cedar Park, City of	LF faucet aerators and shower heads at a discounted price (50%)	$ 117,484	146,962	536.41 164.619 af	$219.02 $713.67	$23.98 $78.15	$ 30,168.25	294873.10	1072.83 329.238 af	$28.13 $91.63	$2.95 $9.60
Georgetown, City of	Plumbing codes require efficient fixtures		123,023	449.03 137.80 af				246045.80	898.06 275.61 af		
Lockhart, City of	Voluntary ordinance for LF shower head and faucets		44,918	163.95 50.315 af				89,835.90	327.90 100.629 af		
Lost Creek MUD	Require LF shower head and faucets in new construction and in replacement of plumbing in existing structures		10,983	40.09 12.303 af				21,966.34	80.18 24.605 af		
Round Rock, City of	Free LF faucet aerators and showerheads	$ 197,192	250,649	914.87 280.763 af	$220 $702.34	$24.09 $76.91	$ 50,636.25	501,298.88	1829.74 561.526 af	$30 $90.18	$3.14 $9.45
San Marcos, City of	Free LF faucet aerators and showerheads	$ 57,737	147,243	537.43 164.934 af	$110 $350.06	$12.05 $38.33	$ 14,826.00	294,486.72	1074.88 329.867 af	$10 $44.95	$1.05 $4.75
Sunset Valley, City of	Distribute info and recommend LF showerheads, aerators		1,586	5.79 1.777 af				3,172.62	11.58 3.554 af		

Table 28: Cost and water savings estimates over time for selected providers with shower/faucet retrofit, rebate, replacement programs

	Costs/savings of one shower head per household					Costs/savings of two faucets per household				
Year	Cost (ave cost $13.63) 50% adoption rate	Total gal savings per day (5.5gpcd)	Annual savings: 100,000 gal	Cost per: 100,000 gal saved	Cost per yr (12.5 yr @ 5%): 100,000 gal saved	Cost (ave cost $1.75) 50% adoption rate	Total gal savings per day (5.5gpcd)	Annual savings: 100,000 gal	Cost per: 100,000 gal saved	Cost per yr (13.3 yr @ 5%): 100,000 gal saved
City of Cedar Park										
2010	$ 117,484	146,962	536.41	$ 219.02	$ 23.98	$ 30,168.25	294873.10	1072.83	$28.13	$ 2.95
2020	$ 46,543	58,221	212.51	$ 219.02	$ 23.98	$ 11,951.61	116442.78	425.02	$ 28.12	$ 2.95
2030	$ 65,203	81,563	297.71	$ 219.02	$ 23.98	$ 16,743.17	163126.29	595.41	$ 28.12	$ 2.95
2040	$ 56,891	71,166	259.76	$ 219.02	$ 23.98	$ 14,608.84	142331.86	519.51	$ 28.12	$ 2.95
2050	$ 57,033	71,344	260.41	$ 219.02	$ 23.98	$ 14,645.42	142688.22	520.81	$ 28.12	$ 2.95
2060	$ 74,860	93,643	341.80	$ 219.02	$ 23.98	$ 19,222.99	187286.85	683.60	$ 28.12	$ 2.95
	50 year water savings:		1,908.58			50 year water savings:		3817.18		
City of Sunset Valley										
2010		1,586	5.79				3,173	11.58		
2020		1,192	4.35				798	2.91		
2030		498	1.82				996	3.63		
2040		622	2.27				1,243	4.54		
2050		776	2.83				1,551	5.66		
2060		968	3.53				1,936	7.07		
	50 year water savings:		20.59 x 100,000 gal			50 year water savings:		35.39 x 100,000 gal		

Initial costs and water savings were estimated for toilet rebate programs, as summarized in Table 29. At 50% utilization or adoption rate of the current population (not accounting for any future adoption or toilet replacement), significant water savings can be achieved at an average cost of $1400 per 100,000 gallons. The potential water savings for the City of Lockhart's voluntary low flow toilet ordinance and the City of Georgetown's mandatory toilet efficiency standards were also calculated (at a 50% compliance rate), indicating significant annual conservation results (29.5 million gal and 80.9 million gal). Estimated conservation savings and costs with population growth are calculated for selected providers in

Table 30. Population growth estimates were obtained from TWDB (2007); water savings/costs were calculated in 10 year increments for the City of Round Rock and potential water savings of City Of Lockhart's water efficient toilet requirements were calculated. Although none were reported, including costs associated with advertising and enforcing requirements would provide a more realistic evaluation.

Table 29: Cost and water savings estimates for water providers with toilet retrofit, rebate, replacement programs

		Current costs/savings of one toilet per household ** costs include cost of toilet rebate only				
Provider	**TOILET REPLACEMENT, REBATE**	**Cost at 50% adoption rate**	**Total gal savings per day (9.91gpcd)**	**Annual savings 100,000 gallons, acre-feet**	**Cost per: 100,000 gal saved, AF saved**	**Cost per yr (25 yr @ 5%): 100,000 gal saved, AF saved**
Austin, City of	ULF toilet **$50 - $200** rebate (average of **$93.75**)	$8,663,578.13	2,197,915.12	8022.39 2,461.98 af	$1,100 $3518.95	$78.05 $249.68
Georgetown, City of	Plumbing codes require efficient fixtures	$ -	221,664.90	809.07 248.30 af	$ -	$ -
Lockhart, City of	Voluntary ordinance for ULF toilets	$ -	80,933.98	295.40 90.658 af	$ -	$ -
Lost Creek MUD	ULF toilet **$50 - $200** rebate (average of **$93.75**)	$ 58,687.50	19,589.98	71.501 21.94 af	$800 $2,674.91	$56.76 $189.8
Round Rock, City of	ULF toilet **$75** rebate	$1,085,062.50	451,624.71	1648.43 505.884 af	$660 $2,144.88	$46.83 $152.19
San Marcos, City of	ULF toilet **$100** rebate	$ 423,600.00	265,305.76	988.37 297.180 af	$440 $1425.40	$31.22 $101.14
Sunset Valley, City of	ULF toilet rebates up to **$325**	$ 44,850.00	2,858.24	10.43 3.202 af	$4,000 $14,006.87	$283.81 $993.83

Table 30: Cost and water savings estimates over time for selected providers with toilet retrofit, rebate, replacement programs

Current costs/savings of one toilet per household ** costs include cost of toilet rebate only					
Year	Cost at 50% adoption rate	Total gal savings per day (9.91gpcd)	Annual savings 100,000 gallons	Cost per: 100,000 gal saved	Cost per yr (25 yr @ 5%): 100,000 gal saved
City of Lockhart					
2010		80,933.98	295.41		
2020		23,532.29	85.89		
2030		19,958.74	72.85		
2040		20,033.07	73.12		
2050		20,127.21	73.46		
2060		19,483.06	71.11		
50 year water savings:		184,068.34	x 100,000 gal		
City of Round Rock					
2010	$ 1,085,062.50	451,624.71	1648.43	$ 658	$ 46.69
2020	$ 911,516.25	379,391.29	1384.78	$ 658	$ 46.69
2030	$ 466,071.43	193,988.25	708.06	$ 658	$ 46.69
2040	$ 501,821.43	208,868.12	762.37	$ 658	$ 46.69
2050	$ 545,738.10	227,147.11	829.09	$ 658	$ 46.69
2060	$ 585,011.90	243,493.66	888.75	$ 658	$ 46.69
50 year water savings:		1,704,513.14	x 100,000 gal		

An estimated annual water savings of 144,544,837 gallons (443.6 AF) is potentially realized from the 5 reported washing machine rebate programs (again assuming no future adoption of washing machine rebates), with calculated savings ranging from 703,225 gal to 540.76 million gal per year), and rebates ranging from $50 to $600, with an average annual cost of $2072 per 100,000 gallons and a lowest estimated annual cost of $490 per 100,000 gallons saved for the City of San Marcos (Table 31). Costs and savings over time, accounting for population growth are estimated for selected providers in Table 32. TWDB (2007) population growth estimates were used to calculate water conservation savings and costs for the Cities of San Marcos and Austin. The values provided for the City of Austin were reduced by 30% to account for other provider coverage in the city.

Table 31: Cost and water savings estimates for water providers with washing machine rebate programs

Provider	WASH MACHINE INCENTIVE PROGRAM	Total Cost at 50% adoption rate	Total gal savings per day (6.68 gpcd)	Annual savings 100,000 gallons, acre-feet	Cost per: 100,000 gal saved, AF saved	Cost per yr (13.5 yr @ 5%): 100,000 gal saved, AF saved
Austin, City of	$100 rebate ($150 rebate with $50 paid via energy dept)	$9,241,150.00	1,481,541.17	5407.63 1,659.54 af	$1700 $5568.50	$176.18 $577.10
Lost Creek MUD	$100 rebate city of austin high efficiency washer rebate program	$ 62,600.00	13,339.56	48.69 14.94 af	$1300 $4,190.09	$134.73 $434.24
Round Rock, City of	rebate of $50 - $100 for high effic washer (ave of $75)	$1,085,062.50	304,425.14	1111.15 341.00 af	$980 $3,182.00	$101.56 $329.77
San Marcos, City of	rebate of $50 - $100 for high effic washer (ave of $75)	$ 317,700.00	178,833.75	652.74 200.32 af	$490 $1585.96	$50.78 $164.36
Sunset Valley	rebates up to $600 (ave of $300)	$ 41,400.00	1,926.65	7.03 2.16 af	$5890 $19,166.67	$610.41 $1986.28

Table 32: Cost and water savings estimates over time for selected providers with washing machine rebate programs

Provider	Total Cost at 50% adoption rate	Total gal savings per day (6.68 gpcd)	Annual savings 100,000 gallons	Cost per: 100,000 gal saved	Cost per yr (13.5 yr @ 5%): 100,000 gal saved
		City of Austin			
2010	$ 9,241,150.00	1,481,541.17	5407.63	$ 1,708.91	$176.18
2020	$ 2,596,050.00	416,198.74	1519.13	$ 1,708.91	$176.18
2030	$ 2,062,770.83	330,703.42	1207.07	$ 1,708.91	$176.18
2040	$ 1,832,291.67	293,753.00	1072.20	$ 1,708.91	$176.18
2050	$ 1,890,354.17	303,061.58	1106.17	$ 1,708.91	$176.18
2060	$ 1,730,833.33	277,487.20	1012.83	$ 1,708.91	$176.18
50 year water savings:		**3,102,745.10**	**x 100,000 gal**		
		City of San Marcos			
2010	$ 317,700.00	178,833.75	652.74	$ 486.72	$ 50.78
2020	$ 97,090.35	$ 55,634.06	203.06	$ 478.13	$ 50.78
2030	$ 125,102.85	$ 71,685.60	261.65	$ 478.13	$ 50.78
2040	$ 139,361.16	$ 79,855.80	291.47	$ 478.13	$ 50.78
2050	$ 148,273.34	$ 84,962.60	310.11	$ 478.13	$ 50.78
2060	$ 110,559.73	$ 63,352.20	231.24	$ 478.13	$ 50.78
50 year water savings:		**534,324.02**	**x 100,000 gal**		

Combined program costs and potential water and monetary savings are summarized below in Tables 33 and 34. For the City of Austin's initial (one year) $19.2 million expenditure, an estimated 5,488 acre-feet of water will be saved annually over the life span of installed conservation plumbing fixtures, while the City of Cedar Park's more modest program cost of $147,652 will yield nearly 494 acre-feet per year for up to 12.5 years, with additional (slightly lower) water savings realized for another 12.5 years.

Table 33: Initial cost estimates for water providers with fixture conservation programs

Provider	Shower Head Cost (ave cost $13.63)	Faucet Aerator Cost (ave cost $1.75)	Toilet Rebate Cost	Washing Machine Rebate Cost	TOTAL PROGRAM COST
Austin, City of	$ 1,187,854.50	$ -	$ 8,663,578.13	$ 9,241,150.00	$ 19,092,582.63
Cedar Park, City of	$ 117,483.79	$ 30,168.25	$ -	$ -	$ 147,652.04
Lost Creek MUD	$ -	$ -	$ 58,687.50	$ 62,600.00	$ 121,287.50
Round Rock, City of	$ 197,192.03	$ 50,636.25	$ 1,085,062.50	$ 1,085,062.50	$ 2,417,953.28
San Marcos, City of	$ 57,736.68	$ 14,826.00	$ 423,600.00	$ 317,700.00	$ 813,862.68
Sunset Valley, City of	$ -	$ -	$ 44,850.00	$ 41,400.00	$ 86,250.00

Table 34: Annual water savings estimates for water providers with fixture conservation programs (assuming no growth)

Provider	Shower Head Annual savings 100,000 gal, acre-feet	Faucet Aerator Annual savings 100,000 gallons, acre-feet	Toilet Rebate Annual savings 100,000 gallons, acre-feet	Washing Machine Rebate Annual savings 100,000 gallons, acre-feet	TOTAL ANNUAL PROGRAM WATER SAVINGS	
					100,000 Gallons	Acre-Feet
Austin, City of	4198.89 1288.589 af	X	8022.40 2,461.98 af	5407.63 1,659.54 af	17,628.93	5,410.11
Cedar Park, City of	536.41 164.619 af	1072.83 329.238 af	X	X	1,609.24	493.86
Georgetown, City of	449.03 137.80 af	898.07 275.61 af	809.10 248.30 af	X	2,156.20	661.71
Lockhart, City of	163.95 50.315 af	327.90 100.629 af	295.40 90.658 af	X	787.25	241.60
Lost Creek MUD	40.09 12.303 af	80.18 24.605 af	71.50 21.94 af	48.69 14.94 af	240.46	73.79
Round Rock, City of	914.87 280.763 af	1829.74 561.526 af	1648.43 505.884 af	X	2,563.30	786.65
San Marcos, City of	537.43 164.934 af	1074.88 329.867 af	988.37 297.180 af	652.74 200.32 af	3,253.42	992.30
Sunset Valley, City of	5.79 1.777 af	11.58 3.554 af	10.43 3.202 af	7.03 2.16 af	34.83	10.69

Landscape Irrigation Conservation Incentives, Ordinances and Water-Wise Landscape Design and Conversion Programs

In addition to drought and watering restrictions, 27 providers reported some form of landscaping program in place (Table 35). Most practices were voluntary and encouraged, but not required. The majority of providers with some form of landscaping conservation program were categorized as large (7), while only 1 small and 1 medium provider reported any recommendations or requirements. All 27 providers fell into either a suburban or urban service area type, although no apparent trend was determined when examining per capita customer water use. Respondents with no landscape programs or ordinances in place (125.88) had lower per capita water use rates than providers with ordinances (134.50), new construction requirements (168.01) and audit programs (136.38). Several water providers reported GPCD rates higher than their corresponding county or planning group averages. Eighteen respondents did not recommend nor require any landscaping conservation practices, nor provide any irrigation audits. There was very little overlap or repetition in the reported landscape and irrigation practices among survey respondents.

Much indoor water consumption is for basic necessities, and can only be reduced to a certain level, while the majority of outdoor water use is discretionary. In fact, although indoor water conservation can achieve modest water savings, outdoor conservation and conversion programs have been shown to significantly reduce water consumption (WRA 2003; WSCASA 2003). It was surprising, therefore, that none of the survey respondents reported utilizing any landscape conversion rebate or incentive programs. The potential savings and costs of implementing traditional turf grass conversion programs are discussed in a following section.

Table 35: Survey respondents with landscape conservation programs

Provider	Provider type	City	County	Area Type	Provider Size	Conservation Meas LANDSCAPE/IRRIGATION INCENT/ORDINANCES
Aqua Water Supply Corporation	IOU	Bastrop +950-square mile area	Bastrop and others	sub/rural	large	Landscape irrigation practices provided and encouraged
Austin, City of	CITY	Austin	Travis	urban	large	* Irrigation equipment upgrades (rebate program) * Irrigation audit: customers w/ underground sprinkler system using more than 25,000 gallons per month in the summer qualify for an irrigation audit. A City water auditor will check system and determine an efficient watering schedule. Many customers have reduced their summer water bills by 20 to 50 percent. * Self irrigation audit package
Cedar Park, City of	CITY	Cedar Park	Williamson	sub	large	Landscape and tree regulations (chapter 15 of the Code of Ordinances)
Georgetown, City of	CITY	Georgetown	Williamson	sub/ urban	large	*Encourage subdivisions to require drought-resistant grasses and low water use plants. *Encourage landscape architects to use native, low water use plants and grasses and efficient irrigation systems. *Encourage licensed irrigation contractors to use drip irrigation systems, when possible, and to design all irrigation systems with conservation features such as sprinklers that emit large drops rather than a fine mist and a sprinkler layout that accommodates prevailing wind patterns. *Encourage local nurseries to offer native, low water use plants and grasses and efficient watering devices
Lakeway MUD	MUD - private	Lakeway	Travis	urban/ sub	large	* Xeriscape demonstration site * Provide customer literature *Landscape irrigation systems encouraged to include: Rain &/or moisture sensors, Backflow prevention device, Pressure reducing valve &/or remote control valves, Pressure reducing valve installed in-line at the meter and serving house as well as irrigation system. Zoning of irrigation system based on plant water requirements. Multiple cycle controllers with irrigation water budget feature. Subsurface drip irrigation encouraged but not required. * Irrigated and newly planted turf areas should have a min soil depth of 4 to 6 in. Import soil if needed to achieve sufficient soil depth. Improved soil will be a mix of no less than 20% compost blended with sand & loam. * Maintain a minimum of 2 in of mulch in all shrub & bed areas. * Builders are encouraged to give homeowners a conservation landscape option using only native or adapted plants.
Lost Creek MUD	MUD - GOV	Austin	Travis	sub	medium	* Irrigation audits and Irrigation equipment upgrades (City of Austin rebate program). *The following methods are encouraged: • The use of low water consuming plants and grasses for landscaping • The use of drip irrigation systems when possible or other water conserving irrigation systems that utilize efficient sprinklers • The use of ornamental fountains that recycle water and use a minimum amount of water.
Round Rock, City of	CITY	Round Rock	Williamson	urban	large	* Requires all automatic irrigation systems have a rain or soil-moisture shutoff device to interrupt watering during and after rain events * Rebate of up to $75 for installing a rain or soil-moisture shutoff device on "existing" irrigation systems
Sunset Valley, City of	CITY	Sunset Valley	Travis	urban	small	* Distribute info on best watering practices, equipment, irrigation systems, xeriscaping, drought resistant/low water grasses, implementation of on site waste water reuse systems
Travis County WCID 17	WCID	(Lakeway, Beecaves, Steiner	Travis	urban	large	* Recommend water wise landscaping * Work with local school districts to use artificial turf or reuse water

Rainwater Harvesting

Because of the small number of respondents, a more in-depth analysis of the rainwater harvesting programs of individual water providers was performed. The Cities of Austin and Sunset Valley offer rebates ($500 and $2000 respectively) for rain collection systems with a minimum storage capacity of 1,000 gallons. Lakeway MUD encourages customers to install collection systems via its public education program, but does not offer rebates. All three providers are assumed to have customer participation or utilization rates of 10%, although it is unlikely that new installation of large collection systems will continue with recurring drought conditions. In addition, it is likely that providers offering rebates will have higher adoption rates and higher conserved water totals. Because of the low water provider response rate, it is difficult to use GPCD water consumption rates as any kind of indicator. The three survey respondents with large rainwater collection system programs have an averaged GPCD slightly higher than the average water use for respondents without similar programs, 141.8 and 140.16 GPCD, respectively (Table 36). However, the three water providers do have customer bases in suburban and urban areas, and each have a higher proportion of high water use customers than the respondents with no programs in place. The City of Austin also offers discounted 75 gallon rain barrels to customers, as does Lost Creek MUD and the City of Round Rock (Table 37). The City of Sunset Valley and Lakeway MUD encourage rain barrel use in their public education programs. Their combined GPCD rate of 123.25 is lower than the average water usage rates for the survey respondents without rain barrel discounts (140.16).

During normal rain conditions, annual water savings from large collection systems ranged from 1.37 million gallons for the City of Austin (at an annual cost of $52.99 over 25 years) to nearly 218,000 gallons in Sunset Valley (costing $240.86 per year over 25 years), as summarized in Table 36. These calculations assume 10% of the single family resident (SFR) customers in 2010 purchased collection systems and does not account for any future population increase or collection system adoption. Estimates including population growth are shown in Table 38. The lifetime rain barrel savings for 50% of the 2010 SFR customers exceed 1 billion gallons for the City of Austin (1,097,436,000 gal per year), at a cost of $35 per barrel. The city charges $65.00 to recoup a portion of the rain barrel cost ($100), resulting in an estimated cost of $3.37 per year over the estimated 15 year lifespan of the rain barrel (total cost of $0.01 per acre-foot saved). Lost Creek MUD's rain barrel discount is identical to Austin's, and potentially realizes 7.8 million gallons over the life span of the purchased rain barrels (assuming 50% of the 2010 SFR customers obtain barrels), costing $3.37 per year (total cost of $1.45 per acre-foot saved). Round Rock offers a deeper discount on rain barrels, increasing overall costs ($7.23 per year), but still achieving 165.7 million gallons in water savings over the lifetime of the barrels (total cost of $0.15 per acre-foot saved). Additional savings over a fifty year period, accounting for customer growth are shown for selected providers are shown in Table 41. The results in Tables 37 and 38, indicate that rainwater collection systems and rain barrels can yield excellent water savings at a very low cost under normal precipitation conditions.

Table 36: Rainwater collection systems water savings and cost estimates

Provider	Collection System	total gal savings per day (21.6 gpd) at 10% adoption rate	Annual savings 100,00 gal	Annual savings AF	Lifetime water savings 100,00 gal	Lifetime water savings AF	Indirect Cost	Direct Cost	Cost per 100,000 gal saved	Cost per AF saved	Cost pr yr (over 15 yr) @ 5%
Austin, City of	rebate up to $500	376,488.00	1,374.18	421.72	20,612.72	6,325.80	$ 50.00	$ 500.00	$ 0.0267	$ 0.087	$ 52.99
Lakeway MUD	Encourage use	8,728.00	31.86	9.78	477.86	146.70	$ 50.00	$ -	$ 0.1046	$ 0.341	$ 4.82
Sunset Valley, City of	rebate up to $2,000	596.16	2.18	0.67	32.64	10.05	$ 50.00	$ 2,000.00	$ 62.8068	$ 203.980	$ 240.86

Table 37: Rain barrel water savings and cost estimates

Provider	Rain Barrel	total gal savings per day (2.3 gpd) at 50% adoption rate	Annual savings 100,000 gal	Annual savings AF	Lifetime water savings 100,000 gal	Lifetime water savings AF	Indirect Cost	Direct Cost	Cost per 100,000 gal saved	Cost per AF saved	Cost pr yr (over 15 yr) @ 5%
Austin, City of	discounted rate ($65 price/$90 cost)	200,445.00	731.62	224.53	10,974.36	3,367.90	$ 10.00	$ 25.00	$ 0.0032	$ 0.01	$ 3.37
Lakeway MUD	Encourage use	12,546.50	45.79	5.21	686.92	78.08	$ 10.00	$ -	$ 0.0393	$ 0.13	$ 0.96
Lost Creek MUD	discounted rate ($65 price/$90 cost)	1,439.80	5.26	1.61	78.83	24.19	$ 10.00	$ 25.00	$ 0.4440	$ 1.45	$ 3.37
Round Rock, City of	discounted rate ($25 price/assumed $90 cost)	30,269.15	110.48	33.91	1,657.24	508.59	$ 10.00	$ 65.00	$ 0.0453	$ 0.15	$ 7.23
Sunset Valley, City of	Encourage use	317.40	1.16	0.36	17.38	5.33	$ 10.00	$ -	$ 0.5755	$ 1.88	$ 0.96

Table 38: Cost and water savings estimates over time for selected providers with rainwater collection and rain barrels programs

Collection Systems	total gal savings per day (21.6 gpd) at 10% adoption rate	Annual savings 100,00 gal	Lifetime water savings 100,00 gal	Cost (Indirect +Direct)	Cost per 100,000 gal saved	Cost pr yr (over 15 yr) @ 5%
Lakeway MUD						
2010	8,728.00	31.86	477.86	$ 50.00	$ 0.10	$ 4.82
2020	2,887.20	10.54	158.07	$ 50.00	$ 0.32	$ 4.82
2030	2,756.80	10.06	150.93	$ 50.00	$ 0.33	$ 4.82
2040	1,721.60	6.28	94.26	$ 50.00	$ 0.53	$ 4.82
2050	1,821.60	6.65	99.73	$ 50.00	$ 0.50	$ 4.82
2060	1,875.20	6.84	102.67	$ 50.00	$ 0.49	$ 4.82
Rain Barrels	**total gal savings per day (2.3 gpd) at 50% adoption rate**	**Annual savings 100,000 gal**	**Lifetime water savings 100,000 gal**	**Cost (Indirect +Direct)**	**Cost per 100,000 gal saved**	**Cost pr yr (over 15 yr) @ 5%**
City of Round Rock						
2010	30,269.15	110.48	1,657.24	75.00	0.05	$ 7.23
2020	9,186.19	33.53	502.94	75.00	0.15	$ 7.23
2030	12,646.77	46.16	692.41	75.00	0.11	$ 7.23
2040	13,616.84	49.70	745.52	75.00	0.10	$ 7.23
2050	14,808.51	54.05	810.77	75.00	0.09	$ 7.23
2060	15,874.20	57.94	869.11	75.00	0.09	$ 7.23

Public Information programs and information distributed

Information was collected from water providers regarding public education programs, including specific components and number of employees. Twenty-seven respondents provided information, with 20 reporting no program in place (Figure 27). Of these 20 respondents, 1 encourages local media coverage of water conservation issues, and also has literature and other information available to customers, 1 maintains a website and has information available to customers, and 1 posts signs and distributes newsletters in their service neighborhood. The remaining 17 water providers do not offer any information to their customers.

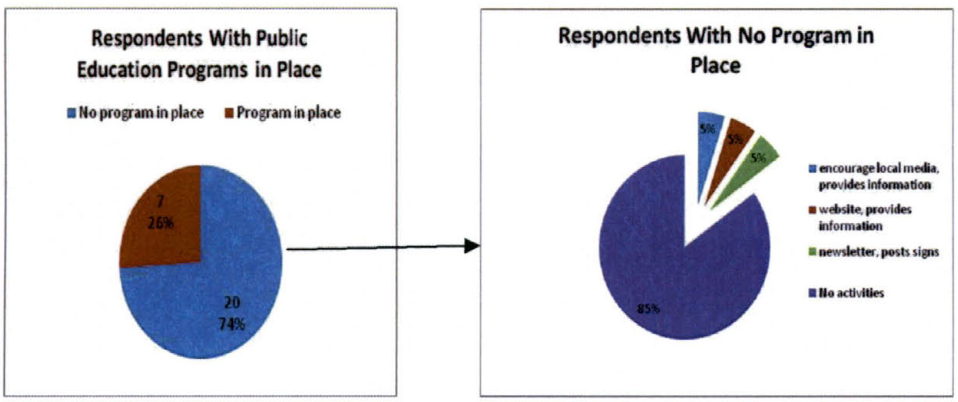

Figure 27: Survey respondents with public education programs in place

The 7 respondents with public education conservation programs in place were rated for aggressiveness, based on number of components, quantity and type of available information, and proportion of customers/community reached. Per capita water use for programs categorized as highly aggressive averaged 112.3 GPCD, water providers with a medium program rating averaged 123 GPCD, and those with a low program rating averaged 137.5 (Figure 28). Water providers with no public education programs in place averaged 140.72.

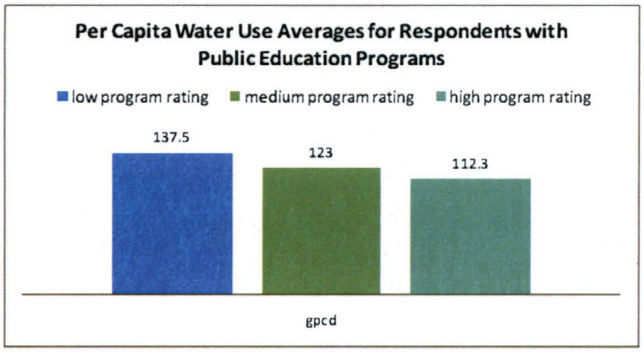

Figure 28: Per capita water use averages for water providers with public education programs

Survey respondents were also compared on the basis of their distribution of information and conservation-related materials, regardless of their public education programs (Figure 29). Most of the 21 providers who reported distributing information send newsletters and bill inserts about conservation issues, watering restrictions and other water-related issues, reported an average 121.57 gallons per capita per day water usage. Other forms of disseminating information include e-mail/e-newsletters, newspaper ads and articles, brochures, pamphlets, new home owner packets and watering schedule calendars. Seven respondents do not distribute information, and have a higher average GPCD of 132.69.

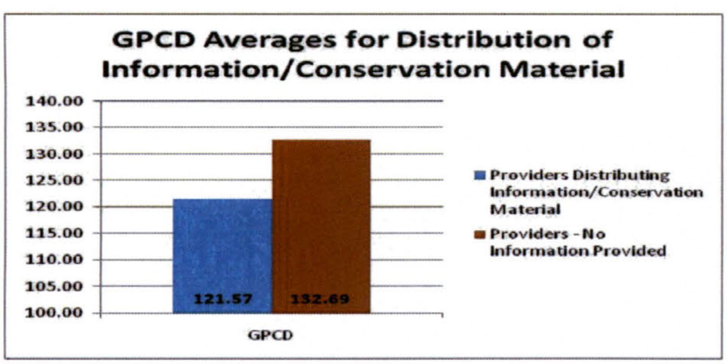

Figure 29: Water consumption averages for providers with and without distribution of conservation information

Employment of Conservation Coordinator

Survey respondents also were asked if they employed a conservation coordinator, and in what capacity (full time, part time, position incorporated in another position, how many employed). Twenty providers do not employ a conservation coordinator in any capacity, and averaged 123.82 GPCD water use. Three providers reported employing a part-time coordinator, or allocating another staff member half time, with an average GPCD of 147.54, while 6 providers reported at least 1 full-time coordinator on their staff, and an averaged GPCD of 146.61 (Figure 30).

Unlike fixture rebate and public information programs, the presence of a conservation coordinator was not correlated with lower water use rates. Interestingly, water providers with no coordinator had significantly lower per capita water rates, than those with part time or full time positions. It was expected that GPCD would be highest among providers without coordinators, and would decrease as the number of employed coordinators increased. There are several possible reasons for this anomaly. As shown in Figures 31 and 32, water providers devoting funds to employing coordinators tended to be larger, with a primarily suburban or urban customer base (with higher GPCD rates, compared with providers of other sizes and area types). Further, the larger providers may also report water use more accurately than smaller providers. Larger systems also may have more leaks, resulting in increased GPCD rates.

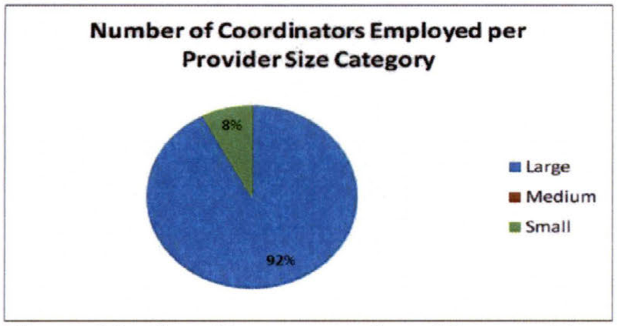

Figure 30: Coordinators employed by provider size category

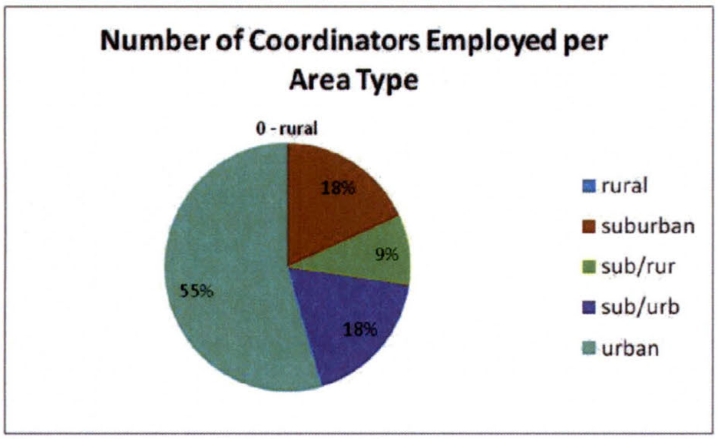

Figure 31: Coordinators employed by water provider area type

Employment of water conservation coordinators also was compared on the basis of the county in which service was provided. As Travis county has the highest urban and suburban population, it is not surprisng the greatest number of coordinators (as reported by survey respondents) are employed in Travis County. Williamson County also has a high proportion of urban and suburban providers, and the next highest employment of coordinators. As shown in Figures 31 and 32, the number of conservation coordnators decreases as the area water provider types becoming increasingly rural (Hays employs 1+ full time coordinator; Bastrop employs 1 part time coordinator; none are employed in Caldwell County). Similar to water provider size, it can be concluded that urban providers with higher water use rates are most likely to have conservation coordinator positions and, because water use histories are not available, it cannot be determined whether or not the presence of a coordinator reduces overall water use. It should be noted, however, that for long-term studies in which multiple water conservation practices were analyzed, the presence of a coordinator was an indicator of the utilization of other water conservation programs, as well as being an accurate predictor of reduced water consumption over time. For the survey respondents in this study, there was a positive correlation between the employment of a conservation coordinator, and the presence of other conservation programs or measures (Figure 33).

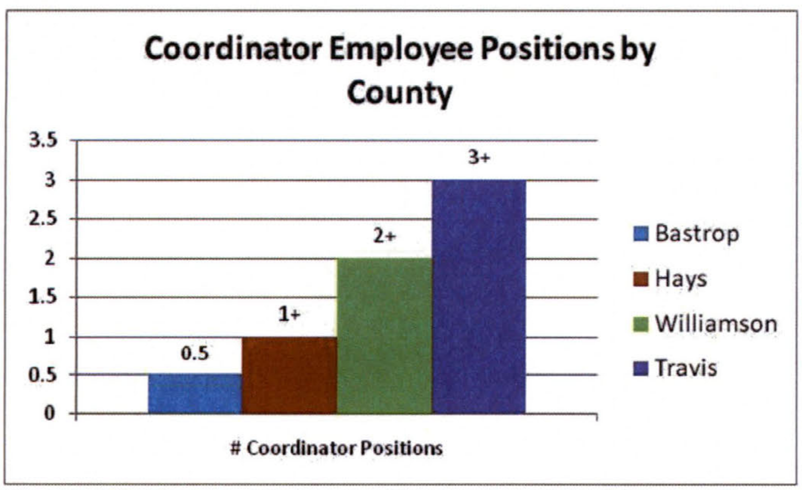

Figure 32: Conservation coordinators employed by county

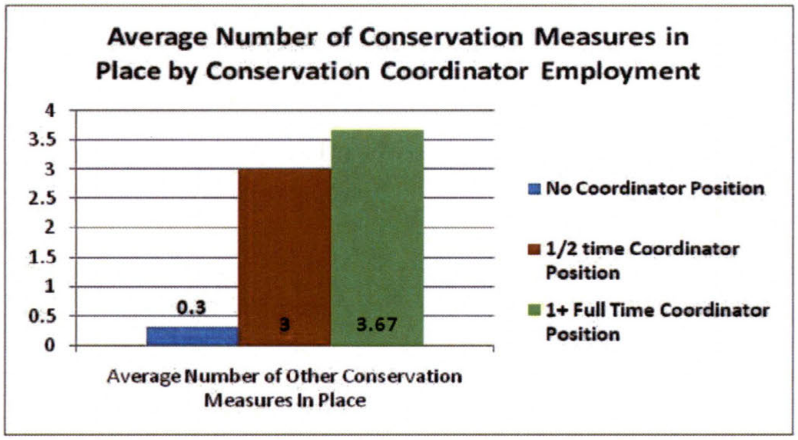

Figure 33: Average number of additional conservation measures for levels of conservation coordinator employment

Water Conservation Pricing

Water pricing formats were collected from 27 providers, with 23 characterized by conservation-oriented pricing, and 4 by flat-rate pricing schemes. Water conservation pricing programs were categorized into low, medium and high levels of aggressiveness, based on the TWDB criteria described in Chapter 2. These criteria include number of pricing tiers, and percentage of price increase between tiers. Eight providers were characterized as having highly-aggressive pricing strategies, 5 providers were classified as having low, or least–aggressive pricing mechanisms, and 10 providers were in the medium level of pricing aggressiveness. However, 3 water providers with medium levels of conservation pricing were removed from the analysis because of extremely low and possibly inaccurately-reported per capita water usage rates. Water providers with no conservation pricing programs in place had the highest water usage rates, with the average per capita usage declining as pricing strategies became more aggressive (Figure 34). Although per capita water usage can only be used as a guideline, it appears the presence of water conservation pricing reduces consumption, therefore acting as an effective water conservation measure, especially since there are few costs associated with implementing pricing changes. The estimated conservation savings of increasing price aggressiveness are discussed in Chapter 4.

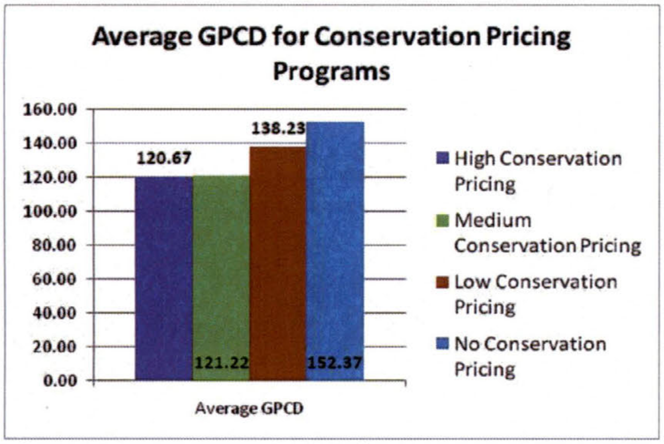

Figure 34: Average GPCD for conservation pricing programs by level of aggressiveness

Water providers with conservation pricing strategies were also analyzed by provider size, area type and county. Among small and medium water providers usage generally decreased with increasing price aggressiveness. Level of water use for larger providers had more variation between pricing categories, i.e. consumption did not decrease consistently with increasingly aggressive pricing strategies (Figure 34). As previously noted, larger providers tend to be located in more urban or suburban areas, with historically higher per capita water use rates. Although large providers' usage rate decreases did not correspond with increasing price aggressiveness, all 3 conservation pricing categories have significantly lower GPCD rates than large providers reporting flat rate pricing systems, as shown in Table 39.

Table 39: Average GPCD for conservation pricing programs by water provider size and program aggressiveness

LARGE Provider	Average GPCD	MEDIUM Provider	Average GPCD	SMALL Provider	Average GPCD
No Conservation Pricing	198.62	No Conservation Pricing	125.00	No Conservation Pricing	164
Low Conservation Pricing	97.00	Low Conservation Pricing	133.75	Low Conservation Pricing	153.47
Medium Conservation Pricing	119.60	Medium Conservation Pricing	85.87	Medium Conservation Pricing	155.71
High Conservation Pricing	145.31	High Conservation Pricing	85.00	High Conservation Pricing	110.40

Suburban water providers fell into low, medium and non-conservation pricing categories, with per capita usage decreasing with increasing price aggressiveness. The average per capita usage rates of suburban/rural respondents decreased between low and medium pricing categories, although respondents with flat rate pricing systems exhibited lower consumption rates than those in the lowest price aggressiveness category. Water providers with an urban customer base reported pricing strategies in both the low and high categories, with usage rates 36% greater for the providers with highly-aggressive rate systems. A low number of responses may have skewed these results, and such factors as length of time pricing strategies have been in effect, and previous usage rates, were not considered. Urban/suburban respondents reported only highly-aggressive and non-conservation pricing programs, with average per capita use rates nearly 25% lower for providers with conservation pricing. Because only 1 rural provider supplied data, it was not included in this comparative analysis, or in Table 40.

Table 40: Average GPCD for conservation pricing programs by area type and pricing aggressiveness

Suburban (pricing level)	average gpcd	Sub/Rural (pricing level)	average gpcd	Sub/Urban (pricing level)	average gpcd	Urban (pricing level)	average gpcd	Urban/Sub (pricing level)	average gpcd
low	143.41	low	163.95	medium	113.53	low	97	high	127.56
medium	109.14	medium	92.95	high	160.00	high	151.2	no conservation pricing	168.01
no conservation pricing	164.00	no conservation pricing	125.00						

The averaged per capita water consumption rates for each available category of conservation and non-conservation pricing programs, as well as overall consumption rates (for all identified providers), are reported by county in Figure 35. Bastrop County's providers, with highly-aggressive pricing strategies, averaged 103.10 GPCD, while water usage rates for providers with mid-range pricing schemes averaged only 79.03. Again, the inclusion of questionable reported usage rates for some providers may have skewed the mid-range pricing GPCD. Data were unavailable for characterizing water providers in the least-aggressive pricing mechanism and non-conservation pricing categories. Overall, the combined GPCD for all identified providers in Bastrop County was significantly higher than the averages for providers reporting conservation pricing programs in place, being 146.41 GPCD (29.6% higher than highly-aggressive providers, and 46% higher than providers with mid- range pricing strategies). Respondents from Caldwell County reported highly-aggressive pricing programs, averaging 85.00 GPCD, mid-range providers averaging 106.87, and no available data for the least-aggressive conservation pricing strategies. Water providers with no conservation pricing in place averaged 125.00 GPCD. Hays County usage rates followed a trend similar to that observed for Bastrop County, with highly-aggressive pricing category GPCD averaging 127.56, 35.61 gallons per person per day higher than the 91.95 GPCD average for the mid-range pricing strategies. Providers categorized as employing the least-aggressive pricing programs averaged 161.22 GPCD, with the overall county average being 150.6. The trend of highly-aggressive providers with higher water usage rates than providers with medium levels of pricing aggressiveness also was observed for Travis and Williamson Counties. Providers reporting highly-aggressive pricing strategies in Travis County averaged 151.20 GPCD, mid-range pricing programs averaged only 127.39, and providers with the least-aggressive conservation pricing averaged 135.86 GPCD. The average water use reported by providers with no conservation pricing programs in place was 166.01 GPCD. For Williamson County, water providers reporting highly-aggressive conservation pricing had the highest average of all the three levels of aggressiveness of 136.50 GPCD, with the mid-range and least-aggressive pricing programs averaging 105.15 and 97.00 GPCD, respectively. Only 1 provider reported flat-rate, non-conservation water pricing, with a GPCD of over 229.0 GPCD, and Williamson County's overall GPCD for all identified providers being 145.07. Each of the average GPCD consumption rates is lower than the overall average use, but do not follow the expected consistent trend of water consumption rates decreasing with increasing price conservation aggressiveness. Most water providers with the highest level of pricing strategies are larger, and have higher proportions of urban and suburban customers. As previously mentioned, larger providers often report water usage more accurately, have a greater potential for water lost to leakage, and have the highest proportion of high quantity water users. It is also possible that GPCD rates are skewed by underreporting of water consumption rates in other pricing aggressiveness categories.

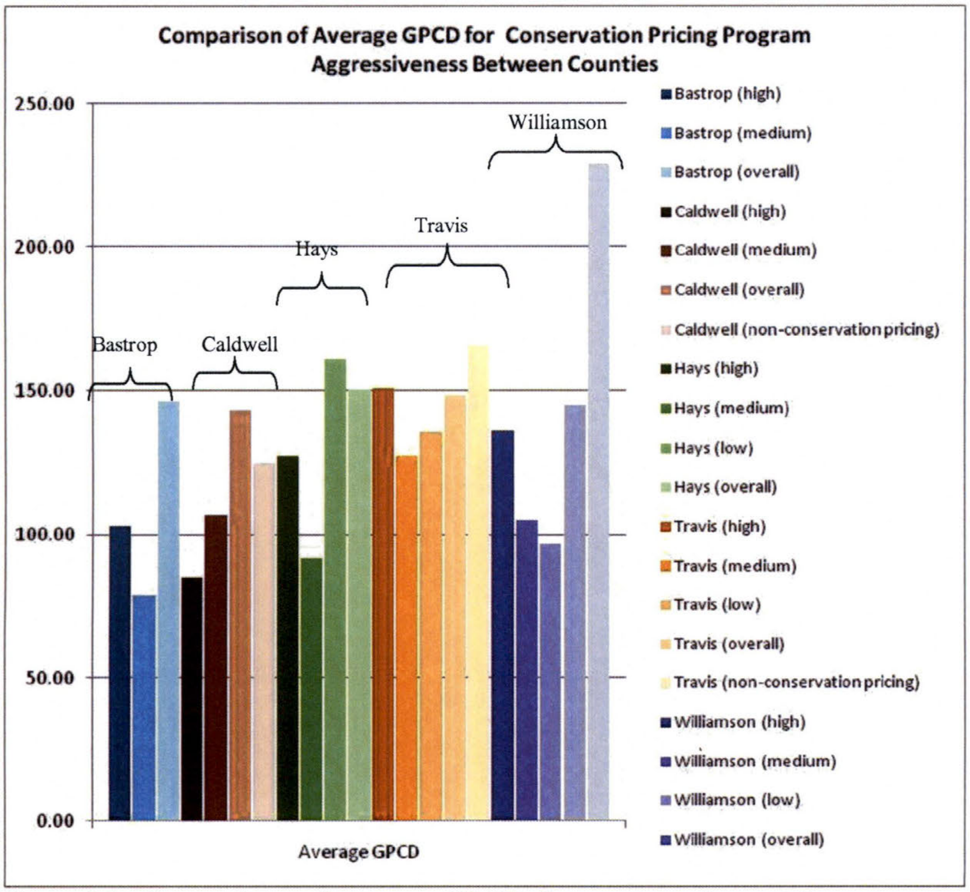

Figure 35: Comparison of average GPCD for conservation pricing programs between counties

System Water Audits and Leak Reduction Programs

Data collected from water providers regarding auditing and leak monitoring programs were categorized by level of aggressiveness, based on the number and frequency of components (Figure 36). With an average per capita water consumption rate of 129.05 GPCD, the leak monitoring and reduction programs of 6 providers were categorized as highly-aggressive, while 3 providers were categorized as low, with an average GPCD of 144.18. Six providers were considered to have a medium level of aggressiveness, although 1 provider was omitted from the median GPCD calculation because of an unrealistic reported customer water consumption rate. The average of the other 5 water providers was 135.22 GPCD. Ten respondents reported some type of program, but gave no specific information. Providers reporting no specific program in place had an average GPCD of 141.75, with 1 outlier removed.

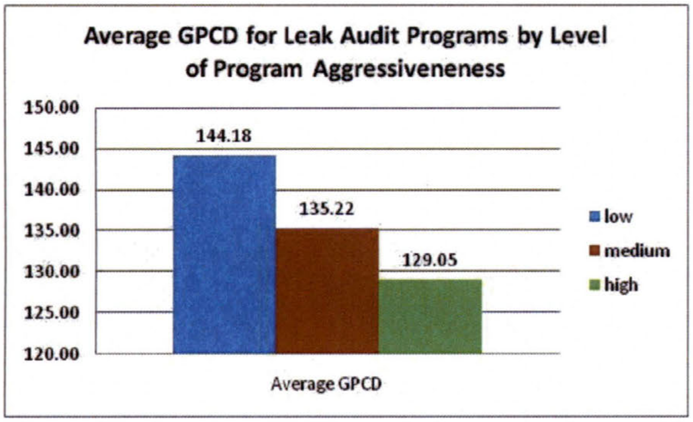

Figure 36: Average GPCD totals for respondents with leak audit programs by program aggressiveness

__**Athletic Field, Golf Course, Park Conservation and Conversion**__

Because it is not categorized as "sold" water, the use of reclaimed, reuse or raw water is typically not considered in water use accounting calculations. However, when reclaimed, reuse and raw water is used in public, municipal and private settings, the quantity of water available for customer use is increased, highlighting its potential as an important and efficient water conservation measure. Table 41 summarizes specific components of respondents' conservation irrigation programs. No respondents reported using Astroturf as a conservation measure, although several noted it was being examined as a possible future measure. Due to time constraints, specific information regarding athletic field, golf course and park conservation was not collected in this study, although the employment of such measures may be used as a proxy for identifying water providers with overall aggressive conservation programs in place. Without knowledge of the number of gallons used, or the total acreage irrigated with potable water substitutes, it is not possible to estimate water conservation savings. Nevertheless, general equations for calculating water savings from xeriscaping, and conversion to synthetic turf, were developed in this study to assist in making future calculations. Water savings and costs of utilizing alternative water sources are not as easy to calculate. Water savings are not typically in the form of actual reductions in water use, but instead can be calculated as increases in the quantities of water made available for customers, as well as the quantity of water that requires less processing or treatment. Calculating costs includes the price of transporting water to the irrigation sites, and in long term planning the amortized costs of the infrastructure and re-use pipelines should also be considered.

Xeriscaping/Landscape Conversion:

Total Annual Water Savings = Average annual irrigation water use (gal/ft^2) - [Total ft^2 converted x (35.96 gal/ft^2)].

Total Annual Cost = {[($1.18 x ft^2 converted) + (Indirect Costs)] / 10 years} + [annual maintenance cost]*

* Annual maintenance costs vary depending on location, type of plants and substrate, but are generally less than maintenance costs for typical turf grass. Water-conserving landscapes require 25% less labor, 39% less fertilizer, 80% less pesticide, and 56% less fuel (Iwata 1994).

Converting Traditional Turf to Synthetic Turf:

Total Annual Water Savings = Average annual irrigation water use (gal/ft^2) - [Total f^{t2} converted x (19.16 gal/ft^2)].

Total Annual Cost = [($4.53 x ft^2 converted) + (Indirect Costs)] / 5 years*
* For heavily-utilized areas, synthetic turf can be expected to last 5 years without maintenance; for lower traffic areas, a life span of 7.5 years without major maintenance or replacement is realistic.

Alternative Irrigation Use*:

Total Annual Water Savings = Average annual irrigation water use (gal) - Total gallons substituted).

Total Realized $ Savings = [Total Annual Water Savings x base rate per gallon water price (average of ICI and residential)] + (Total gallons substituted x per gallon cost for treatment) - Total Annual Cost.

Total Annual Cost = (Infrastructure, transport costs) / lifespan of infrastructure.

*Although these equations are oversimplified, it is important to consider potential alternative uses for irrigation water, as well as the long-term costs of any necessary pipelines, transport devices, etc.

Table 41: Reported athletic field, golf course and park conservation measures

Provider	County	Area Type	Provider Size	Conservation Meas ATHLETIC FIELD/GOLF COURSE/PARK
Austin, City of	Travis	urban	large	Athletic fields and parks have a mandatory year watering schedule of Tuesdays and Fridays. Most golf courses are on reclaimed water or raw water.
Cedar Park, City of	Williamson	sub	large	Reclaimed water program for irrigation; xeriscaping practiced at all parks.
Georgetown, City of	Williamson	sub/ urban	large	Utilizes wastewater effluent to provide water for irrigation. Currently provides effluent from three of its five wastewater treatment plants to six golf courses in the Georgetown area. Effluent irrigation water is also provided to the City's park and school district football field.
Lost Creek MUD	Travis	sub	medium	The District provides 100% of treated effluent to the Lost Creek Country Club for irrigation of its golf course.
Round Rock, City of	Williamson	urban	large	Reuse water irrigating one golf course. Reuse line to be extended to water other parts of town & park, to be finished next year.
Sunset Valley, City of	Travis	urban	small	Restrict or eliminate irrigation in drought.
Travis County WCID 17	Travis	urban	large	UT golf course irrigated w/ Steiner Ranch wastewater; irrigate 200 acres landscaped areas in Steiner Ranch with treated effluent; irrigate Flint Rock Falls golf course with treated effluent in spray and drip irrigation; Supplement irrigation needs w/ raw water from lake Travis

Greywater

Several water providers reported the use of greywater for irrigating public spaces.

Others recommend its use to their commercial customers. Only one provider

(County Line WSC) reported any ordinance requiring greywater use in the City of Uhland (only for new residential construction), so it was not possible to categorize greywater use across water provider characteristics. Greywater savings were estimated for County Line customers in the City of Uhland under two population growth scenarios, as summarized in Table 42-43.

An average of 26 gallons of greywater per capita per day can be produced by new single-family residences containing efficient plumbing fixtures (Green Building Program Sustainable Building Sourcebook 2008). The City of Uhland has historically grown at an annual rate of 13% between 2000 and 2008, with an average household size of 2.9 persons. In Table 41, the city's growth rate is held constant through 2060. The closest cities with available demographic forecasts are Kyle and Lockhart, which are expected to have rapid growth averaging nearly 27% between 2010 and 2020, with continuing growth between 9 and 12% occurring between 2020 and 2060, as shown in Table 43 (TWDB 2007; US Census Bureau 2002). Applying the averaged growth values for Kyle and Lockhart to Uhland yields more than 90,300 gallons per year in municipal water savings by 2060.

Table 42: City of Uhland annual new construction household greywater savings (gal per year) with 13% constant population growth rate

	2008	2010	2020	2030	2040	2050	2060
Population	436	493	557	629	711	803	908
Population, New Construction	109	123	139	157	178	201	227
Household Greywater savings (gal per yr)	8,218.60	9,287.02	10,494.33	11,858.59	13,400.21	15,142.24	17,110.73
Total Greywater savings (gal per yr)	8,218.60	17,505.62	27,999.95	39,858.54	53,258.75	68,400.99	85,511.72

* Assuming that 25% of increased population resides in newly constructed homes.

Table 43: City of Uhland annual new construction household greywater savings (gal per year) with population growth rates equivalent to projected rates for the cities of Lockhart and Kyle (Caldwell and Hays Counties)

	2008	2010	2020	2030	2040	2050	2060
Population	436	493	626	701	764	848	924
Population, New Construction	109	123	156	175	191	212	231
Household Greywater savings (gal per yr)	8,218.60	9,287.02	11,794.51	13,209.85	14,398.74	15,982.60	17,421.04
Total Greywater savings (gal per yr)	8,218.60	17,505.62	29,300.13	42,509.99	56,908.73	72,891.33	90,312.37

* Assuming that 25% of population resides in newly constructed homes.

Although there is little site-specific information for Central Texas, noting the substantial increased population growth rates predicted for central Texas in the coming years, these available data suggest the requirements for using greywater within the context of new residential construction could yield significant water savings, as well as reducing the water delivery requirements of water providers.

CHAPTER FOUR

FUTURE WATER DEMAND PROJECTIONS

Future water demanded for municipal water use in the state of Texas is predicted to increase dramatically over the next 50 years (4.6 million acre-feet, 5.67 km3, or 1.4999 trillion gallons), driven primarily by rapid population growth and ultimately leading to water shortages of 5.9 million acre-feet by 2030, and increasing to 8.8 million acre-feet by 2060 without new securing supplies or adoption of management strategies (TWDB 2006; U.S. Department of Interior 2006; WRA 2003). Municipal water conservation is expected to alleviate approximately 30% of Texas's total water shortages, as suggested in the 2007 State Water Plan (TWDB 2006). While projected demand is calculated based on expected population growth, little specific information is given regarding conservation measures, water use reduction efforts, or related costs. Population projections for regional planning groups G, K, and L and Central Texas counties are expected to grow at least 100% in the next 50 years, as reported in Tables 11 and 12 (Chapter 2) and also below for convenience. Regions G, K and L's estimated future water demands are shown in Table 43 below where Central Texas Counties' contribution to total Regional Planning Group water demand are reported, with Williamson County contributing to both Groups G and K. Hays County also spans two Regional Planning Groups, K and L.

Table 11: Regional population projections for 2000 – 2060 (Source: Texas Water Development Board, 2006)

Region	2000 Census	2010	2020	2030	2040	2050	2060	Increase From 2000 to 2060 (%)
G	1,621,961	1882,896	2,168,682	2,458,075	2,739,717	3,034,798	3,332,100	105
K	1,132,228	1,359,677	1,657,025	1,936,324	2,181,851	2,447,058	2,713,905	140
L	2,042,221	2,460,599	2,892,933	3,292,970	3,644,661	3,984,258	4,297,786	110

Table 12: Regional county population projections for 2000 – 2060 (Source: Texas Water Development Board, 2006)

County	2000 Census	2010	2020	2030	2040	2050	2060	Increase From 2000 - 2060 (%)
Bastrop	57,733	75,386	97,601	123,734	153,392	190,949	237,958	312
Caldwell	32,194	45,958	59,722	71,459	83,250	95,103	106,575	231
Hays	97,589	166,342	242,051	302,795	363,678	436,388	493,320	406
Travis	812,280	969,955	1,185,499	1,385,236	1,550,538	1,722,737	1,888,543	132
William-son	249,967	352,811	476,833	625,189	787,039	963,542	1,153,166	361

Table 44: Projected water demand (in Acre-feet) for TWDB Planning Regions G, K, L and Central Texas counties within planning regions

	Total Projected Water Demand AF					
	2010	2020	2030	2040	2050	2060
Region G	**347,389**	**397,090**	**444,820**	**491,312**	**542,172**	**595,482**
Williamson Co	57,688	78,184	102,651	129,241	158,485	190,243
Co % of planning group	17%	20%	23%	26%	29%	32%
Total % of planning group	**17%**	**20%**	**23%**	**26%**	**29%**	**32%**
Region K	**252,637**	**304,735**	**352,737**	**394,101**	**439,049**	**484,170**
Bastrop Co	11,679	14,762	18,327	22,505	27,818	34,610
Co % of planning group	5%	5%	5%	6%	6%	7%
Hays Co	7,192	10,656	13,446	16,266	19,742	22,498
Co % of planning group	3%	3%	4%	4%	4%	5%
Travis Co	189,602	229,928	266,748	296,675	327,840	357,541
Co % of planning group	75%	75%	76%	75%	75%	74%
Williamson Co	8,841	11,095	13,761	16,625	19,743	23,082
Co % of planning group	3%	4%	4%	4%	4%	5%
Total % of planning group	**86%**	**87%**	**89%**	**89%**	**90%**	**90%**
Region L	**395,996**	**451,111**	**503,375**	**547,136**	**592,343**	**637,235**
Caldwell Co	6,306	7,898	9,222	10,555	11,926	13,328
Co % of planning group	2%	2%	2%	2%	2%	2%
Hays Co	17,278	24,409	29,964	35,414	42,121	47,474
Co % of planning group	4%	5%	6%	6%	7%	7%
Total % of planning group	**6%**	**7%**	**8%**	**8%**	**9%**	**10%**

Implementing conservation practices over the 50 year planning period is projected to yield water savings of 45,218 acre-feet in Region G, although no specific information is given in the Region's planning report. Williamson County's expected contribution to the Region's water conservation savings between 2010 and 2060 is approximately 25%, or 11,078 AF (Table 44).

Although lacking administrative and programmatic costs, a TWDB (2006) model estimates Region K's capital costs of conservation to total $2,903,692, and provide 194, 315 acre-feet of water, not including reuse. Municipal water savings from Central Texas contributing counties Bastrop, Hays, Travis and Williamson are calculated to account for 88.6% of Region K's total water conservation savings, with a mean value of 172,163 AF (Table 44).

The Region L Water Planning Group compiled water management strategies to meet the next 50 years of projected water shortages, including municipal water conservation practices estimated to result in 109,927 acre-feet of water savings, although no cost analysis was performed. Caldwell and a portion of Hays Counties are projected to contribute 8,684 AF, slightly less than 8% of the total municipal water conservation savings (Table 44).

Combined, the three Regional Planning Groups are projected (or requested) to reduce water demand via municipal conservation savings by 349,460 AF. Table 45 shows that the five Central Texas Counties will be responsible for 191,926 AF of water conservation savings, nearly 55% of the total expected Regional Planning Group's savings.

Table 45: Projected municipal water conservation savings for Regional Planning Groups G, K, L and Central Texas counties

Region	Total Projected Savings in AF (2010-2060)	Mean Central TX Portion of Region's Projected Savings in AF (2010-2060)
G	45,218	11,078
K	194,315	172,163
L	109,927	8,684
TOTAL		**191,925**

Several municipal water demand reduction best management practices were examined for potential savings applications for Central Texas water providers, including plumbing fixture, rain barrel, and rain catchment system rebates and watering restrictions. Other measures, including washing machine rebates and xeriscaping incentives can be estimated in the model, but were not calculated in this chapter. Additional savings measures such as conservation pricing, public education programs and leak reduction programs were not explored, but provide significant conservation savings and must not be ignored. Two scenarios were used in this study for estimating conservation saving necessary to meet projected water savings over the fifty year planning horizon. In the first scenario, water conservation savings increased in each ten year period, while the second scenario calculated the total savings necessary to meet projections equally over each decade. Both scenarios are described in the sections below and calculations are presented in Table 46. For the sake of simplicity, a county's percentage of the total water demand for its Planning Group Region is used to estimate the portion of water necessary to conserve. In reality, the water users within that county may have higher or lower GPCD's than water users in other areas of the Regional Planning Group. It would be relevant to do a projection of water savings based on GPCD water use per county as opposed to total water demand, but due to time and funding constraints such an analysis was not performed in this study.

Increasing Water Savings/Demand Reductions (Increasing Percentage of Total Projected Water Savings per 10 Year Period)

In the following section, estimated proportions of water conservation savings for regions G, K, and L (presented in Table 44) were calculated, increasing in each of the five ten year periods: 10% between 2010-2020, 15% during the 2020-2030 period, 20% in 2030-2040, and additional 5% increases in the 2 remaining periods, 25% and 30% in 2040-2050 and 2050-2060. Increasing population was also included in calculations and caused valuations to be slightly greater than the report amounts in Tables 44 and 45 as population increases were estimated per decade time period in this calculation and were averaged over the 50 year period in Tables 44 and 45. The following equation was used to estimate Central Texas Counties' portion of the total water savings:

County(ies) Contribution to Regional Planning Group's Projected Water Savings (in acre-feet) per 10 year period = **[(Regional Group Water Savings Total x % attributed to period) x (% of Projected Total County Water Demand)]**.

For example, when deriving the water conservation savings for Central Texas in 2010-2020 and 2020-2030, with Hays and Caldwell Counties water demand accounting for 6% and 7% of total Regional Planning Group L demand of 109,927 AF (in 2010 and 2020, respectively), the following calculations were used:

2010-2020 Projected Water Savings (in acre-feet) = [(109,927 X 10%) x (6%)] = 660 AF; (Table 49).

2020-2030 Projected Water Savings (in acre-feet) = [(109,927 X 15%) x (7%)] = 1154 AF; (Table 49).

Uniform Water Savings/Demand Reductions (20% of Total Projected Water Savings per 10 Year Period)

For regions G, K, and L the estimated proportion of water conservation savings presented in Table 48) was divided equally among the five decade long periods. However, because increases in population had to be considered, the following equation was used for determining Central Texas Counties' portion of the total water savings:

County(ies) Contribution to Regional Planning Group's Projected Water Savings (in acre-feet) per 10 year period = **[(Regional Group Water Savings Total/5) x (% of Projected Total County Water Demand) + X]**, where X is equal to a small quantity (in acre-feet) that is held constant for each Regional Planning Group and time period. The purpose of X is to account for rounding errors and unequal rates of population growth.

For example, Region G's total estimated savings for the 50 year period was projected to equal 45,218 AF. In 2010, Williamson County accounts for 17% of Region G's water demand. For the 2010-2020 time period, Projected Water Savings (in acre-feet) is calculated as [(45,218/5) x (17%) + 136] = 1,672 AF (Table 45).

Table 46: Central Texas projected water conservation savings scenarios

		Total Projected Savings AF		
		Region G Williamson Co Subtotal	Region K Bastrop, Hays, Travis, Williamson Co Subtotal	Region L Caldwell, Hays Co Subtotal
Increasing Distribution Per 10 yr Period	10% 2010-2020	769	16,711	660
	15% 2020-2030	1,357	25,358	1,154
	20% 2030-2040	2,080	34,588	1,759
	25% 2040-2050	2,939	43,235	2,199
	30% 2050-2060	3,934	52,465	2,968
	Region TOTAL	45,218	194, 315	109,927
	Central TX Total	11,078	172,357	8,739
Uniform Distribution (20%) per 10 yr Period	2010-2020	1,673	33,578	1,385
	2020-2030	1,945	33,967	1,605
	2030-2040	2,216	34,744	1,825
	2040-2050	2,487	34,744	1,825
	2050-2060	2,759	35,133	2,045
	Region TOTAL	45,218	194, 315	109,927
	Central TX Total	11,080	172,166	8,684

Due to the difficulty in calculating conservation savings for water providers in counties encompassed in multiple Region Planning Groups, savings are also presented by county in Table 47 below. Both the uniform and increasing conservation/demand reduction scenarios were used for realizing projected water savings over the 50 year planning horizon. Unlike the Regional Planning Group calculations, the county population growth rates were averaged over the 50 year planning period in order to homogenize or minimize substantial differences between 10 year planning periods. The two scenarios are described in the sections below and calculations are presented in Table 47.

Increasing Water Savings/Demand Reductions (Increasing Percentage of Total Projected Water Savings per 10 Year Period)

The estimated proportion of water conservation savings coupled with average population growth/increasing water demand was calculated for each of the five counties. Calculated water savings rates increased in each of the five ten year periods, beginning with 10% between 2010-2020, 15% during the 2020-2030 period, 20% in 2030-2040, 25% and 30% in 2040-2050 and 2050-2060. The following equation was used to estimate Central Texas Counties' portion of the total water savings:

County Projected Water Savings (in acre-feet) per 10 year period = **[(Regional Group Water Savings Total(s) x (% attributed to period) x (Mean % of Projected County(ies) Water Demand)]**.

For example, with Hays County's water demand is projected to account for an average of 3.5% of Region K's total and average of 5.5% total Regional Planning Group L's demand over the fifty year planning period. Necessary savings of 194,315 and 109,927 AF are projected for Regions K and L, respectively. The following calculations were used to derive water conservation savings for Hays County in 2010-2020 and 2020-2030:

2010-2020 Hays County Projected Water Savings (in acre-feet) = [(194,315 X 10%) x (3.5%)] + [(109,927 X 10%) x (5.5%)] = 1,285 AF; (Table 46).

2020-2030 Hays County Projected Water Savings (in acre-feet) = [(194,315 X 15%) x (3.5%)] + [(109,927 X 15%) x (5.5%)] = 1,927 AF; (Table 46).

Uniform Water Savings/Demand Reductions (20% of Total Projected Water Savings per 10 Year Period)

For each Central Texas County, the estimated proportion of total necessary water conservation savings was divided equally among the five decade long periods. The following equation was used to calculate 20% of total regional savings by county while accounting for population growth:

County Projected Water Savings (in acre-feet) per 10 year period = **[(Regional Group(s) Water Savings Total/5) x (Mean % of Projected County(ies) Water Demand)]**

For example, Williamson County accounts for 17% of Region G's water demand and 4% of Region K's demand. For the 2010-2020 time period, Central Texas Projected Water Savings (in acre-feet) is calculated as [(45,218/5) x (17%)] + [(194,315/5) x (4%)] = 15,460 AF (Table 47).

Table 47: County projected water conservation savings scenarios (Bastrop, Caldwell, Hays, Travis, and Williamson Counties)

		Total Projected Savings AF								
		Bastrop Total	Caldwell Total	Hays Region K Subtotal	Hays Region L Subtotal	Hays Total	Travis Total	Williamson Region G Subtotal	Williamson Region K Subtotal	Williamson Total
Increasing Distribution Per 10 yr Period	10% 2010-2020	680	220	680	605	1,285	15,545	769	777	1,546
	15% 2020-2030	1,020	330	1,020	907	1,927	23,318	1,153	1,166	2,319
	20% 2030-2040	1,360	440	1,360	1,209	2,569	31,090	1,537	1,555	3,092
	25% 2040-2050	1,700	550	1,700	1,511	3,212	38,863	1,922	1,943	3,865
	30% 2050-2060	2,040	660	2,040	1,814	3,854	46,636	2,306	2,332	4,638
	County Total	6,801	2,199	6,801	6,046	12,847	155,452	7,687	7,773	15,460
Uniform Distribution (20%) per 10 yr Period	2010-2020	1,360	440	1,360	1,209	2,569	31,090	1,537	1,555	3,092
	2020-2030	1,360	440	1,360	1,209	2,569	31,090	1,537	1,555	3,092
	2030-2040	1,360	440	1,360	1,209	2,569	31,090	1,537	1,555	3,092
	2040-2050	1,360	440	1,360	1,209	2,569	31,090	1,537	1,555	3,092
	2050-2060	1,360	440	1,360	1,209	2,569	31,090	1,537	1,555	3,092
	County Total	6,801	2,199	6,801	6,046	12,847	155,452	7,687	7,773	15,460

The values for water savings in each county in Table 47 were used to calculate specific conservation savings necessary to meet TWDB projections for selected providers within each county. Necessary water savings for each provider was determined by computing the proportion of a providers' customer base of the total county population and therefore the percentage of total county water conservation savings attributable to the provider (Tables 48-57). Several providers surveyed have customers in multiple counties. However, only the percentage of customers and water demand located in a particular county are assessed within that county, and the results may not be indicative of the entire provider's service population. Such providers are listed in the county in which the majority of their service areas are located. In the next section, calculations of specific water providers include the total service population (regardless of multiple county coverage) and are denoted as such.

Table 48: Projected water conservation savings for selected water providers in Bastrop County (increasing water savings distribution)
* All units in Acre Feet

Bastrop County Municipal Water Providers	Water Use per year 2010-2020	% of Total Co. Water Use	Water Use per year 2020-2030	% of Total Co. Water Use	Water Use per year 2030-2040	% of Total Co. Water Use	Water Use per year 2040-2050	% of Total Co. Water Use	Water Use per year 2050-2060	% of Total Co. Water Use
AQUA WSC	5,424	0.46	6,547	0.44	7,827	0.43	9,377	0.42	11,326	0.41
savings per year (AF)	315.81		452.37		580.82		708.33		830.58	
BASTROP, CITY OF	1,460	0.13	1,755	0.12	2,115	0.12	2,518	0.11	3,040	0.11
savings per year (AF)	85.01		121.26		156.95		190.21		222.93	
BASTROP WEST WATER SYS	62	0.01	78	0.01	97	0.01	121	0.01	152	0.01
savings per year (AF)	3.62		5.36		7.20		9.16		11.12	
ELGIN, CITY OF	1,063	0.09	1,193	0.08	1,344	0.07	1,521	0.07	1,757	0.06
savings per year (AF)	61.89		82.43		99.73		114.89		128.85	
J&R MOBILE HOME PARK	7	0.001	9	0.001	12	0.001	12	0.001	12	0.0004
savings per year (AF)	0.43		0.64		0.86		0.87		0.85	
K&K WATER CO.	37	0.00	46	0.00	58	0.00	78	0.00	281	0.01
savings per year (AF)	2.14		3.19		4.27		5.89		20.61	
MANVILLE WSC	67	0.01	94	0.01	125	0.01	161	0.01	207	0.01
savings per year (AF)	3.90		6.50		9.28		12.16		15.18	
SMITHVILLE	732	0.06	838	0.06	972	0.05	1,122	0.05	1,319	0.05
savings per year (AF)	42.62		57.90		72.13		84.75		96.73	

Table 49: Projected water conservation savings for selected water providers in Bastrop County (uniform water savings distribution) * All units in Acre Feet

Bastrop County Municipal Water Providers	Water Use per year 2010-2020	% of Total Co. Water Use	Water Use per year 2020-2030	% of Total Co. Water Use	Water Use per year 2030-2040	% of Total Co. Water Use	Water Use per year 2040-2050	% of Total Co. Water Use	Water Use per year 2050-2060	% of Total Co. Water Use
AQUA WSC	5,424	0.46	6,547	0.44	7,827	0.43	9,377	0.42	11,326	0.41
savings per year (AF)	631.62		603.16		580.82		566.66		553.72	
BASTROP, CITY OF	1,460	0.13	1,755	0.12	2,115	0.12	2,518	0.11	3,040	0.11
savings per year (AF)	170.01		161.69		156.95		152.17		148.62	
BASTROP WEST WATER SYS	62	0.01	78	0.01	97	0.01	121	0.01	152	0.01
savings per year (AF)	7.23		7.15		7.20		7.33		7.41	
ELGIN, CITY OF	1,063	0.09	1,193	0.08	1,344	0.07	1,521	0.07	1,757	0.06
savings per year (AF)	123.78		109.91		99.73		91.92		85.90	
J&R MOBILE HOME PARK	7	0.001	9	0.001	12	0.001	12	0.001	12	0.0004
savings per year (AF)	0.85		0.86		0.86		0.70		0.56	
K&K WATER CO.	37	0.003	46	0.003	58	0.003	78	0.003	281	0.01
savings per year (AF)	4.29		4.25		4.27		4.71		13.74	
MANVILLE WSC	67	0.01	94	0.01	125	0.01	161	0.01	207	0.01
savings per year (AF)	7.80		8.66		9.28		9.73		10.12	
SMITHVILLE	732	0.06	838	0.06	972	0.05	1,122	0.05	1,319	0.05
savings per year (AF)	85.24		77.20		72.13		67.80		64.48	

Table 50: Projected water conservation savings for selected water providers in Caldwell County (increasing water savings distribution) * All units in Acre Feet

Caldwell County Municipal Water Providers	Water Use per year 2010-2020	% of Total Co. Water Use	Water Use per year 2020-2030	% of Total Co. Water Use	Water Use per year 2030-2040	% of Total Co. Water Use	Water Use per year 2040-2050	% of Total Co. Water Use	Water Use per year 2050-2060	% of Total Co. Water Use
COUNTY LINE WSC	204	0.03	308	0.04	405	0.04	501	0.05	600	0.05
savings per year (AF)	7.12		12.87		19.32		26.11		33.20	
CREEDMOOR-MAHA WSC	234	0.04	304	0.04	367	0.04	431	0.04	494	0.04
savings per year (AF)	8.16		12.70		17.51		22.46		27.34	
LOCKHART, CITY OF	2,451	0.39	3,094	0.39	3,629	0.39	4,180	0.40	4,725	0.40
savings per year (AF)	85.51		129.28		173.15		217.81		261.49	
LULING, CITY OF	1,067	0.17	1,210	0.15	1,299	0.14	1,384	0.13	1,486	0.12
savings per year (AF)	37.22		50.56		61.98		72.12		82.24	
MARTINDALE WSC	142	0.023	153	0.019	158	0.017	162	0.015	170	0.0143
savings per year (AF)	4.95		6.39		7.54		8.44		9.41	

Table 51: Projected water conservation savings for selected water providers in Caldwell County (uniform water savings distribution) * All units in Acre Feet

Caldwell County Municipal Water Providers	Water Use per year 2010-2020	% of Total Co. Water Use	Water Use per year 2020-2030	% of Total Co. Water Use	Water Use per year 2030-2040	% of Total Co. Water Use	Water Use per year 2040-2050	% of Total Co. Water Use	Water Use per year 2050-2060	% of Total Co. Water Use
COUNTY LINE WSC	204	0.03	308	0.04	405	0.04	501	0.05	600	0.05
savings per year (AF)	14.23		17.16		19.32		20.88		22.14	
CREEDMOOR-MAHA WSC	234	0.04	304	0.04	367	0.04	431	0.04	494	0.04
savings per year (AF)	16.33		16.94		17.51		17.97		18.23	
LOCKHART, CITY OF	2,451	0.39	3,094	0.39	3,629	0.39	4,180	0.40	4,725	0.40
savings per year (AF)	171.02		172.37		173.15		174.25		174.33	
LULING, CITY OF	1,067	0.17	1,210	0.15	1,299	0.14	1,384	0.13	1,486	0.12
savings per year (AF)	74.45		67.41		61.98		57.69		54.82	
MARTINDALE WSC	142	0.023	153	0.019	158	0.017	162	0.015	170	0.0143
savings per year (AF)	9.91		8.52		7.54		6.75		6.27	

Table 52: Projected water conservation savings for selected water providers in Hays County (increasing water savings distribution) * All units in Acre Feet

Hays County Municipal Water Providers	Water Use per year 2010-2020	% of Total Co. Water Use	Water Use per year 2020-2030	% of Total Co. Water Use	Water Use per year 2030-2040	% of Total Co. Water Use	Water Use per year 2040-2050	% of Total Co. Water Use	Water Use per year 2050-2060	% of Total Co. Water Use
BUDA, CITY OF	1,252	0.07	2,128	0.09	2,603	0.09	3,088	0.09	3,666	0.09
savings per year (AF)	93.09		168.00		223.21		280.06		335.44	
COUNTY LINE WSC	947	0.05	1,999	0.08	2,319	0.08	2,393	0.07	2,612	0.06
savings per year (AF)	70.41		157.82		198.85		217.03		239.00	
DRIPPING SPRINGS WSC	348	0.02	501	0.02	660	0.02	817	0.02	1,013	0.02
savings per year (AF)	25.88		39.55		56.59		74.10		92.69	
KYLE, CITY OF	2,740	0.16	3,940	0.16	4,217	0.14	4,377	0.12	4,874	0.116
savings per year (AF)	203.73		311.06		361.61		396.96		445.97	
WIMBERLEY WSC	776	0.04	997	0.04	1224	0.04	1442	0.04	1736	0.04
savings per year (AF)	57.70		78.71		104.96		130.78		158.85	

Table 53: Projected water conservation savings for selected water providers in Hays County (uniform water savings distribution) * All units in Acre Feet

Hays County Municipal Water Providers	Water Use per year 2010-2020	% of Total Co. Water Use	Water Use per year 2020-2030	% of Total Co. Water Use	Water Use per year 2030-2040	% of Total Co. Water Use	Water Use per year 2040-2050	% of Total Co. Water Use	Water Use per year 2050-2060	% of Total Co. Water Use
BUDA, CITY OF	1,252	0.07	2,128	0.09	2,603	0.09	3,088	0.09	3,666	0.09
savings per year (AF)	186.18		224.00		223.21		224.04		223.63	
COUNTY LINE WSC	947	0.05	1,999	0.08	2,319	0.08	2,393	0.07	2,612	0.06
savings per year (AF)	140.83		210.42		198.85		173.62		159.33	
DRIPPING SPRINGS WSC	348	0.02	501	0.02	660	0.02	817	0.02	1,013	0.02
savings per year (AF)	51.75		52.74		56.59		59.28		61.79	
KYLE, CITY OF	2,740	0.16	3,940	0.16	4,217	0.14	4,377	0.12	4,874	0.116
savings per year (AF)	407.46		414.74		361.61		317.57		297.32	
WIMBERLEY WSC	776	0.04	997	0.04	1224	0.04	1442	0.04	1736	0.04
savings per year (AF)	115.40		104.95		104.96		104.62		105.90	

Table 54: Projected water conservation savings for selected water providers in Travis County (increasing water savings distribution) * All units in Acre Feet

Travis County Municipal Water Providers	Water Use per year 2010-2020	% of Total Co. Water Use	Water Use per year 2020-2030	% of Total Co. Water Use	Water Use per year 2030-2040	% of Total Co. Water Use	Water Use per year 2040-2050	% of Total Co. Water Use	Water Use per year 2050-2060	% of Total Co. Water Use
ARROYO DOBLE WSC	140	0.001	175	0.001	194	0.001	216	0.001	227	0.001
savings per year (AF)	11.48		17.75		22.67		28.31		32.36	
AUSTIN, CITY OF	150,180	0.79	183,509	0.80	214,242	0.80	241,074	0.81	268,462	0.82
savings per year (AF)	12,312.89		18,610.45		24,970.32		31,579.54		38,189.34	
BRIARCLIFF VILLAGE	254	0.001	350	0.002	439	0.002	494	0.002	552	0.002
savings per year (AF)	20.82		35.50		51.17		64.71		78.52	
JONESTOWN WSC	122	0.001	145	0.001	164	0.001	176	0.001	190	0.001
savings per year (AF)	10.00		14.71		19.11		23.06		27.03	
LAGO VISTA, CITY OF	2,006	0.01	2,698	0.01	3,340	0.01	3,733	0.01	4,161	0.01
savings per year (AF)	164.47		273.62		389.28		489.01		591.91	
LAKEWAY MUD	3,259	0.02	4,716	0.02	5,796	0.02	6,467	0.02	7,199	0.02
savings per year (AF)	267.20		478.27		675.54		847.15		1,024.07	
LOST CREEK MUD	935	0.005	921	0.004	906	0.003	891	0.003	882	0.003
savings per year (AF)	76.66		93.40		105.60		116.72		125.47	
MANOR, CITY OF	285	0.002	312	0.001	336	0.001	351	0.001	369	0.001
savings per year (AF)	23.37		31.64		39.16		45.98		52.49	
MANVILLE WSC	1,731	0.01	2,350	0.01	2,898	0.01	3,237	0.01	3,622	0.01
savings per year (AF)	141.92		238.32		337.77		424.03		515.24	
SUNSET VALLEY, CITY OF	94	0.0005	117	0.001	146	0.001	183	0.001	228	0.001
savings per year (AF)	7.71		11.87		17.02		23.97		32.43	
TRAVIS COUNTY WCID #17	2,856	0.02	3,944	0.02	4,966	0.02	5,584	0.02	6,271	0.02
savings per year (AF)	234.16		399.98		578.80		731.48		892.06	
W. TRAVIS CO. REGIONAL WS	782	0.004	1,114	0.005	1,420	0.01	1,605	0.01	1,811	0.01
savings per year (AF)	64.11		112.98		165.50		210.25		257.62	

Table 55: Projected water conservation savings for selected water providers in Travis County (uniform water savings distribution) * All units in Acre Feet

Travis County Municipal Water Providers	**Water Use per year 2010-2020**	% of Total Co. Water Use	**Water Use per year 2020-2030**	% of Total Co. Water Use	**Water Use per year 2030-2040**	% of Total Co. Water Use	**Water Use per year 2040-2050**	% of Total Co. Water Use	**Water Use per year 2050-2060**	% of Total Co. Water Use
ARROYO DOBLE WSC	140	0.001	175	0.001	194	0.001	216	0.001	227	0.001
savings per year (AF)	22.96		23.67		22.67		22.65		21.57	
AUSTIN, CITY OF	150,180	0.79	183,509	0.80	214,242	0.80	241,074	0.81	268,462	0.82
savings per year (AF)	24,625.78		24,813.40		24,970.32		25,263.30		25,459.02	
BRIARCLIFF VILLAGE	254	0.001	350	0.002	439	0.002	494	0.002	552	0.002
savings per year (AF)	41.65		47.33		51.17		51.77		52.35	
JONESTOWN WSC	122	0.001	145	0.001	164	0.001	176	0.001	190	0.001
savings per year (AF)	20.00		19.61		19.11		18.44		18.02	
LAGO VISTA, CITY OF	2,006	0.01	2,698	0.01	3,340	0.01	3,733	0.01	4,161	0.01
savings per year (AF)	328.93		364.81		389.28		391.20		394.60	
LAKEWAY MUD	3,259	0.02	4,716	0.02	5,796	0.02	6,467	0.02	7,199	0.02
savings per year (AF)	534.39		637.68		675.54		677.71		682.70	
LOST CREEK MUD	935	0.005	921	0.004	906	0.003	891	0.003	882	0.003
savings per year (AF)	153.32		124.53		105.60		93.37		83.64	
MANOR, CITY OF	285	0.002	312	0.001	336	0.001	351	0.001	369	0.001
savings per year (AF)	46.73		42.19		39.16		36.78		34.99	
MANVILLE WSC	1,731	0.01	2,350	0.01	2,898	0.01	3,237	0.01	3,622	0.01
savings per year (AF)	283.84		317.76		337.77		339.22		343.48	
SUNSET VALLEY, CITY OF	94	0.0005	117	0.001	146	0.001	183	0.001	228	0.001
savings per year (AF)	15.41		15.82		17.02		19.18		21.62	
TRAVIS COUNTY WCID #17	2,856	0.02	3,944	0.02	4,966	0.02	5,584	0.02	6,271	0.02
savings per year (AF)	468.31		533.29		578.80		585.17		594.70	
W. TRAVIS CO. REGIONAL WS	782	0.004	1,114	0.005	1,420	0.01	1,605	0.01	1,811	0.01
savings per year (AF)	128.23		150.63		165.50		168.20		171.74	

Table 56: Projected water conservation savings for selected water providers in Williamson County (increasing water savings distribution) * All units in Acre Feet

Williamson County Municipal Water Providers	Water Use per year 2010-2020	% of Total Co. Water Use	Water Use per year 2020-2030	% of Total Co. Water Use	Water Use per year 2030-2040	% of Total Co. Water Use	Water Use per year 2040-2050	% of Total Co. Water Use	Water Use per year 2050-2060	% of Total Co. Water Use
BLOCK HOUSE MUD	903	0.02	1,288	0.02	1,749	0.02	2,242	0.02	2,796	0.02
savings per year (AF)	24.20		38.20		52.68		67.05		81.82	
CEDAR PARK, CITY OF	10,744	0.19	14,886	0.19	20,708	0.20	25,883	0.20	31,068	0.20
savings per year (AF)	287.93		441.51		623.74		774.02		909.17	
GEORGETOWN, CITY OF	8,610	0.15	1,169	0.01	15,141	0.15	19,003	0.15	23,293	0.15
savings per year (AF)	230.74		34.67		456.05		568.28		681.64	
LEANDER, CITY OF	1,971	0.03	2,728	0.03	3,610	0.04	4,578	0.04	5,657	0.04
savings per year (AF)	52.82		80.91		108.74		136.90		165.55	
NORTH AUSTIN MUD #1	983	0.017	983	0.013	983	0.010	983	0.008	983	0.0062
savings per year (AF)	26.34		29.16		29.61		29.40		28.77	
ROUND ROCK, CITY OF	19,239	0.33	25,937	0.33	33,896	0.33	42,617	0.33	52,298	0.33
savings per year (AF)	515.59		769.28		1,020.96		1,274.44		1,530.44	

Table 57: Projected water conservation savings for selected water providers in Williamson County (uniform water savings distribution) * All units in Acre Feet

Williamson County Municipal Water Providers	Water Use per year 2010-2020	% of Total Co. Water Use	Water Use per year 2020-2030	% of Total Co. Water Use	Water Use per year 2030-2040	% of Total Co. Water Use	Water Use per year 2040-2050	% of Total Co. Water Use	Water Use per year 2050-2060	% of Total Co. Water Use
BLOCK HOUSE MUD	903	0.02	1,288	0.02	1,749	0.02	2,242	0.02	2,796	0.02
savings per year (AF)	48.40		50.94		52.68		53.64		54.55	
CEDAR PARK, CITY OF	10,744	0.19	14,886	0.19	20,708	0.20	25,883	0.20	31,068	0.20
savings per year (AF)	575.85		588.69		623.74		619.21		606.11	
GEORGETOWN, CITY OF	8,610	0.15	1,169	0.01	15,141	0.15	19,003	0.15	23,293	0.15
savings per year (AF)	461.47		46.23		456.05		454.62		454.43	
LEANDER, CITY OF	1,971	0.03	2,728	0.03	3,610	0.04	4,578	0.04	5,657	0.04
savings per year (AF)	105.64		107.88		108.74		109.52		110.36	
NORTH AUSTIN MUD #1	983	0.017	983	0.013	983	0.010	983	0.008	983	0.0062
savings per year (AF)	52.69		38.87		29.61		23.52		19.18	
ROUND ROCK, CITY OF	19,239	0.33	25,937	0.33	33,896	0.33	42,617	0.33	52,298	0.33
savings per year (AF)	1,031.15		1,025.72		1,020.96		1,019.55		1,020.29	

Water Provider Potential Conservation Savings and Costs

This study developed a series of simple models or tools to assist Central Texas water providers in assessing potential conservation savings and related costs. The model is described in greater detail later in this chapter. Tables 58-64 below are outputs from this model which contain methods for calculating water conservation savings and costs presented in Chapter 3. For a specific provider, the full suite of available measures can be observed for cost and potential water savings. Although the tool is simple to use, it ignores multi-family and ICI conservation applications. The model was designed to be able to input new population and household data or water conservation savings metrics as necessary. The following rebate and cost values (described in Chapter 3) were used, unless otherwise specified:

Potential showerhead water savings = 5.5gpcd; cost = $13.63
Potential faucet aerator kit/replacement savings = 5.5 gpcd; cost = $1.75
Potential toilet savings = 9.91 gpcd; cost = $85 ($75 for toilet, $10 for admin cost)
Potential rain barrel savings = 2.3 gpd; = $60 ($50 for barrel, $10 admin cost)

It is important to note that in many cases, and especially for private and for-profit water providers, the expenditure of hundreds or thousands of dollars to implement conservation measures aimed at reducing per capita water use is not advantageous to the provider or likely to be incurred. In these cases, it would be best to examine the costs and benefits of leak reduction measures and the adoption of or increase in use of conservation pricing. Better understanding the relationship between water savings resulting from increasing pricing tiers and potential losses in revenue will be critical to incentivizing private and for-profit providers to reduce gpcd and overall water use.

Bastrop County Water Provider Conservation Savings Projections

Two providers in Bastrop County were selected for assessment of conservation program savings necessary to meet projected water conservation goals. In these simplified analyses, the savings of instituting additional conservation measures (or any conservation measures if no program currently exists) was examined for the increasing savings distribution scenario. First, the "low hanging fruit" or simplest and least expensive measures to implement were considered: showerhead replacement, faucet aerator replacement/retrofit and rain barrels. As shown in Table

58, J&R Mobile Home Park, a small provider, is projected to be required to save between .43 and .85 acre-feet per year. J&R is a groundwater supplied private municipality that reported no conservation measures in place other than monitoring customers' outdoor water use and checking in with customers who have unusually high bills (because the community is so small and the water manager lives in the park). Although this is a very small water provider, substantial savings can be realized at fairly little cost to the water provider. In this example, certain conservation best management practices (BMPs) would be inappropriate due to the water provider's size. Rain barrels would be cost prohibitive for this provider, as would toilet rebates, without financial assistance. For example, between 2020 and 2030, a per year conservation savings of .64 AF is equivalent to 6.4 AF for the ten year period. Table 58 shows that adopting the following conservation practices during this time period would exceed the calculated conservation savings projection by providing 7.62 AF of water during the 10 year planning period at a total amortized cost of $305 (Similar calculations can be made for each 10 year period):

50% adoption rate of showerhead replacement 5.08 AF per 10 year period ($243),
50% adoption rate of faucet aerator replacement 2.54 AF per 10 year period ($62).

Alternatively, although not shown in the table output, model calculations estimate that implementing outdoor water use regulations, which could reduce daily usage by 16 gallons per day, could yield 0.25 AF of water conservation savings per year (between 2020 and 2030) at an approximate annual cost of $389 ($300 per year amortized over the ten year period).

Smithville is a slightly larger city municipal water provider, currently servicing approximately 4,500 people and not reporting any conservation measures other than a supply leak audit program. Its population is expected to increase at a slower rate than other areas in the county, yielding water conservation savings between 64.48 and 85.24 acre-feet per decade (Table 58). As with J&R Mobile Home Community, simply applying showerhead or faucet replacement programs would exceed the projected necessary savings at a relatively low cost. For the period of 2020-2030, water savings of 77.2 AF per year is required, totaling 772 AF for the 10 year period. 658.46 AF can be achieved over the 10 year period with just the implementation of low flow faucet aerator replacements/kits in 50% of residential homes, at a cost of $4825. Additional savings may be realized from new construction or remodeling where efficient fixtures are installed at no cost to the water provider. Providing 50% of residents with low flow showerheads would potentially save an additional 164.62 AF over the decade, exceeding the minimum required conservation savings and costing less than $19,000. Again, conservation savings and costs can be estimated for each 10 year period.

Table 58: Potential water conservation savings for selected providers in Bastrop
County in Acre-Feet

	J&R MOBILEHOMEPARK, Bastrop Co. Increasing Conservation Savings Scenario					
		2010-2020	2020-2030	2030-2040	2040-2050	2050-2060
	Water Use per Year (AF)	7.39	9.3	11.54	11.54	11.54
	Savings Goal per Year (AF)	0.43	0.64	0.86	0.87	0.85
	Population	66	83	103	103	103
50% Adoption Rate	Potential Showerhead Savings	2.03	2.54	3.18	3.17	3.17
	Potential Faucet (2) Savings	4.07	5.08	6.35	6.35	6.35
	Potential Showerhead Cost (amortized at 5%)	-$194	-$243	-$303	-$303	-$303
	Potential Faucet (2) Cost (amortized at 5%)	-$50	-$62	-$78	-$78	-$78
10% Adoption Rate	Potential Showerhead Savings	0.41	0.51	0.64	0.63	0.63
	Potential Faucet (2) Savings	0.81	1.02	1.27	1.27	1.27
	Potential Showerhead Cost (amortized at 5%)	-$39	-$49	-$61	-$61	-$61
	Potential Faucet (2) Cost (amortized at 5%)	-$10	-$12	-$16	-$16	-$16
	City of Smithville, Bastrop Co. Uniform Conservation Savings Scenario					
		2010-2020	2020-2030	2030-2040	2040-2050	2050-2060
	Water Use per Year (AF)	732	838	972	1122	1319
	Savings Goal per Year (AF)	85.24	77.20	72.13	67.80	64.48
	Population	4,540	5,344	6,290	7,364	8,724
50% Adoption Rate	Potential Showerhead Savings	139.85	164.62	193.76	226.84	268.73
	Potential Faucet (2) Savings	559.40	658.46	775.03	907.36	1074.93
	Potential Rain Barrel Savings ($50 rebate)	23.30	27.43	32.28	37.79	44.77
	Potential Showerhead Cost (amortized at 5%)	-$15,964	-$18,791	-$22,117	-$25,894	-$30,676
	Potential Faucet (2) Cost (amortized at 5%)	-$4,099	-$4,825	-$5,679	-$6,649	-$7,877
	Potential Rain Barrel Cost ($50 + $10)	-$70,273	-$82,718	-$97,361	-$113,985	-$135,036
10% Adoption Rate	Potential Showerhead Savings	27.97	32.92	38.75	45.37	53.75
	Potential Faucet (2) Savings	55.94	65.85	77.50	90.74	107.49
	Potential Rain Barrel Savings ($50 rebate)	4.66	5.49	6.46	7.56	8.95
	Potential Showerhead Cost (amortized at 5%)	-$3,193	-$3,758	-$4,423	-$5,179	-$6,135
	Potential Faucet (2) Cost (amortized at 5%)	-$683	-$804	-$947	-$1,108	-$1,313
	Potential Rain Barrel Cost ($50 + $10)	-$14,055	-$16,544	-$19,472	-$22,797	-$27,007

Caldwell County Water Provider Conservation Savings Projections

Two providers in Caldwell County were analyzed for conservation program savings necessary to meet projected water conservation goals. The savings of instituting additional conservation measures For County Line SUD was examined using the increasing savings distribution scenario. County Line SUD is a small local water provider that recently changed from a WSC to a SUD, with the majority of its customers located in Caldwell County and a small customer base in Hays County. The SUD does distribute educational material to its customers yearly, has a leak audit program and conservation pricing. This provider is expected to more than double its customer base in Caldwell County during the 50 year planning period. A portion of the SUD's customers reside in the City of Uhland which has instituted a greywater policy for all new construction. Assuming that 5% of the SUD's population will reside in newly constructed homes in Uhland, conservation savings resulting from greywater realized at no cost to the SUD, ranging from 18.37 AF between 2010 and 2020 to 55.69 AF between 2050 and 2060 (Table 59).

Between 2020 and 2030, required conservation savings were estimated at 12.87 AF per year or 128.7 AF over the 10 year period. If potential greywater conservation savings were ignored, the 128.7 AF could nearly be met by instituting a faucet aerator retrofit/kit program for 50% of the population and providing showerhead retrofits for 20% of the provider's population, yielding water savings of 119.46 AF and 8.12 AF, totaling 127.58 AF and costing $3823 ($1495 + $2328) for the decade.

The City of Lockhart's service population is currently over 16,000 and is expected to double by 2050. In this calculation, a uniform savings distribution was used to estimate an average annual savings of 173 AF or 1730 AF per decade. The utility currently has a form of conservation pricing, available conservation literature, leak audit measures, and regulations in place for toilet, showerhead and other plumbing efficiency measures but does not actively enforce the regulations. Between 2020 and 2030, as shown in Table 59, if 25% of customers adhered to the City's regulations, approximately 2145 AF could be saved over the ten year period. Potential enforcement and public education costs of $32,376 for the 10 year period ($2500 per year amortized at 5%) were estimated. The addition and enforcement of landscape watering regulations is also a relatively cost efficient measure yielding potential conservation savings of 22 AF per 10 year period. Seasonal watering restrictions adopted by 10 % of the customer base (2 times per week) could potentially save 22.8 AF over the 10 year period, with expenditures of $2000 per year for public education, mailings and other methods of enforcement, amortized at 5%. Offering $50 rebates for rain barrels (for 50% of the service population) with a $10 per barrel administration cost could reduce use by 64.66 AF per decade with a total 10 year expenditure of $48,796. Rain collection systems are slightly less cost efficient, yielding 121.45 AF per 10 years (assuming a 10% adoption rate) at a total cost of just over $367,000.

Table 59: Potential water conservation savings for selected providers in Caldwell County in Acre-Feet

	County Line SUD, Caldwell Co. Increasing Conservation Savings Scenario	2010-2020	2020-2030	2030-2040	2040-2050	2050-2060
	Water Use per Year (AF)	204	308	405	501	600
	Savings Goal per Year (AF)	**7.12**	**12.87**	**19.32**	**26.11**	**33.20**
	Population	1262	1939	2565	3193	3824
25% Compliance Rate	Estimated Greywater Savings	18.377	28.235	37.351	46.496	55.685
50% Adoption Rate	Potential Showerhead Savings	38.87	59.73	79.01	98.36	117.79
	Potential Faucet (2) Savings	77.75	119.46	158.02	196.71	235.59
	Potential Showerhead Cost (amortized at 5%)	-$3,788	-$5,821	-$7,700	-$9,585	-$11,479
	Potential Faucet (2) Cost (amortized at 5%)	-$973	-$1,495	-$1,977	-$2,461	-$2,948
10% Adoption Rate	Potential Showerhead Savings	7.77	4.06	5.37	6.69	8.01
	Potential Faucet (2) Savings	31.10	47.78	63.21	78.69	94.24
	Potential Showerhead Cost (amortized at 5%)	-$758	-$1,164	-$1,540	-$1,917	-$2,296
	Potential Faucet (2) Cost (amortized at 5%)	-$195	-$299	-$395	-$492	-$590

	City of Lockhart, Caldwell Co. Uniform Conservation Savings Scenario	2010-2020	2020-2030	2030-2040	2040-2050	2050-2060
	Water Use per Year (AF)	2,451	3,094	3,629	4,180	4,725
	Savings Goal per Year (AF)	**171.02**	**172.37**	**173.15**	**174.25**	**174.33**
	Population	16,328	21,083	25,111	29,154	33,216
25% Compliance Rate	Estimated Toilet Savings	906.25	1170.17	1393.74	1618.14	1843.59
	Estimated Showerhead Savings	251.48	324.72	386.76	449.03	511.59
	Estimated Faucet (2) Savings	502.97	649.44	773.52	898.06	1023.18
	Potential Cost of Increasing Ordinance Participation ($2500 yr) (amortized at 5%)	-$32,376	-$32,376	-$32,376	-$32,376	-$32,376
50% Adoption Rate	Potential Rain Barrel Savings ($50 rebate)	50.08	64.66	77.02	89.42	101.88
	Potential Rain Barrel Cost ($50 + $10) (amortized at 5%)	-$37,760	-$48,756	-$58,071	-$67,421	-$76,815
10% Adoption Rate	Potential Landscape Reg. Savings	17.26	22.28	26.54	30.81	35.10
	Potential Rain Collection System Savings ($500 rebate)	94.06	121.45	144.66	167.95	191.35
	Potential Landscape Reg. Cost ($2000 yr)	-$25,901	-$25,901	-$25,901	-$25,901	-$25,901
	Potential Rain Collection System Cost ($500 + $50) (amortized at 5%)	-$276,905	-$357,545	-$425,856	-$494,421	-$563,308

Hays County Water Provider Conservation Savings Projections

Potential water savings for the City of Kyle, a large provider expecting rapid growth, were analyzed using the increasing savings scenario. The only reported conservation measure was an increasing rate pricing structure. Following the population growth trend between 2010 and 2060, the conservation savings required to meet calculated reductions more than double over the 50 year planning period. Between 2020 and 2030, conservation savings of 311 AF were calculated, totaling 3110 AF for the 10 year period. Providing low flow shower heads and faucet aerators to 50% of the service population would yield 92% of the necessary conservation savings, 2876.4 AF. The total cost for providing these fixtures is estimated at $108,229. However, much of the residential development in Kyle is recent and newer construction may already include more efficient plumbing fixtures, reducing the cost to the provider. Additional measures including watering restrictions and rain barrels would yield additional savings but were not calculated in the scenario.

Conservation savings for Dripping Springs WSC are presented here for the uniform distribution scenario. Significantly smaller than the City of Kyle, this medium sized provider is expected to conserve 52.74 AF per year (527.4 over the 10 year period) between 2020 and 2030 and reported only a leak reduction/audit program (Table 60). Although this is a uniform distribution, population is projected to increase dramatically causing the value of necessary savings to increase throughout the 50 year period. Unlike previous examples, model outputs did not account for the majority of conservation savings. Adopting showerhead and faucet savings programs could potentially yield 112 AF and 224 AF, respectively. The cost of providing efficient showerheads to 50% of the population is estimated to be $10,068 over 10 years. The cost of providing faucet aerators averaged $2,585 and was the most efficient option. Rain barrels were estimated to yield only 15.32 AF per 10 year period with a cost of over $46,000 while potential outdoor watering restrictions could save 10.56 AF with a cost of approximately $12,950. Implementing the showerhead and faucet programs (50% adoption rate), as well as adopting the watering restrictions and increasing the adoption rate 30% would provide 70 % of conservation savings equivalent to 368 AF over the 10 year period (202-2030) where 527 AF of savings was required. Additional measures including leak reduction strategies, residential and commercial audits and xeriscaping incentives or new construction restrictions could account for the additional 169 AF. In the following 10 year periods, conservation savings projections do account for a greater percentage of the required savings: between 2030-2040 488.59 AF of savings over the 10 year period will account for 86% of required savings; 609.82 AF of water saved between 2040 and 2050 will provide more than the estimated required conservation savings, as will 755.43 AF of savings between 2050 and 2060.

Table 60: Potential water conservation savings for selected providers in Hays County in Acre-Feet

	City of Kyle, Hays Co. Increasing Conservation Savings Scenario					
		2010-2020	2020-2030	2030-2040	2040-2050	2050-2060
	Water Use per Year (AF)	2740	3940	4217	4377	4874
	Savings Goal per Year (AF)	**203.73**	**311.06**	**361.61**	**396.96**	**445.97**
	Population	20,772	31,126	33,613	35,203	39,197
50% Adoption Rate	Potential Showerhead Savings	639.86	958.80	1035.41	1084.39	1207.42
	Potential Faucet (2) Savings	1279.72	1917.61	2070.82	2168.78	2414.84
	Potential Showerhead Cost (amortized at 5%)	-$57,470	-$86,116	-$92,997	-$97,396	-$108,446
	Potential Faucet (2) Cost (amortized at 5%)	-$14,757	-$22,113	-$23,880	-$25,010	-$27,847
10% Adoption Rate	Potential Showerhead Savings	127.97	191.76	207.08	216.88	241.48
	Potential Faucet (2) Savings	511.89	767.04	828.33	867.51	965.94
	Potential Showerhead Cost (amortized at 5%)	-$11,494	-$17,223	-$18,599	-$19,479	-$21,689
	Potential Faucet (2) Cost (amortized at 5%)	-$2,951	-$4,423	-$4,776	-$5,002	-$5,569
	Dripping Springs WSC, Hays Co. Uniform Conservation Savings Scenario					
		2010-2020	2020-2030	2030-2040	2040-2050	2050-2060
	Water Use per Year (AF)	348	501	660	817	1,013
	Savings Goal per Year (AF)	**51.75**	**52.74**	**56.59**	**59.28**	**61.79**
	Population	2487	3639	4832	6031	7471
50% Adoption Rate	Potential Showerhead Savings	76.61	112.10	148.84	185.78	230.14
	Potential Faucet (2) Savings	153.22	224.19	297.69	371.56	460.27
	Potential Rain Barrel Savings ($50 rebate)	10.47	15.32	20.34	25.39	31.45
	Potential Showerhead Cost (amortized at 5%)	-$6,881	-$10,068	-$13,369	-$16,686	-$20,670
	Potential Faucet (2) Cost (amortized at 5%)	-$1,767	-$2,585	-$3,433	-$4,285	-$5,308
	Potential Rain Barrel Cost ($50 + $10) (amortized at 5%)	-$31,576	-$46,203	-$61,350	-$76,573	-$94,856
10% Adoption Rate	Potential Landscape Reg. Savings (16 GPD per household per day)	7.21	10.56	14.02	17.50	21.67
	Potential Landscape Reg. Cost ($1000 yr)	-$12,950	-$12,950	-$12,950	-$12,950	-$12,950

Travis County Water Provider Conservation Savings Projections

In Table 61, an increasing water conservation schedule for The City of Lago Vista, currently supplying over 6000 customers, shows average annual required conservation savings of 273.62 AF between 2020 and 2030 (2736.2 AF total). Lago Vista reported a conservation program with leak reduction audits and conservation pricing. 767 AF of water can potentially be conserved with the implementation of showerhead replacement and faucet aerator programs, accounting for 28% of the total required conservation savings. An additional 117.8 AF can be saved through the implementation of outdoor or landscaping watering restrictions (2 days per week watering schedule) during the 10 year period. Toilet rebate programs could save an additional 461 AF, bringing the unmet conservation savings to 1390 AF per decade (nearly 51%). Additional measures including education and price increases will likely be necessary to reduce per capita use and decrease the gap between water demanded and necessary conservation savings.

Travis County WCID #17 currently provides water to over 14,000 customers and is a progressive conservation district that is currently exploring the use of Astroturf on public school grounds and has an active water reuse program. The WCID's conservation program also includes conservation pricing, leak auditing and reduction, recommendations for water wise landscaping and the distribution of education materials. However, the implementation of landscape irrigation regulations, plumbing efficiency programs, and rain barrel rebates or give away programs could yield significant additional water savings, shown in Table 61. For example, in the 10 year period 2020-2030, water conservation savings of 2649.41 AF (total 10 year cost of $448,666) can be realized with the following measures:

494.52 AF 75% compliance to revised landscaping irrigation regulations,
686.4 AF 50% participation in showerhead replacement program,
1372.81 AF 50% participation in faucet/aerator replacement program,
95.68 AF 50% participation in rain barrel rebate/giveaway program.

Although most of these measures have life spans of greater than 10 years (10-13 years), a ten year life span was assumed, so that new rebates/retrofits/replacements would be necessary in every 10 year planning period, as well as to account for the possibility of misuse decreasing efficiency of the fixtures.

These potential conservation savings would contribute nearly 49% of the calculated required water conservation savings (uniform) of 533.29 AF per year, 5332.9 AF per decade. Additional conservation savings could potentially come from increasing the participation rate above 50% for landscaping/outdoor watering restrictions or increasing the strength of pricing tiers. Further conservation savings could be recognized from washing machine or xeriscaping rebates, but the realized per unit savings are significantly more expensive.

Table 61: Potential water conservation savings for selected providers in Travis County in Acre-Feet

	City of Lago Vista, Travis Co. Increasing Conservation Savings Scenario					
		2010-2020	2020-2030	2030-2040	2040-2050	2050-2060
	Water Use per Year (AF)	2006	2698	3340	3733	4161
	Savings Goal per Year (AF)	**164.47**	**273.62**	**389.28**	**489.01**	**591.91**
	Population	6,132	8,307	10,316	11,571	12,898
50% Adoption Rate	Potential Showerhead Savings	188.89	255.89	317.77	356.43	397.31
	Potential Faucet (2) Savings	377.78	511.78	635.55	712.86	794.62
	Estimated Landscape Reg. Savings (16 GPD/per household)	86.96	117.80	146.29	164.09	182.90
	Estimated Toilet Savings	340.34	461.06	572.57	642.23	715.88
	Potential Showerhead Cost (amortized at 5%)	-$17,291	-$23,423	-$29,088	-$32,627	-$36,369
	Potential Faucet (2) Cost (amortized at 5%)	-$4,440	-$6,015	-$7,469	-$8,378	-$9,339
	Estimated Landscape Reg. Cost ($4,000 yr)	-$51,802	-$51,802	-$51,802	-$51,802	-$51,802
	Potential Toilet Rebate ($100 + 20) Cost (amortized at 5%)	-$60,891	-$82,489	-$102,439	-$114,901	-$128,078
10% Adoption Rate	Potential Showerhead Savings	37.78	51.18	63.55	71.29	79.46
	Potential Faucet (2) Savings	75.56	102.36	127.11	142.57	158.92
	Potential Showerhead Cost (amortized at 5%)	-$3,458	-$4,685	-$5,818	-$6,525	-$7,274
	Potential Faucet (2) Cost (amortized at 5%)	-$888	-$1,203	-$1,494	-$1,676	-$1,868
	Travis Co. WCID # 17, Travis Co. Uniform Conservation Savings Scenario					
		2010-2020	2020-2030	2030-2040	2040-2050	2050-2060
	Water Use per Year (AF)	2,856	3,944	4,966	5,584	6,271
	Savings Goal per Year (AF)	**468.31**	**533.29**	**578.80**	**585.17**	**594.70**
	Population	15,838	22,283	28,236	31,954	35,887
75% Compliance Rate	Estimated Landscape Reg. Savings (16 GPD/per household)	351.49	494.52	626.64	709.15	796.43
	Estimated Landscape Reg. Cost ($6,000 yr)	-$77,703	-$77,703	-$77,703	-$77,703	-$77,703
50% Adoption Rate	Potential Showerhead Savings	487.87	686.40	869.78	984.31	1105.46
	Potential Faucet (2) Savings	975.74	1372.81	1739.56	1968.62	2210.92
	Potential Rain Barrel Savings ($50 rebate)	68.01	95.68	121.24	137.21	154.09
	Potential Showerhead Cost (amortized at 5%)	-$46,594	-$65,555	-$83,068	-$94,006	-$105,576
	Potential Faucet (2) Cost (amortized at 5%)	-$11,965	-$16,834	-$21,331	-$24,139	-$27,111
	Potential Rain Barrel Cost ($50 + $10) (amortized at 5%)	-$205,109	-$288,575	-$365,669	-$413,819	-$464,753
10% Adoption Rate	Potential Showerhead Savings	97.57	137.28	173.96	196.86	221.09
	Potential Faucet (2) Savings	195.15	274.56	347.91	393.72	442.18
	Potential Showerhead Cost (amortized at 5%)	-$9,319	-$13,111	-$16,614	-$18,801	-$21,115
	Potential Faucet (2) Cost (amortized at 5%)	-$2,393	-$3,367	-$4,266	-$4,828	-$5,422

Williamson County Water Provider Conservation Savings Projections

The City of Georgetown, a large provider with a rapid population growth rate, hosts a very informative water conservation website, has water conservation pricing, an aggressive leak management system, and has adopted an aggressive plumbing code for efficient fixtures and toilets. The municipality also employs a conservation coordinator, recommends water wise landscaping and irrigation techniques, utilizes reuse for irrigation and provides educational materials. Although the municipality adopted the 2003 International Plumbing Code regulations, it is unclear what portion of the customer population has complied with the standards. In order to have new construction and remodeling permits approved, fixtures and toilets must meet standards, but there are no means for enforcing standards in existing residences and buildings. No rebates are offered for fixtures, toilets or appliances. Increasing water conservation savings are shown in Table 62. Between 2020 and 2030, 462.30 AF per year, totaling 4623 AF are expected to be conserved. Potential savings from the plumbing code regulations significantly exceed the required savings. In this calculation it is assumed that significantly less than 50% of customers comply. If compliance rates were increased by 50%, then conservation savings for the 2020-2030 period would yield:

1717.93 AF of conservation savings from efficient showerhead installation,
3435.87 AF of conservation savings from efficient faucet installation,
3095.41 AF of conservation savings from efficient toilet installation.

No cost information was calculated in the table, but it is realistic to assume that some level of expenditure would be necessary to increase compliance among existing customers. Potential savings and costs of washing machine rebates and rain barrels were also calculated and are presented in Table 62 below. Paying $100 rebates for high efficiency washing machines to 20% of residential customers would yield just over 834 AF of water savings at an estimated cost of $619,069. Rebating $50 for rain barrels in 50% of the residential service population would save only 256.57 AF and cost over $773,000.

Block House MUD is a smaller government owned MUD with a weak conservation pricing program, leak auditing through the City of Cedar Park, and is contemplating the implementation of several conservation measures. The MUD currently services approximately 7,700 individuals. When calculating a uniform savings scenario, annual savings goals range from 48.4 AF in 2010 to 54.55 AF in 2060. Between 2020 and 2030 50.94 AF per year, totaling 509.4 AF are expected to be conserved.

At a 50% adoption rate, implementing showerhead replacement, faucet retrofit and rain barrel rebate programs will yield 123.77 AF of conserved water over the 10 year period, at an approximate amortized cost of only $18, 379 (over the 10 year period). These savings account for 24.3% of the calculated necessary savings. Additional savings of 71.49 AF from toilet rebates costing $20,255. Further savings, although not as cost efficient as simple plumbing efficiency program components include washing machine rebates, landscaping or outdoor water use restrictions. Increased conservation pricing tiers could also reduce per capita and overall water use.

Table 62: Potential water conservation savings for selected providers in Williamson County in Acre-Feet

	City of Georgetown, Williamson Co. Increasing Conservation Savings Scenario					
		2010-2020	2020-2030	2030-2040	2040-2050	2050-2060
	Water Use per Year (AF)	8610	11619	15141	19003	23293
	Savings Goal per Year (AF)	**230.74**	**34.67**	**456.05**	**568.28**	**681.64**
	Population	40,888	55,770	73,473	97,702	113,633
50% Compliance Rate	Estimated Showerhead Savings	1259.51	1717.93	2263.26	3009.60	3500.34
	Estimated Faucet (2) Savings	2519.02	3435.87	4526.51	6019.21	7000.68
	Estimated Toilet Savings	2269.41	3095.41	4077.98	5422.76	6306.98
20% Adoption Rate	Potential Washing Machine Rebate ($100) Savings	611.89	834.60	1099.53	1462.12	1700.53
	Potential Washing Machine Rebate ($100 + 20) Cost (amortized at 5%)	-$453,873	-$619,069	-$815,579	-$1,084,531	-$1,261,371
50% Adoption Rate	Potential Rain Barrel Savings ($50 rebate)	188.11	256.57	338.02	449.49	522.78
	Potential Rain Barrel Cost ($50 + $10) (amortized at 5%)	-$567,341	-$773,836	-$1,019,474	-$1,355,663	-$1,576,714

	Block House MUD, Williamson Co. Uniform Conservation Savings Scenario					
		2010-2020	2020-2030	2030-2040	2040-2050	2050-2060
	Water Use per Year (AF)	7,669	10,452	14,322	18,530	23,108
	Savings Goal per Year (AF)	**48.40**	**50.94**	**52.68**	**53.64**	**54.55**
	Population	903	1,288	1,749	2,242	2,796
50% Adoption Rate	Potential Showerhead Savings	27.82	39.68	53.88	69.06	86.13
	Potential Faucet (2) Savings	55.63	79.35	107.75	138.12	172.26
	Potential Rain Barrel Savings ($50 rebate)	3.32	4.74	6.44	8.25	10.29
	Potential Showerhead Cost (amortized at 5%)	-$2,277	-$3,248	-$4,410	-$5,654	-$7,051
	Potential Faucet (2) Cost (amortized at 5%)	-$585	-$834	-$1,133	-$1,452	-$1,810
	Potential Rain Barrel Cost ($50 + $10) (amortized at 5%)	-$10,024	-$14,297	-$19,415	-$24,887	-$31,037
10% Adoption Rate	Potential Showerhead Savings	5.56	7.94	10.78	13.81	17.23
	Potential Faucet (2) Savings	12.98	18.52	25.14	32.23	40.19
	Potential Showerhead Cost (amortized at 5%)	-$455	-$650	-$882	-$1,131	-$1,410
	Potential Faucet (2) Cost (amortized at 5%)	-$117	-$167	-$227	-$290	-$362

Multiple County Water Provider Conservation Savings Projections

Many providers have customers in more than one county. In order to better understand conservation savings goals, the providers' coverages in each county must be summed. In the example below, conservation savings and cost options for Aqua WSC's coverages in the Central Texas counties of Bastrop, Caldwell and Williamson, as well as additional coverages in Lee and Fayette counties are presented (Table 63). Projected water use and portion of necessary conservation savings for Aqua WSC's total customer base for all counties served were calculated, based on TWDB population and water use projections and their corresponding percentages of regional planning group water use and conservation projections.

The calculated water conservation savings necessary to meet state water plan recommendations using the uniform savings distribution scenario ranged between 850.41 AF per year between 2010-2020 to 746.73 AF per year in 2050-2060 and averaged 792.23 AF per year over the 50 year planning period. Table 64 shows potential conservation measures that could contribute to the required savings. Aqua WSC's conservation program currently includes conservation pricing, a leak audit program, a public education program and a part time conservation employee position. A 50% adoption rate for a showerhead rebate or replacement program will potentially yield 2249.73 AF during the 2020-2030 period at a cost of $256,804. Implementing a faucet aerator replacement program utilized by 50% of customers could save 4499.47 AF and cost only $65,994 during the 10 year period. 2026.81 AF could be realized from a 50% adoption rate of a toilet replacement rebate program at a cost of just over $1.6 million. An additional 258.30 AF could be realized from a 10% adoption rate of a rain barrel rebate program. The rebate and administrative cost expenditure for the rain barrels would be approximately $226,093. 10% adoption of outdoor or landscaping watering restrictions could reduce customer use by 258.30 AF during the 2020-2030 period, at a per year amortized administration cost of $19,246.

Table 63: Projected water conservation savings for all counties of service for Aqua WSC (uniform water savings distribution) * All units in Acre Feet

County	Water Use per year 2010-2020	% of Total Co. Water Use	Water Use per year 2020-2030	% of Total Co. Water Use	Water Use per year 2030-2040	% of Total Co. Water Use	Water Use per year 2040-2050	% of Total Co. Water Use	Water Use per year 2050-2060	% of Total Co. Water Use
Bastrop	5,424	0.46	6,547	0.44	7,827	0.43	9,377	0.42	11,326	0.41
savings per year (AF)	**631.62**		**603.16**		**580.82**		**566.66**		**553.72**	
Caldwell	267	0.042	339	0.043	396	0.043	458	0.043	518	0.043
savings per year (AF)	**18.63**		**18.89**		**18.89**		**19.09**		**19.11**	
Fayette	90	0.02	115	0.03	135	0.03	150	0.03	168	0.03
savings per year (AF)	**8.99**		**10.12**		**10.75**		**11.12**		**11.35**	
Lee	443	0.13	494	0.14	532	0.14	567	0.14	596	0.14
savings per year (AF)	**9.76**		**10.01**		**10.12**		**10.23**		**10.25**	
Travis	1088	0.006	1251	0.005	1390	0.005	1484	0.005	1582	0.005
savings per year (AF)	**178.40**		**169.16**		**162.01**		**155.52**		**150.03**	
Williamson	76	0.0010	88	0.0009	103	0.0008	121	0.0008	140	0.0007
savings per year (AF)	**3.01**		**2.65**		**2.46**		**2.36**		**2.28**	
Aqua TOTAL Savings per year (AF)	**850.41**		**813.98**		**785.06**		**764.98**		**746.73**	
Aqua TOTAL Water Use per year (AF)	**7,388.00**		**8,834.00**		**10,383.00**		**12,157.00**		**14,330.00**	

Total Projected Water Demand AF						
County/Region	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
Fayette	3,890	4,417	4,879	5,244	5,751	6,495
Region K	252,637	304,735	352,737	394,101	439,049	484,170
% of Region total	**0.02**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Lee	2,932	3,284	3,572	3,802	4,009	4,207
Region G	347,389	397,090	444,820	491,312	542,172	595,482
% of Region total	**0.008**	**0.008**	**0.008**	**0.008**	**0.007**	**0.007**

Review of Existing Tools

Model outputs for the City of Bastrop Water Utility are shown and compared below using the tool developed in this study and two existing tools. The utility reported a service population of 7,936 individuals and 3 individuals per household. TWDB projections were used in the model developed for this study to estimate water conservation savings and costs over a 50 year planning period and potential conservation savings results are compared for the three models. In this uniform savings distribution calculation summarized in Table 65, the necessary annual water conservations savings target for the 10 year period 2010-2020 is 170.01AF. Implementing showerhead replacement programs with 50% customer adoption rate would yield 244.46 AF of savings between 2010 and 2020, or an average of 24.45 AF per year at a total cost of $23,347 and an average annual cost of $2,335. Faucet aerator/replacements in 50% of households would conserve 977.84 AF per decade or an average or 97.78 AF per year at an average cost of $600 per year. Savings from a toilet replacement/rebate program would yield approximately 220.24 AF per decade or 22 AF annually. The ten year amortized cost of rebating one toilet per household for 50% of customers would be $145,598, an annual cost of $14,560. Rain barrel rebates would conserve an additional 34.08 AF, 3.4 AF per year at a ten year program cost of $102,775 or $10,278 annually. This output does not include savings that would be obtained from the natural rate of replacement for plumbing fixtures or for customers who implement conservation measures without rebates or incentives.

Table 65: Potential water conservation savings for the City Of Bastrop in Acre-Feet

	City of Bastrop, Bastrop Co. Uniform Conservation Savings Scenario					
		2010-2020	2020-2030	2030-2040	2040-2050	2050-2060
	Water Use per Year (AF)	1460	1755	2115	2518	3040
	Savings Goal per Year (AF)	**170.01**	**161.69**	**156.95**	**152.17**	**148.62**
	Population	7,936	12,475	15,920	21,003	25,155
50% Adoption Rate	Potential Showerhead Savings	244.46	384.28	490.40	646.97	774.87
	Potential Faucet (2) Savings	977.84	1537.12	1961.59	2587.90	3099.49
	Potential Toilet Savings	220.24	346.20	441.80	582.87	698.09
	Potential Rain Barrel Savings ($50 rebate)	34.08	53.57	68.36	90.18	108.01
	Potential Showerhead Cost (amortized at 5%)	-$23,347	-$36,700	-$46,835	-$61,789	-$74,004
	Potential Faucet (2) Cost (amortized at 5%)	-$5,995	-$9,424	-$12,027	-$15,867	-$19,003
	Potential Toilet Cost (amortized at 5%)	-$145,598	-$228,872	-$292,076	-$385,331	-$461,506
	Potential Rain Barrel Cost ($50 + $10) (amortized at 5%)	-$102,775	-$161,557	-$206,171	-$271,998	-$325,769

Quantifying the Effectiveness of Various Water Conservation Techniques in Texas (TWDB/GDS 2002)

The cost analysis spreadsheet designed for the Quantifying the Effectiveness of Various Water Conservation Techniques in Texas Study (TWDB/GDS 2002) evaluates water providers' costs of implementing multiple conservation measures. The study and spreadsheets can be accessed on the Texas Water Development Board's website (http://www.twdb.state.tx.us/assistance/conservation/gdsstudy.asp). In the example below, the cost of water conservation measures, including toilet retrofit, shower head and faucet replacement, washing machine rebate, irrigation audits, rainwater collection and rain barrels are calculated for the City of Bastrop (Region K – rural, suburban). One half of Bastrop's population was considered rural and the other half was considered urban. To simplify the calculation, only single family residences were considered. From previously collected data and calculations (Chapter 2), 3 individuals per household and a total population of 7,936 (3,938 individuals and 1,574 meters for each rural and suburban settings) were entered into the study's example spreadsheet (Table 66). The model assumes 38.3 inches per year of rain, 6 months of outdoor watering and 10% of total single family households as "high use – consuming more that 20,000 gal during a 6 month period". It was also assumed that due to the natural rate of replacement 10% of existing customers were already utilizing the conservation measures. Water savings for each replaced or retrofitted fixture were calculated using the 1999 American Water Works Association Research Foundation's Residential End Use Study, which unfortunately is now relatively outdated.

Table 66: Cost analysis spreadsheet data input for rural and suburban Bastrop (TWDB/GDS 2002)

Regional Data	
Population	3,968
SF Population	3,968
MF Population	-
Institutional Population	-
SF Units	1,574
MF Units	-
Average Yearly Rainfall (inches)	38.3
SF Household Size	3.00
No of Irrigation Months	6
% of High Use SF customers	10%

Table 67 below shows values used to estimate savings per person in gallons per day (gpd) per measure (column 1), savings per household in gpd, the number of fixtures or conservation devices per household (column 3), water saved for each measure in gpd (column 4), program costs per measure (column 5), cost per acre foot of water conserved per year at a 5% amortization rate (column 6), and methods of disseminating conservation measures (columns 7 and 8).

Table 67: Values used to calculate water conservation costs and savings for Region K rural and suburban areas (TWDB/GDS 2002)

	Savings per Residential Capita (gpd)	Savings per Living Unit (gpd)	No. of Measures per Living Unit	Savings per Measure (gpd)	Measure Costs	Cost per AF of Water Saved (Amortized)	Standard Delivery Description	Other Delivery Options
Residential	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
SF Toilet Retrofit	10.5	31.5	2.0	15.8	$ 85	$ 342	free or rebate	direct install
SF Showerheads and Aerators	5.5	16.5	2.0	8.3	$ 7	$ 98	kits picked up by customer	door to door distribution or direct install
SF Clothes Washer Rebate	5.6	16.8	1.0	16.8	$ 120	$ 679	rebate from water utility only	joint rebate with energy utility
SF Irrigation Audit-High User	16.7	50.0	1.0	50.0	$ 70	$ 459	staff	hire contractor
SF Rainwater Harvesting	14.0	42.1	1.0	42.1	$ 250	$ 510	rebate	
SF Rain Barrels	1.5	4.6	1.0	4.6	$ 45	$ 848	rebate or distribution	

For the City of Bastrop, total water savings calculations were equivalent for rural and suburban populations. Table 68 displays the water conservation savings and costs for each rural and suburban component. A specific explanation of each column is given in Table 69. Assuming an adoption rate of 50% for toilet retrofits and replacement showerheads and faucet aerators, a 10% adoption rate for washing machine rebates, 5% rate for customers utilizing irrigation audits and installing rainwater collection systems and 30% adoption rates for rain barrels, estimated values are as follows: 41,484 gpd (46.5 acre-feet/yr) of water conserved at an annual per acre-foot cost of $2936 and total program costs of $180,066. These calculations can be doubled to determine total savings for the city (82,968 gpd, 92.9 AF/yr, $5873 per AF cost and $360,131 in program costs). As evidenced with earlier calculations, showerhead and faucet aerator retrofits. Although rain barrels were the second least expensive measure, the model showed the highest price per acre-foot cost. Plumbing related retrofits or replacements have similar life spans to rain barrels, but conserve water on a daily basis while barrels only substitute outdoor water use during periods of rainfall. This model found that rainwater harvesting systems while more expensive than rain barrels, yield lower total cost per AF of water saved due to greater water storage ability.

Table 68: TWDB/GDS 2002 model output for City of Bastrop, rural and suburban areas

Residential	Savings per Residential Capita (gpd)	Savings per Living Unit (gpd)	No. of Measures / Living Unit	Savings per Measure (gpd)	Current Penetration Rate	Potential Penetration Rate	Number of Proposed Measures	Potential Savings for the Region (gpd)	Potential Savings for the Region (acre-ft/yr)	Program Costs per Measure	Total Program Costs	Cost per AF of Water Saved (Amortized)	Standard Delivery Description
	1	2	3	4	5	6	7	8	9	10	11	12	13
SF Toilet Retrofit	10.5	31.5	2.0	15.8	10%	50%	1,259	19,832	22.22	$ 85	$ 107,032	$ 342	free or rebate
SF Showerheads, Aerators	5.5	16.5	2.0	8.3	10%	50%	1,259	10,388	11.64	$ 7	$ 8,814	$ 98	kits picked up by customer
SF Clothes Washer Rebate	5.6	16.8	1.0	16.8	0%	10%	157	2,644	2.96	$ 120	$ 18,888	$ 679	rebate from water utility
SF Irrigation Audit-High User	16.7	50.0	1.0	50.0	1%	5%	63	3,148	3.53	$ 70	$ 4,407	$ 459	staff
SF Rainwater Harvesting	14.0	42.1	1.0	42.1	0%	5%	79	3,317	3.72	$ 250	$ 19,675	$ 510	rebate
SF Rain Barrels	1.5	4.6	1.0	4.6	0%	30%	472	2,154	2.41	$ 45	$ 21,249	$ 848	rebate or distribution
							Totals:	41484.1	46.5	577	180,066	$ 2,936	

Table 69: Descriptions of columns in model outputs -Table 68 (TWDB/GDS 2002)

Column 1 - savings per person in gallons per day (For SF Toilet Retrofits, Showers and Aerators, Clothes Washers. For other measures, Column 1 is calculated by dividing Column 4 by the SF household size using the measure.)
Column 2 - savings per housing unit in gallons per day (Column 3 x Column 4)
Column 3 - the number of measures needed for each living unit
Column 4 - gallons saved per day for each measure
Column 5- the percent of customers that have already implemented this measure
Column 6- the potential number of customers who could be expected to implement the program with substantial marketing and outreach
Column 7- estimated number of measures [(column 6- column 5)*number of SF units]
Column 8- potential savings for the region in gallons per day (column 4 x column 7)
Column 9- potential savings for the region in acre-feet [(column 8*365)/325851]
Column 10 - program costs including rebates, staff time and marketing
Column 11- total program cost (column 7 x column 10)
Column 12 - cost per acre foot of water saved each year [(column 5 x 325,851 gallons/AF) / (column 4 x 365 days)]) amortized at 5% interest over the life of the measure
Column 13 - delivery option(s) for which costs are estimated

Alliance for Water Efficiency's Tool

AWE's Excel-based model was developed to evaluate potential conservation savings, and associated costs and benefits of measures within conservation programs on a water provider or municipal level. The tool and user's guide can be obtained by members with permission via the website, www.allianceforwaterefficiency.org. Utility, demographic and other information is entered into the tool, which, much like the tool developed for this Central Texas study, provides a standardized methodology for calculating water savings and related benefits and costs. The tool can be utilized by water providers in a variety of ways to assist in water resource planning and operations:

- Compare alternative conservation measures in terms of their water savings potential, impact on system costs, and potential benefits to utility customers.
- Develop long-range conservation plans. Construct conservation portfolios containing up to 50 separate conservation program activities.
- Track the implementation, water savings, costs, and benefits of actual conservation activities over time.
- Evaluate a utility's changing revenue requirement with conservation.

Figures 37 and 38 below show output from AWE's model that is, for the most part consistent with the values calculated in this study. AWE's tool shows additional passive savings over time.

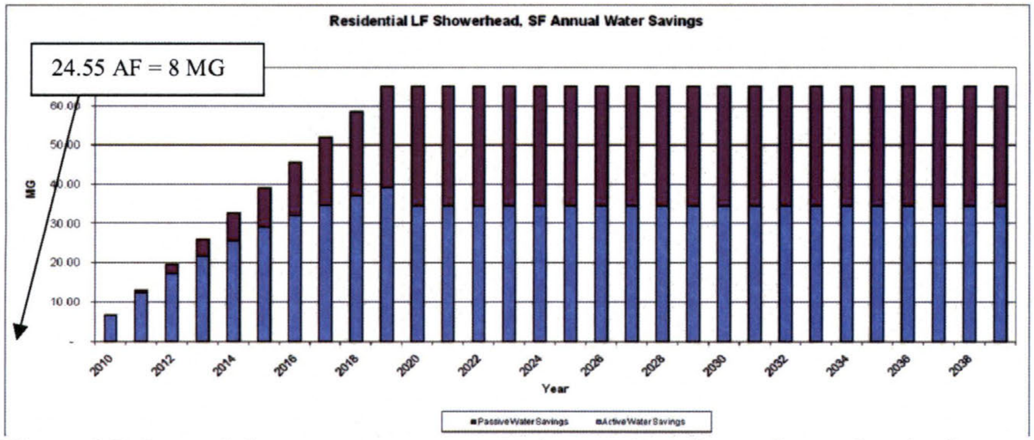

Figure 37: Potential gross water conservation savings from showerhead rebate program for the City of Bastrop Utility (in MG)

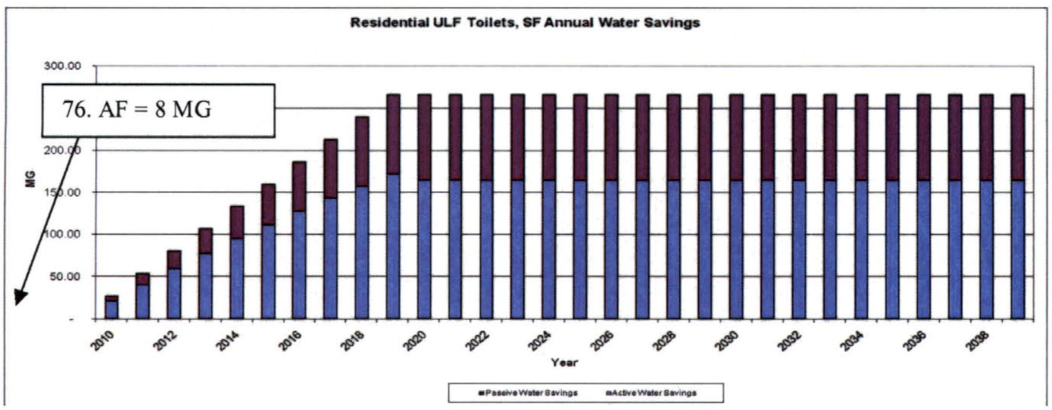

Figure 38: Potential gross water conservation savings from toilet rebate program for the City of Bastrop Utility (in MG)

Although AWE's model does not use faucet aerators as a conservation measure (which could be manually added), the results of all three models show that plumbing retrofit and rebate programs are efficient and cost effective means for increasing conservation savings or reducing per capita use. TWDB/GDS's and AWE's model also assess the efficiency of residential audits, washing machine rebate programs and landscaping measures which were not addressed with the tool developed for this study. However, with identified cost and savings metrics, this tool could easily be modified to include those types of conservation measures. The following two tables (Tables 70, 71) show the calculated outputs or values for the three models as well as the average cost per AF of water conserved. It is clear that faucet aerators and showerhead programs are very cost efficient, but further calculations need to be done to assess the efficacy of toilet and rain barrel rebating programs.

Table 70: Comparison of 3 model outputs

Measure/Cost	AARO Study Calculator	TWDB/GDS Model	AWE Tool
Faucet savings	97.78 AF	Combined w/ showerheads	X
Faucet cost	$600		
Showerhead savings	24.45 AF	11.64 AF	26 AF
Showerhead Cost	$2,335	$8,814	$6,703
Toilet savings	22 AF	22.22 AF	26.59 AF
Toilet cost	$14,560	$107,342	$15,681
Rain Barrel savings	34 AF	2.41AF	X
Rain Barrel cost	$10,278	$21,249	

Table 71: Cost per AF of water saved for 3 model outputs

Measure/Cost	AARO Study Calculator	TWDB/GDS Model	AWE Tool
Faucet	$6	X	X
Showerhead	$96	$98* Showerhead + Faucet	$258
Toilet	$661	$342	$589
Rain Barrel	$302	$848	X

CHAPTER FIVE

RECOMMENDATIONS FOR WATER CONSERVATION POLICY

In view of predicted future water shortages in Texas of up to 9 million acre-feet, due in part to rapid population growth (TWDB 2007; U.S. Department of the Interior 2006), the Texas Water Development Board, U.S. Bureau of Reclamation, and U.S. Department of Interior have called for adoption of water conservation practices to reduce municipal water demands. Unsustainable water withdrawals and potential drought conditions could leave up to 85% of the state's population with unmet water needs, with a cost of over $9 billion dollars by 2010, rising to $98.4 billion by 2060 (TWDB 2006; TWDB 2007).

Although the policy and management recommendations provided in this chapter to reduce water use through conservation are based on information from several sources, including models developed to estimate water conservation savings in the region, existing case studies, relevant literature, and a preliminary evaluation of water conservation programs, government initiatives, regulations and policies in other semi-arid area in the Southwestern United States, they focus primarily on analyses of data collected from Central Texas water providers. Recommendations also were formulated on the basis of the results presented in Chapters 3 and 4.

A major concern of survey respondents was inadequate capacity to determine the efficacy of existing water conservation measures. Although several providers reported some water conservation measures in place, they were unable to effectively calculate the resultant water savings. In addition, some surveyed providers expressed difficulty in measuring changes in water use patterns resulting from rate increases. Another trend among survey respondents was the lack of accurate measurement systems to monitor water leaks and losses. While several larger providers had state–of-the-art audit programs in place (detailed in Chapter 3), many smaller- and medium-sized providers do not have an effective water leak or loss measurement program.

Many water providers in this and other studies (as well as agricultural and ICI water users) commented that it was difficult to locate useful information regarding water conservation best management practices. In fact, there are few, if any, technical/financial guides or public outreach and education curricula for water conservation in Central Texas.

The water conservation recommendations in this chapter are listed for the three water use sectors: (1) Municipal; (2) Industrial/Commercial/Institutional (ICI); and (3) Agricultural, being briefly described for each sector. As described in previous chapters, future municipal water totals are expected to comprise the majority of water supplied, followed by ICI water consumption. In contract, agricultural water allocations are expected to decline in coming years. Thus, the majority of recommendations below refer to the municipal and, to a lesser extent, ICI sectors. An additional section for general recommendations also is included, while specific information regarding conservation measures and best management practices for municipal water providers was presented in Chapter 4.

Policy Recommendations for Municipal Water Conservation

Specific policy recommendations applicable to municipal water users, discussed in more detail in the following section, include the following measures:

1) Standardize methods for measuring and reporting water consumption;
2) Standardize methods and metrics for determining water conservation savings and costs;
3) Mandate components in provider-submitted water conservation plans;
4) Adopt and implement statewide water conservation incentives;
5) Develop useful literature/products for preparing water conservation plans;
6) Develop enhanced public education curricula development, by region;
7) Implement more strenuous leak audit and measurement programs and reporting, including provisions for low-cost (subsidized) leak-detection services, especially for smaller providers;
8) Increase communication between providers and regulatory entities via Internet reporting, etc.

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1) *Standardize methods for measuring and reporting water consumption*

Specific gpcd categories would facilitate more accurate reporting practices. There currently is no standard for measuring and reporting gpcd, resulting in different municipalities measuring consumption in a different manner. This reality makes direct comparisons and aggregated water savings estimates very difficult. Water consumption measurements should first be organized and reported by category, with protocols or standards for each, including the same time periods for peak, non-peak and seasonal water use, as follows:

- Residential gpcd (single family and multi-family);
- Institutional categories (customer connections using majority of water for municipal type needs).

Overall commercial and industrial water use must be excluded from gpcd calculations. The practice of some water providers in calculating total or overall gpcd by dividing aggregated total water use by the estimated service population should be discontinued, since it results in inaccurate per capita water consumption rates. For Williamson County, for example, the average gpcd can vary by as much as 163.79 gallons (i.e., 229.27 reported for Leander versus 65.43 reported for Block House MUD) because of different water measurement practices.

Separate measurement and reporting of water losses and leakage will further increase accuracy in all water sales and use categories. Lost or leaked water is often aggregated with total water use, and subsequently considered in per capita measurements. Although practiced by several Central Texas Water Providers, the inclusion of non-salable and non-billable water quantities (including hydrant use and line flushing) in GPCD calculations should not be continued. Guidelines for accurately measuring population & household information also will increase gpcd measurement accuracy. Using a single source for population or household data (e.g., US census data, or a specific set of equations based on area type [rural, suburban, urban] for calculating household inhabitation) will allow for standardized calculations. Recent studies have classified water service areas as rural, suburban and urban, all of which tend to have different household sizes and corresponding gpcd averages. Specific classification criteria are described in Chapter Two, with the results of different gpcd values by area types being provided in Chapter 3.

2) *Standardize methods and metrics for determining conservation savings and costs*

Two major impediments to accurately measuring conservation savings include: (i) lack of accurate information regarding achievable water savings per conservation measure; and (ii) difficulties in estimating customer participation rates.

Adoption of standard water conservation savings values based on existing studies will allow water providers to estimate and compare savings from specific conservation practices. Average values for several types of water conservation devices and practices are provided in Chapter 1, with examples of calculated water savings being presented in Chapters 3 and 4. These values should be revisited with the publication of the newest versions of Vickers' Conservation Handbook in 2011.

Historically, water providers have had difficulty determining participation levels in various water conservation programs. As specific best management practices become mandatory, however, it will become easier to track customer use rates. For example, if 1.6 gallon (high efficiency) flush toilets are mandatory in new construction, and also required in home sales retrofits, the participation rate should approach 100% over time. As plumbing devices "wear out" over time and become less effective (or in some cases being used incorrectly), it is acceptable to assume participation rates of 80%. Average participation rates found in various water conservation program studies are discussed in Chapter Two, and in the 2002 study of the Texas Water Development Board (TWDB/GDS 2002), and may be used as proxies for participation rates for selected conservation measures. Some conservation practice participation rates are much more difficult to measure, requiring development of a tracking protocol. Installation of rainwater collection and graywater systems, for example, may be difficult to assess in cases where rebates are not offered. When rebates are offered, or products are sold at cost, detailed records will allow providers to estimate water conservation savings over the life of the conservation installation (i.e., toilet, rain barrel, etc), utilizing standardized measurements for the number of household residents, average water and fixture usage, rainfall rates, etc). Methods for expanding participation, as well as enhancing record keeping, include adoption of mandatory and incentivized measures. For mandatory measures (e.g., plumbing retrofits in new construction and existing home sales), participation rates can be tracked through recorded home sales. Participation rates also can be tracked through incentivized measures programs, because the participation of individual users or providers utilizing rebates and other incentives can be recorded.

3) ***Mandate components in provider-submitted conservation plans***

Increase plumbing efficiency standards

It is recommended that water providers be required to adopt or exceed determined plumbing standards. Although national plumbing standards are approved by the American National Standards Institute, they are mostly voluntary. The American Society of Mechanical Engineers (ASME), and the International Association of Plumbing and Mechanical Officials (IAPMO), accredited through the American National Standards Institute (ANSI), establish national standards for plumbing fixtures and fittings. ASME and IAPMO committees maintain voluntary efficiency standards related to toilets, urinals, showerheads, faucets, pre-rinse spray valves, and other plumbing fixtures and fittings. California recently adopted and amended regulations requiring increased efficiency toilets (1.28 gallon toilets) for all municipal and commercial properties before certificates of occupancy can be issued (California SB 407). This essentially means more strenuous standards will be in effect for plumbing fixtures in new construction, while sales of existing structures will require retrofits and upgrades of plumbing fixtures to meet the new standards. Other states and municipalities are considering similar legislation or regulations to require adherence to higher efficiency plumbing standards in new construction.

Requirement of these increased standards and high efficiency fixtures in all new construction, remodels or sales retrofits in Central Texas could potentially save millions of gallons of water annually, and could be facilitated with an incentive-based approach. Installing high efficiency (water and energy) components in new construction is not significantly more expensive than traditional construction, especially as available fixtures and fittings begin to meet national plumbing standards. Certain fees, including construction permits, initial tax payments and licensing fees, could be reduced or waived to incentivize the use of efficient fixtures in new construction. Incentives such as tax credits and rebates also could be offered to offset the costs of retrofitting existing residential and commercial properties at the time of their resale. The costs of such credits or rebates would themselves be offset by the realized water savings resulting from the increased use efficiencies. Again, as with new construction, national standards dictate available fixtures and fittings for retrofitting, ensuring increased water efficiency in properties with older, less efficient plumbing fixtures.

As detailed in Chapter 3, one small Central Texas city enacted a policy requiring all new residential and commercial construction to include graywater systems. Although it would be difficult to enact such policies on a large scale, it may be possible to incentivize certain types or categories of new construction to utilize graywater systems. Residential homes built on acreage, residential multi-unit buildings and certain industrial buildings, for example, are more conducive to installation of graywater systems with minimal public health risks, and their collective water savings can be substantial.

Implement landscape irrigation standards for new development

Studies have shown that at least 15-20% of outdoor landscape irrigation water is wasted, often due to poorly designed, installed or maintained irrigation systems. In 2007, the Texas Legislature passed HB4, SB3 and HB1656, directing the Texas Commission on Environmental Quality (TCEQ) to develop water efficient irrigation standards for the design, installation and operations of in-ground automatic irrigation systems. The TCEQ delegated the implementation of these standards to cities with populations over 20,000, and gave water districts such as the LCRA the ability to adopt and enforce TCEQ rules. The legislation also allows cities and water districts to collect a fee to cover the costs, so that no additional financial burden is placed on the utility. (This section developed in collaboration with Nora Mularky, LCRA).

Limit irrigated landscape for new construction

Limiting total irrigated landscaped area to no more than 2.5 times the footprint of the home, or a 12,000 sq. foot maximum, will reduce water use for irrigation by hundreds of thousands of gallons of water annually. LCRA expects lower average GPCD rates for customers in new developments that have incorporated limits on residential spray irrigation to 2.5 times the foundation footprint, with a 12,000 sq foot maximum into their deed restrictions. Similarly, the City of San Antonio recently passed residential n ordinance limiting newly installed irrigation systems to no more than 10,000 sq feet. (This section developed in collaboration with Nora Mularky, LCRA).

Require minimum soil depth standards, where applicable

Six to eight inches of topsoil is the minimum depth necessary to support healthy turf clay based sub-soil. In some areas of Central Texas, particularly west of the I35 corridor, shallow soils are prevalent. Requiring newly constructed homes in these areas to have an adequate depth of quality soil increases the ability of lawns to be more drought tolerant and retain moisture, reducing watering requirements. (This section developed in collaboration with Nora Mularky, LCRA).

Require program reductions for water providers with excessive gpcd values

It has been found that small mandatory reductions in per capita use can be relatively effective. Annual reductions of 1-2% of gpcd and total use over long-term (10 -15 yr) planning horizons have successfully equated to total reductions of 10-25% in both per capita and total usage, even in the face of population growth (personal communication with Val Little and Amy Vickers; Nov 9, 2009). Several Central Texas water providers have already voluntarily implemented, and are achieving, similar goals. With a better understanding of what suites of water conservation measures and best management practices are most effective, such goals become increasingly realistic, therefore more likely to be achieved via implementation of water conservation programs. Such incentives as reduced rate loans, or grants for infrastructure repair, or education/outreach programs, might possibly increase the adoption of annual per capita reductions. Water providers are currently required to report water conservation savings goals, although they often have no way to measure how the reductions occurred, and are not required to achieve the reduction goals. For providers with excessively high gpcd rates (i.e., rates more than 30% above average for the area type, county, size, etc), it is recommended that technical support be provided to help establish and achieve water use reduction goals.

Establish minimum rates and conservation pricing requirements

A fairly strong correlation between the strength of conservation pricing and per capita water consumption has been reported for several water conservation studies, including this present study. More advanced and accurate pricing objective tools and models are becoming available to water providers and managers, including a pricing objective matrix from Malcom Pirnie Consulting (Pirnie 2010), which forecasts revenue and water use changes achievable with various pricing schemes. The objective is to maximize water savings and conservation behaviors, while at the same time minimizing revenue losses. Economic research has demonstrated that setting pricing tiers, with elevated price levels for disproportionately high water users, tends to offset revenue losses from reductions realized by raising general use tiers. This approach already is practiced by some providers in Central Texas, including the city of Round Rock.

Establishing minimum rates and water conservation pricing tiers on a regional or state level would encourage conservation at the user level, while also maintaining critical revenue for water providers without financially burdening low-income customers. It would likely be necessary to account for provider and customer types and locations when setting the water pricing requirements. Sewer fees may be incorporated into pricing schemes for urban areas, for example, while rural residential users may not utilize sewer systems, and may have higher water use patterns attributable to small scale irrigation and livestock watering.

Establish regional or statewide seasonal watering requirements and permanent outdoor watering restrictions

Outdoor water usage in Central Texas constitutes a large percentage of total residential water use, as well as a considerable portion of commercial consumption. It is the water usage category, therefore, that can yield the most significant water conservation savings. Recent outdoor watering restrictions resulting from drought conditions in Central Texas were extremely successful at lowering peak water usage. Accordingly, it is recommended that a standard, year-round outdoor water use restriction be implemented, as is currently done by the city of Austin, that implements a 2 day per week outdoor watering schedule throughout the year. Many Central Texas municipalities currently have similar watering restrictions in their drought contingency and conservation plans, although not all have the same regulations, schedules and enforcement policies, nor do their wholesale customers. "Across the board" outdoor water use regulations, including year-round watering schedules, would allow greater regional water stability during peak water demand periods, potentially reducing overall residential and ICI use by a large percentage. It is further recommended that state, county, regional planning groups and river authorities require neighborhood associations to defer to their provider's watering restrictions during drought emergencies.

New research demonstrates that automated sprinklers and timers are very wasteful, using up to 50% more water than manual systems or hand watering. Based on these findings, policies that discourage or prohibit future installation of automated irrigation systems are also recommended. A more effective approach would perhaps be to utilize methods similar to the San Antonio Water System's consumer audit program, which identifies and assists customers with high water usage patterns to reduce their consumption through more efficient use of outdoor watering fixtures and systems.

4) ***Adopt statewide conservation incentives***

Municipalities, cities, states and other regulatory powers across the country, particularly the Southwest, are beginning to offer tax incentives for graywater and rainwater collection system installations, landscape conversion, and even plumbing retrofits or high efficiency plumbing fixtures in new construction. For example, the state of Arizona gives regulatory tax credits for home builders and home owners that install graywater systems or rainwater collection systems. In addition to rebates for installing conservation devices and systems, tax incentives are proving to be effective motivators for municipal and ICI customers. With potential future water shortages estimated to cost billions of dollars, tax incentives may prove a financially viable method of reducing water consumption. Tax breaks also may be a preferable alternative to rebates, the latter requiring cash payments to participants.

Several Central Texas water providers, as well as other providers nationwide, offer financial rebates for installing conservation devices and systems. Locally, these providers tend to fall into larger city and municipality categories. Private providers currently have little incentive to provide rebates, while smaller public providers lack the financial resources to provide rebate programs. Statewide rebate programs are likely to reach more customers, and will provide for easier record keeping and tracking of participation rates, as well as equalizing the per unit costs of water savings.

5) *Develop useful literature/products for preparing conservation plans*

The TWDB and local River Authorities provide sample conservation and drought contingency plans, and the TWDB has published several water conservation best management practices documents. Little literature is available (or widely distributed), however, to assist in the formulation of a water conservation management plan with realistic consumption reductions and leak/loss reduction goals. It would be very useful to have a collection of documents and a "tool box," available to water providers, containing useful information for developing and implementing water conservation goals and successful management strategies. In fact, a collection of useful information and data has been compiled in this study (Appendix C), and could be used as a base for expansion of water conservation information.

6) *Develop enhanced public education curricula development by region*

It has been demonstrated that water providers with public education programs have lower average water consumption rates. Water conservation and marketing experts are recommending innovative techniques for public education programs, emphasizing community-based social marketing (Sarah Katz 2009). Successful public education programs targeted to increased public awareness have the greatest potential for lowering outdoor water usage, and increasing other water conservation-based behaviors. Several educational information sources currently exist (e.g., Water IQ), although very little of the available resources are region-specific, nor do they provide guidance for developing public education programs. Developing such curricula with a regional emphasis encompassing local hydrologic and community information will facilitate the ability of water providers to implement successful public education programs. This may be especially beneficial to smaller providers with limited financial and personnel resources. It also is recommended that education components be developed for ICI water customers, focusing on implementation of conservation activities, explanations of rules and regulations, and tools for determining water and cost savings.

7) *Implement more strenuous leak audit and measurement programs and reporting*

As noted in Chapter 1, between 212,221 to 464,219 acre-feet (0.262 to 0.573 km^3) of water is lost to leaks or unmetered usage each year, equating to between 5.6 - 12.3% of the total volume of water abstracted for human uses in Texas (TWDB/GDS 2006; TWDB 2007). In these latter TWDB studies, some water providers reported water losses, due primarily to leakage, exceeded 25% of their total water supplies. Many providers also reported they do not calculate the percentage of water lost to leakage. Since leak and water loss management may be a very effective supply side conservation practice, it is imperative to require more stringent minimum auditing and measurement requirements, as well as maximum leakage standards. Timely reporting of leakage and loss information will allow for a more accurate assessment of infrastructure needs, including assistance with infrastructure repairs. Prior to establishing maximum leakage/loss requirements, current statewide and regional trends should be carefully examined, including audit systems currently in place, availability of detection equipment, and financial constraints. It is possible that leakage/loss requirements should vary on the basis of size, location and age of water providers.

The Texas Water Development Board (TWDB) offers low and no-interest loans for infrastructure repair. It is not always easy, however, for small providers to: (i) obtain information regarding loans: (ii) meet the qualifications for such loans; or (iii) afford major leak repairs and infrastructure repairs, even with loan assistance. Accordingly, state assistance with leak auditing, identification and repair, in the form of grants or equipment cost-share programs, may significantly increase the ability of small and rural water providers to minimize water losses from leakage. Low or no-cost loans for leak detection and repair equipment for groups or "co-ops" of rural providers, for example, would enable each provider to perform more frequent leak audits and make necessary repairs, while sharing the financial burden for equipment purchase and upkeep costs. The TWDB does offer training and the ability to borrow leak detection equipment. For providers who do not own equipment or contract leak audit services, the Water Development Board might require training and loan services to be utilized on an annual basis.

As technology improves, more intensive leak auditing is available at a much-lower price. The city of El Paso (EPWU), for example, has installed state of the art "leakage meters" that provide real-time reports to water managers, including alerts for possible leaks. These meters reduce the manpower hours required to physically inspect for leaks, allowing personnel to instead focus on repairing them. EPWU's goal is to eventually reduce total water leakage below 7%, and considering the revenue from the additional available water, and reallocation of personnel hours, it is likely this leakage detection and monitoring program will pay for itself in just a few years. Offering incentives and purchasing assistance (loans, grants) would enable providers to purchase such meters, allowing for significant water leakage loss reductions.

8) ***Increase communication between providers and regulatory entities via internet reporting, etc.***

Although increased reporting requirements and frequencies for retail and wholesale water customers/providers would initially be burdensome to both the water provider and the state (or other regulatory entity), the development of a web-based reporting application or platform could have far-reaching benefits. If water providers reported conservation saving estimates, water usage and leakage/loss rates in real time (or at least more than once per year), and the results were available in a digital format, statewide and regional analyses of trends would be much more accurate, including water availability projections and conservation savings, thereby allowing for increased utility (e.g., report generation). Further, increased reporting requirements would effectively improve management efforts, potentially allowing water provider managers to access their reported data in a digital format, including report generation, tracking of progress toward goals, and statewide or regional comparison information. This also would increase the reliability of water shortage and demand estimates calculated by the TWDB, especially during times of drought and peak water use.

<u>Use Advanced Metering Infrastructure (AMI) technology to access real-time water use information</u>

AMI technologies adopted in other regions have resulted in increased customer service quality and improvements in system reliability. By obtaining recording water use in frequent intervals, utilities can notify customers when consumption patterns change or are higher than normal, thus enabling customers to monitor their consumption in a nearly real-time environment and allowing utilities to help track and manage nonrevenue generating water losses. (This section developed in collaboration with Nora Mularky, LCRA).

Policy Recommendations for Industrial/Commercial/Institutional (ICI) Conservation

Specific policy recommendations applicable to ICI water users include the following measures:

1) Standardize methods for measuring water usage and for determining conservation savings and costs;
2) Standardize reporting procedures;
3) Develop useful literature/products for preparing conservation plans;
4) Establish requirements and standards for irrigation and recycled / re-use water sources;
5) Increase access to reclaimed water supplies where relevant infrastructure exists.

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1) ***Standardize methods for measuring usage and for determining conservation savings and costs***

As with municipal water uses, establishing industrial/commercial/institutional (ICI) water user categories will allow more accurate estimations of water consumption. Examples of specific ICI reporting categories include schools, medical facilities, laundromats, car washes, office/retail convenience and grocery stores, restaurants, manufacturing (several categories within manufacturing), technological/computer component fabrication and others, each with distinct water needs, use patterns, and potential best management practices. Establishing ICI water-use categories, based on water use size, type and percentages (cooling, processing, rinsing, municipal needs) will also highlight potential conservation savings, allowing for more in-depth analyses of water use (See Appendix B). The city of Austin commercial and industrial customers, for example, utilize over 11 million gpd on industrial processes, over 5 million gpd in office buildings, nearly 1 million gpd on irrigation, and nearly 2 million gpd each for health care facilities, schools, and restaurants/bars, each category having distinct water conservation opportunities.

Water loss/leakage and recycled water use are also important components to measure, since they each exhibit great water savings potential. Requiring maximum allowable rates for water losses, leakage and evaporation will increase water-use efficiency, as will formulation of conservation goals for large ICI customers (through guided audits). Keeping pace with municipal practices, ICI conservation savings can be standardized on the basis of existing studies. An upcoming publication is expected to provide detailed water savings and cost potentials for ICI water conservation and best management practices (Vickers 2011).

Excluding commercial and industrial water use from gpcd calculations is also essential for accurate record keeping, including discontinuing the practice of calculating gpcd by the dividing total water use by the estimated population.

2) ***Standardize reporting procedures***

In addition to water providers increasing the accuracy of municipal water use data, it also is important to define relevant use categories for ICI water users, in terms of user type and specific customer uses, including water leakage and loss. To this end, industrial water use and conservation savings categories and measurements are suggested in Appendix B. Standards should be used internally by ICI customers to establish water conservation plans and meet conservation goals. Many commercial water users stated they did not have water conservation goals or plans in place, and were subject to little-to-no reporting requirements, other than those associated with discharge and chemicals. Improved knowledge of ICI water used could lead to development (and recommendations) of more efficient best management practices and greater water conservation savings.

3) ***Develop useful literature/products for preparing conservation plans***

There is sparse practical literature on water conservation planning, pricing, expected savings and implementation for ICI water users. Several ICI water users stated an interest in products to help them with internal auditing and planning, including simple models. Guidelines for installation, expected financial costs and water savings for waterless or high efficiency toilets and urinals, for example, as well as rainwater and condensate collection for toilet flush use, would likely increase the willingness of ICI water users to consider such measures. Several interviewed ICI managers stated they often do not explore conservation measure because of a lack of access to specific cost and implementation information. The existing studies compiled during this project are available in Appendices D and E.

4) *Establish requirements, standards for irrigation and recycled / re-use water sources*

Several municipalities and related regulatory entities across the country have instituted ICI water recycling and reuse requirements. Cooling towers and cleaning processing/equipment, for example, can often be retrofitted to reuse water for at least one additional cycle, while water that has not been exposed to significant chemicals can be used for lawn irrigation. One city in Arizona now requires that a minimum of 50% of lawn irrigation water come from water reuse or recycle sources. Several other cities throughout the Southwestern United States, including Austin, Texas, have implemented restrictions on the extent of irrigable lawns of ICI customers. Reviewing data collected from water users and providers could provide potential re-use and recycling best management practices. Recommendations could include requiring 50% of ICI outdoor watering/irrigating to be from rainwater, recycled, re-use or graywater sources. Water use audits recommended by the TWDB may also highlight water use practices that could be implemented to reduce water consumption, with the successful adoption of these practices being incentivized with rebates, tax credits, reduced permit fees, etc.

5) *Increase access to reclaimed water supplies where infrastructure exists*

Although implementing infrastructure for distributing reuse water can be costly, significant water savings can be realized in cases where infrastructure is, or can be, efficiently installed. The University of Texas, for example, collects over 130,000 gpd of condensate, sump pump and other similar excess water by-products. This water can be used in cooling towers, irrigation and other processes. In other cases, condensate water collection has been used for flushing toilets, foundation watering, and industrial processes not requiring potable water. Offering incentives or regulations for ICI customers to utuilize reclaimed water could be a cost-effective means of conserving water supplies.

Policy Recommendations for Agricultural Water Conservation

Specific policy recommendations applicable to agricultural water users include the following measures:

1) Require on-farm audits for permitted water users/irrigators;
2) Distribute water conservation information and technical assistance;
3) Provide incentives for alternative crops; land management/brush control.

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1) *Require on-farm audits for permitted water users/irrigators*

Although many farms and agricultural producers already utilize irrigation audits from NRCS and other agencies, requiring audits every 2-5 years could significantly improve water use efficiency and reduce water leakage and loss (underground, surface level and evaporative). It also would identify wasteful water practices to be addressed. As with ICI customers, water use data collected from on-farm audits can provide useful information and data, as well as refinement of best management conservation practices.

2) *Distribute conservation information and technical assistance*

As with other water use sectors, the dissemination and availability of information and planning tools would likely increase participation/adoption rates for water conservation practices, ultimately resulting in water savings. Recent studies (e.g., Texas A&M's Agri-Life; Texas Water Resources Institute) in other areas of Texas, and requests for project proposals by the Texas Water Development Board, highlight the need for distributing information regarding water conservation technology and best management practices.

3) *Provide incentives for alternative crops, land management/brush control*

Future reductions in permitted water for agricultural use will require implementation of best management practices, including a transition to less water-intensive or alternative crops, as well as land management techniques that improve water efficiency. Providing incentives for implementing water saving activities will potentially yield a net water savings, while also protecting smaller producers from revenue losses. Examples of agricultural best management practices for water conservation are provided in Appendix A.

Additional Recommendations Regarding Water Conservation

In addition to the specific recommendations highlighted above for the three major water use categories, several general recommendations appear to be applicable for all three categories. These additional general recommendations are summarized as follows:

• Increase Overall Water System Efficiency -- Recent research has highlighted relationships between energy efficiency and water conservation. In fact, critical linkages between energy efficiency and water efficiency are often overlooked and undervalued. Regulations and incentives aimed at overall system efficiency (at treatment and delivery levels), therefore, will effectively increase water savings, reduce energy use, and positively affect overall costs for both resources.

• Coordinate Water Conservation Regulations -- Enforcement of restrictions and water conservation or efficiency policies often occurs at the local, city and municipality level, frequently being uncoordinated. Enforcing water conservation regulations and watering restrictions may be a key factor in reducing overall water consumption, and ensuring high customer participation rates. For policies implemented at the state level, local enforcement may be more coordinated, and violators may perceive greater disincentives associated with statewide regulations. Incorporating monitoring and enforcement information into water conservation and public education programs may also reduce violations, increasing participation in water conservation activities.

- Consider Water Conservation Pilot Programs as Guidance -- Water conservation studies have suggested it may be beneficial to employ pilot programs before region or statewide implementation of conservation recommendations and regulations. Small-scale implementation or review of current programs will provide insight and potential adaptive strategies for larger-scale regional or statewide programs, as will the utilization of tools, such as those referenced in Chapter 4.

- Reduce Water Usage to Maximum Extent -- A new federal initiative has been promoted to reduce water use by 16% in all federal facilities and buildings (Presidential Executive order 13423). Similar state or regional mandates would not only facilitate achievement of significant water savings, but could also increase awareness of water conservation issues.

Appendix A

Agricultural Water Conservation Best Management Practices for Central Texas

In parts of Central Texas (Regions K and L), irrigation water comprises over 20% of total water expenditures and by 2030 projected agricultural unmet water demands will outnumber unmet municipal demands by more than three hundred percent in Central Texas (TWDB 2005, 2006) due to changes in water allocation. Due to economic and environmental limitations, supply augmentation is not feasible. Conservation and reuse of irrigation water appear to be more appropriate solutions and could include best management practices such as lining of irrigation canals or replacement with pipelines, drip irrigation techniques and the reuse of municipal and/or agricultural waste water for direct irrigation (Dzurik 2003). Such conservation practices for agricultural irrigation water in Texas are identified by the TWDB's Water Conservation Implementation Task Force (TWDB & TSSWCB 2006). Due to the Central Texas region's unique climate and variety of soil types, only a handful of conservation measures are applicable, but if implemented, stand to save thousands of acre-feet of water each year.

Irrigation Scheduling

Irrigation scheduling establishes the time of application, duration and quantity of water applied to a crop based on the moisture present in the crop root zone and the amount of water consumed by the crop since the last irrigation. Managing irrigation schedules requires tracking soil moisture in conjunction with potential evapotranspiration data referenced to a specific crop and local weather conditions, and can minimize unnecessary watering and maximize crop yields per unit of water TWDB 2005). Soil moisture can be monitored using several types of measuring devices, ranging from low-tech, inexpensive devices to neutron probes.

Gypsum blocks utilize electrical conductivity to measure soil water tension. First used as early as the 1940's, gypsum block can be read manually with a hand held reading device. The blocks are commonly employed and are relatively inexpensive (less than $20 each) and have a very low per measurement point cost. However, they do not have a very long life span, and in certain soil types and weather conditions gypsum blocks may require frequent calibration or annual replacement (SOWACS website - http://www.sowacs.com/archives/98-02/msg00000.html; TWDB 2005).

Gypsum blocks – courtesy of Iowa State University – University Extension

Tensiometers also measure water tension but do not require calibration and can be reused, having a much longer life span than gypsum blocks Muñoz-Carpena and Dukes, no date). Their effectiveness is limited by soil type (ineffective in some coarse sand and dense clay soils) and they require maintenance throughout the growing season. They can give readings that are falsely high, allowing for more irrigation than necessary. Granular matrix sensors also measure water tension, but are typically more accurate than gypsum blocks and tensiometers (Shock et al. 2005). They tend to require less calibration than gypsum blocks but can require maintenance if the soil becomes too dry. In addition, granular matrix sensor technology reduces the problems inherent in gypsum blocks (slow response time and dissolution of the block) by using a mostly insoluble granular fill material held in a fabric tube supported in a metal or plastic screen (Shock et al. 2005). Data from granular matrix sensors can be captured and plotted over time, to establish future irrigating patterns (Muñoz-Carpena and Dukes, no date).

Capacitance or frequency domain (FD) probes estimate the water/moisture content by measuring related soil electrical properties. Probes usually consist of two or more electrodes (i.e., plates, rods, or metal rings around a cylinder) that are inserted into the soil. On the ring configuration the probe is introduced into an access tube installed in the field. When connecting this capacitor (made of metal plates or rods imbedded in the soil) together with an oscillator to form an electrical circuit, changes in soil moisture can be detected by changes in the circuit operating frequency (University of Florida UF/IFAS website http://vfd.ifas.ufl.edu/gainesville/irrigation/capacitance_probe.shtml).

They do require calibration before use and must be placed carefully to avoid air pockets which can skew soil moisture measurements.

In recent years, the neutron probe, also called the neutron moisture meter, has become a popular soil moisture measurement tool for larger farming operations, due to its high level of accuracy. Unlike gypsum blocks, granular matrix sensors and FD probes, neutron moisture meters are not hindered by temperature, barometric pressure and other environmental factors (http://sanangelo.tamu.edu/agronomy/sorghum/neutron.htm.) The neutron moisture meter consists of two main components, a probe and a gauge. The probe contains a source of fast neutrons, and the gauge monitors the flux of slow neutrons scattered by the soil. In using the neutron meter, a cased hole in the ground is necessary for lowering the probe to obtain readings. The neutron probe must be calibrated prior to use (for soil type), as well as in depth training in radiation safety and licensure to handle 'the low level radioactive neutron source". Because of these requirements the probe is not typically utilized for soil moisture "monitoring and irrigation scheduling" by individual farms, but instead by government agencies and consultants.

Neutron Moisture Meter – courtesy of Texas A&M University (San Angelo)

Irrigation scheduling is based on temperature, precipitation, humidity and evapotranspiration rates (evapotranspiration is the sum of water lost through transpiration of a plant and evaporation). Weather information and evapotranspiration rates are collected and distributed via local water/agriculture districts, weather centers, universities, government agencies and private software/service companies. Irrigation scheduling programs can be used to determine the best time and duration for irrigation applications by linking to the irrigation system's flow control valves to release irrigation water only when necessary (TWDB 2005). Texas A&M's Agricultural program provides no-cost software for irrigation scheduling.

Soil surveys contain information about soil types, permeability and available water capacity, all of which are factors involved in determining soil capacity. Plants differ in their ability to withdraw water from soils, their water use rate, and their ability to withstand soil water stress. When the moisture content in the soil declines to a certain point, plants begin to irreversibly wilt (permanent wilting point). Each crop and/or crop variety will have a different PWP which must be determined. Plants can be allowed to deplete a certain pre-selected percentage of the PAW before irrigating again (TWDB 2005). Determining the root depth of the crop planted and the corresponding soil moisture capacity allows for planning of irrigation amounts and frequencies and can prevent overwatering/irrigating. Estimation of soils' capacity to hold moisture can prevent overwatering/irrigating and is an important part of an irrigation program (Shock et al. 2005). Soil surveys for each county in Texas counties are available via the Natural Resources Conservation Service (http://www.tx.nrcs.usda.gov/soil/index.html).

Volumetric Measurement of Irrigation Water Use The volumetric measurement of irrigation water use provides the water user with information needed to assess the performance of an irrigation system and better manage an irrigated crop. There are numerous types of volumetric measurement systems or methods that can be used to either directly measure the amount of irrigation water used or to estimate the amount of water from secondary information such as energy use, irrigation system design, or mechanical components of the irrigation system (Gerston et al. 2002; TWDB 2001). Direct measurement methods usually require either the installation of a flow meter or the periodic manual measurements of flow. Indirect measurement methods estimate the volume of water used for irrigation from the amount of energy used, irrigation equipment operating or design information, irrigation water pressure, or other information. Indirect measurements require the correlation of energy use, water pressure, system design specifications, or other parameters to the amount of water used during the irrigation or to the flow rate of the irrigation system when irrigation is occurring.

Similar to an audit, the practice itself does not actually conserve water, but instead gives the irrigator information about water associated costs. Information gained from volumetric measurement allows the irrigator to recognize where implementing management practices and conservation measures will be the most effective.

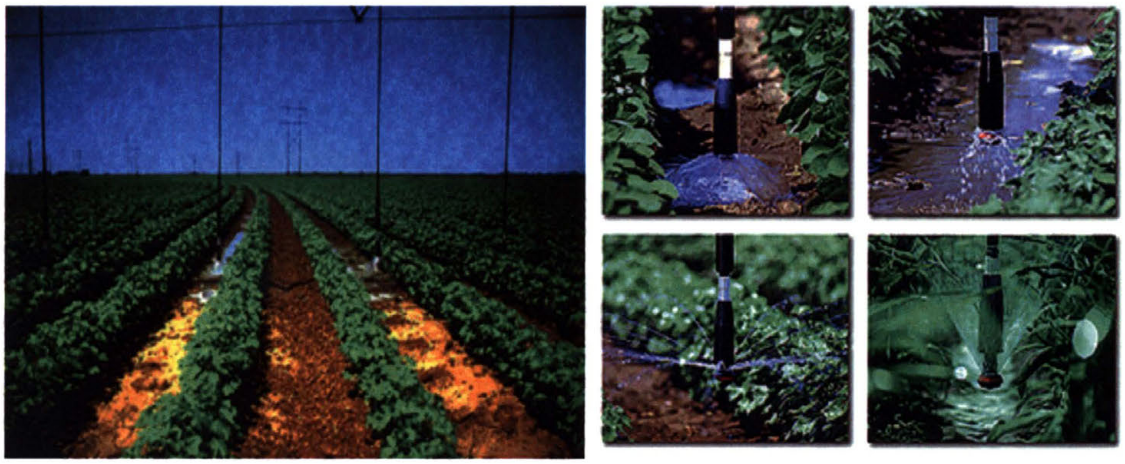
Low Pressure Center Pivot Sprinkler Irrigation Systems

Low Elevation Spray Application (LESA) irrigation systems distribute water directly to furrows at low pressure (6-10 psi) through sprinklers positioned at 12-18 inches above ground level. Conventional high pressure sprinkler irrigation systems pray 5-7 ft above the ground, so they are susceptible to spray evaporation and wind drift, causing high water loss and uneven distribution. LESA systems apply water in streams rather than fine mists to eliminate wind drift and to reduce spray evaporation, deep percolation and under watering. (TWDB 2001). Low Energy Precision Application (LEPA) irrigation systems further reduce evaporation by applying water in bubble patterns or by using drag hoses or drag socks to deliver water directly to the furrow. LEPA irrigation can be up to 20-40% more efficient that traditional sprinkler and furrow irrigation. In addition, the expenses of installing or converting existing irrigation systems to LEPA systems can be offset in approximately 6 years via reductions in energy costs (between 35-50%), significantly reduced labor costs (up to 75%), decreases water quantities and increased crop yields (TWDB & TSSWCB 2006).

LEPA and LESA systems concentrate water on a smaller area and increase the water application rate on the area covered. The application rate must be monitored closely to follow the soil intake curve, and furrow diking should be used to prevent runoff. These irrigation systems yield approximately 40% reductions of both electricity and water, compared to traditional irrigation methods (The National Renewable Energy Laboratory 2001). Additional benefits of LESA and LEPA systems include reduced fuel consumption, lower operating costs, easier application of chemicals and reduced wetting of leaves and foliage which reduce opportunities for disease. Both lateral move (side roll) and center pivot systems can be readily converted to LEPA.

As with rainwater harvesting, adoption of LEPA/LESA methods could potentially generate significant reductions in total water use and requirements for maximum system capacity, especially in the spring and summer months when peak municipal usage coincides with peak agricultural water use. The implementation of LEPA/LESA practices can potentially reduce per acre water requirements by 20 percent (using 2000 Region L water rates). Calculations show that the implementation of LEPA practices and furrow dikes would be feasible on 75 percent of irrigated acreage in Region L, and that at a cost of $113/acre feet/yr, 23,074 acre feet/yr of water savings could be achieved. (TWDB 2006).

LEPA – courtesy of Senniger Irrigation Inc., Clermont, FL



Drip/Micro-Irrigation System

These low pressure systems continually discharge low volumes of water and added nutrients directly to plant's root zones, saving irrigation water as well as water necessary for sprayed fertilization (TWDB 2001; TWDB 2005). This continual delivery of water and nutrients increases the grower's ability to manage crop production and evaporation is almost entirely eliminated, greatly increasing uniformity of irrigation water. Studies have found that drop irrigation reduces plant stress and may increase yield (Burt and Styles 2007). Reduced moisture contact with leaves and foliage reduces disease risks. Concentrated irrigation zones reduce weed growth which lessens the need for chemicals and decreases salt build up. Drip systems are also the only irrigation systems that allow for efficient water use in problematic or less than ideal soil compositions, sloped areas and irregularly shaped growing areas (Burt and Styles 2007;

TWDB 2005). According to TWDB, and the Texas Agricultural Extension center, installation of drip irrigation increased cotton yields from 650 lb per acre to 1,200 lb per acre for one producer in Lubbock County and increased melon yields by 60% in Starr County, despite a 67% decrease in total irrigated water use and 60% reduction in nitrogen application (TWDB 2001).

Drip irrigation – courtesy of mzungudays.com (2008)

Lining of On-Farm Irrigation Ditches

This practice is accomplished by installing a fixed lining of impervious material in an existing or newly constructed irrigation field ditch. The three most commonly used impervious liners for irrigation canals in Texas are Ethylene-Propylene-Diene Monomer (EPDM), urethane, and concrete (TWDB 2005). EPDM is the least costly to install at approximately $0.85 per square ft, while concrete installations is the most expensive, but have the longest life span and can reduce seepage loss by at least 80%. According to a ten year study performed by the U.S. Department of Interior, the cost of installing concrete linings ranges from $1.92 to $2.33 per square ft, but has the lowest maintenance cost (USDOI 2006). Urethane lining often has the lowest seepage rates, but requires hazardous chemicals during installation and averages $1.43 per square ft (USDOI 2006). Regardless of the type, canal lining reduces seepage rates and increases flow rates, ultimately reducing the amount of irrigation water necessary and the total expenditures for irrigation water.

Replacement of On-/farm Irrigation Ditches with Pipelines

Replacement of on-farm ditches with low-pressure pipelines is an alternative practice to lining ditches. Smaller ditches with flow capacities less than 4.5 cubic feet per second (2000 gpm) are best suited for replacement with a buried pipeline, as pipelines have a smaller transport capacity than irrigation ditches. The principal limitations to consider when converting farm ditches to pipeline irrigation systems are cost and flow capacity (TWDB 2005; TWDB 2006). Installation of pipelines can be expensive and labor intensive. Design and field engineering are required, as well as trenching or excavating equipment. In order to determine the cost effectiveness of installing pipelines, the seepage rate of the ditch must be known. The seepage rate of ditch can be estimated by conducting one or more ponding tests with a typical section of the ditch prior to the ditch being lined or replaced. A ponding test measures the rate at which the level of water ponded behind an earthen dam placed in the ditch drops over two to twenty-four hours. The amount of the ditch that is wetted by the pond behind the dam must be measured (Gerston et al. 2002). The seepage rate can be calculated as acre-feet per mile of ditch per day. The total quantity of water lost to seepage from the ditch is estimated by multiplying the seepage rate times the number of days per year the ditch is used to convey water. For example a small farm ditch with a wetted perimeter of 5 feet and a length of ½ mile is found to have a seepage rate of 1.0 acre-feet per mile per day (TWDB 2005). However, most irrigation ditches in Central Texas are significantly shorter. Use of pipelines virtually eliminates seepage and the installation and maintenance costs can be weighed against the cost the acre-feet of water lost.

Gated and Flexible Pipe for Field Water Distribution Systems

Installation of gated and flexible pipes often occurs in conjunction with upgrading from on-farm ditches to pipelines for irrigation water transport. Gated pipe or flexible pipe can be used in place of irrigation ditches or traditional pipes to distribute water to furrow and border irrigated fields (Gerston et al. 2002). Flexible pipe is a very low pressure (less than 5 psi) thin wall (less than 25 mil) pipe that is unrolled and can have ports installed after the pipe is pressurized. Ports or gates are installed in the pipes at regular intervals and can be opened to control flow rates of irrigation water. Flexible pipe is easier and less costly to install but lasts only one or two year. Gated pipe is made of aluminum or PVC and is much more costly to purchase and install and has a longer range of durability, lasting between ten and forty years (Gerston et al. 2002; TWDB 2005). The flow rate out of each gate is controlled by the percent opening of the gate. Flexible plastic pipe can also be used as a surface pipeline to convey water between fields and can improve the application efficiency of furrow irrigation by allowing the delivery of larger stream sizes of water per irrigated row. Using gated or flexible pipe for water transport reduces or eliminates seepage loss and evaporation lost in irrigation ditches. In general, water savings can be roughly determined by calculating the quantity of water lost to seepage from the use of unlined ditches. Adoption of such irrigation transport pipelines also allows peripheral acreage that is sloping or uneven to be irrigated, allowing additional planting and acreage, as well as a faster return on the investment. According to figures on the National Resources Conservation Service website installation costs average $4.00 to $6.00 per ft. for gated pipelines and significantly less for flexible piping (NRCS.usda.gov: grant cost sharing worksheet 2007).

Surge Flow Irrigation for Field Water Distribution Systems

Surge flow irrigation techniques are designed to be used with gated pipe or flexible pipe water distribution systems in soil types that swell and reduce infiltration rates in response to irrigation. Butterfly valves powered by battery or solar powered timers can be added to existing pipelines to release alternating flows or pulses (Gerston et al. 2002). These valves have an average life span of ten years, and are often paired with gated pipes because of their durability (Gerston et al. 2002; TWDB 2005). This method of applying water in a series of surges to furrows, borders and basins is thought to increase infiltration and distribution uniformity. Because water is applied intermittently, the soil percolation rate is slowed, resulting in a "hydrologically improved surface" for future surges, ultimately reducing water loss by up to 30% (TWDB 2005). Estimation of the amount of water saved from increasing the irrigation application efficiency can be made by measuring the amount of water delivered to the field prior to installing surge flow and comparing it to the amount of water delivered to the field by using surge flow (Gerston et al. 2002; NRCS 2007). Cost for a surge valve with an automated controller will range between $800 and $2,000 depending on the size of the valve and the controller options. If installed at the same time as gated pipe, the cost for those systems is outlined in the Gated or Flexible Pipe BMP. Assuming that 0.25 acre-foot per acre per year of water is saved by using a surge valve, the annual cost per acre-foot of water saved ranges from $20 to $25 (NRCS 2007; TWDB 2005).

Crop Residue Management and Conservation Tillage

Farming practices that leave remnants from previously harvested crops on the surface of the field, such as no till, strip till, mulch tillage, and ridge tillage minimize plowing during and after the growing season and can significantly minimize water losses, lowering irrigation requirements. Conservation tillage in can be utilized by both irrigated and dryland farming and preservation of soil moisture in areas where there is significant winter precipitation to allow conversion of irrigated land to dryland farming and is especially efficient when used in corn, cotton and cereal grains, which are often grown in Central Texas (http://www.ncsu.edu/sustainable/tillage/tillage.html; Morse et al. 1993). Residue management and conservation tillage allow for the management of the amount, orientation and distribution of crop and other plant residue on the soil surface year-round on crops grown where the entire field surface is tilled prior to planting. Conservation tillage improves the ability of the soil to hold moisture, reduces the amount of water that runs off the field, and reduces evaporation of water from the soil surface (NRCS 2002). Optimum soil coverage of at least 30% (of crop stubble/remnants) can reduce soil moisture evaporation by up to 50% (Gerston et al.

2002; TWDB 2005). Increased spring soil moisture content resulting from conservation tillage may allow a farmer to conserve one or more irrigation applications per year (typically 0.25 to 0.50 acre-feet per acre). Reduction in soil moisture loss during the irrigation season may save an additional 0.5 acre-foot per acre (NRCS 2002).

Corn grown in conservation tillage – courtesy of NRCS/UDSA

Conservation tillage – courtesy of Michigan's Conservation Reserve Enhancement Program (Western Lake Erie Basin Partnership)

Furrow Dikes

Furrow dikes are typically implemented to reduce run-off from row crop productions. Furrow diking is relatively labor intensive, but is not extremely costly either for installation or maintenance. Small earthen dams are constructed between furrow ridges at regular intervals to retain irrigation and rainwater (Gerston et al. 2002; TWDB 2005). Dikes allow for slower infiltration of water into the soil, yielding lower runoff rates and increased soil moisture retention. Furrow dikes are a fundamental part of low-energy precision application systems. LEPA systems apply water directly into the furrows, minimizing evaporation, run-off and water waste (TWDB 2005).

It can be difficult to calculate water savings realized from furrow dikes for several reasons: rainfall quantity, durations and intensity, the infiltration rate of the soil, the slope of the furrow, and application characteristics of irrigation water/sprinkler treatments (Tucker and Feagley 1998). TWDB has calculated a 12% reduction in water use due to decreased or eliminated run off with the implementation of furrow dikes in other parts of the state (Gerston et al. 2002; TWDB 2005). Studies further estimate implementation costs range from $5 to $30 per acre, per crop, per season (Tucker and Feagley 1998). The quantity of water saved by installation of such varies from field to field and season to season, but a conservative estimate would be three inches per season, or 0.25 acre-feet per acre (Gerston et al. 2002).

Furrow Dikes in a Texas Cotton Field – courtesy
of High Plains Underground Water Conservation
District

Land Leveling

Leveling uneven terrain reduces the runoff potential of irrigation water in furrow, border, or basin irrigating crop production Land leveling generally applies to mechanized grading of agricultural land based on a topographic survey. Most land leveling is done using a laser controlled scraper pulled by a tractor. The laser is set to predetermined cross and run slopes, and the scraper automatically adjusts the cut or filled land over the plane of the field as the tractor moves. Land leveling work falls into two general categories: 1) large scale land shaping typical to newly irrigated land or land that has never been graded, and 2) land level or floating of a field prior to preparation of seed beds or borders. The time required per acre of land to grade a field depends on the size of the land grading equipment and the quantity and distance that soil must be moved. Typically, the time required to "touch-up" a field prior to planting is measured in hours per acre, whereas initial grading of a field may take one or more days per acre (NRCS 2007). The cost of land leveling for new irrigation fields is usually estimated based on the soil type, the cut to fill ratio, and the total number of cubic yards which must be cut (Gerston et al. 2002; NRCS 2007). Cost per yard of cut varies from approximately $1.00 to $2.00 per cubic yard depending largely on diesel fuel costs. Initial costs per acre for land leveling can range from $50 to $400. Touch up land leveling usually costs less than $50 per acre and most commonly less than $25 per acre (TWDB 2005). When using sprinkler style irrigation systems, leveled fields can reduce run off and increase the uniformity of water distribution. Furrow irrigation systems can increase water efficiency by creating uniform slopes to allow for maximum water absorption. Laser controlled land leveling and contouring can reduce irrigation water totals by 20-30% and increase crop yields by 10-20% (TWDB & TSSWCB 2006).

Contour Farming

This was one of many procedures promoted by the U.S. Soil Conservation Service (the current Natural Resources Conservation Service) during the 1930s. The U.S. Department of Agriculture established the Soil Conservation Service in 1935 during the dust bowl when it became apparent that soil erosion was a huge problem (NRCS 2007; NRCS website accessed May 2009).

Land leveling rends to be utilized on mildly sloping land, while contour farming is more appropriate for production on modest slopes. Contour farming is the practice of tillage, planting and other farming operations performed on or near the contour of the field slope. This method is most effective on slopes between two and ten percent.

Tillage and planting operation follows the contour line to promote positive row drainage and reduce ponding (Gerston et al. 2002; TWDB 2005). Crop row ridges are installed on contours to create small ridges or dams, which, like furrow dikes slow water flow, increase infiltration and reduces erosion.

The cost for preparing contour rows as compared to conventional rows is minimal. The primary cost per acre for contour farming is for the field layout and surveying of the contours. The cost for surveying varies from $1 to $3 per acre (NRCS 2007). Secondary costs for contour farming may include additional farming and harvesting costs for small row lengths in corners and ends of the field. The total costs can compared to irrigation costs in previous growing seasons, but must be normalized for differences in rainfall from growing season to growing season.

Another aspect of contour farming is contour ripping/pasture renovation performed to maintain permeability of soils and increase residence time of water in soils. Ripping increases infiltration and reduces runoff from treated landscapes. Increasing infiltration reduces the potential for soil erosion as overland flow is disrupted and runoff water is distributed downward into the soil profile. The reduction in overland flow can also reduce the potential for nutrient-impacted sediment transport into local streams and rivers, thus reducing the potential for downstream impacts. NRCS's definition of this practice is the modifying of physical soil and/or plant conditions with mechanical tools by treatments such as pitting, contour furrowing, and ripping or sub-soiling (NRCS 2003). Other practices, such as pasture renovation efforts using aerators or other mechanical methods to increase the soil's infiltration capacity, can also be included in this definition. The purpose of these practices is to increase plant vigor as well as renovate and stimulate the plant community for greater productivity and yield. Costs to implement this BMP will include mostly fuel, labor, and equipment costs. Pasture renovating equipment starts at about $1,000 for a small implement and goes up in price from there (Gregory and Meier 2008). If a small amount of land will be covered using this treatment, then using a smaller implement and tractor will suffice; however, if large tracts of land will be renovated then larger, more expensive equipment will be needed (Gregory and Meier 2008). This method will cut down on overall labor and fuel costs and will pay for itself in the long run. An alternative to owning and operating this specialized equipment would be to hire someone who has the equipment to come in and perform the task. Costs to hire someone will vary depending on the location, number of acres covered, and the desired practice. USDA-NASS (2004) reports the average cost of hiring someone in Central Texas to till a pasture using a deep ripper is $13.89 per acre.

Deep Ripping Technique – Courtesy of NRCS

Conversion of Supplemental Irrigated Farmland to Dry-Land Farmland

For producers utilizing ground or surface water for irrigation, an alternative is to convert irrigated land to dry-land farming which includes cessation of irrigation to certain portions of planted crops and/or converting the type of crop planted, such as conversion of cotton or corn to pasture (Creswell and Martin 1993). Crop yields from dry-land farming vary season to season depending on the amount and timing of precipitation. Rainfall in Central Texas may be sufficient for producing several crops, depending on the year. Over the last few years drought conditions have made crop yields uncertain. Typically the crop yields produced by dry-land farming are significantly lower than yields produced by irrigated farming. Permanent pasture is the most common type of dry-land farming and is popular as a dry-land crop because pasture can survive longer periods of no rainfall compared to typical row crops such as milo, corn, or cotton (TWDB 2005). If row crops are grown, there are several farming practices such as crop residue (described above), mulching, bunding (a process to furrowing, also described above), as well as several plowing and tillage methods.

The effect of conversion from irrigated farming to dry-land farming on crop yields, crop production costs including the costs of irrigation, and farm profits should be evaluated by comparing information from dry-land farming in the same geographic and climatologic area in which the irrigated land is located. After the agricultural water user has evaluated the increased risks associated with dry-land farming, the water user should then convert an amount of previously irrigated land to dry-land farming that is acceptable to the user based on the amount of increased risk (Gerston et al. 2002; TWDB 2005). The quantity of water saved by conversion from supplemental irrigated farmland to dry-land farmland can be estimated based on historical water use records for the crop type and geographic location where the crop was grown. The cost-effectiveness of conversion to dry-land farming requires complex economic and climate analysis. Dry-land farming can be significantly less costly than irrigated farming. However, since crop yields are often less, and the risk of crop failure may be significantly increased, the amount of profit per acre of dry-land is usually less than irrigated land. Texas Agricultural Extension Service estimated that crop yields grown in nearby Bexar, Medina, and Uvalde Counties for dry-land farming are one-third to one-half less than for irrigated farming (TWDB 2005).

Software and online-based Irrigation Technology

The USDA Arid-Land Agricultural Research Center has developed and updates software-based surface-irrigation technologies that can be utilized for increasing on-farm irrigation efficiency (WinSRFR). The WinSRFR software allows evaluation of infiltration properties based on soil physical principles, in order to design and manage surface irrigation systems. One interesting utility of this software application is the ability to account for surface water irrigation flows and transport that are not always uniform or consistent. Currently, USDA researchers are improving the software package to include methodologies for assessing potential effects and water savings of adding on-farm irrigation system improvements or best management conservation practices. The finished software package will be available via the website (http://www.ars.usda.gov; http://www.ars.usda.gov/Research/docs.htm?docid=13920).

Texas A&M Agri-life Extension's Irrigation Technology Center provides online resources for calculating evapotranspiration rates to assist in determination of water quantities for irrigation application and weather data by County, an application rate calculator, as well as irrigation measurement demonstrations and links to useful reports and other information. The website also offers online education courses and an extensive online irrigation literature and research database (http://itc.tamu.edu/; http://texaset.tamu.edu/index.php).

Appendix B

Industrial, Commercial and Institutional Water Conservation Best Management Practices for Central Texas

Water is a fundamental production and process component for many industrial, commercial, and institutional (ICI) water users in Central Texas. Increasing water efficiency through the implementation of best management practices can increase financial efficiency and profits by reducing water related expenditures (purchase of water and sewage fees). Typical ICI expenditures account for 1-2% of total annual operating costs (Seneviatne 2007; Vickers 2001). Reducing water use also can lessen overhead costs. Increased water use efficiency potentially allows for expansion of production capabilities without realizing the full costs of increasing capacity sans water conservation practices. Historically, water prices have increased annually and future water prices will likely follow the same trends of increasing to keep pace with inflation and rising demand. Improving water use efficiency may reduce future costs as water prices rise (East Bay Municipal Utility District 2008).

As mentioned in the full report, multiple government agencies and water providers offer rebates, grants, and tax incentive to encourage water conservation at the ICI level.

In Texas, various tax exemptions/incentives include: rainwater harvesting systems, water recycling and reuse systems, TCEQ certified wastewater systems.

One major ICI water demand is cooling, or reduction of heat due production processes. Also included in this demand is air conditioning. Other large industrial uses of water include conveyance, rinsing and cleaning of products and containers. Many ICI facilities use significant quantities of water for landscape irrigation and employee needs. Water quality demanded for ICI uses differs by facility type and processes, encompassing a broad spectrum, from ultra-pure treated water to non-potable water, increasing the opportunities for conservation and reuse potential (Gerston et al. 2002).

Such variety in types of water uses and facility water demands of different ICI water users makes direct comparisons and assessments of conservation difficult. Specific comparisons including overall water use, water available for reuse and water used per employee per day can be estimated and are vital to creating water conservation plans in the ICI sector. In many instances, gallons used per unit of production can be calculated by dividing the water utilized in the production of a product or service by total production output (Vickers 2001). Conservation savings from the implementation of efficient practices can be determined by comparing similar ICI uses and their gallons per unit quantity or comparison of pre and post implementation amounts of water used.

Effective water conservation programs in the commercial, institutional and industrial sector increase efficiency and lower costs, allowing for water supplies adequate to meet the demands of forecasted ICI growth. More importantly, reductions in ICI water use also allow for additional municipal water supplies which will be needed in light of large population growth projections (Gerston et al. 2002; TWDB 2006).

Combined industrial, commercial, and institutional water use accounts over 50 percent of nonagricultural water use in Texas, currently surpassing municipal use, and is forecasted to increase nearly 47 percent in the next half century. The projected water demand for the five industrial sectors in the state (chemical manufacturing, steam electric power, petroleum refining, pulp and paper, and primary metals) exceeds 80 percent of the available 2.67 million acre-feet (TWDB 2006). Because industrial wastewater treatment and discharge are priced by volume, conserving water has an added incentive of reducing operational costs. As new water treatment technologies become available, and the costs of water increase ICI water users may find water recycling and other conservation applications to be increasingly cost-effective (Vickers 2001). Case studies and water-efficiency audits have estimated conservation hardware upgrades to yield 15 to 20 percent reductions in water usage with investment payback periods between one and four years (American Water Works Association 2002; Bowman 1995; New Mexico Office of the State Engineer 1999; Vickers 2001). ICI adoption of conservation programs, or suites of water saving measures have been shown to yield 15 to 35 percent reductions in water use and have similar payback periods (Dziegielewski 2000; Vickers 2001). Such conservation practices include water saving measures for cooling applications, industrial water processes, landscaping and other water reduction applications.

Cooling towers and other cooling systems use evaporation to lower the temperature of water that conveys heat from mechanical equipment such as air conditioning systems, heat exchangers, condensers, or process machinery. Often the single largest water use for hospitals, office buildings, electric power generation plants, and manufacturing and industrial plants, cooling towers and systems are used in a wide array of Central Texas facilities, (Gerston et al. 2002; Vickers 2001). Recent studies have identified several management practices that can be implemented to reduce water quantities used in cooling towers and systems: improvement of system monitoring and operation, contaminant and residue removal from cooling water, employment of alternative sources such as reuse for added or "make up" water (water added to replace evaporative losses), and less reliance on evaporative cooling for heat reduction, by combining air and water cooling methods. In addition, elimination of "once through" cooling systems with re-circulating systems is recommended (American Water Works Association 2002; Gerston et al. 2002; East Bay Municipal Utility District 2008; New Mexico Office of the State Engineer 1999; Vickers 2001). Finally, "blow down" or excess water in cooling and water sued in production processes can be collected and utilized for other purposes, such as landscape irrigation (Vickers 2001).

Overall Industrial and commercial audits

Overall audits are typically the first step in industrial and commercial conservation plans, and include evaluating and improving efficiency of site specific water uses, employee and management water uses, cleaning, rinsing and cooling processes, steam and boiler operations, landscaping and waste water reduction. In addition to water savings, benefits of comprehensive audits include lowered utility costs, energy savings, and reduced process costs. Audits highlight areas where implementation of best management practices such as water waste reduction, industrial submetering, landscape conversion, and cooling system advances can increase water savings and efficiency (Gerston et al. 2002).

Audits include detailed examination of water entering and exiting a system or facility and track water inventories. Information gleaned from water audits, such as calculations of on-site water uses, potential losses, waste and associated costs can be used as the foundation for implementation of a conservation program specific to the needs of the facility (Gerston et al. 2002; Seneviatne 2007; Vickers 2001).

Steps for ICI audits recommended by Vickers (2001) and TWDB (1995) include:

1) Preparation

Initial information collected includes facility maps; lay outs and locations of water supply meters and submeters; numbers of employees and work schedules; inventories of plumbing fixtures and equipment and processes, including water quality limitations; and outdoor water use information such as irrigation scheduling, area of landscaping (square footage) landscape type. Three years of water use data should be collected along with utility records and quantities of wastewater generated.

A Guide for Industrial, Commercial, and Institutional Water Conservation Handout (AWWA, no date) also recommends collecting the following information when conducting an ICI audit:

Employee contact names and phone numbers

Inventory of services and/or products produced and water requirements

Operating schedule, hours of operation for equipment

List of all water using equipment and discuss equipment use with operators who have knowledge of procedures and operations.

Number of units produced, meals served, number of rooms, employees, restrooms, air conditioning units, etc

List of permits for withdrawal, release, etc

Potential areas for reuse, reduction

2) Conducting the survey

On-site facility examinations and water use surveys should inventory all water utilizing equipment, including verification of hours of operation, meter calibrations, and manufacturers' listed flow rates. If possible, water quality should be measured, in order to assess feasibility of water reuse. Daily and monthly usage totals for each water use area and total facility usage should be calculated compared with the utility measured sales to the facility to determine losses, waste and other potentially unaccounted for uses.

3) Preparation of a facility audit report and cost effectiveness analysis

The information collected should be incorporated into a facility audit report that includes illustrated facility diagrams, water flow charts delineated by water use areas, a current survey of equipment utilizing water equipment, flow rates (actual and recommended), a schedule of operations for all manufacturing or process areas and equipment, landscaping irrigation data recommendations for landscaping equipment repairs and upgrades, water use recommendations from on site observations, an analysis of water costs by operating area and for the entire facility, and identification of areas that would benefit from implementation of conservation and reuse. Finally, calculations of metered water that is unaccounted for should be reported. A cost-effectiveness analysis should be created to ascertain the water conservation practices that will be the most cost effective to implement.

4) Recommendations for action

The end product of a facility audit report is the preparation of a water conservation plan. An audit report should provide suggested water conservation measures and management practices, as well as a timetable for implementation and, if necessary, a leak detection program. The report should also contain regular water audit schedules (weekly during spring and summer months, and monthly in the fall and winter) for managing equipment and process flow rates, adjusting irrigation needs, and communicating action plan to employees.

The AWWA also suggests delegating the execution of the establishment of water conservation goals and final plan to a task force, specific individual or group. Water conservation goals should consider water supply restrictions, water pricing, regulatory requirements, as well as health and safety measures and a water conservation plan should include the following elements:

A water management policy statement

Quantitative goals and achievement timetable

Suggestions by employees

Evaluation of each efficiency measure

Immediate action that is no or low-cost

Needs for engineering design

Prioritization of actions by water savings and cost-effectiveness

Schedule of implementation

Responsible parties

Funding sources

Provision for evaluation, revisions, and criteria

Estimated conservation savings resulting from recommendations for implementation of management and conservation practices should range between 10 percent and 35 percent, if a similar audit has not been performed (Vickers 2001).

The AWWA also provides the following guidance for performing a successful ICI audit and for following a conservation plan after implementation:

"**Include employees –** No program will work without employee involvement. Information, feedback, and input are often the best source on how to change day-to-day operations to achieve water conservation goals. Provide training, education programs, and establish a system where employees can report leaks and water waste.

Think outside the box – Work with other agencies, companies, and local utilities. Other ideas and resources may be available to assist you in developing a successful water conservation program.

Publicize your success – Let your employees, the community, and other businesses know of your successes. A successful water management program demonstrates a willingness to become an active partner in the community and is good for public relations!

Review and revise – All programs must be reviewed and revised periodically. Keep records of past actions and review to see if goals are being met. Make changes to your water conservation plan as needed. Implement measures that will save money through-out the life of the program. Businesses that implement efficiency measures establish a competitive edge."

Finally, the AWWA recommends the following best management practices to increase water use efficiency, many of which are described in further detail below:

Building Operations

Check for and repair leaks

Meter all major uses separately

Read water meters regularly to track potential leaks

Shut off water to unused areas

Keep employees informed

Use automatic shut off valves for equipment that is not in operation

Consider water use when purchasing or replacing equipment

Examine ways to modify processes

Install self-closing, air-cooled water fountains

Use gray water for irrigating landscape

Restrooms

Check for and repair leaks

Remind users to conserve

Retrofit older fixtures

Install low-flow showerheads and faucets

Install low-flush or waterless toilets and urinals

Consider dual flush toilets

Install metered or sensor faucets, urinals, and toilets

Maintenance

Mop instead of washing, sweep instead of mopping

Sweep instead of using a hose

Use a high-pressure nozzle when a hose in necessary

Clean windows only when needed

Cooling and Heating

Meter and record water use

Check for and repair leaks

Cooling systems and towers

Eliminate once through cooling

Install a re-circulating system

Reuse blowdown for irrigation

Reuse treated water for makeup

Use air-cooling where possible

Consider evaporative cooling

Consider hybrid cooling towers

Consider side stream filtration or pulse power treatment

Boilers and heaters

Minimize blowdown

Check and replace steam traps regularly

Reuse condensate and blowdown

Process Use

Monitor water use

Recycle and reuse water

Install automatic shut-off valves

Utilize closed-loop systems

Eliminate once-through cooling

Use air-cooled systems

Alter process filtering to maximize product recovery

Separate water process streams

Landscape

Check for and repair leaks

Use drought tolerant/native plants and turf

Adjust sprinklers to irrigate landscape only

Water deeply, but infrequently

Install automatic rain sensors
Water during early morning or evening hours

Install timers and moisture sensors

Use drip irrigation

Use fertilizer sparingly

Install shut-off nozzles on hoses

Food Service

Thaw food in refrigerator or microwave

Provide water only on request

Scrape dishes instead of rinsing

Install high-pressure, low-volume spray washers

Replace worn washers

Wash full loads only

Reuse final rinse water for prewash or garbage disposal

Install automatic shut-off valves

Choose water efficient equipment

Install sensor dishwashers

Use air-cooled or flake ice machines

Don’t use running water to melt ice

Install separate meters for larger operations

Laundries

Choose water efficient equipment

Wash full loads only

Recycle final rinse water for pre-wash

Install sub-meters to track potential leaks

Recover steam condensate and/or vented flash steam

Pools and Spas

Check for and repair leaks

Cover pools when not in use

Lower the temperature when not in use

Keep filters clean to reduce backwash

Adjust pool levels to minimize splash out

Consider alternative water treatments

Vehicle Washing

Wash vehicles only when needed

Adjust solenoids, valves, nozzles, and equipment to minimize water use

Use high-pressure washes

Inspect and replace worn jets and parts

Install water recycling equipment

X-ray Processing/Labs

Equip x-ray processors with shut-off valves

Reduce the flow rate to the processors to a rate of 2 gallons per minute of less

Eliminate continuous water streams for aspiration of liquids or other purposes

Eliminate single-pass cooling of instrument analyzers

Use sterilizers which use re-circulating cooling water

Install silver recovery systems

Install flow restrictors on water-ring vacuum pumps or replace with oil-ring pumps

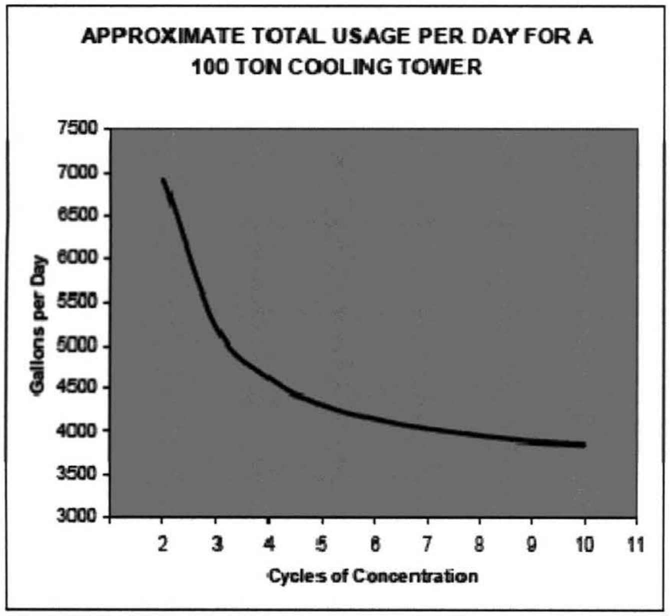
Use of "captured" and reuse water for cooling towers and systems

Improving cooling efficiency can be achieved by reusing or "capturing" evaporated water as well as reusing water in cooling processes. Minimizing the amount of water lost from the system to evaporation is the first step in increasing efficiency. In order to maximize recycling during the cooling process, dissolved solids that accumulate during cooling must be removed. During evaporation, of dissolved solids accumulate in the water used for cooling, affecting efficiency of the process (Vickers 2001). Cooling tower water-use efficiency is commonly measured using a concentration ratio (CR), also known as cycles of concentration. The concentration ratio denotes the number of times water is utilized in the cooling process before being released as blow down. Recent advances in chemical treatment and monitoring technology have been shown to significantly increase concentration ratios in cooling towers and other cooling systems (East Bay Municipal Utility District 2008; Vickers 2001). Implementing these technologies reduces the quantities of required make-up water needed to replace blow down, thus lessening the total amount of water demanded per day.

Concentration ratios (CR) are determined from dissolved solids present in the make-up water (CM) and blow down water (CB), denoted as: CR = CB / CM. The percent of cooling water estimated to be to be conserved is equivalent to (CR2 – CR1) / (CR2 x

(CR1 – 1)),where CR1 is equivalent to the concentration ratio before implementation of more efficient practices and CR2 is concentration ratio after increasing cycles (Vickers 2001). The graph shows water use levels associated with different cycles of concentration, or concentration ratios for a 100 ton cooling tower.

Cooling Tower Water User versus Cycles of Concentration (Gerston et al. 2002)



Kobrick and Wilson (1993) graphed the association between the CR and the quantity of water utilized by an average cooling tower. The percentage of water that can be conserved by increasing the CR was calculated using the equation in Figure below:

$$\text{Percent conserved} = \frac{CR2 - CR1}{CR1\,(CR2 - 1)} \times 100\%$$

where: CR1 = concentration ratio before increasing cycles, and
CR2 = concentration ratios after increasing cycles.

EXAMPLE 1: Increasing the concentration ratio from 2 to 4 results in a water savings of 33%.

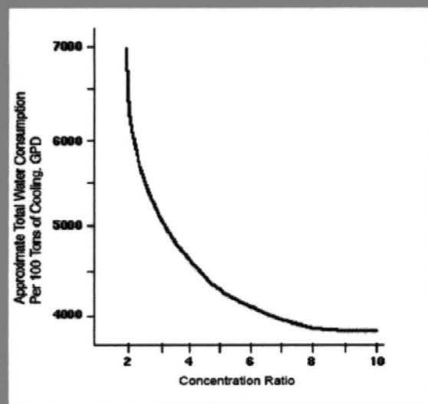


Figure 5-3:
Cooling Tower Water Consumption vs. Concentration Ratio

Sources: "Uses of Water and Water Conservation Opportunities for Cooling Towers" by J. Douglas Kobrick, P.E. and Mark D. Wilson, Black & Veatch; City of San Jose Environmental Services Department

An analysis of cost effectiveness for implementing new cooling system technology should include capital equipment costs, changes in staff and labor costs, chemical and treatment costs, additional costs or savings in energy use, costs for waste disposal, and potential savings in wastewater treatment costs Gerston et al. 2002). Historical records (pre and post implementation measurements and data from similar ICI users) as well as manufacturers' data can be used to estimate water savings due to increased concentration ratios and increased water from recapture of evaporation.

New Mexico Office of the State Engineer (1999) developed a simple payback period calculation for cooling tower improvements. Specifications include:

250 tons of refrigeration capacity, operating 150 days annually, with a current efficiency of 3.0 cycles of concentration before water is flushed from the system. Total water

consumption before implementation of improvements is equivalent to 22,000 gpd for 150 days/year (3.3 million gal/year). Proposed conservation actions include the addition of conductivity and pH controllers to treat water with chemicals, allowing for increase in cycles from 3.0 to 5.0.

After the implementation of the conservation application, consumption fell to 18,000 gpd for 150 days/yr (2.7 million gal/year), amounting to an annual water savings of 600,000 gallons/year. Cost savings (first annum) associated with the reduced water consumption were $2,200 for sewer and water expenditures and $1,900 for chemical purchases, totaling $4,100. The capital cost of implementing the conservation application was $5,500, with a Payback Period (in years) of 1.34 years.

Gerston et al. (2002) presented an audit of a small industrial facility, and the three resulting recommendations regarding cooling tower efficiency: additional CR, increased frequency of maintenance and repair of facilities and overall system to increase efficiency, and examine applications for reuse of cooling tower blowdown.

The audited system consumed 20,000 gallon per day (14 gal per mo) and increasing the CR from 2 to 6 decreased the amount of blowdown water by 8,000 gallons per day, necessitating a revised procedure of monitoring and increased controls for pH and conductivity with an approximate capital cost of $7,500 and annual chemical and maintenance costs of approximately $250 per month ($3,000 per year). Water supply for the cooling tower was supplied by private wells, negating monthly water usage fees. The average cost of transporting the water and disposing of wastewater is $2 per 1000 gallons.

Estimated water savings totaled 8,000 gallons x 360 days = 2,880,000 gal (8.84 ac ft), with financial expenditures of $5,760 a year ($480 per month) or $652 per acre foot per year with a simply calculated payback period of 2.7 years. A simple present worth analysis was completed, assuming a 6 percent rate over the 10 year estimated life of the cooling tower controls and clearly demonstrates that the conservation application is cost effective. Values are shown in the table below.

Net Present Value of Increasing CR Cycles
in Gerston et al. Study

6%, 10 years	Amount	Years	PV
Capital Costs	$ 7,500	0	($7,500)
O & M Contractor	$ 250	per mo	($22,518)
Water Savings	$ 480	per mo	$43,235
Net Present Value			$13,217

The recommendation to improve the cooling tower system efficiency via improved maintenance (increased coil cleaning, reduced heat load, installation of variable speed fans and pumps, adjustment of belts, shielding repair). Estimated water savings of 15% can be expected from increasing maintenance and repair standards, equaling 1,800 gallons per day (Pacific Institute 2003). Initial repair costs of $5,000 with annual maintenance expenditures of $1,000 over a 10 year period. Again, over a 10 year period, an analysis of cost effectiveness shows that increasing maintenance and repair to improve efficiency would be effective, as shown in the table below.

Net Present Value of Increasing Cooling Tower Efficiency in Gerston et al. Study

6%, 10 years		Amount	Years	P V
Capital Costs	$	5,000	0	($5,000)
Periodic cleaning, etc	$	1,000	every 2 yrs	($3,573)
Water Savings	$	108	per mo	$9,728
Net Present Value				$1,155

Gerston et al.'s last recommendation was to consider new opportunities for reusing blowdown water. After reductions in water quantity due to application of additional cycles of concentration, availability of reusable water was not significant. This operational processes of the particular facility examined required relatively high water quality. The available 2,000 gallons per day of blowdown would require a collection tank, additional pumping and treatment costing $10,000 and additional monthly operating costs would amount to $100. In this case, assuming a 10 year life span of the storage, delivery and treatment equipment, this measure would be cost ineffective.

Net Present Value of Blowdown Reuse in Gerston et al. Study

6%, 10 years		Amount	Years	P V
Capital Costs	$	10,000	0	($10,000)
Treatment costs	$	100	per mo	($9,007)
Water Savings	$	108	per mo	$9,728
Net Present Value				($9,279)

Replacement of once-through cooling apparatus with air-cooled equipment or re-circulating water-cooled equipment

Once through cooling systems, also known single pass cooling systems, present another considerable opportunity for conservation. In these systems, water is utilized only once and is then disposed of. The types of equipment typically employing single-pass cooling include: CAT scanners, degreasers, rectifiers, hydraulic presses, x-ray processors, condensers, air conditioners, air compressors, vacuum pumps and viscosity baths. Once-through cooling systems that consume water by forced evaporation are especially inefficient and can be replaced with recirculation cooling equipment to reduce water use or existing equipment can be modified to operate on a closed-loop or recirculating cooling system. Single pass water-cooled equipment such as compressors and vacuum pumps can be easily and inexpensively replaced with air-cooled models (Gerston et al. 2002). Retrofitting of single-pass cooling equipment such as x-rays with recirculating water systems can cut water use by 90 percent and investment costs can be recouped in as little as 3 years (AWWA 2002; Gerston et al. 2002; Seneviatne 2007). Costs of converting to air cooled systems range from $1000 to $50,000 depending on the type and size of the system. Due to substantial water savings, payback periods for conversion to air-cooled equipment are often as little as one year (Gerston et al. 2002; Seneviatne 2007).

As with implementing captured and reuse water for cooling systems, updating single pass systems to recirculating or air cooled systems requires a review of capital equipment costs, staff and labor costs, chemical and treatment costs, additional costs or savings in energy use and potential savings in wastewater treatment costs (Gerston et al. 2002; Seneviatne 2007). Data from similar ICI users as well as manufacturers' data can be used to estimate water savings. If conversion to recycled cooling systems is not a cost effective option, then single-pass effluent can be utilized for other purposes such as industrial processes or landscape irrigation.

Use of reclaimed, recycled water and captured water for industrial process water

Reuse of process water or other sources of non-potable water such as treated effluent, rainwater collected on site, condensate, graywater, storm water, or sump pump discharge as a substitute for potable or raw water reduces the need for treated, potable water (Vickers 2001). Reclaimed and captured water is less expensive to treat (long term) and because the end use is adjacent to the source, distribution systems and maintenance are minimized (Seneviatne 2007). Recycled water supply is unaffected by drought helps conserve traditional sources of water such as groundwater and surface water. Texas state law (30 TAC Chapter 210.32) identifies two types of reclaimed water:

Type I reclaimed water is defined as use of reclaimed water where contact between humans and the reclaimed water is likely. Examples of such use include landscape irrigation, fire protection, and toilet or urinal flushing.

Type II reclaimed water is defined as reclaimed water where contact between humans and the water is unlikely. Examples of Type II use include dust control, cooling tower applications and other industrial processes.

If the quality of water is not seriously altered by one process, it can be used in another process resulting in significant water savings. Rinse water often retains a relatively high level of quality and can be reused in applications that do not require potable water. For example, spent rinse water can often be reused in other rinsing application, in cooling towers or for transport processes. In addition, water can be reused sequentially as it declines in quality and treatment between processes can prolong the life span of the recycled water (New Mexico Office of the State Engineer 1999).

Use of captured rainwater or reclaimed water for landscape irrigation

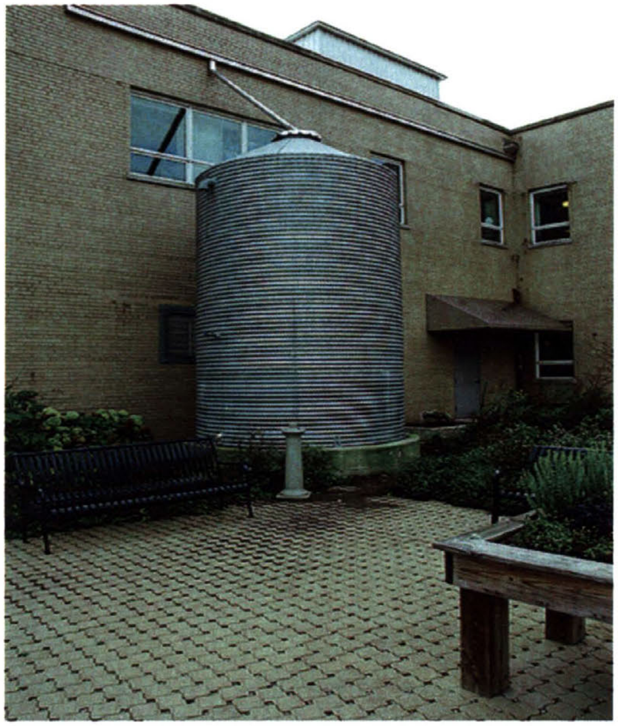
As in municipal and residential settings, captured rainwater can be utilized for irrigation, lessening the demand for treated, supplied water. Similarly, water used in processing or cooling can be dedicated to landscape watering. Using water sources other than potable purchased water reduces peak stress on water delivery systems by reducing demand, saves energy used to transport and supply water, and reduces user water costs. In addition, the utilization of rain water or water reclaimed from industrial processes reduces the total amount of wastewater that must be disposed of and treated (Seneviatne 2007). The reduction in wastewater costs alone can result in substantial savings.

The Texas Rainwater Harvesting Evaluation Committee's (TRHEC) Report to the 80th Legislature highlighted several Central Texas entities using rainwater for landscape irrigation, including the Lady Bird Johnson Wildflower Research Center and the Wells Branch Municipal Utility District Office in Austin and the New Braunfels Municipal Building (TWDB 2005b).

Two different categories of onsite water can typically be "captured" for recycling: graywater and blackwater. Graywater includes water from sinks, washing, rinsing, and other similar processes. Blackwater includes water from toilets, urinals, and processes that leave water with traces of oil, fat, grease, contaminants and various chemicals (New Mexico Office of the State Engineer 1999). Most types of ICI greywater can be used for landscape purposes with little or no treatment. Blackwater, depending on the type and source, may require treatment before it can be utilized. Often, chemical applications to remove contaminants or holding areas to allow settling of particulates can make blackwater safe for landscape use (Hoffman/TWDB 2005; Vickers 2001).

In order to maximize the conservation value of rain and reuse water, landscape design emphasizing drought tolerant, native plants should also be implemented. Low water demand landscaping and Xeriscaping have been shown to significantly reduce watering requirements and with the utilization of collected rainwater or reuse water, potable metered water may be reduced or eliminated (Gerston et al. 2002).

Rain cistern – courtesy of Chicago Center for
Green Technology



Replacement of conventional landscapes with water-thrifty landscapes

Low water demand landscaping can reduce water required by ICI customers and traditional landscapes can be converted at relatively low costs, with very short payback periods. Over time, reductions in water use can present significant savings (Pacific Institute 2003). When replacing traditional landscapes, it is assumed that at least a 15 percent reduction in water needs should be realized (Gerston et al. 2002; Vickers 2001). Vicker's Handbook of Water Conservation reports potential ICI landscape water savings average over 25 percent (Vickers 2001). A study in Austin found that xeriscaping reduced water requirements by 43 per cent (Vickers 2001). Landscape conversions can include removal of turf grasses or use of grasses on only on slopes and hillsides to prevent erosion; installation of native plants and landscaping materials that require little or no water; use of mulches and efficient irrigation practices (Vickers 2001).

Xeriscaping at a Grocery Store in Phoenix, AZ – Courtesy of Safe Way Grocery Stores

Retrofit or replacement of older toilets in high-traffic areas

Reducing the amounts of water used by employees for flushing toilets can reduce water demanded, just as in residential settings. Retrofitting existing toilets can lower total water use significantly and installation of high efficiency water saving toilets can save several gallons per employee per day.

Calculating achieved water savings from retrofitting or replacing older toilets involves several factors, but is relatively simple. Multiplying the estimated number of uses per day by total employees, customers, etc. by the amount of water used for each flush both before and after toilet upgrades is a simple method of calculation water savings.

Residential studies have estimated water savings from toilet replacement at approximately 10.5 gallons per person per day and retrofit savings around 5.5 gallons per person per day, and it is expected that ICI water savings results would be similar (AWWA 1999; California Urban Water Conservation Council 2005).

A study performed by San Antonio Water Supply (and the TWDB) found that payback period for installation of high efficiency toilets (1.28 gallons per flush or less) was only approximately one year, at a cost of between $200 and $500 per toilet and achieved water savings up to 80% (TWDB 2006). Other water efficiency advances such as high efficiency urinals, waterless urinals, flapperless toilets, dual flush toilets and foam toilets have been found to reduce water use by up to 90 percent with very short payback periods (Seneviatne 2007; Vickers 2001).

Success Stories

- The Frito-Lay plant in San Antonio conserves 1 billion gallons of water annually due to the implementing conservation efforts in 1999. The plant utilizes the water from potato and corn snack production to replace specific freshwater needs and has reduced water use for these processes by between 35% and 50% (Vickers 2001).

- American Airlines Maintenance Base located in Fort Worth (AFW) implemented a water recycling program. Improvements included an upgraded reverse osmosis system capable of treating 40 million gallons of wastewater. Conversion of a treated-effluent tank into a reverse osmosis tank and refurbishing of an outdated automation control system reduced AFW's total water usage by 24% to 36%. The conservation savings translated to nearly $1 million in savings (Gerston et al. 2002).

- Freescale, Inc. located in Austin manufactures microchips, a process requiring ultra pure water. Freescale's water reuse and recycling program, implemented in 2006, is responsible for the savings of several millions of gallons of both potable and waste water. Freescale has reduced the generation of wastewater by more than 50%. Implemented conservation practices that reuse and recycle manufacturing/process water also decreased the required demand for potable water by 51%. In 2007, these reductions amounted to over 160 million gallons of water conserved and 90 million gallons of wastewater avoided.

- Intel, the world's largest producer of computer chips is the largest private employer in the Albuquerque, NM and is also one of the state's highest industrial water users, and as in response to the community and internal concerns about water shortages, has implemented a progressive suite of water conservation practices. Intel's three processing sectors are referred to as "Fabs"): Fab 11, (consists of 2 buildings, completed in 1995), Fab 7 and Fab 9. In 2003, prior to the completion of Fab 11, the other two sectors utilized 2.8 million gallons of water per day (mgd). Fab 11's water demand was expected to be an additional 7.2 mgd, with no conservation mechanisms in place. Before the completion of the third sector (Fab 11), Intel began to implement water conservation best management practices and processes which, by 2006 reduced total water use to approximately 4 mgd (62% reduction), in spite of a 70% increase in production from 1995.

Initially, Intel utilized fresh water for all operations: Fab process use, exhaust scrubbers, cooling towers, air conditioning, and irrigation. Through the implementation of conservation measures and processes, significant quantities of process and cooling tower water are recycled. Only 15% of Intel's total water demand is now allocated to scrubbers and irrigation, with a small portion lost to evaporation. Manufacturing water use demand has been decreased through increases in water purification system efficiency, redesigns yielding increases in optimization of water utilized by "wet benches", and reuse of outgoing process water in cooling towers and air pollution scrubbers (yielding savings of over 757,000 gpd).

Further water use reductions resulted from processes allowing Intel to yield 1 gallon of greywater from every 1.54 gallons of ultrapure water produced, which is then used for irrigation. Intel replaced traditional landscaping with xeriscaping on its 31 acres and improved irrigation system efficiency, resulting in a 60% reduction in irrigation use and allowing greywater to account for nearly all of the necessary irrigation water allocation. Intel's total water demand in 1996 was reduced by 209 million gallons through this greywater filtration process. In 1999, efficiency was improved again through the development of a purification process called the High Recovery Reverse Osmosis Process (HRROP), now widely used throughout the industry. HRROP increase water conservation savings by an additional 700,000 gallons per day (New Mexico Office of the State Engineer 1999; Vickers 2001).

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Appendix C

Central Texas Water Conservation Resources

WEBSITES (WATER CONSERVATION)

Athletic Field Conservation
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http://www.mass.gov/dcr/recreate/fields.htm
http://www.saws.org/conservation/aquifermgmt/variance/athletic.shtml

Condensate Reuse
http://www.spiraxsarco.com/resources/steam-engineering-tutorials/condensate-recovery/introduction-to-condensate-recovery.asp
http://www.ncgreenbuilding.org/site/ncg/public/tech_details.cfm?tech_id=113&project_id=85

Golf Course Conservation
http://www.ecossistemas.com/The_egology_of_golf_courses.pdf
http://www.sgeg.org.uk/documents/SGEGNatureConservationGuidelines.pdf
http://www.snr.arizona.edu/project/golfcourse
http://acspgolf.auduboninternational.org/

Landscape Irrigation Conservation
http://www.fws.gov/science/SHC/lcc.html
http://www.ces.ncsu.edu/depts/hort/consumer/hortinternet/water_conservation.html
http://urbanlandscapeguide.tamu.edu/conservation3.html
http://www.p2pays.org/ref/23/22010.pdf
http://www.co.palm-beach.fl.us/erm/permitting/water-resources/water-irrigation/
http://climateconservation.org/
http://www.irrigation.org/

New Construction Graywater
http://greywater.sustainablesources.com/
http://www.graywater.net/
http://www.oasisdesign.net/greywater/buildersguide/index.htm

Rainwater Harvesting
http://www.rain-barrel.net/

http://rainwaterharvesting.tamu.edu/
http://www.twdb.state.tx.us/publications/reports/rainwaterharvestingmanual_3rdedition.pdf
http://www.gdrc.org/uem/water/rainwater/introduction.html
http://www.rainxchange.com/

Residential Clothes Washer Incentive Program
http://www.oregon.gov/ENERGY/CONS/RES/RETC.shtml
http://www.valleywater.org/Programs/High-EfficiencyClothesWasherRebate.aspx
http://www.dteenergy.com/pdfs/clothesWasherApplication.pdf
http://www.ci.gallup.nm.us/GJU/Gallup-Clothes%20Washer%20Rebate%20APPLICATION.pdf
http://www.fypower.org/res/tools/rgl_results.html?z=92648&s=res&c=Appliances
http://www.scribd.com/doc/26350711/Form-920C%E2%80%93Incentive-Application-ENERGY-STAR%C2%AE-Clothes-Washers
http://www.idahopower.com/EnergyEfficiency/Residential/Programs/HomeProducts/washers.cfm

Residential Toilet Replacement Programs
http://www.ci.austin.tx.us/watercon/sftoilet.htm
http://www.toronto.ca/watereff/flush/
http://www.peelregion.ca/watersmartpeel/indoor/toilet-program-1.htm
http://www.cwwa.ca/pdf_files/TRP%20Guideline_no%20picture.pdf

School Education
http://ga.water.usgs.gov/edu/
http://www.epa.gov/highschool/

Showerhead, Aerator, and Toilet Flapper Retrofit
http://www.huduser.org/publications/pdf/Book1.pdf
http://www.nmwd.com/conservation_interior.php
http://www.swfwmd.state.fl.us/publications/files/retrofit.pdf
http://www.stpete.org/water/indoor_conservation.asp

System Water Audit and Water Loss
http://allianceforwaterefficiency.org/Water_Loss_Control_Introduction.aspx
http://www.twdb.state.tx.us/assistance/conservation/Municipal/Water_Audit/wald.asp
http://escholarship.org/uc/item/3gx868tg

Water Conservation Pricing
http://www.roundrocktexas.gov/home/index.asp?page=1560
http://www.northgeorgiawater.com/html/217.htm
http://www.jea.com/about/news/stories/waterconservkey.asp

Water Reuse
http://www.watereuse.org/
http://bioprocessh2o.com/
http://www.waterreuse.org/

http://www.sandiego.gov/water/waterreusestudy/

Water Survey for Single-Family and Multi-Family Customers
http://www.ebmud.com/for-customers/residential-customers/conservation-incentives/site-water-surveys
http://www.westernresourceadvocates.org/media/pdf/SWAppendixA.pdf
http://www.econservision.com/02_WAP/02_01_wap.htm

Water Wise Landscape Design
http://www.bewaterwise.com/ww_landscaping.html
http://www.pubs.ext.vt.edu/426/426-713/426-713.html
http://www.gardensoft.com/
http://www.savedallaswater.com/waterwise.htm
http://www.bae.ncsu.edu/programs/extension/publicat/wqwm/ag508_2.html

General tips
http://www.wateruseitwisely.com/
http://www.epa.gov/nps/chap3.html
http://www.interleaves.org/~rteeter/waterlib.html

(City of Austin) http://www.ci.austin.tx.us/watercon/
(City of El Paso) http://www.epwu.org/conservation/education.html
(City of San Marcos) http://www.ci.sanmarcos.tx.us/departments/www/Water_Conservation.htm

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Appendix D

Water Provider Survey/Information Collected

Central Texas Water Conservation Information Collected

1. **Confirmation of**:
   a. **Location** (City, County, Distribution area)
   b. **Source water** (source type and location, % allocations, retail or wholesale purchases)

2. **Number and type of customers**/connections/meters/individuals/households served (single family, multifamily, ICI, agricultural)

3. **Pricing structures**

4. **Average customer use information** (per capita, per household, per sector, MGD total usage)

5. **Current conservation measures** in place (list provided for reference)

6. **Estimated savings** from current conservation program (water or monetary)

7. **Future conservation** program components planned

8. **Community education programs** in place (type, number of employees, activities)

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