Alternative Water Conservation Policy Tools for Oklahoma Water Systems

Final Report

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Problem and Research Objectives:

As the Comprehensive State Water Plan moves toward making recommendations, an evaluation of viable, practical, and politically acceptable water conservation policy tools is needed. Experts agree that the pressure on Oklahoma's water supply may increase due to population growth, environmental regulations, climate change, and several other factors. With continuing competition among water consuming municipalities to secure their water supplies, and pressure from the rapidly growing urban complex in North Texas, every option will be needed to conserve Oklahoma's water resource. Although there is increasing experience around the U. S. with crisis-oriented drought response tools, most of this experience has not been shared, or evaluated, or packaged as conservation policy tools. The research will evaluate such tools and bring them out for consideration and evaluation as part of the Water Plan.

Despite the demonstrated vulnerability to drought in Oklahoma, few water managers have formal contingency plans for crises. Lack of awareness of feasible water conservation policy alternatives presents a significant barrier to development and adoption of contingency plans. The primary goal of this project is to increase water managers' and other stakeholders' awareness of: (1) available alternative water conservation policy tools, (2) their feasibility for local conditions, and (3) their relative costs and water savings. Our specific objectives are:

- <u>Objective 1</u>: Catalogue and analyze alternative water conservation policy tools that are potentially applicable to water supply managers in Oklahoma (e.g., pricing schemes, quantity controls [voluntary or involuntary], subsidies, and education/awareness or information feedback programs). **Completed.**

- <u>Objective 2</u>: Determine which water conservation policy tools are currently being applied in Oklahoma. **Completed.**

- <u>Objective 3</u>: Synthesize the results from Objectives 1 & 2 into a framework document for use in expert panel sessions (Objective 4 below). Alternative method used, but status is **Completed**.

- Objective 4: Evaluate the relative feasibility of the alternatives from the water managers' perspective. **Completed.**

- Objective 5: Evaluate the relative feasibility of the alternatives from the water users' perspective (survey of willingness to adopt). **Completed.**

- Objective 6: Analyze, synthesize, report and extend the results. **Completed.**

Using a literature review and surveys, we identify and evaluate water conservation policy tools that are suitable for local conditions in Oklahoma. First, we conducted a literature review that includes the gray literature (e.g., technical reports) with the help of collaborators at universities in other states (Florida, Tennessee, Arkansas, Texas, and New Mexico). Second, we designed and conducted a survey of water supply managers in Oklahoma and other Southern states to identify which water conservation policy tools are currently being used. Third, we created a framework literature review document and identified potentially feasible conservation policy tools. Fourth, we are designing and will soon conduct a region-wide survey of water users to identify willingness to support potential alternative policy mechanisms. Finally, we will synthesize the results and report the findings to stakeholders as appropriate. This project is expected to generate valuable information that can be used to support the efforts of the Comprehensive State Water Plan process.

Methodology:

To complete **Objective 1**, we conducted an extensive review of the water conservation literature. The review included both peer-reviewed publications as well as the gray literature (e.g., technical reports and circulars). Collaborators at peer institutions (University of Florida, University of Tennessee, University of Arkansas, Texas A&M University, and New Mexico State University) helped with the literature review for water-related publications within their respective states. In addition to determining what water conservation policy tools are currently being used in the Southern states, we determined the relative effectiveness and cost of each, where possible.

Literature Review of Water Conservation Mechanisms

I. Background

Until recently, *the* solution to water shortage was expanding supplies. Severe droughts, climate change, and the desire for sustainability has shifted the focus (somewhat) to increase efficiency of water use and reducing water use (e.g., Renwick and Archibald 1998; Michelson et al. 1999; Howarth and Butler 2004; Olmstead and Stavins 2008).

The Federal Energy Policy Act of 1992 established and mandated new plumbing efficiency standards for new household fixtures, such as maximum flow rates for showerheads and toilets, and standards for faucet aerators. As part of the act, the US Department of Energy was required to issue recommendations that encourage state and local governments to establish incentive programs for water conservation (Dunham et al. 1995). To facilitate information-sharing, the American Water Works Association and the US Environmental Protection Agency were commissioned to establish the *WaterWiser* clearinghouse on water efficiency (www.waterwiser.org). The 1996 amendments to the Safe Drinking Water Act increased the focus on water conservation by establishing voluntary guidelines (basic, intermediate and advanced) for water systems (EPA 2009). These efforts grew out of the 1970s energy crisis as an effort to decrease hot water usage (Dunham et al. 1995). In the 1970s and 1980s, several water utilities successfully demonstrated the effectiveness of water conservation at reducing energy use. For example, the Osage Municipal Utilities energy saving program included the distribution of low-flow showerheads and faucet aerators, and reduced annual energy growth to 3% from 7.2% (Dunham et al. 1995). By the late 1980s, water districts were beginning to deploy water conservation as a substitute for expanding supplies (e.g., Goleta, CA). Connecticut was the first state to require water conservation measures as a way to reduce the impact of population growth on strained water supplies. In 1989, Connecticut adopted a law that mandated residential retrofit for more efficient plumbing fixtures and formal water conservation planning (Dunham et al. 1995).

More recently, there has been a large amount of research and application of water conservation mechanisms. For example, in 2002 the US EPA published a review of case studies on water conservation in 17 states, cities, and regional water districts. These included Arizona, California, Florida, Kansas, Massachusetts, New Mexico, North Carolina, New York, Pennsylvania, Oregon, Ontario (Canada), and Texas (EPA 2002). Today, most water districts view water conservation mechanisms as complements and in some cases partial substitutes for additional storage and conveyance infrastructure (Kennedy and Goemans 2008).

Nationwide, water use per person is 160 gallons per day (Dickinson et al. 2003). Although the agricultural sector is the largest water user in these states, it is unrealistic to expect large-scale transfers of water rights from agricultural to urban areas (e.g., Brewer et al. 2007). As constraints on water supplies are reached, it is likely that urban and suburban areas will need to reduce water demand through a combination of price and non-price conservation mechanisms.

Severe droughts are typical precursors to water conservation programs, particularly non-price programs that limit or require particular instruments, appliances or behaviors (Syme 2000). This usually accompanies a shift in planning focus from short- to long-term (Syme 2000). Initially, it was mainly states in the Western US that implemented such programs, but today drought-stricken southern states are also turning to water conservation as a means to ensure adequate and safe water supplies (Olmstead and Stavins 2008).

Water districts and utilities that have studied water conservation as part of a broad collection of potential supply-enhancing alternatives typically find a strong role for conservation:

"Conservation effectively provides an additional resource by freeing up water that was previously consumed inefficiently or wasted. In this sense, it is the most cost-effective source of water available to the community. It is also a resource over which the local community has a great deal of autonomy to implement, since it depends on our own efforts and less on influences outside the community." – Southern Nevada Water Authority (2004).

These studies demonstrate the effectiveness of water conservation: "Many utilities throughout the region reduced per capita demand by up to 30% in response to the drought, and reductions of 15% to 20% were fairly typical." – Western Water Advocates (2003) from "Smart Water: A Comparative Study of Urban Water Use Efficiency across the Southwest." Boulder, CO. Effective water conservation can even eliminate the need for new supply (Cooley et al. 2007).

Water conservation programs usually involve several co-integrated measures that fall into one of five categories: financial (pricing, rebate, incentive), technological (mandatory specifications), educational (awareness, etc), maintenance (leak detection) and operational (reducing water pressure). Governments and utilities have employed a wide variety of mechanisms to conserve scarce water resources. Below, we summarize the use of water conservation mechanisms in the US, including information on relative cost, effectiveness, participation rates, and factors that impacted program success.

II. Price Mechanisms

The price of publicly-supplied water is typically not based on market transactions. Instead, utilities and municipalities set both water rates and rate structures. In most cases, households face a fixed fee for service, with an additional volumetric charge per unit of water they consume that may step up or down according to "blocks" of water use. The block rate structure is typically either uniform (unit price does not vary by quantity), decreasing (price per unit falls as consumption quantity increases), or increasing (price per unit rises as quantity increases) (Klein et al. 2006). Rates can be adjusted during specific months or seasons of high water demand, or during the drought times. Rate structures with high fixed rates, but low variable (volumetric) rates do not promote conservation (Cooley et al. 2007).

Studies have generally reported an inelastic relationship between water demand and price (Inman and Jeffrey 2006), and water demand generally does not respond to price rises above a certain point (e.g., Dalhuisen et al. 2003). Dalhuisen et al. (2003) conducted a meta-analysis of 64 regions in the US and Europe and generated 314 separate price elasticities for water. They found that elasticities varied greatly by region. European elasticities averaged -0.28. In the US, elasticities averaged -0.17 in western states and only -0.005 in eastern states. Lower income households have more elastic water demand (UKWIR 1996; Renwick and Green 2000). Renwick and Green (2000) found that households earning less than $20,000 per year had elasticities five times larger than households earning $100,000 or more. However, this does not hold below some minimum amount of water needed for absolute necessities (Howarth and Butler 2004).

Outdoor water use studies report much more elastic demand (e.g., UKWIR 1996; Renwick and Archibald 1998). Perhaps this is expected, since indoor water use is linked to the necessities of bathing, eating, etc while outdoor use is linked to aesthetics or recreation. Also, there is a discussion in the literature about whether customers are able to interpret their water bills and hence, understand and respond to water rate signals (e.g., Shin 1985, Whitcomb 2004).

Irrigation accounts for the bulk of water use. Elasticity studies show that during the summer months, elasticity of demand is 5-10% larger compare to winter months (e.g., Klein et al. 2006). Nieswiadomy (1992) found that elasticities can differ greatly by region, with water users in the southern and western states having more than twice the demand elasticity of the rest of the US. In California, the demand elasticity in Santa Barbera was almost three times larger than in nearby Goleta (Renwick and Green 2000).

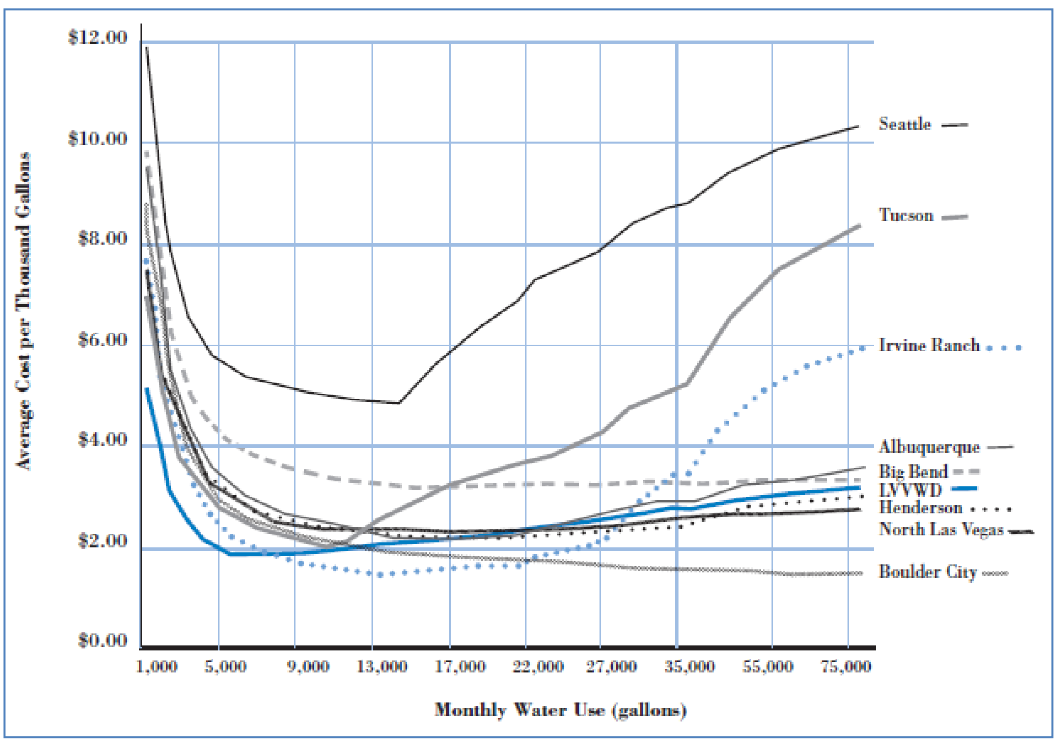
Block structure impacts elasticity, for example with households in a two-tier inclining block structure having five times larger elasticity than those in a uniform block (Cavanaugh et al. 2002). Despite evidence that users may respond more to average than marginal costs of water (Nieswiandony 1992), from an economic efficiency perspective, the price of water should be set equal to its long-run marginal costs of supply (Olmstead and Stavins 2008). This price would reflect water's full economic cost, including related costs of pumping, storage, treatment, infrastructure maintenance, and related expenses.

Water prices are typically set below the LRMC (e.g., Timmins 2003). There are political, geo-physical, informational and other factors that preclude setting the price of water equal to its long-run marginal cost. Criteria used by water utilities in designing water rates include revenue level and stability; fairness and impacts on low-income customers; ease of understanding by customers and ease of implementation; water use efficiency and conservation; and adequate long-run water supply. While these objectives are not mutually exclusive, they sometimes can conflict with each other, the most common example being the potential tradeoff between water conservation and utility revenue objectives.

The use of water rates to achieve water use efficiency and conservation objectives has its pros and cons. The benefits of conservation water rates include: (a) communication of general water conservation need, rewarding efficient users, and penalizing non-efficient water use; (b) reduces operating costs, and delays the need for system expansion and acquiring additional water supplies and storage capabilities; (c) drought preparedness by public utilities and customers; (d) environmental benefits associated with water conservation (e.g., Wang et al. 2005, Alliance for Water Efficiency 2008). The two main pitfalls of conservation rate are: (a) the tradeoff between water conservation and utility revenue requirement objectives; and (b) increased volatility and difficulty of predicting utility revenues (Wang et al. 2005). Approaches used to address the issues of revenue variability and uncertainty include revenue stabilization funds, bond issuing or retiring, tax and/or water rate adjustments, and spending excess revenues on conservation and public education programs.

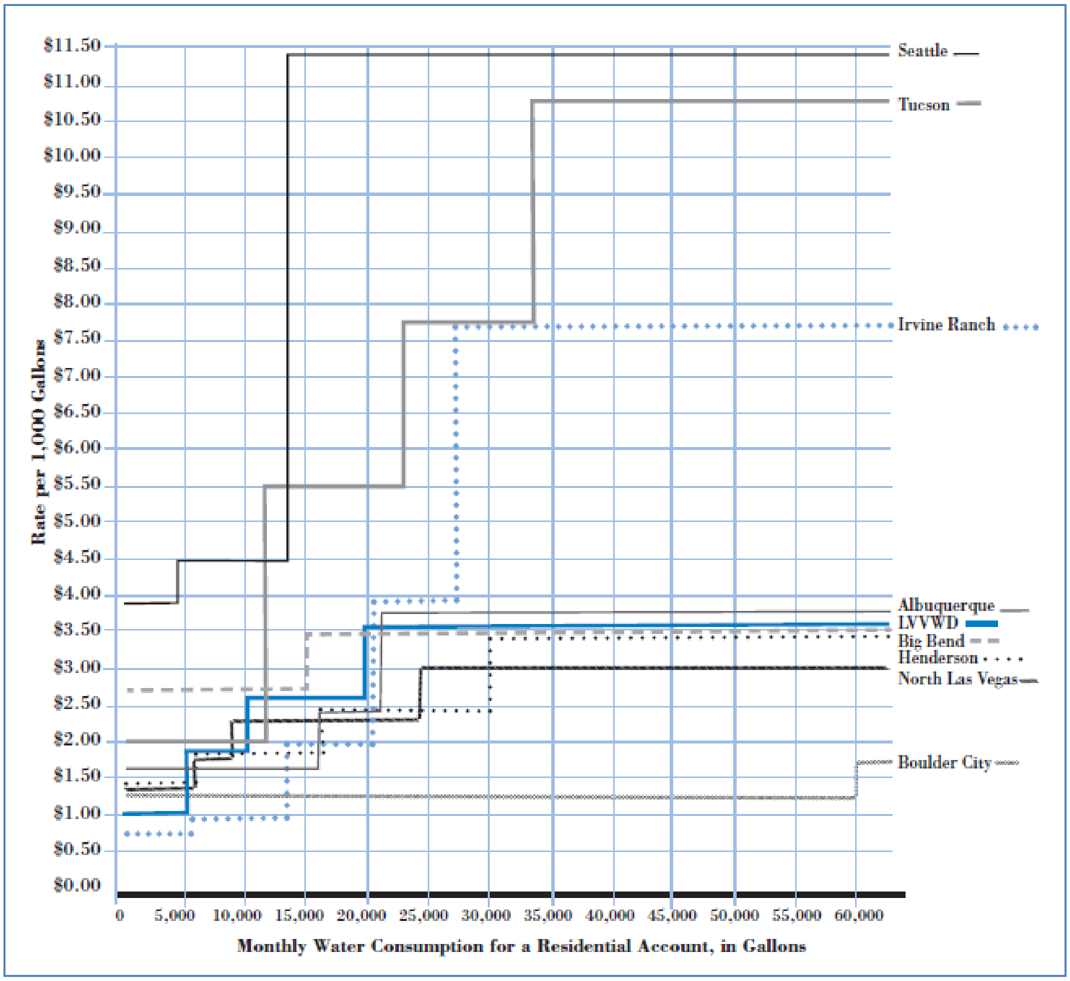
Examples of rate structures and average cost functions for several communities are shown below (Figures 1 and 2).

Figure 1. Example of Average Water Cost Functions



Cooley et al. (2007).

Figure 2. Example of Block Rate Structures for Several Communities



Source: Cooley *et al*. (2007).

III. Non-Price Mechanisms

Price mechanisms, while effective, are inherently limited. Public resistance to rate increases and increasing price inelasticity necessitate the use of non-price mechanisms. Also, integrating price and non-price mechanisms may improve the overall effectiveness (both in economic and water savings terms). Several studies support the notion of synergy between price and non-price mechanisms (e.g., Moncur, 1987; Campbell et al., 2004), and that the effectiveness of price changes is significantly impacted by non-price mechanisms (Howe and Geomans, 2002). Below, we describe a host of non-price mechanisms that have been successfully applied in the United States.

A. Education and Awareness

As Howarth and Butler (2004) note, gaining public support for water conservation may be crucial to programmatic success. As a result, awareness and education campaigns are usually accompany other water conservation mechanisms. For example, the effectiveness of pricing mechanisms can be strongly influenced by the billing process (Stevens et al. 1992; Kulshreshtha 1996). In fact, significant decreases in water use might only accompany a large price hike if the public is highly aware of the price increases and the new price schedule (Nieswiadomy 1992). Carter and Milon (2005) used survey and household water use data from three Florida utilities. Only 6% of their respondents knew the price they paid for water. They also found that households with increasing block rates were *less* likely to know what they paid for water, but that those who said they knew the price of their water had 2-5 times larger elasticities (they also used more water on average).

A few studies have measured the disaggregated impact of education and awareness on water use. Renwick and Green (2000) report an average 8% water savings in eight urban California areas due to education/information. US EPA (1998) estimates that an education program in Austin was responsible for 2-5% annual water savings. Wang et al. (1999) estimated a 4.8% reduction in summer water use between 1992 and 1997 due to bill inserts and pamphlets in New Castle County, Delaware. Nieswiadomy (1992) used a survey of 430 US water utilities to estimate the impact of public education campaigns in the West, South, North Central and Northeast United States. The results indicated that these campaigns are only effective in the West, perhaps due to their experiences with droughts. Renwick and Green (2000)'s panel data regression analysis of eight urban California water agencies found an average 8% water savings associated with public awareness campaigns, while Howarth and Butler (2004) report zero impact on demand in Swindon, England. Shaw et al. (1992) found that San Diego's intensive education and advertising campaign achieved a 22% reduction in water use. Syme et al. (2000) reviewed the literature on the impact of public awareness campaigns on voluntary water conservation. They estimate that up to 25% of short-term water savings can be attributed to such campaigns, but long-run impacts have not be measured. On the other hand, Wang et al. (1999) found public awareness campaigns to have no statistically-significant effective when used in conjunction with price and device retrofit in New Castle County, Delaware. They used panel data on 500 households to estimate water use changes from 1992 to 1997. The information program appeared to have a very slight and short-term impact (only 1 year), but the number of households changing water use was perhaps too small for the model to adequately estimate the impacts of the campaign.

Decisions to curb water demand have been influenced by the degree to which towns have experienced a perceptible limit to their supply. A crisis brings the focus to water and allows water managers to redefine the problem, thus allowing conservation as a possible solution. 'Regional' water systems may impact perceptions of water vulnerability (Brown 2006).

Outreach efforts can also improve retrofit kit installation rates (Dunham et al. 1995). Dunham et al. (1995) report that Seattle's retrofit kit program achieved a 34% installation rate without and 68% with a campaign that included advertising, newspapers, and 'organizers.'

The state of Colorado used a xeriscaping DVD to help promote efficient lawn landscapes (CFWE 2007). From April to June 2007, 97,900 DVDs were mailed to residents in Douglas and Arapahoe counties. A random mail survey to 3000 DVD recipients followed (n=208). Only 48% of respondents had viewed the video. The DVD promoted awareness of water issues (92% of viewers). However, the effectiveness of the DVD is suspect. While 76% reported already using water conservation measures, only 78% said they would pursue water conservation after watching the video.

Awareness programs can be particularly cost-effective. For example, a recent innovation in billing includes conservation 'report cards' that use smiley faces to indicate how energy efficient customers are compared to their neighbors (NY Times 2009). This approach is being used in 10 major metropolitan areas. In Sacramento, after 6 months, customers receiving the report cards reduced their energy use by an average of 2% compared to those not receiving report cards. A similar program by the Owatonna Public Utility in Minnesota cost $654,532 for about 11,300 electric, 10,000 natural gas and 9,400 water customers – about $58/household (People's Press 2008). In studies using social norms to motivate environmental conservation, it has been found that among three types of messages – conserving to save the earth for future generations, personal financial savings, and a majority of neighbors had already taken steps to curb their energy use – only the message regarding neighbors' behavior had significant effect (Goldstein et al. 2008).

B. Restrictions and Household Rationing

Voluntary and mandatory measures are effective water conservation mechanisms. Voluntary measures publicize suggested water use behaviors, such as off-peak or every-other-day lawn irrigation. Mandatory measures impose penalties for violating use mandates.

Mandatory measures seem to provide positive results. Los Angeles achieved a 36% drop in demand due to mandatory restrictions over the same period (Shaw et al. 1992). Also, new plumbing codes (EPA 1998) have resulted in overall 5-10% water savings since 1996. In Goleta, California, restrictions on certain uses, such as washing cars and irrigating lawns during peak hours, reduced water use by 29% (Renwick and Archibald 1998). The city of Tampa's Sensible Sprinkling landscape evaluatations program achieved a 25% reduction in water use (EPA 2002). The program includes irrigation and plumbing codes, fines for violations, and water use restrictions. Outdoor irrigation is limited to one day/week and prohibited between 8am and 6pm, and irrigation systems must incorporate rain sensors. Free rain sensors are distributed along with education materials. The landscape code limits irrigated turfgrass to 50% in new developments. Also, drought-tolerant, native plants are encouraged. Renwick and Green (2000) estimate that rationing led to a 19% drop in demand in eight California communities.

There is very little evidence supporting the effectiveness of voluntary measures. One noted exception is Shaw et al. (1992), who estimated that San Diego's water use fell by 27% due to voluntary restrictions during a 1990-1991 drought. Kenney et al. (2004) examined voluntary and mandatory restrictions on lawn irrigation in eight Denver areas. They found that voluntary restrictions produced between 4-12% drops in water use, while mandatory restrictions led to much larger drops of 18-56%. Lee and Warren (1981) also found that mandatory measures were much more effective than voluntary ones. They examined 12 Iowa districts that adopted voluntary measures in 1977, four of which later imposed mandatory measures. Predicted and actual water use was compared. Narayanan et al. (1985)'s study of 33 Utah communities from 1976-1977 found evidence that voluntary restrictions may lead to increased water use, perhaps because users expect stronger restrictions to follow.

Mandatory measures returned the highest water use reduction, but voluntary measures were also very effective in towns that were located near other towns with severe water shortages. Renwick and Green (2000) found that mandatory restrictions on peak-hour lawn irrigation and washing impervious surfaces led to a 29% drop in use. Their study involved eight California utilities between 1989 and 1996, while California was in a drought.

C. Retrofits, Rebates, and Improved Devices (low flow toilets, showers, washers, etc)

Retrofit programs involve modifying existing appliances, etc with devices that improve efficiency. This includes faucet aerators, toilet displacement dams, low-flow showerheads and the like. Related programs would also include replacing inefficient appliances, for example with low volume toilets, front-loading clothes washers, and certain dishwashers.

Retrofit programs can be fairly effective – reducing water use by about 10% on average (Inman and Jeffrey 2006; Wang et al. 1999; Mayer et al. 2003; Maddaus 1984; Turner et al. 2004). Given the typically low cost of such programs, retrofit measures are very effective on a water-saved-per-dollar-spent basis. Tables 1 - 6 reports a comparison of cost, water saved and participation rates for various water conservation measures.

While much more expensive, replacement of household appliances with newer, more efficient versions can significantly reduce water demand by 35-50% on average (Inman and Jeffrey 2006). The most exhaustive studies of retrofits and replacements were conducted by Mayer et al. (2000), Mayer et al. (2003), and Mayer et al. (2004b) with over 100 homes in Seattle, San Francisco, and Tampa. In each case, homes were retrofitted with faucet aerators, low-flow showerheads, and high efficiency toilets and clothes washers. These studies identified leakage –

primarily from faulty toilet valves – as being responsible for a large amount of water loss. Reduction of water waste from leaks accounted for the majority of retrofit savings in San Francisco and Tampa Bay. Toilet replacement accounted for the highest savings for Seattle, and second-most for San Francisco and Tampa Bay. In San Francisco, total demand reduction was 39.4% with leakage and 27.9% without (Mayer et al. 2003). Hot water use dropped by 21.8% - a potentially significant savings in energy as well.

Conservation kits that include several devices (e.g., faucet aerators and low-flow showerheads) as well as information/education materials are also effective. Renwick and Green (2000) found that free retrofit kits that included toilet displacement dams, dye tablets to detect toilet leaks, and a low-flow showerhead reduced average water use by 9%. An econometric model by Renwick and Archibald (1998) found that the presence of an additional low-flow toilet in each household reduced water use by 10%, and for each low-flow showerhead, water used fell by 8%. Mayer et al. (1998) found similar results – almost 20% water savings from low-flow toilets and 9% savings from low-flow showerheads. In some cases, low-flow fixtures and appliances produced no statistically-significant water savings. Ultra low-flush toilets in Santa Barbera, California (Renwick and Green 2000) is one such example. The city of Tampa replaced 27,239 toilets, savings 254.9 million gallons/year (EPA 2002). Although population has increased by 20% from 1989 – 2001, per capita water use has fallen by 26%.

Campbell et al. (1999) used regression analysis of 1200 water bills from 1990-1996 in Phoenix, Arizona. Among the tools analyzed were water price increases, low-flow retrofits and kits, and a local ordinance mandating water saving devices for new and replacement fixtures. While estimated to conserve 1,000 times less water than a 10% price increase, the ordinance was most effective of the non-price measures.

The US GAO (2000) provides a description of program costs, savings, and duration of six toilet retrofit/replacement programs (Table 1). These occurred primarily during the 1990s in Austin (Texas), Los Angeles (California), New York (New York), Phoenix (Arizona), Tampa (Florida), and Hillsborough County (Florida). For the six programs, 2,330,939 toilets were distributed free or through rebate programs. Estimated water savings ranged from 23.4 to 53.8 gallons per day, and total water savings were 102,018,864 gallons per day. The total cost of the programs was $409.6 million, or $0.25 per gallon saved per day. Average costs per toilet were $175.72. Dunham et al. (1995) reviewed case studies of five successful water conservation programs. These were primarily rebate/bill credit programs (New York, Los Angeles, San Antonio, Austin, and Seattle), threat of regulation (Los Angeles), and showerhead kits (Seattle).

Table 1. Rebate and Retrofit Case Studies

	Total cost	# of measures	Cost of measure	Water savings
Program				
New York toilet rebate	$270mn	1-1.25mn	$150(each addl)-$240(first)/toilet	29-68 gpcd
Los Angeles toilet rebate	$6.56mn	65,167	$110/toilet + $25 for install/promo	58.6 gpcd +/- 14 gpcd
San Antonio toilet rebate	$315,000	4,200	$75/toilet	79,000 gpd
Austin toilet rebate	$155,000	7148	$40 (residential) -$75 (commercial) credit	172,000 gpd
Seattle retrofit kit (showerhead)	$3,877,500	330,000	$11.75/kit	Not available
Seattle toilet rebate	Not available	Not available	$100-$150/facility	30%

Source: Dunham et al. (1995).

Conservation programs typically enjoy high returns to investment (see Tables 2 – 4). For example, the Houston, TX retrofit program projects a 3.7 to 1 benefit-cost ratio, and a predicated total savings of $262 million (EPA 2002). The program included a combination of conservation kits (showerheads and aerators), school-age education, and low-flow toilet replacement. One study used undergraduate students with self-administered water audits. Apartment users had higher water use, but when correcting for direct payment of the water bill, this effect disappeared. Residence managers can save over $45/person/year by installing standard low-flow water use devices: $39.53 in residence halls, $54.86 in apartments, and $40.65 in single family homes (Buckley 2004). Davis (2008) estimated net savings from efficient, front-loading washer installation. In the Bern, Kansas program, 98 households were provided with free replacement washing machines. 83% of households saved money on energy in present value terms. The cost of washing clothes fell by 65% (from $.11/lb to $.04/lb). The washers use 44% less energy and 41% less water. Present-value cost savings from energy were $524 at a 5% discount rate. Efficient washers cost, on average, $239 more. Total cost per cycle were $.30 less for the efficient machines. Water use per cycle fell from 10.4 gallons for hot and

27.8 gallons for cold to 4.3 gallons for hot and 19.4 gallons for cold. Dickinson et al. (2003) conducted a nationwide survey of 1,200 households to estimate the impact of plumbing standards (efficient showerheads, toilets and faucets) on water use. On average, efficient toilets use 52% less water, showerheads 21% less water, and faucets use 2% less water. The total drop in water use from these fixtures was 32%. For each household that installed all three, utilities saved $26/person; communities saved $127 on average. A total of $7.5 billion on infrastructure was saved. Including hot water savings, the total savings could be $35 billion in the US.

Table 2. Conservation Results (Expected) for Cary, NC Programs

Program	Water savings/yr 2009 (mgd)	Water savings/yr 2019	Unit cost of water saved	First 5 yrs cost	Benefit/cost ratio
Residential water audits	0.053	0.077	546.85	71,335	1.13
Public education	0.3	0.41	400.59	314,280	1.53
Toilet flapper rebate	0.005	0	828.04	11,762	1.03
Water reclamation facility	0.27	0.3	n/a	n/a	n/a
Landscape water budgets	0.013	0.023	754.33	64,175	0.88
New home points program	0.5	0.77	38.18	100,000	16.2
Landscape/irrigation codes	0.02	0.04	276.07	128,350	2.6
Inverted-block rate structure	0.14	0.42	49.4	54,000	14.26
Combined results	1.17	2	137.5	655,552	4.44

Source: EPA (2002).

Table 3. Residential Indoor End Uses of Water

End Use	Without Conservation		With Conservation		Water Savings	
	Percent (%)	Gcd*	Percent (%)	Gcd*	Percent (%)	Gcd*
Toilets	27.7	20.1	19.3	9.6	52	10.5
Showers	17.3	12.6	20.1	10.0	21	2.6
Faucets	15.3	11.1	21.7	10.8	2	0.3
Baths	1.6	1.2	2.4	1.2	0	0
Clothes Washers	20.9	15.1	21.3	10.6	30	4.5
Dishwashers	1.3	1	2	1	0	0
Other Domestic	2.1	1.5	3.1	1.5	0	0
Leaks	13.8	10	10.1	5	50	5
Total Indoor Use	100	72.6	100	49.7	32	22.9

Source: Dickinson et al. (2003); *Gcd = gallons per capita per day.

Table 4. Estimates of Indoor Water Use with and without Conservation

End Use	Without Conservation		With Conservation		Water Savings
	Percent of total (%)	Amount gpcd	Percent of total (%)	Amount gpcd	Percent (%)
Toilets	28.4%	18.3	23.2%	10.4	44%
Clothes washers	23.1%	14.9	23.4%	10.5	30%
Showers	18.8%	12.2	22.4%	10.0	18%
Faucets	16.0%	10.3	22.5%	10.0	2%
Leaks	10.2%	6.6	3.4%	1.5	77%
Baths	1.9%	1.2	2.7%	1.2	0%

Dishwashers	1.6%	1.1	2.4%	1.1	0%
Total Indoor Use	100%	64.6	100%	44.7	31%
Toilets	28.4%	18.3	23.2%	10.4	44%

Source: AWWA Water Wiser 1997, cited by EPA 2009.

D. Offsetting Behavior, Demand Hardness, and Persistent Impacts

Offsetting behavior can sometimes result in *increases* in water use after retrofits and replacements (Campbell et al. 2004; Geller et al. 1983). The installation of low-flow showerheads may lead to longer showers (Mayer et al. 1999). For example, a study of 129 households in Blacksburg, Virginia found evidence of this behavior following the installation of toilets dams, aerators, and two other plumbing devices (flow control device and shut-off shower control) in an experiment that also included information feedback and education. Davis (2008) conducted a field trial involving front-loading clothes washers, and found a 5.6% increase in washing after the replacement. Geller et al. (1983) also found offsetting behavior in their study of 129 residences for 70 days. They used a 2x2x2 design involving education, daily consumption feedback, and retrofit. The retrofit group yielded less water savings than expected, which they attributed to offsetting. They noted other studies where the water users were not informed of expected savings associated with the retrofits. In those studies, water savings were substantially more. They also suggest that low water prices can render education programs ineffective. Campbell et al. (2004)'s study of a 6-year program in Phoenix, Arizona discovered strong offsetting behavior that was significantly counteracted by moral suasion (the idea that the whole community is working toward a common goal). Indeed, the authors caution against simply relying on retrofit/replacement programs without complementary education and awareness programs and/or rules. Offsetting behavior may occur when households know that conservation devices are causing conservation, but communication in the form of moral suasion (person-to-person communication about cooperation toward a common goal) can overcome this effect (Campbell et al. 2004). Davis (2008) found that, after receiving a highly efficient washing machine, washer use increased by 5.6%. On average, the washers use 48% less energy and 41% less water per use, so savings were still overwhelmingly positive.

Demand hardening can occur as water conservation measures are implemented, and as systemic inefficiencies are reduced, additional water conservation measures are less-and-less effective (Cooley et al. 2007). Cooley et al. (2007), however, found that demand no evidence of demand hardening from indoor or outdoor efficiency measures in Las Vegas, Nevada. The authors noted that households that adopted low-flow faucets and efficient appliances can still reduce their water use during shortages by adjusting their behavior. Given the benefits of water conservation over the long-run (e.g., reduced vulnerability to drought), they argue, communities should not forego water conservation for fear of demand hardening.

Water conservation programs can lead to persistent behaviors that outlast the need for water use reductions (Gilbert et al. 1990; Shaw et al. 1992; Shaw and Maidment 1988). Shaw et al. (1992) examined San Diego's voluntary water restrictions, and found that they persisted for several months although weather conditions normalized. Shaw and Maidment (1988) found that the effects of a mandatory restriction lasted at least a year after the program was discontinued. The authors suggest that this might be the result of homeowners adjusting their habits to decrease consumption.

E. Lawn Irrigation (sprinkle, drip, restrictions, ordinances, etc.) and Xeriscape Landscaping

Several factors impact the level of outdoor water use. Households with more expensive and technologically-sophisticated irrigation systems use more water than those with manual systems (Syme et al. 2004). Water use tends to increase with the sophistication of lawn irrigation equipment (Lyman 1992; Mayer et al. 1999; Renwick and Archibald 1998; Cavanagh et al. 2002). Households with sprinkler systems use 9% more water on average than those without (Renwick and Archibald 1998). Those with in-ground sprinkler systems use 35% more outdoor water; if the system has an automatic time, they use 47% more (Mayer et al. 1999). By comparison, those with drip irrigation systems use 16% less, and those with hand-held irrigation use 33% less. Chestnut and McSpadden (1991) estimated that users in Los Angeles, California with automatic irrigation systems use 11.2% more water on average. Renwick and Archibald (1998) found that adoption of efficient irrigation systems reduce average household use by 11%. The effects were much more pronounced for large lots (average 31% drop) than small landscapes (average 10% drop). Technologies that incorporate evapo-transpiration and soil moisture sensors are likely to significantly reduce water use.

F. Leak Control and Water Metering

Leaks can account for a tremendous percentage of water use; fixing leaks can sometimes achieve more water savings than other conservation tools (Inman and Jeffrey 2006).

Metering allows utilities to determine water use on a per unit basis. If used in conjunction with pricing and other financial incentives, metering can be particularly effective at reducing systemic water demand. On average, metering reduces water demand by 20% (Inman and Jeffrey 2006). The effects tend to be much stronger for outdoor than indoor demand (e.g., Maddaus 2001). Metering also tends to have a large initial impact that is eroded over time. Maddaus (2001) reported an 18.9% reduction in water use from 1997-1998 in Davis, CA following metering. From 1997-1999, the average reduction only measured 8.7%. Metering also shows significant reductions for multi-family buildings. Mayer et al. (2004b) found that a combination of sub-metering and a price increase led to a 15.6% reduction in per capita demand.

IV. Limitations of studies

We note that water use and conservation policies often lack clear purpose (Renwick &Green 2000), which can lead to poor data collection on policy impacts. Also, the implementation of multiple policies at once (e.g., retrofits and inclining block rates at the same time) muddle the analysis.

Further, data limitations are a serious barrier to evaluating the effectiveness of water use and conservation policies. For example, data that are both cross sectional and time series (panel data) are usually unavailable. Fewer than half the studies reviewed by Hewitt and Hanemann (1995) used disaggregated, household-level data needed for an individual demand model. As a result, many studies rely on aggregate data that cannot reflect individual heterogeneity (income, race, etc); and elasticity calculations are prone to large error (Martinez-Espineira 2006). Also, in most studies involving water pricing, prices have not varied a great deal, which means that the relevant range for elasticity calculations is necessarily very limited. One noted exception is Pint (1999), who estimated the impact of large price increases (and increasing block rates) – over 400% increase for the highest block.

Michelson et al. (1999) point out that simple pre/post analysis fails to take into account other factors that might impact water use, for example droughts. Length of study can influence results. Mechanism effectiveness is not uniform over time (Michelson et al. 1999). For example, water use fell by 18.9% in the first year of a metering program in Davis, California, but leveled-out at only an 8.7% decrease over the first two years (Maddaus 2001).

Many studies may suffer from omitted variables. Some studies that include a weather variable find it statistically-significant (e.g., Kenney et al. 2004; Hewitt and Hannemann 1995; Nieswiadomy 1992), but many have not (e.g., Gegax et al. 1998; Michelson et al. 1999). Other factors, such as household characteristics, are well known to influence demand. Income elasticity estimates are positive and inelastic (Piper 2003), generally between 0.2 and 0.6 (Cavanagh et al. 2002). For example, Cochran and Cotton (1985) estimate income elasticity to be 0.58 for Oklahoma City. Size of household is also a factor (e.g., Nieswiadomy 1992; Renwick and Archibald 1998; Cavanaugh et al. 2002; Piper 2003). For example, Cavanagh et al. (2002) examined data from 1,082 households and found that for each additional person in the household, water use increases by 22%. On the other hand, Nieswiadomy (1992) found that household size was only significant in the south region for a marginal price model, for the northeast and west for an average price model of demand, and for the west using a price perception model. However use depends on age as well. For example, highest per-capita water users in Moscow, Idaho are children under 10 and the lowest are teens (Lyman 1992). In their study, they found that children used 2.5 times more water than teens, and 1.4 more than an adult. Dwelling characteristics can also impact demand. For example, Cochran and Cotton (1985) found that number of households (i.e., more multi-family versus single family) per thousand population was a statistically-significant predictor of demand; however, the variable was insignificant when water price and per capita income entered the model. Home age also impacts use, as newer homes tend to be more efficient (e.g., Mayer et al. 1999; Cavanagh et al. 2002). However, Cavanagh et al. (2002) caution that homes built in the 1960-70s are relatively heavy water users because they do not have the smaller connections and fewer water fixtures of much older homes, or the efficient fixtures that are required of homes built after the 1980s. Mayer et al. (1999) suggest that the retrofit and replacement programs are perhaps most effective for homes built in the 1970s and 1980s. Number of bathrooms tends to increase water use (Hewitt and Hanemann 1995). For example, Cavanagh et al. (2002) estimate that each additional bathroom increases water use by 6%. However, Lyman (1992) found a negative correlation. House size, generally, is also linked to water use. Cavanagh et al. (2002) estimate a 13-15% increase in water demand for each additional 1000 square feet. Lot size is also positively correlated with water use (Lyman 1992; Renwick and Green 2000; Cavanagh et al. 2002). For example, Renwick and Green (2000) report a 2.7% increase in water demand for each 10% increase in lot size.

Attitudes about conservation and water use can impact water demand, but Syme et al. (2000) point out the consensus in the literature of a weak correlation between conservation attitudes and conservation behavior.

Savings of 35% - 70% are possible from changes in residential landscaping and improved management of outside watering, which often accounts for more than 50% of total residential water use. Hurd (2006) examines landscapes in three New Mexico cities to identify and measure behavioral factors affecting water conservation. Using survey data, landscape choices are analyzed with a mixed logit model that assesses the effects of landscape and homeowner characteristics on choice probabilities. Water cost, education, and regional culture are significant determinants of landscape choice. Moral suasion can also have a positive influence (Hurd 2006).

Some studies involve intrusive monitoring that may influence the results.

Residential water use reductions are linked to a number of concrete benefits that may not be fully captured by economic evaluations. Water conservation programs can lead to reductions in costs faced by water suppliers, such as for maintaining, operating, expanding or acquiring water-related infrastructure (Maddaus 1999). Australian water policy is based on the concept that a drop of water saved equals a drop of water supplied (Fane et al. 2004).

Although price and non-price mechanisms are usually co-implemented, the vast majority of studies do not explicitly measure the impact of interactions between price and non-price mechanisms (e.g., Nieswiadony 1992; Renwick and Archibald 1998). A noted exception is Michelson et al. (1999). Their study of panel data over 11 years from seven western cities (2 in California, 3 in New Mexico, and 2 in Colorado) included a price/non-price interaction variable; however the term was statistically insignificant (although they did not differentiate between different kinds of non-price programs). Individual program effectiveness is also influenced by the number of other programs implemented. There is evidence that a combination of price and non-price programs improves the overall effectiveness of both (e.g., Moncur 1987); however, marginal returns to the number of programs are apparent (Michelson et al. 1999). Michelson et al. (1999) found that cities employing fewer water conservation mechanisms experienced slightly larger per-mechanisms effects. On the other hand, Gegax et al. (1998) argue for a critical mass of programs below which conservation is negligible; and Wang et al. (1999) found no statistically-significant impact of an education campaign when used in conjunction with price and retrofit programs in Delaware.

A. Current Institutional and Political Barriers

Concerns about revenue streams are important barriers to the use of water conservation tools. Public utilities may not have sufficient incentives to support water conservation programs, particularly because conservation practices are expensive to implement and investments are not quickly recovered (Wang et al. 1994). Municipalities receive revenue by selling water (Kennedy & Geomans 2008). Price-based mechanisms could lead to short-run profits that exceed statutory maximums (Mansur and Olmstead 2007). Water conservation absent rate increases can lead to financial shortfalls (Anderson 1996). For example, voluntary water restrictions in Los Angeles, California during a 1991 drought led to a more than 20% drop in the utility's revenues (Hall 2000). Rate increases soon followed to make up the shortfall. Establishment of a contingency fund, in conjunction with long-run demand forecasting, can alleviate some of these concerns (Chesnutt et al. 1996).

Politics also govern the use of conservation. In the late 1970s, Tucson, Arizona was the first American city to set water rates equal to marginal cost. This resulted in a large price increase, and a year later the entire city council was ejected from office (Hall 2000). During droughts conservation policies are politically acceptable (Syme et al. 2000), (Kennedy & Geomans 2008), (Brown 2006). But generally, lawn watering restrictions are politically "unpalatable" (Brown 2006).

Institutional barriers are also a problem, including: clouded titles, water transfer restrictions, illusory water savings, insecure rights to conserved water, shared carry-over storage, interstate compacts, conservation attitudes, land tenure arrangements, and uncertain duty of water. Price is a major limiting factor. (Ward, Michelson, and DeMouche 2007). Legal limitations hinder municipalities to pricing water during drought situations (Kennedy & Geomans 2008). Since increasing prices are politically dangerous municipalities have little cash to maintain infrastructure (Brown 2006) causing water loss.

Permit structure can also hinder water conservation efforts. For example, in Florida, agricultural water producers receive consumptive use permits from Water Management Districts. These permits allow water withdrawal for "reasonable and beneficial uses such as public supply (drinking water), agricultural and landscape irrigation, and industry and power generation" (FWMD 2009). Water conservation can lead to consumption below the permitted level, which can lead to a reduction in permitted withdrawals. This type of permit system creates a strong disincentive for water conservation, particularly for agricultural producers, and it does not allow temporal or spatial transfer of permitted water amounts.

In the context of water markets, lack of transferability hinders efficiency of water use. Brooker et al. (2005) estimated that future drought damages in the Rio Grande Basin (New Mexico and Texas) could be reduced 20-33% by allowing interstate water markets that allow transfers.

Lack of information and guidance for water utilities, particularly smaller and rural utilities, is a formidable barrier. In Oklahoma, a lack of guidance in the design of conservation rate structures can hinder water conservation. Also, a lack of information about the effectiveness and efficiency of alternative conservation tools available to utilities (specific to their customer base), a lack of monitoring and enforcement of mandatory water use restrictions in some locations, and a reliance of some landowners on un-monitored private wells present hurdles to water conservation (Borisova [personal communication] 2009).

In seemingly wet states, such as Florida, the apparent abundance of water can make it difficult to garner public support for water conservation. This is particularly true in places where groundwater can be accessed close to the surface by private landowners. This view of water does not account for seasonal variation, droughts, or environmental uses. A 2003 study in Georgia found that the biggest reason why residents do not adopt water conservation plans is a lack of feedback about whether their efforts were effective (Duda 2003).

One important barrier to public support for conservation is the potential impacts on low-income users. The impacts of water conservation programs have unequal impacts on some groups. For example, Davis (2008) estimates that 17% of water users would not benefit from water and energy efficient clothes washers. They used data from 98 households in Bern, Kansas that received front-loading, efficient clothes washers free of charge. They constructed a utility model and estimated expected impacts. Costs of installation exceeded water and energy-saving benefits for households that used relatively little water pre-installation.

In Oklahoma, other factors play a serious role as well. For example, cost/benefit analysis is lacking for water conservation programs and projects; agricultural water use is largely unmetered; there is a lack of information about water conservation options for rural areas; older and rural systems with narrow funding options must contend with sunk costs for inefficient systems; local ordinances prevent the use of some conservation tools (e.g., prohibition of rain barrels rules in Tulsa); water is perceived as abundant in many areas, and this has led to a lack of awareness of the value of water; and groundwater is viewed as a property right and not under the purview state interference.

B. Questions Unanswered by the Literature

- Long-run vs short run effectiveness (Kennedy and Goemans 2008); which programs work best under drought conditions?
- Forecasting non-price policy affects (Olmstead and Stavins 2008). What is the lag time? How much water will be conserved?
- When does more knowledge of water use increase/decrease consumption?
- Efficient billing procedure? (bill which is understandable to customers)
- Public involvement into the design of conservation programs?

C. Description of water conservation mechanisms

The US Environmental Protection Agency provides guidance for water systems seeking to implement water conservation measures (EPA 1998; EPA 2009):

Level 1 Measures

Source-water metering: helps account for system losses.

Service-connection metering: needed to supply customers with use information and to more accurately track and bill for water use.

Public-use water metering: Helps with loss control, costing and pricing.

Leak repair: system audits, leak detection and repair; automated sensors; loss-prevention program.

Pricing: metered rates, cost analysis, conservation signals.

Advanced pricing: Allocate costs by customer class and/or type of water use; seasonal variations. Conservation rate structures, marginal cost pricing. Take advantage of different elasticities of demand. Address potential revenue instability with revenue-adjustment mechanisms.

Information/water bill: Clear and understandable, informative, and sometimes educational water bill.

Education programs: School programs, printed/video materials, speakers, etc.

Level 2 Measures

Audits of large-volume and large-landscape users: Identify categories of water use, and opportunities for efficiency.

Selective end-use audits: Residential audits by water-use practices within each customer class (e.g., older housing).

Retrofits, replacements: Efficient toilets, showerheads, faucets.

Pressure management: Pressure-reducing valves, systemwide pressure control.

Landscape efficiency: Promotions, irrigation sub-metering, landscape planning, and irrigation management.

Level 3 Measures

Reuse and recycling: Graywater use (treated wastewater for nonpotable uses) for industrial, agricultural, groundwater recharge, and direct use.

Water use regulation: (SR) Restrictions on nonessential uses (lawn watering, car washing, filling swimming pools, washing sidewalks, and irrigating gold courses); restrictions on commercial car washes, nurseries, hotels and restaurants; standards for water-using fixtures and appliances, bans on decorative fountains, non-recirculating car washes & laundries; bans on other types of water use or practice as needed.

V. Other Cost and Water Savings Data

Tables 5 and 6 report the results of two studies on water savings and conservation program costs in two states – Arizona and Texas. Both provide valuable reference data for evaluating and planning water conservation programs in Oklahoma.

Table 5. Summary of Cost and Savings from Arizona Water Conservation Tools

User Type	Program	Base demand	Water savings	Cost of measure
Residential	Pool cover rebate	-	-	$362/AF
	W.E.T. indoor rebate	-	-	$163/AF
	AZ state water bank	-	-	$461/AF
	Water smart landscape rebate	-	-	$467/AF
	W.E.T. outdoor rebate	-	-	$652/AF
	Efficient appliances/fixtures	78	40%	-
	toilets	21	55%	-
	leaks	14	86%	-
	clothes washers	15	40%	-
	showers/bath	13	12%	-
	dishwashers	1	38%	-
	other domestic	3	0%	-
	faucets	11	0%	-
	Efficient landscapes	-	40%	-
Commercial	Efficient appl./fixtures (hotels & casinos)	80	29%	-
	showers	16.2 per guest	29%	-
	faucets	9	17%	-
	toilets	10.9	54%	-
	laundry	13.7	42%	-
	kitchen	16.7	14%	-
	icemakers	1.1	20%	-
	cooling	12.3	20%	-
Supply Expansion	6-basin groundwater pipeline	-	-	$1,163/AF
	5-basin groundwater pipeline	-	-	$1,320/AF
	River diversion	-	-	$2,039/AF

Source: Cooley et al. (2007)

Table 6. Estimates of Water Conservation Cost and Savings in Texas

	Savings /capita - urban	Savings/ capita - sub urban	Savings/ capita - rural	People/ unit - urban	People/ unit – sub urban	People/ unit - rural	Savings/ unit - urban	Savings/ unit - sub urban	Savings/ unit - rural	Measures/ unit	Savings/ measure (gpd)	Cost/ measure	Cost/AF saved (amort)	Delivery method
Residential														
SF Toilet Retrofit	10.5	10.5	10.5	2.5	2.7	2.2	26.7	28.5	23.0	2.0	13.3	$85	$403.45	free or rebate
SF Showerheads and Aerators	5.5	5.5	5.5	2.5	2.7	2.2	14.0	14.9	12.0	2.0	7.0	$7	$115.77	free
SF Clothes Washer Rebate	5.6	5.6	5.6	2.5	2.7	2.2	14.2	15.2	12.3	1.0	14.2	$120	$801.17	rebate
SF Irrigation Audit-High User	19.7	18.4	22.8	2.5	2.7	2.2	50.0	50.0	50.0	1.0	50.0	$70	$458.95	staff
SF Rainwater Harvesting	15.6	14.6	18.1	2.5	2.7	2.2	39.7	39.7	39.7	1.0	39.7	$250	$541.33	rebate
SF Rain Barrels	1.7	1.6	2.0	2.5	2.7	2.2	4.3	4.3	4.3	1.0	4.3	$45	$900.03	rebate or distrib.
MF Toilet Retrofit	10.5	10.5	10.5	1.6	1.7	1.7	16.9	18.3	17.3	1.2	14.1	$75	$337.80	free or rebate
MF Showerheads and Aerators	5.5	5.5	5.5	1.6	1.7	1.7	8.8	9.6	9.1	1.2	7.4	$4	$62.78	free
MF Clothes Washer Rebate	1.0	1.0	1.0	1.6	1.7	1.7	1.7	1.7	1.7	0.056	30.0	$120	$552.51	rebate
MF Irrigation Audit	1.6	1.4	1.5	1.6	1.7	1.7	2.5	2.5	2.5	n/a	125.0	$150	$393.39	staff
MF Rainwater Harvesting	5.7	5.3	5.6	1.6	1.7	1.7	9.2	9.2	9.2	n/a	461.7	$2050	$381.87	rebate

Commercial														
Toilet Retrofit	-	-	-	-	-	-	-	-	-	-	26.0	$150	$365.44	free or rebate
Coin Clothes Washer Rebate	-	-	-	-	-	-	-	-	-	-	45.0	$170	$521.81	rebate
Irrigation Audit	-	-	-	-	-	-	-	-	-	-	125.0	$150	$393.39	staff
General Rebate	-	-	-	-	-	-	-	-	-	-	1.0	$1.2	$103.21	rebate
Rainwater Harvesting	-	-	-	-	-	-	-	-	-	-	461.7	$2050	$381.87	rebate

Source: GDS Water Associates (2002)

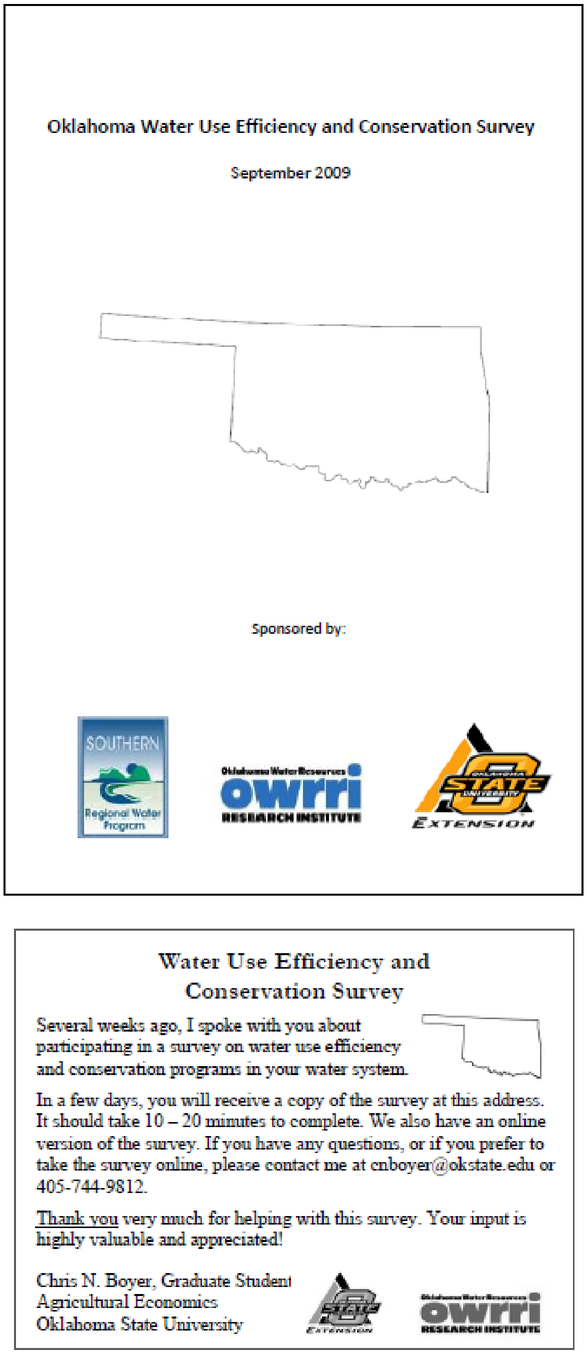
Survey Methods

We conducted a survey of Oklahoma water supply managers to achieve **Objective 2 – determine which water conservation policy tools are currently being applied in Oklahoma**. The survey was designed to elicit responses that adequately determine: (1) to what degree water supply managers consider adequate water quantity to be a problem, (2) what water conservation policy tools they are currently applying, (3) what other tools they may have tried in the past, (4) whether they are willing to adopt water conservation tools, and (5) what additional types of information they would need to determine whether to apply these tools.

To reduce unforeseen issues with survey content or communication, we recruited former water district members to provide feedback on the survey. We also pre-tested the survey using water supply managers to ensure a valid instrument and adjusted as necessary.

Surveys were implemented following Dillman's (2006) Tailored Design Method for surveys from July – November 2009. We identified 821 potential respondents using the Oklahoma Rural Water Association and Oklahoma Municipal League directories. Working with collaborators in three other states (Arkansas, Tennessee, and Florida), we identified, contacted, and ultimately received completed surveys from 695 water managers.

Water supply managers were contacted via a pre-survey request to participate (by telephone, email or mail as needed). The survey instrument was delivered by email and/or mail. Example survey materials for the hardcopy version are shown in Figure 3. The online version can be viewed at http://www.surveymonkey.com/s/5G3ZTHD and the questions are in Appendix A. Surveys were coded and reminders will be sent to non-respondents with additional questionnaires as necessary to improve the response rate. Survey results are reviewed in the Results section.


Oklahoma Water Use Efficiency and Conservation Survey

September 2009

Sponsored by:

Water Use Efficiency and Conservation Survey

Several weeks ago, I spoke with you about participating in a survey on water use efficiency and conservation programs in your water system.

In a few days, you will receive a copy of the survey at this address. It should take 10 – 20 minutes to complete. We also have an online version of the survey. If you have any questions, or if you prefer to take the survey online, please contact me at cnboyer@okstate.edu or 405-744-9812.

Thank you very much for helping with this survey. Your input is highly valuable and appreciated!

Chris N. Boyer, Graduate Student
Agricultural Economics
Oklahoma State University

Figure 3. Example reminder postcard and survey cover

We specified predictive models of price-based and non-price conservation programs by water utilities to determine the influence of various factors on adoption. We specified a bivariate probit model to evaluate the impact of demographics, attitudes and perceptions of conservation, and future planning activities.[1] The dependent variable in this model was categorized into three choices: (1) no conservation adoption; (2) PC adoption; and (3) NPC adoption. An advantage of this model is it tests if PC and NPC decisions are correlated or made *jointly* (Greene, 2000); that is, they are considered as substitutes by water utilities. Renwick and Archibald (1998) and Kenny et al. (2008) both state that there needs to be a better understanding of the relationship between PC and NPC use. This model is expressed as

$$\Pr = \left[PC = 1, NPC = 1 \mid x\right] = \Phi_2[\beta_{PC}'x, \beta_{NPC}'x, \rho) \quad (1)$$

where Φ_2 is the bivariate standard normal cumulative distribution function; *x* is a matrix of independent variables; β_{PC} *and* β_{NPC} are vectors of coefficients; and ρ is the correlation between the equations for PC and NPC. PC was defined as using an inclining block rate structure, and NPC was defined as the used of any programs such as mandatory water restrictions, awareness/education, low flow devices, etc.

Results of the bivariate probit model (discussed below) indicated that there is no statistically-significant relationship between PC and NPC; as such, we chose to specify logit models to estimate the influence of various factors on the adoption of PC and NPC, individually. The first logit model considers the choice between no conservation use and PC adoption, and the other logit model considers the choice between no conservation use and NPC adoption. Logit models provide more direct interpretation and allow the calculation of marginal effects, unlike the bivariate probit. The coefficients from the two logit models did not significantly differ from the coefficients in the bivariate probit model (model results are provided in the Principal Findings and Significance section below).

The NPC and PC logit models are expressed as:

$$\log \frac{P_i}{1 - P_i} = \alpha + \sum_{j=1}^{n} \beta_j x_{ij} + u_i \quad (2)$$

where P_i is the probability of the *i* th dependent variable is one Prob(y_i = 1); α is the intercept; *x* is a matrix of the *i* th observation and the *j* th explanatory variable; u_i is the error term that follows the logistic distribution; and β_j is the vector of coefficients for the explanatory variable. The left hand side of the equation is the odds ratio of adopting conservation, and is a linear function of the

[1] A multi-nominal logit was also used to evaluate the impact of explanatory variables. The dependent variable in this model was categorized into four choices: (1) no conservation adoption; (2) PC adoption; (3) NPC adoption; and (4) both PC and NPC adoption. However, the survey data did not contain enough respondents that adopted both PC and NPC, and therefore, the model did not prefer well.

explanatory variables. The odds ratio estimates tell the odds that of each explanatory variable has on PC and/or NPC adoption, while holding the other parameter estimates constant.

Based on initial conversations with water supply managers, pre-test results, and full survey results, **Objective 3 – create a framework document for expert panel members** was deemed unnecessary. We were able to collect the necessary information using an extended version of the water managers survey. To achieve **Objective 4 – evaluate the relative feasibility of the alternatives from the water managers' perspective**, we included directly relevant questions in the full survey. Responses to these questions helped identify potential barriers to a range of alternatives. We discuss the findings on barriers to conservation adoption below.

We used a multistage survey design process (e.g., Dillman et al. 2007). Based on the literature review and interviews with water system managers, we developed the survey, then pre-tested it on a sub-sample of 88 water utility managers. Comments from the pre-test were used to improve the survey. The final version of the survey contained 33 questions.

Recent research has focused on water conservation policy tools as feasible responses to water crises. Table 7 provides a brief overview of the major studies. Water prices in the US are typically below their long-run marginal cost (Hanemann, 1997; Timmins, 2003). Water suppliers seem to price water at the short-run average cost of supplying water (transportation, storage, etc.) (Olmstead and Stavins, 2007). Given low and often no price signals regarding water use, studies suggest that water conservation does not happen absent regulation or some general environmental awareness that leads to less use (Howe, 1997).

During the last severe water shortage in Oklahoma, several water districts reluctantly increased prices to reduce water demand. There is anecdotal evidence that this was effective. Studies in other states suggest that similar price increases have significant impacts on water use (e.g., Pint, 1999). Olmstead and Stavins (2007) found a wide range of water conservation policy tools that have been applied throughout the United States, noting that price-based approaches have been most effective. Stevens et al. (1992) found that water pricing changes have significant impact on residential water demand, with an elasticity of demand between -0.1 and -0.69. Other studies have found similar estimates (e.g., Male et al., 1979). Some communities use different pricing mechanisms. For example, about 46% of Massachusetts municipalities use increasing block pricing for water, and only 5% apply flat fees (Tighe and Bond, 2004).

Table 7. Past Studies that Examined Price and Non-Price Conservation.

Conservation Program	Study	Effectiveness
Price – Price Elasticity of Demand	Campbell et al. 2004; Hurd 2006; Kenney et al. 2008; Renwick and Archibald 1998; Wang et al. 1999; Olmstead et al. 2007; Brookshire et al. 2002; Espey et al. 1997; Dalhuisen et al. 2003; Gaudin 2006	Average of 5% reduction in water demand with a 10% in price
Non-Price - Education/Awareness	Howarth and Bulter 2004; Geller et al. 1983; Michelson et al. 1999; Syme et al. 2000; Campbell et al. 2004; Wang et al. 1999; Inman and Jeffery 2006; Miri 1998	0-25% reduction in water demand
Non-Price - Retrofit Devices	Geller et al. 1983; Michelson et al. 1999; Renwick and Archibald 1998; Renwick and Green 2000; Timmins 2003; Turner et al. 2004; Wang et al. 1999; Campbell et al. 2004; Buckley 2004; Maddaus 1984; Campbell et al. 1999; White and Fane 2002; Baer 2001	8-32% reduction in water demand
Non-Price - Rebates	Michelson et al. 1999; Renwick and Archibald 1998; Renwick and Green 2000; White and Fane 2002; Howe and White 1999	0-10% reduction in water demand
Non-Price – Outdoor Watering Restrictions	Mansur and Olmstead 2007; Michelson et al. 1999; Olmstead and Stavins 2008; Renwick and Green 2000; Renwick and Archibald 1998; Campbell et al. 2004; Howe and White 1999; Shaw and Maidment 1988	19-29% reduction in water demand
Non-Price- Efficient Lawn Irrigation Systems	Hurd 2006; Kenney et al. 2004; Kenny et al. 2008; Renwick and Archibald 1998; Schuck and Profit 2004; White and Fane 2002; Mansur and Olmstead 2007; Miri 1998	7-53% reduction in water demand

[a] Most studies include multiple NPC in the analysis, and some include both price and non-price conservation.

Other water conservation policy tools may yield superior results for certain regions of Oklahoma. For example, although controversial, adding water meters can result in significant savings (OECD, 1999). One national study found an average 20% reduction in water use (Maddaus, 1984). Water use restrictions have found mixed conservation results (e.g., Schultz et al., 1997; Renwick and Green, 2000). Policies with education components may further improve conservation success (e.g., Corral, 1997).

There is evidence that community preferences for water policy are not identical across Oklahoma. Every two years, the Oklahoma Municipal League conducts a survey of municipal utility rates (OML, 2007). These indicate a great deal of variability in water pricing schemes across communities of different sizes. In other states, some communities have even charged variable rates based on non-use – for example by head of livestock or number of barber shop chairs on premises (Baumann et al., 1997, pp. 137 – 138).

There is surprisingly little cost-benefit analysis on water conservation (Timmins, 2003). The cost-per-gallon-saved is very rarely calculated for water conservation programs. The costs of applying alternative policy instruments can differ greatly by community attributes. For example, initial costs of water conservation technology adoption can be relatively high. For example, one study estimates that the cost of retrofitting toilets is between $81.56 and $223.07 for two US cities (Olmstead and Stavins, 2007).

In addition of efficiency concerns, distributional impacts of water policy changes may also be significant (Mansur and Olmstead, 2006). Water policy changes are unlikely to change water use behavior uniformly. Studies have surveyed water users during times of drought (e.g., Schultz et al., 1997), and find that some user groups reduce their water use considerably. Some water pricing policies may actually increase water use among higher-income users, while poor households are left worse-off.

If policies are chosen without regard to local preferences, water policy changes can generate political discontent. For example, when Tucson, Arizona adopted a variable rate water pricing scheme following a 2-year drought, the entire city commission was voted out of office the following year (Hall, 2000). Recently, more emphasis has been placed on directly involving the public in the policy decision-making process. A necessary preliminary step to engaging the public in policy design is education on the issues and alternatives. Awareness campaigns have been particularly effective at improving public knowledge. For example, a recent unpublished study in Florida evaluated the impact of a public awareness campaign in the St. John’s River Water Management District (SJRWMD, 2007).

More research is needed to determine what water conservation policy tools are appropriate for local conditions in Oklahoma.

Results

Survey responses

We anticipated having 200 water managers as potential respondents, but were able to achieve a much higher response rate: 292 responses for 59% response rate. For this size pool, this response rate provides statistically-valid results and a small margin of error. We are aware that Camp, Dresser & McKee are conducting several surveys involving water managers. We expected that this might increase respondent fatigue and lead to a relatively lower response rate. Given past experience with surveys of water managers in Oklahoma, as well as the increased chance of respondent fatigue, we did not expect a high (over 40%) response rate, particularly from smaller, rural water districts. We were prepared to address this issue by over-sampling small and/or rural water managers as needed, but we found that rural coverage bias was not an issue (Boyer and Adams, forthcoming).

We received a total of 695 responses from surveys conducted in four states for a 41% response rate, considered high for mixed-mode surveys (Dillman et al., 2007; Dickerson et al., 2000). 594 of these were by web-based survey and 101 responses by hard copy survey. Across the four states, we received 292 surveys responses from Oklahoma utilities (59% response rate), 155 from Florida (48%), 149 from Arkansas (41%), and 99 from Tennessee (20%). These responses provide a sampling error less than ±2.85% at a 95% confidence level. We tested for non-response bias (e.g., Armstrong and Overton, 1977) and coverage bias (e.g., Boyer et al., forthcoming), but found no serious problems (Boyer and Adams, forthcoming). Table 8 provides a summary of some of the more interesting respondent characteristics.

Table 8. Summary Statistics of Water Utilities.

Size	OK	FL	TN	AR
Small	67%	24%	24%	63%
Medium	20%	23%	44%	22%
Large	12%	53%	32%	15%
Water Source				
Ground water	42%	87%	36%	48%
Surface water	58%	13%	64%	52%
Secondary source	18%	19%	23%	17%
No Secondary source	82%	81%	77%	83%
Changes in Per-Capita Demand				

Decreased > 10%	1%	12%	4%	4%
Decreased 5-10%	3%	35%	7%	7%
No Change	58%	44%	58%	57%
Increased 5-10%	32%	7%	27%	24%
Increased > 10%	5%	3%	4%	8%
Plans to Meet Future Demand				
Non-price conservation	6%	18%	10%	6%
Increase rates	22%	19%	15%	19%
Repair & Maintenance	38%	23%	40%	43%
Alternative sources	2%	18%	3%	1%
New Supply	31%	21%	31%	30%

Utilities were classified as small (delivers less than 0.5 million gallon water per day (MGD)), medium (0.5 MGD to 2.0 MGD), and large (more than 2.0 MGD). Approximately 50% of the respondents were small sized utilities, 25% were medium sized utilities, and 25% were large sized utilities. As expected, the majority of the Oklahoma and Arkansas respondents were small sized utilities, and the majority of the Florida respondents were large sized utilities. Tennessee had more large utilities than small utilities, but most respondents were medium sized.

The primary water source for the utilities differs significantly across the four states. Florida utilities depend heavily on groundwater (82%) as their primary source of water, and Oklahoma, Arkansas, and Tennessee rely more on surface water than groundwater. The majority of the utilities in each state did not have a secondary source of water. A secondary source was defined to include both sources owned by the utility and those available through agreement with other systems.

Utility managers were asked to estimate how they perceive their customers' per-capita water demand has changed in the last five years. The majority of the utilities in each state responded that per-capita water demand has not changed. However, Florida water managers believe more of their customers' per-capita water use has decreased than increased, suggesting they believe customers have become more efficient water users in the last five years. While Arkansas, Tennessee, and Oklahoma water managers believe more of their customers have increased their per-capita water use than decreased, suggesting they believe their customers have become less efficient water users.

To ensure the utilities have enough water to meet its future demand, the majority of small utilities plan on repairing old infrastructure or securing a new water supply (Figures 4 and 5). Large utilities responses were more equally distributed across non-price programs, increase rates, repair and maintenance, alternative source, and new supplies. Oklahoma, Arkansas, and Tennessee plan on repairing old infrastructure or securing new water supplies, while Florida is more evenly distributed across the answer choices. Oklahoma utilities plan on adopting more PC than the other states, and nearly 20% of the Florida utilities plan on using an alternative water source such as rainwater harvesting or desalinations.

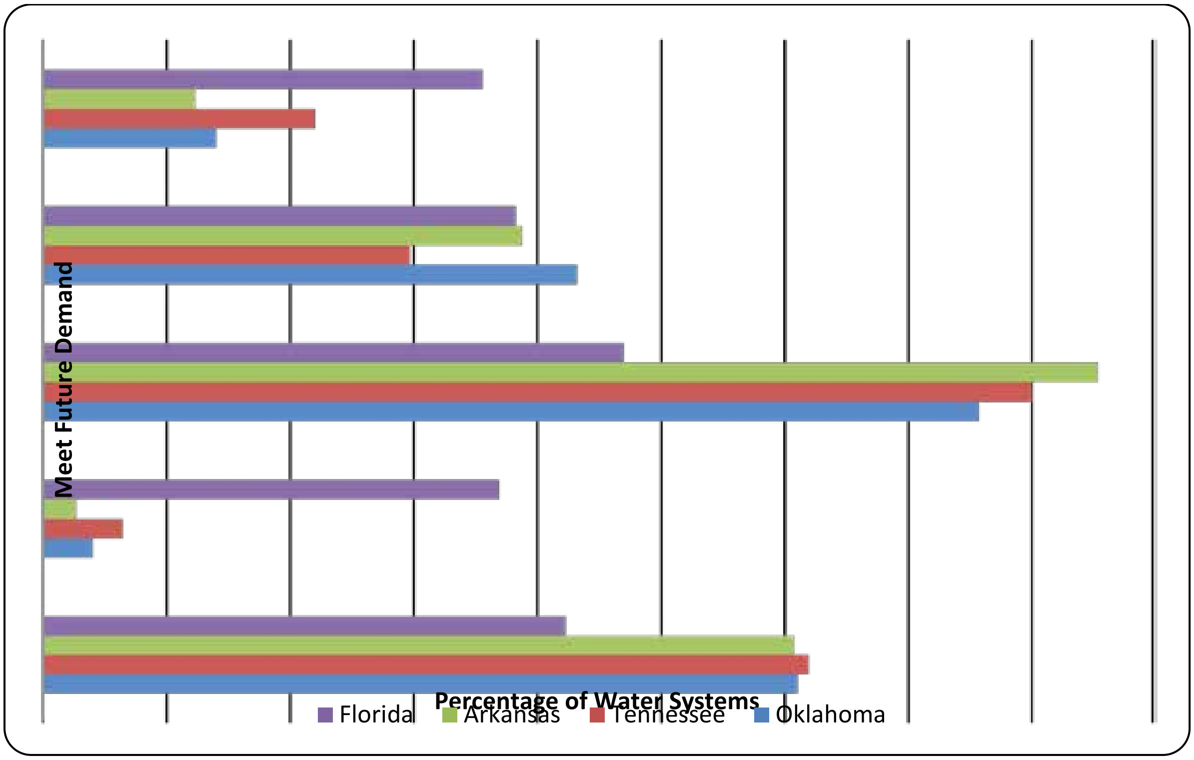


Figure 4. Plans to Meet Future Demand by State.

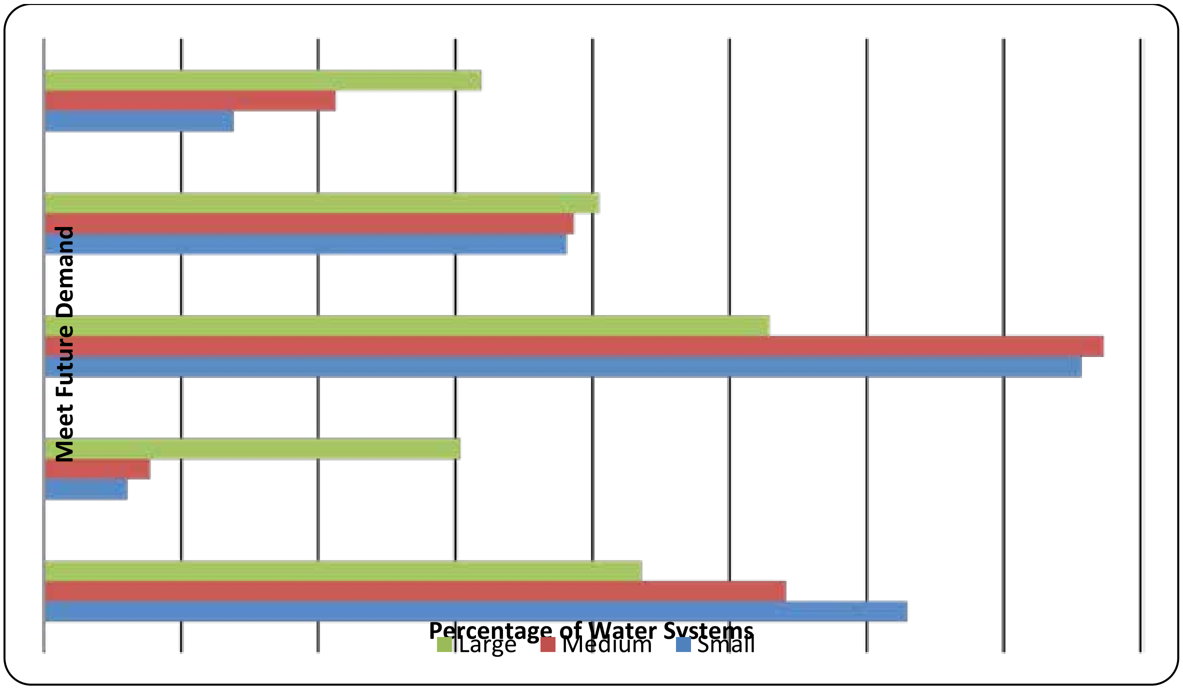


Figure 5. Plans to Meet Future Demand by Utility Size.

Over half of the utilities had not used any PC or NPC programs in the last five year (Figure 6 and 7). The use of NPC and PC programs was fairly equal, and a small percentage had adopted both PC and NPC. Florida adopted PC and both PC and NPC the most, and Oklahoma used NPC the most. Arkansas and Tennessee utilities had adopted the least amount of conservation. Large utilities adopted NPC and both PC and NPC more the small and medium sized utilities. NPC programs can be expense (e.g., rebates on low-flow devices) and sometimes require several man hours (e.g., awareness/education), making it hard for small utilities to adopt the NPC programs. Small utilities adopted PC more than medium and large utilities. Several comments received from rural utilities said that raising treatment costs and regulatory costs are heavy financial burden on their utility, and switching to an inclining block rate helps cover raising costs better than the uniform or declining block rate.

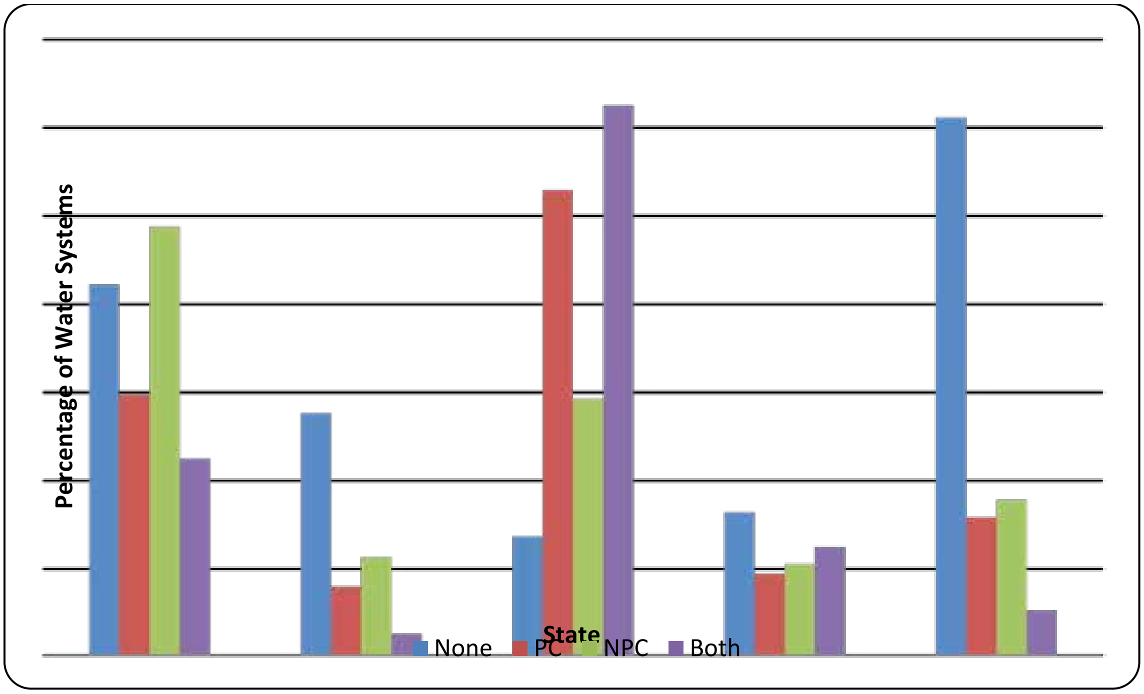


Figure 6. Water Conservation Adoption in the Last Five Years by State.

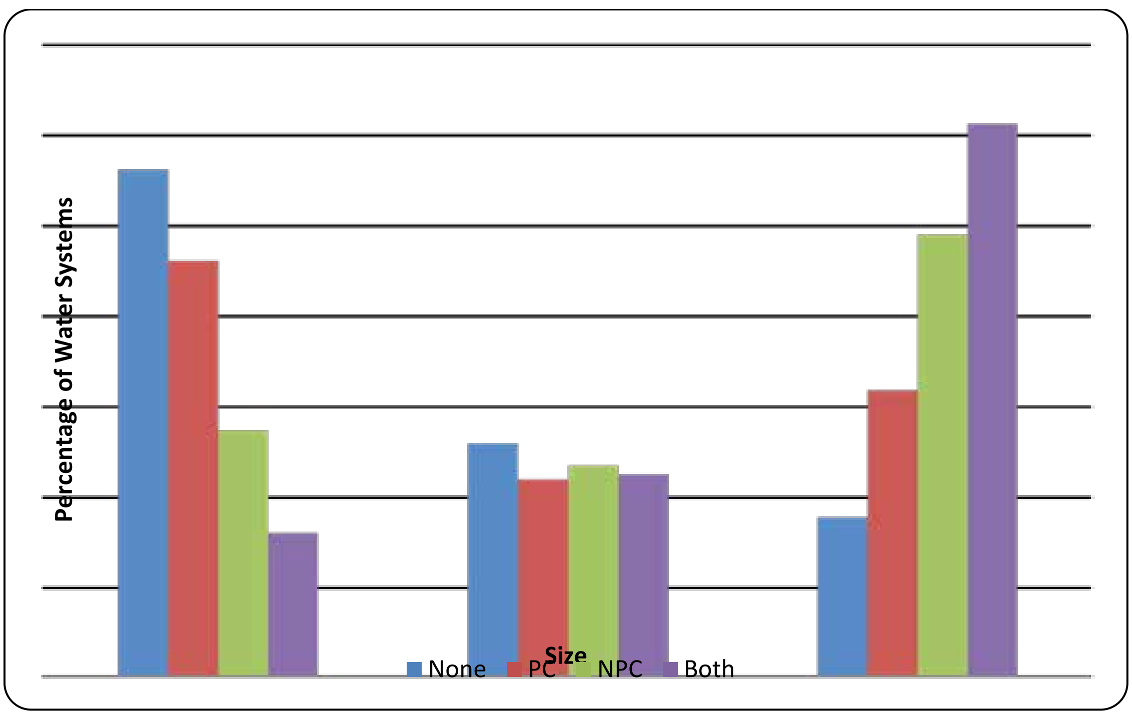


Figure 7. Water Conservation Adoption in the Last Five Years by Utility Size.

We asked utility managers their perception of customers' price elasticity of water demand. The question asked to state how the utility believe their customers would respond to a 10% increase water prices. The majority believe a price increase would not change their customers water use, 35% of the utilities believe their customers water use would decrease, and a small group believed water users would increase water use. Economic theory and previous research finds price elasticity of water demand to be inelastic (i.e., customers respond slightly to price changes), but not perfectly inelastic (i.e., customers are unresponsive to price changes) as most the utilities believe. Water demand becomes more elastic as rates increase (Olmstead and Stavins, 2008), and what utilities in these states might be indicating that their rates are low enough on the demand curve that the price elasticity is close to zero.

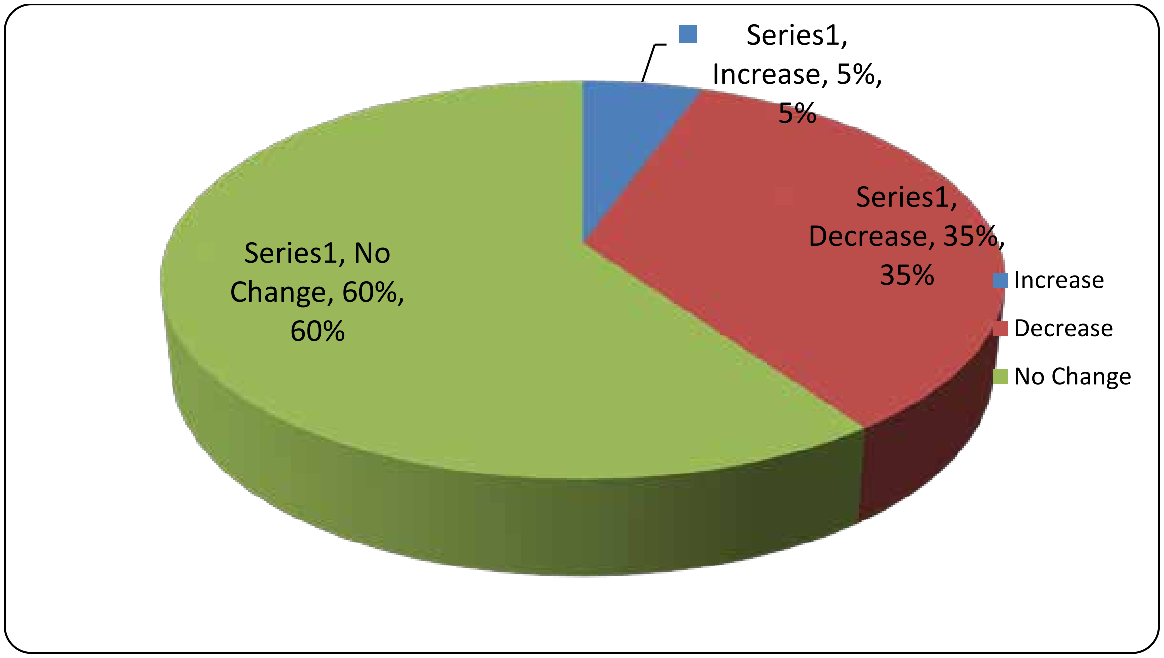


Figure 8. Managers' Perception of Customers Response to a 10% Increase in Price.

Predictive Models of Conservation Adoption

The bivariate probit model produced good overall results with a large number of statistically-significant explanatory variables for both PC and NPC equations. The ρ statistic indicates the relationship between the PC and NPC choices, and a likelihood ratio test of $\rho=0$ was not statistically significant ($\chi 2$ (1 d.f.)=0.05, p=0.9323) (Table 9). This suggests the utilities in our sample do not jointly consider using PC and NPC adoption together. A positive correlation would suggest utilities are adopting PC and NPC, and a negative correlation suggests that utilities are adopting PC or NPC, but no correlation means there is no relationship between adopting PC and NPC.

Table 9. Bivariate Probit Model of Factors Influencing Conservation Adoption.

	Dependent Variables

Independent variable§	Price Based Conservation		Non-Price Conservation	
	Coefficient	P-value	Coefficient	P-value
Demographics				
Florida	0.808**	0.0360	1.069***	0.0001
Oklahoma	0.926***	0.0039	0.550**	0.0242
Arkansas	0.163	0.6319	0.145	0.5991
Municipal Organization	0.561**	0.0412	0.413*	0.0583
Small size (< 0.5 million gallons/day)	0.407**	0.0254	0.007	0.9641
Purchase primary water source	0.584***	0.0056	0.339*	0.0513
Groundwater primary water source	0.507**	0.0213	-0.088	0.6275
Has secondary source	-0.682*	0.0649	-0.182	0.5001
Management recommends cons. adoption	-1.123**	0.0277	0.113	0.7202
Had a per-capita water use increase, last 5 yrs	0.414*	0.0886	-0.056	0.7900
Notify customers of rate changes - website	0.036	0.9064	0.512**	0.0139
Notify customers of rate changes - meeting	-0.095	0.5806	0.080	0.5806
Notify customers of rate changes – special mail out	0.335**	0.0495	0.159	0.2829
Attitudes and Perceptions				
Determining rate schedule - cost of delivery	0.224**	0.0418	0.122	0.1890
Determining rate schedule - consumer waste	0.073	0.4221	-0.128*	0.0975
Reason for past rate increase - treatment costs	0.425**	0.0131	0.133	0.4532
Reason for past rate increase - utility maintenance	0.619**	0.0323	0.496*	0.0799
Reason for past rate increase - conservation	1.609***	0.0001	1.061***	0.0001
Internally studied demand elasticity	0.692**	0.0219	0.022	0.9366
Climate change will not impact water supplies	-0.136	0.4676	-0.324**	0.0476
Future Planning				
Meet future demand - alternative source	0.592**	0.0488	0.591***	0.0090
Meet future demand - infrastructure expansion/replacement	0.428**	0.0142	-0.069	0.6357
Meet future demand - manage demand	0.902***	0.0001	0.172	0.3661
Barrier to meeting demand - treatment costs	0.276	0.1042	0.053	0.7093
Barrier to meeting demand - inability to increase withdrawals from source	-0.517*	0.0579	0.594***	0.0035
Correlation of Price and Non-Price Conservation				
Rho (ρ)	0.0100	0.9323		

* Significant at the 10% level; ** Significant at the 5% level; *** Significant at the 1% level.
§ Excludes insignificant variables, except Arkansas.

Similar to the bivariate probit, the logit models have a large number of significant explanatory variables. Logit model results were statistically significant and were theoretically correct. The likelihood ratio test implies the overall PC and NPC models were highly statistically significant (Table 10). The logit models accurately predicted 91.9% of PC adoption and 86.0% of NPC adoption. Table 11 reports the odds ratio estimates and significance levels for the explanatory variables (nonsignificant parameter estimates are not shown). Odds ratio of the significant variables are used to explain the probability an explanatory variable has on PC and NPC adoption, while holding all other explanatory variables constant.

Table 10. Logit Model Goodness of Fit for Price and Non-Price Conservation.

	Price Conservation		Non-Price Conservation	
Model test statistics	Statistic	P-value	Statistic	P-value
-2 Log Likelihood	-648.825	-	-692.778	-
Likelihood ratio: χ^2 (48 d.f.)	287.769	0.0001	226.368	0.0001
Model fit (Percent correctly predicted)	91.9%	-	86.0%	-

Table 11. Odds Ratio Estimates for Factors Influencing Price and Non-Price Conservation Adoption.

	Dependent Variables			
	Price Based Conservation		Non-Price Conservation	
Independent variable§	Coefficient	P-value	Coefficient	P-value
Demographics				
Florida	4.213**	0.0399	6.695***	0.0001
Oklahoma	5.040***	0.0026	1.084**	0.0325
Arkansas	1.326	0.6529	0.400	0.7381
Municipal Organization	2.513*	0.0554	1.992*	0.0893
Small size (< 0.5 million gallons/day)	2.114**	0.0221	0.848	0.8952
Purchase primary water source	2.863***	0.0045	1.829*	0.0778
Groundwater primary water source	2.458**	0.0311	0.821	0.5661
Has secondary source	0.030*	0.0754	0.626	0.3776
Management recommends cons. adoption	0.147**	0.0270	1.196	0.7632
Had a per-capita water use increase, last 5 yrs	2.119*	0.0929	0.858	0.7412
Notify customers of rate changes - website	1.078	0.8810	2.537**	0.0155
Notify customers of rate changes - meeting	0.865	0.6653	1.156	0.6394
Notify customers of rate changes – special mail out	1.762*	0.0856	1.237	0.4751
Attitudes and Perceptions				
Determining rate schedule - cost of delivery	1.492*	0.0855	1.264	0.1801
Determining rate schedule - consumer waste	1.117	0.4927	0.776*	0.0825
Reason for past rate increase - treatment costs	2.155**	0.0179	1.313	0.4768
Reason for past rate increase - utility maintenance	2.829*	0.0652	2.478	0.1444
Reason for past rate increase - conservation	16.968***	0.0001	6.528**	0.0002
Internally studied demand elasticity	3.389*	0.0630	1.101	0.8130
Climate change will not impact water supplies	0.792	0.4824	0.529**	0.0447
Future Planning				
Meet future demand - alternative source	2.702*	0.0613	2.825**	0.0158
Meet future demand - infrastructure expansion/replacement	2.152**	0.0257	0.842	0.5479

Meet future demand - manage demand	5.297***	0.0001	1.279	0.4993
Barrier to meeting demand - treatment costs	1.602	0.1196	1.066	0.8204
Barrier to meeting demand - inability to increase withdrawals from source	0.357*	0.0963	2.929**	0.0058

* Significant at the 10% level; ** Significant at the 5% level; *** Significant at the 1% level.
§ Excludes insignificant variables, except Arkansas.

The results of our models identify several factors that influence the adoption of NPC and PC, including utility system demographics, water managers' attitudes and perceptions, and utilities' approach to planning for future water needs.

Several demographic factors influence NPC and PC adoption. For PC, municipally-owned utilities are 2.5 times more likely to adopt conservation than private, cooperative, and other ownership types. For NPC, municipally-owned utilities were 2.0 times more likely to adopt conservation. This indicates that non-municipal ownership is a potential barrier to conservation adoption. For PC only, utility size is a strong determinant of conservation adoption, with small utilities (<0.5 MGD) 2.1 times more likely to adopt conservation.

Water source also appears to drive conservation adoption. For PC, utilities that use groundwater as their primary source are 2.5 times more likely to adopt conservation, while those whose primary source is purchased are 2.9 times more likely to conserve. For NPC, having purchased water as a primary source increased the likelihood of adopting conservation by 1.8 times. These results may indicate that utilities with primary sources that are potentially more insecure (particularly during droughts) or costly are more likely to conserve. For PC, having a secondary source of any kind very slightly increases the use of conservation. This may be because utilities that seek secondary sources perceive their primary sources as less secure or more costly than utilities that do not.

Management decision-making, mode of notifying customers of rate changes, and recent per-capita water use changes also influence conservation. For NPC, utilities that rely on management to recommend conservation (as opposed to city or state officials, customers, etc) are 0.15 times more likely to conserve, and those that notify customers of rate changes with special mail-outs are 1.8 times more likely to conserve. For NPC, utilities that notify via website are 2.5 times more likely to conserve. Also, utilities that have experienced a per-capita water use increase in the last five years are nearly 2.1 times more likely to adopt PC. Such increases may put a strain on existing infrastructure, and necessitate demand management through price signals.

Finally, in both PC and NPC models, Oklahoma and Florida utilities were significantly more likely to adoption conservation as compared to Tennessee (our baseline) or Arkansas. For PC, Oklahoma utilities were 5.0 times more likely and Florida utilities were 4.2 times more likely to adopt conservation; for NPC, Oklahoma utilities were 1.1 times more likely and Florida utilities were 6.7 times more likely. The dummy variable indicating a utility was from Arkansas was not statistically significant in either model. These results indicate that there may be inherent differences between states, perhaps due to state-level policy, population growth, or other factors that influence the adoption of PC and NPC, but are not captured by our models.

Water utility managers' attitudes and perceptions also play a large role for both PC and NPC. Managers were asked to indicate the primary factors that influence their rate schedule, and reasons for past rate increases. For PC, managers that indicate cost of delivery was the primary driver of the rate schedule were 1.5 times more likely to adopt conservation. For NPC, conservation adoption was more likely when managers indicated that consumer waste was the primary driver of the rate schedule. For PC, there were several reasons for past rate increases were statistically-significant: treatment costs (2.2 times more likely), utility maintenance (2.8 times more likely), and most notably conservation (17.0 times more likely). This indicates that an inclining block rate might help utilities cover costs of delivery and repair and maintenance costs more effectively than uniform rates or declining block rates. Conservation as a reason for past rate increases also played a large role in the adoption of NPC (6.5 times more likely). This result was not unexpected, since utilities that have considered conservation before should be more likely to adopt PC and NPC in the future.

Awareness of how changes in water pricing would impact water use also strongly influence the adoption of PC. Utilities that have conducted these elasticity studies were 3.4 times more likely to use PC. Knowing their customers price elasticity of water demand allows utilities to better understand the impacts of price changes on water use, and can help design a more effective inclining block rate.

Finally, managers' views on climate change impacts on water supplies have some influence on the adoption of NPC. Utilities are, on average, 0.5 times more likely to adopt NPC when its manager believes that climate change with significantly impact water availability in their area. Many managers specifically commented about the uncertainty of climate change on their water supplies and future planning.

Utilities' approach to future planning also influences PC and NPC. Adoption of PC was significantly influenced by utilities' planning on the following to meet future demand changes: seeking alternative non-traditional sources (i.e., graywater reuse; 2.7 times more likely), infrastructure expansion/replacement (2.2 times more likely), and managing demand (5.3 times more likely). For NPC, only seeking alternative source was significant (2.8 times more likely).

Finally, we asked managers to indicate what factors they viewed as primary barriers to adoption conservation. Only the inability to increase withdrawals from existing sources was a statistically-significant driver of conservation adoption. For PC, it increased adoption by 0.4 times while for NPC it increased adoption by 2.9 times. An explanation for this finding is that water managers believe the price elasticity of water is inelastic and an increase in price will not decrease use enough. Also, population growth was found not to be a primary barrier to meeting future demand. While large cities are growing in population, rural communities are decreasing. The large number of rural utilities in the survey can explain why, on average, population growth was not a statistically-significant barrier to meeting future demand.

Analysis of the results is ongoing, and additional models are being investigated. These may allow additional interpretation of interactions between several of the above variables. However, both the PC and NPC logit models performed well and provide important insight into factors driving the adoption of PC and NPC. For example, using the model results for PC, the type of utility most likely to adopt price-based conservation would be: (1) a small utility located in Oklahoma that purchases its primary source of water from other utilities; (2) a municipal utility in Florida that relies on groundwater as a primary source, and does not have a secondary source of water; (3) one that determines current rates largely based on cost of delivery, and has increased rates in the past primarily due to rising treatment costs and to encourage conservation; (4) utilities that have conducted an internal study to evaluate consumers' price elasticity of demand for water, suggesting that understanding customer demand might be important component in adopting PC; and (5) plans on accessing non-traditional sources, improving infrastructure and managing consumer demand for water to meet future demand.

The logit model for NPC had fewer statistically significant explanatory variables than PC, but still provides useful insight to utilities that were most likely to adopt NPC. Utilities with a high likelihood of adopting NPC would most likely be: (1) a municipality located in Florida and uses a website to notify customers about rates changes; (2) one that has changed the water rate in the past to send a conservation signal; and (3) considering using alternatives sources of water in the future, and is current withdrawing the maximum amount of water from its source, which suggest these utilities have nearly exhausted its primary water source. NPC programs are commonly used to manage short-term droughts, and are not always as straightforward as PC programs to implement. We suspect that utilities' decision makers can be hesitant to use these programs due to the cost, labor requirements, and uncertainty of success for these programs, which might explain the difficulty in predicting utilities adoption of NPC programs.

To achieve **Objective 5 – evaluate the relative feasibility of the alternatives from the water users' perspective**, we conducted a survey of Oklahoma residents. Using the same approach identified for Objective 2, we designed, pre-tested and implemented a statewide survey.

The second survey focused on residential water users' motivations, attitudes, and perceptions about water use and conservation alternatives. This study provides timely and valuable insight on the preferences of water users in Oklahoma and how they use and conserve water. Increased strain is currently being placed on water systems, from population growth and diminishing freshwater supplies, making it crucial to assess all options available to those in charge of managing and developing policies for these systems. Specific objectives of this survey included: (1) determining if receptivity to water conservation mechanisms is affected by the attitudes, perceptions, characteristics and experiences of household water users; (2) determining if adoption of a water conservation behavior or mechanism is associated with the receptivity of household water users; and (3) determining if rural households engage in water conservation behaviors differently than urban households.

Determining the influence of a household's attributes, motivations, attitudes, and perceptions on their water use and adoption of conservation practices can provide a framework for predicting their responsiveness to prospective water policies and conservation programs. We employ a model that measures a respondent's receptivity to adopting water conservation.

Many studies have examined the effects that common household characteristics have on demand for water (Campbell et al. 2004; Inman and Jeffrey 2006; Renwick and Archibald 1998; Renwick and Green 2000). Some of the common attributes that have been examined are: income, density of neighborhood, household occupancy, number of people per household, home ownership status, home lot size, etc.

One important aspect of adopting conservation policies is to know how individual's attitudes and perceptions influence their behavior towards water conservation. Nieswiadomy and Cobb (1993) found that utility managers may be more likely to select conservation rate pricing structures if the individuals in their region are more interested in conservation. Howarth and Butler (2004) discuss the need for utilities to assist individuals in a process of moving from ignorance to awareness to interest to desire to finally adopting a behavior. It is important to understand what factors are influencing the household's decision to move towards practicing conservation behavior.

One model that is helpful in determining if a household will adopt a water conservation mechanism is the 'receptivity' model (Jeffrey and Seaton 2004). The receptivity model has been used in Australia (Brown and Davies 2007; Clarke and Brown 2006) as a way to determine the receptivity of households to implementing water conservation mechanisms. Positive attitudes and awareness about conservation alone is not a good predictor of adopting water conservation behavior. It is important to determine what the barriers to households changing their behavior are and the receptivity model provides a way to model that.

The four main categories of the receptivity model are: awareness (capable of searching for knowledge that is new), association (recognition of the potential benefit of this knowledge by associating it with needs and capabilities), acquisition (the ability to acquire technologies and learn new models), and application (actually apply knowledge to achieve benefit). See Table 12. The categories provide a way of determining how receptive a household will be to a water conservation mechanism. They also reveal what types of barriers are preventing individuals from adopting the behavior.

Table 12. Attributes of household water users influencing adoption of a conservation behavior

Attributes of Households	**Category**
Willingness to adopt conservation / Application	Conservation intention (dependent variable)
Household Income [a b d]	Demographics
Household Occupancy [a b d]	Household composition
Household Lot Size [a d e]	Dwelling characteristics
Renter Status [d]	Dwelling characteristics
Location	Climate
Number of bedrooms in each household [a]	Dwelling characteristics
Awareness	Awareness/ Cognitive vs. habit behaviors
Access to Technology [b]	Access
Association	Association
Types of water-related technologies in use [a b d]	Past water use behavior / Acquisition
Garden, pool, etc	Outdoor area interest & use
Institutional Trust	Institutional trust & fairness
Fairness	Institutional trust & fairness

Restrictions are too restrictive	Restrictions attitude
Cost is high	Pricing attitude
Average cost of water [a]	Pricing & use regulations
Consumer perception that water shortages are likely in the near future [a]	Perceived risk of shortages
Conservation orientation perceived by customers [a c]	Conservation attitude, generally
Cultural/Social Norms [b]	Subjective norm
Inter-personal Trust (Perceived control)	Perceived behavioral control
Cost of installation vs. Potential savings [b]	Pricing & use regulations (or factors)
Climate Factors [b]	Climate & seasonal factors

[a] Wang et al. 2005; [b] Inman and Jeffrey, 2006; [c] Brown and Davies, 2007; [d] Renwick and Archibald, 1998; [e] Renwick and Green, 2000; [f] Jorgensen et al., 2009; [h] Atwood et al., 2007

Table 13. Direct and indirect drivers of water saving behaviors (from Jorgensen et al., 2009)

Direct drivers	In-direct drivers
• **Climate/seasonal variability** (Berk et al., 1980; Campbell et al., 2004; Klein et al.2006) • **Incentives/disincentives** (e.g., tariff structure and pricing, rebates on water saving technologies, etc.) (Berk et al., 1980; Campbell et al., 2004; Dandy et al.,1997; Lyman, 1992; Martin et al., 1984; Nieswiadomy, 1992; Renwick and Archibald, 1998; Renwick and Green, 2000) • **Regulations and ordinances** (e.g., water restrictions, local government planning regulations) (Klein et al., 2006; Lee, 1981; Renwick and Green, 2000) • **Property characteristics** (e.g., lot size, pool, bore, tank, house size, house age, etc.) (Campbell et al., 2004; Cavanagh et al., 2002; Lyman, 1992; Olmstead et al., 2003; Renwick and Archibald, 1998; Renwick and Green, 2000; Syme et al., 2004) • **Household characteristics** (e.g., household composition, household income, water saving technology, water supply technology) (Campbell et al., 2004; Gilg et al., 2005; Loh and Coghlan, 2003; Mayer et al., 1999; Nancarrow et al., 2004; Renwick and Archibald, 1998; Syme et al.,	• **Personal characteristics** (e.g., subjective norm, behavioral control, attitude toward the behavior) (Beedell and Rehman, 1999; Hines et al., 1986; Leviston et al., 2005) • **Institutional trust** (i.e., trust in the water provider) (Lee, 1981; Lee and Warren, 1981) • **Inter-personal trust** (i.e., trust in other consumers) (Lee, 1981; Lee and Warren, 1981) • **Fairness and equity** (i.e., in decision-making processes, water restrictions, tariffs, new pipelines) • **Environmental values & conservation attitudes** (Corral-Verdugo et al., 2002; De Young, 1996; Syme et al., 1990–1991; Syme et al., 2004) • **Socio-economic factors** (e.g., income, household composition, age, gender, education, etc.) (Agthe and Billings, 1997; Campbell et al., 2004; Loh and Coghlan, 2003; Nancarrow et al., 2004)

2004; Tognacci et al., 1972) • **Personal characteristics** (e.g., intention to conserve water, knowledge of how to conserve water) (Corral-Verdugo et al., 2002; De Young, 1996; St Hilaire et al., 2003; Syme et al., 1990–1991; Syme et al., 2004)	

While research has continued to place an emphasis on water conservation through demand-side management, most of the studies have been performed on urban household water demand (Campbell et al., 2004; Renwick and Archibald, 1998; Renwick and Green, 2000; Michelsen et al., 1999). There is a lack of data available on how rural household water users will respond to water conservation policies. New studies are encouraged for areas that have not been examined because it is difficult to adopt water conservation policies based on previous studies from regions that are have different characteristics (Espey et al., 1997).

Another limitation of the current research is that most of the household attributes that have been studied tend to be general demographic and household characteristics. Information is needed about how a household's attitudes and perceptions influence their willingness to adopt conservation mechanisms. One way to measure that is to use the 'receptivity' model (Brown and Davies, 2007; Jeffrey and Seaton, 2004) as way to evaluate what stage a household is in adopting conservation mechanisms.

Conceptually, the receptivity model explains adoption of water conservation tools along a continuum with adoption of a tool as the ultimate step that is influenced by: (1) awareness of the need for water conservation in the respondent's community; (2) association of specific water conservation tools as a solution to water supply problems; (3) ease of acquisition of specific water conservation tools, which includes affordability, search problems, access, technical difficulty, etc; and (4) application/application of water conservation tools. The receptivity model has been implemented in Australia, but it has not yet been applied in the U.S.

Using this model, we test the following hypotheses: (1) the receptivity (as defined by awareness, association, acquisition, and application) of households to water conservation will be associated with their attitudes, perceptions and experiences; (2) water conservation choices and behavior will be associated with the receptivity of households to water conservation; (3) receptivity to water conservation will be different between rural and urban household water users; and (4) water conservation choices and behaviors will be different between rural and urban household water users. This model may also provide a way to determine if off-setting behavior can be expected based on what component of the model is most influencing each household.

Methods

In 2010, we design, pre-tested and implemented a survey of Oklahoma residents to determine their views on specific water conservation tools. Based on a review of the literature, we designed a survey on water use and conservation. The survey was reviewed by survey experts (n=4) and pre-tested on Oklahoma State University students (n=27) and residents of Stillwater, Oklahoma (n=33). The final survey contained 32 questions on various water-related attitudes and behaviors. A copy of the survey is found in Appendix B.

Using a marketing firm, we identified potential respondents with equal numbers of males/females and otherwise balanced according to the 2000 US Census for Oklahoma. We employed the Dillman (2007) survey method for online surveys as described above (see Objective 2).

The hypotheses were tested using a multinomial logit model (e.g., Greene, 2000). Receptivity to water conservation *j* is described by the characteristics X_j of the household *i*. To get the coefficients used in the likelihood function, I will run the following logit model (1):

$$(1)\ U_{receptivity} = \alpha_j + \beta_{attitudes} X_{ij} + \beta_{perceptions} X_{ij} + \beta_{characteristics} X_{ij} + \beta_{experiences} X_{ij}$$

To determine the likelihood of household *i* being receptive to water conservation *j*, I will use the log-likelihood function (2):

$$(2)\ \text{Logit} = \sum_{i=1}^{N} \sum_{j=1}^{J} d_{ij} \log\left[\frac{1}{1+\sum_{j=2}^{J} e^{\alpha_j + \beta_{ij1}x_1 + \beta_{ij2}x_2 + \ldots + \beta_{ijn}x_n}}\right]$$

where β_{ijn} denotes the n^{th} attribute of household *i* for receptivity category *j*, and X_n represents the n^{th} characteristic for attitudes, perceptions, and experiences. D_{ij} represents a dummy variable that takes the value of 1 if Y_i=1 and 0 otherwise.

To compare the effects of different attitudes, perceptions, and experiences on receptivity to water conservation *j,* by household *i*, we determine their marginal effects as estimated by equation (3):

$$(3)\ \frac{\partial P_j}{\partial x_i} = P_j(\beta_j - \sum_{k=1}^{J} P_k B_k)$$

The relative influence of each receptivity category *j* is evaluated with attitudes and perceptions X_n, where *n* represents the number different household attitudes or perceptions. If the p-value for the coefficient β_{jn} estimated is less than or equal to 0.05, then the likelihood of being receptive to water conservation *j* is influenced by the attitude or perception X_n of household *i*. A similar approach is taken to test each hypothesis.

Results and Interpretation

We implemented the survey online in January 2011. Respondents were recruited by a marketing firm (Market Tools, Inc.) who provided a balanced sampling frame according to the 2000 US Census for Oklahoma. The survey was completed by n=841 Oklahoma residents, for a response rate of 43.6% and a 3.4% margin of error. Analysis is ongoing, and here we present preliminary analytic results.

Recall that the purpose of this study is to match Oklahoma water managers' perceptions of water conservation tools (discussed above) with those of Oklahoma water users, and identify feasible water conservation tools. We employ the receptivity model (Brown and Davies, 2007; Jeffrey and Seaton, 2004) to explore water users' views of water conservation tools, and identify potential key barriers to their use in Oklahoma communities. We empirically measure receptivity as a composite measure that includes questions regarding awareness (of a need for water conservation in the respondent's community), association (of specific water conservation tools as a solution to water supply problems), acquisition (of specific water conservation tools, in terms of difficulty of finding, affording, and installing the tools) and application (of water conservation tools).

Application/adoption of water conservation tools is defined as having installed, used or otherwise having applied the tool. Awareness was comprised of questions related to whether the respondent's community was adequately meeting current water needs, whether climate change was expected to have negative impacts on their community, and whether the community was adequately prepared to meet its near-future water needs. Assocation was comprised of views on effectiveness of specific tools. Acquisition was comprised of views on cost, difficulty of finding, and difficulty of installing/maintaining specific tools.

Application

Oklahomans report engaging in several water conservation efforts (see Table 14). Chief among these is repairing leaks (55%), followed changing behaviors or daily routines (42% for outdoor use, 40% for indoor use), installing new indoor devices (32% for faucets/showerheads, 23% for toilets, and 18% for appliances), installing outdoor devices (4% for rain barrels), changes in outdoor plants (4%), and "other" (3%). Nearly one-in-eight (15%) engage in none of these conservation activities.

Table 14. Summary of Current Conservation Tool Use

Conservation Alternative	Adoption Rate	No Barrier Identified
Repaired a leaky faucet, showerhead, or toilet	55.4%	67.1%
Changed behavior and daily routines for outdoor use	42.1%	56.5%
Changed behavior and daily routines for indoor use	39.8%	42.4%
Installed new low-flow faucets and/or showerheads	31.7%	34.3%

Installed ultra low-flush toilets	22.7%	23.7%
Installed a water-conserving dishwasher and/or washer	17.5%	24.3%
Installed a rain barrel for outdoor water use	4.04%	8.3%
Replaced lawn or other water-consuming plants	3.57%	19.1%
Other	3.21%	-
None of the above	15.1%	-

Awareness, Association and Acquisition

We asked respondents to identify primary barriers to their use of water conservation tools for both indoor and outdoor use. Responses differed significantly by type of tool (Tables 15 and 16). Note that we allowed respondents to pick more than one "primary barrier". Nearly two-thirds of respondents indicated that repairing leaks had no barriers (67.1%), which may explain the very high use of this conservation tool (55.4%). Over half of respondents (56.5%) indicated this was the case for changing outdoor water use behaviors. This was also indicated for a large percentage of respondents regarding installation of low-flow faucets and/or showerheads (34.3%), installing water-conserving appliances (24.3%), installing ultra low-flush toilets (23.7%), and replacing lawn or other water-consuming plants (19.1%). Only 8.3% of respondents indicated that there were no barriers to installing a rain barrel.

A significant percent (15.3% - 38.4%) of respondents indicated that the primary barrier to water conservation tool use is a lack of water shortage. This was lowest for installing indoor water conserving devices (15.3% for faucets and showerheads, 18.4% for appliances, and 18.5% for toilets) and repairing leaks (15.5%). Nearly one-quarter (28.3%) said this was the primary barrier for changes in behaviors. Lack of a current water shortage was a much larger driver for outdoor conservation. Nearly one-quarter identified this as the primary barrier for changes to behavior (22.9%) and installing a rain barrel (26.4%), and over one-third said this was the case for replacing lawn/plants (38.4%). These summary results suggest that information regarding water shortages may have a large influence on the use of conservation tools, especially for outdoor water use.

Effectiveness of water conservation tools appears to be a barrier to adoption, but not many respondents indicated it was the primary barrier to repairing leaks (3.4%) and appliances (3.8%). Roughly 6 – 8% of respondents indicated this was the primary barrier to adopting changes in outdoor behaviors (5.7%), installing low-flow faucets and showerheads (6.8%), replacing lawn/plants (7.8%), installing ultra low-flush toilets (8.6%), and changing indoor water behaviors (8.7%). Notably, the effectiveness of rain barrels was viewed as a primary barrier by one-in-ten respondents (10.0%).

Cost did appear to be a large driver of some conservation tools: appliances (54.6%), toilets (49.4%), lawn/plants (31.3%), faucets/showerheads (21.9%), and rain barrels (18.5%). Few respondents indicated cost as a primary barrier to changes in water behaviors (3.5% for indoor, 3.7% for outdoor) or repairing leaks (6.2%). These results indicate areas where economic incentives may help improve conservation tool use.

The level of difficulty with installing and/or adopting conservation tools was also a primary barrier for many respondents. Nearly one-third indicated this was the case for toilets (29.9%). Replacing lawn/plants and installing a rain barrel were also seen by many as difficult (18.9% and 15.7%, respectively). This was also a primary barrier to installing low-flow faucets and showerheads (9.7%), changing indoor water use behaviors (9.1%), repairing leaks (8.4%), installing water-conserving appliances (8.0%), and changing outdoor water use behaviors (5.2%). This indicates that technical support for installing both indoor and outdoor devices might provide substantial improvement in the use of these conservation tools.

Lack of information about water conservation tools is a major barrier for replacing lawn or other water-consuming plants, with nearly half of all respondents indicating this was the primary barrier to their use (46.1%). Over one-third also said this was the case for rain barrels (36.0%). These results indicate that extension and other information sources need to be further supported if these tools are viewed as a high priority for water managers. Lack of information is also a large problem for other tools: for toilets (13.0%), appliances (12.4%), faucets/showerheads (12.1%), changes in indoor behavior (8.1%), repairing leaks (6.9%), and changes in outdoor behavior (6.0%).

Table 15. Perceived Barriers to Adoption of Indoor Conservation Practices

Conservation Practice	No Barrier	Not Enough Savings	Cost Is Too High	Difficult to Install /Adopt	Not Enough Info.	Currently No Water Shortage
Changes in behavior and daily routines	42.4%	8.7%	3.5%	9.1%	8.1%	28.3%
Installing low-flow faucets and/or showerheads	34.3%	6.8%	21.9%	9.7%	12.1%	15.3%
Installing ultra low-flush toilets	23.7%	8.6%	49.4%	29.9%	13.0%	18.5%
Installing water-conserving appliances	24.3%	3.8%	54.6%	8.0%	12.4%	18.4%

Repairing leaks	67.1%	3.4%	6.2%	8.4%	6.9%	15.5%

Table 16. Perceived Barriers to Adoption of Outdoor Conservation Practices

Conservation Practice	No Barrier	Not Enough Savings	Cost Is Too High	Difficult to Install/ Adopt	Not Enough Info.	Currently No Water Shortage
Changes in behavior and daily routines (e.g. water lawn less)	56.5%	5.7%	3.7%	5.2%	6.0%	22.9%
Replacing lawn or other water-consuming plants	19.1%	7.8%	31.3%	18.9%	46.1%	38.4%
Installing a rain barrel	8.3%	10.0%	18.5%	15.7%	36.0%	26.4%

Tables 15 and 16 describe perceived barriers to non-price conservation tools that the typical water user can adopt; but water managers and other community decision-makers may be considering the use of: (1) conservation pricing to promote water use efficiency; (2) raising average water rates; and (3) restrictions of outdoor water use. Indeed, as the price of water increases, we expect that concerns about cost of water conservation tools, their water savings, and a lack of water shortage would be overcome. We also expect that other tools would see increased use due to higher water prices and outdoor water use restrictions.

We asked respondents to indicate how likely they would be to support outdoor watering restrictions and conservation pricing – for just high-volume users and for all water users (Table 17). We found highest support for the use of mandatory water restrictions (which would be enforced in conjunction with fines for those violating the restrictions) – an overwhelming 34.0% definitely would support this tool being used in their community, while 42.4% probably would support its use. In total, over three-fourths (76.4%) of respondents would likely support this tool being used in their community. Only 8.8% indicated opposition to its use.

Conservation pricing, or tiered water rate schedules, also was broadly supported by the respondents. Six-in-ten indicated support for this conservation tool, with 21.6% definitely supporting and 38.4% probably supporting its use. Only 17.5% indicated opposition to its use, and nearly one-quarter (22.6%) was unsure. Interestingly, we found strong opposition to the use of higher average water prices for all users. Only 19.6% indicated support for higher average water prices: 5.7% definitely would, and 13.9% probably would support its use. A majority (54.8%) oppose its use: 23.3% definitely would not support, and 31.5% probably would not support using this approach to promoting conservation. Over one-quarter (25.6%) were unsure.

Table 17. Preferences on Watering Restrictions and Price Increases

Conservation Alternative	**Definitely would NOT support**	**Probably would NOT support**	**Unsure**	**Probably would support**	**Definitely would support**
Mandatory Water Restrictions	3.3%	5.5%	14.8%	42.4%	34.0%
Increased water prices for high-volume users (Conservation Pricing)	7.0%	10.5%	22.6%	38.4%	21.6%
Increased water prices for all users	23.3%	31.5%	25.6%	13.9%	5.7%

In an effort to gauge how sensitive water users are to prices, we asked respondents to indicate the smallest increase in water prices that would be needed for them to adopt additional conservation tools (Table 18). Our findings are consistent with the literature on the price elasticity of demand, which shows that a 5% - 10% increase in water prices results in a 1% drop in water use (e.g., Klein et al., 2006; Nieswiadomy, 1992; Renwick and Green, 2000). We found that over one-third of respondents would seek to adopt water conservation tools if water prices rise by 10%. Indeed, nearly two-thirds (65.1%) would adopt additional water conservation tools if prices rose 20%, and almost nine-in-ten (85.6%) would adopt conservation tools if prices rose 30%. A price rise of 40% would bring an additional 5.7% of water users to adopt conservation tools, and a 50% rise would yield 94.4% of respondents' using additional water conservation tools. Only 5.6% would need water prices to rise by more than 50% on average to adopt any water conservation tools. These results indicate that water users are rather sensitive to water prices, and that water price increases may be a strong motivator for the adoption of water conservation tools.

Table 18. Smallest Increase in Water Prices Needed for Adoption of Conservation Tools

Increase in water prices	**Percent Frequency**	**Cumulative Percent Frequency**
0-10%	35.90%	35.90%

10-20%	29.19%	65.09%
20-30%	20.50%	85.59%
30-40%	5.71%	91.30%
40-50%	3.11%	94.41%
More than 50%	5.59%	100.00%

The use of water conservation tools depends not just on price, cost, water savings, and other barriers discussed above; they also depend on the efforts of others in the community and pressure to support the community (i.e., "moral suasion"). We asked respondents to gauge the efforts of their neighbors and their water utility regarding water conservation (Table 19). We found a large percentage of respondents who were unsure (40.6% for their neighbors' efforts, and 35.0% for their utility's efforts). Roughly one-quarter hold pessimistic views about their neighbors' efforts (26.0%) and their utility's efforts (25.8%). Nearly one-third hold optimistic views about their neighbors' efforts and their utility's efforts on water conservation (33.5% and 36.5%, respectively). Only 2.8% of our respondents do not get water from a water utility, and could not answer the utility-related question. These results indicate that respondent are generally uncertain about conservation efforts, but are slightly more likely to view their utilities and neighbors as making efforts to support and promote conservation than not making efforts.

Table 19. Views about Others' Conservation Efforts

Views on Others' Conservation Efforts	Definitely NO	Probably NO	Unsure	Probably Yes	Definitely Yes	Not applic-able
Do your neighbors make an effort to conserve water?	7.7%	18.3%	40.6%	28.7%	4.8%	-
Does your local water utility promote water conservation?	8.7%	17.1%	35.0%	25.9%	10.6%	2.8%

We empirically evaluated the receptivity model using a series of econometric models that explain the adoption of water conservation tools as a function of the factors discussed above. Several models were evaluated using various factors as explanatory variables. Recall that we define receptivity as a composite of four factors: Awareness, Association, Acquisition, and Application.

In our econometric models, **Awareness** is comprised of (1) views on whether there is currently enough water to meet the needs of your community ("Current Need", question 2), views on whether the respondent's community will need to increase water supply or reduce water use in the next 20 years ("Future Need", q. 3), and whether climate change will reduce water supply in their area ("Climate Change", q. 20). **Association** is captured by views on effectiveness of each water conservation tool ("Effectiveness", q. 5, 11 and 12). **Acquisition** is comprised of the smallest price change that would lead to water conservation tool adoption (q. 17), whether the respondent's household would use less water if the cost increased by 20% (question 18), and how much the respondent's households water has changed in the last 5 years (q. 15).

In Tables 20 and 21, we report the parameter estimates for our econometric model (Table 20), and the calculated marginal effects based on the parameter estimates (Table 21). The logit model parameter estimates indicate the change in log odds with each one level change in the explanatory variable, which is not very intuitive. The marginal effects, however, are interpreted as the change in probability of an average respondent adopting a particular water conservation tool for each one-level increase in a particular explanatory variable. We discuss only the marginal effects here.

Table 20. Receptivity Model Effects

	Inter-cept	Current Need	Future Need	Climate Change	Effective-ness	Price Change	Use-change20	Use Changed
Indoor	-3.5229	-0.1919**	0.1930**	0.1209*	0.7968***	-0.0802	0.1325*	-0.2465***
Low-flow	-3.6406	-0.1516*	0.2214**	0.1086	0.6395***	0.0302	-0.0201	-0.0813
Low-flush	-4.5333	0.00433	0.2757**	0.0318	0.6693***	-0.00242	-0.00363	-0.1605**
Applian-ces	-5.1519	0.0851	0.0887	0.00142	0.8563	-0.00673	-0.1499	-0.000584
Leaks	-2.8139	-0.0138	0.2840***	-0.0623	0.6061***	-0.0597	-0.0855	0.0443
Outdoor	-3.7736	-0.1624*	0.3433***	0.1300*	0.7234***	-0.0885	0.0491	-0.2105**
Plants	-5.9764	-0.3319*	0.3221	0.1564	0.6464**	0.0727	-0.0135	-0.1615
Rain Barrels	-6.5180	-0.3194*	0.2093	0.0878	1.0637***	-0.3142*	0.0303	-0.0596
None	0.5331	0.1266	-0.5006**	-0.0393	-	0.0249	-0.2044	-0.0618**

*** = 1% Significance, ** = 5% Significance, * = 10% Significance

Table 21. Receptivity Model Marginal Effects

	Current Need	Future Need	Climate Change	Effective-ness	Price Change	Usechange -20	Use Changed
Indoor	-0.0451**	0.0454**	0.0284*	0.1875***	-0.0189	0.0312*	-0.0580***
Low-flow	-0.0323*	0.0472**	0.0232	0.1364***	0.0064	-0.0043	-0.0173
Low-flush	0.0007	0.0448**	0.0052	0.1087***	-0.0004	-0.0006	-0.0261**
Appliances	0.0115	0.0120	0.0002	0.1154	-0.0009	-0.0202	-0.0001
Leaks	-0.0034	0.0690***	-0.0151	0.1472***	-0.0145	-0.0208	0.0108
Outdoor	-0.0393*	0.0831***	0.0315*	0.1752***	-0.0214	0.0119	-0.0510**
Plants	-0.0083*	0.0080	0.0039	0.0161**	0.0018	-0.0003	-0.0040
Rain Barrels	-0.0066*	0.0043	0.0018	0.0219***	-0.0065*	0.0006	-0.0012
None	0.0154	-0.0608**	-0.0048	-	0.0030	-0.0248	-0.0075**

*** = 1% Significance, ** = 5% Significance, * = 10% Significance

We found that the receptivity model is useful for explaining the likelihood of Oklahoma water users adopting water conservation tools. Variables comprising awareness were statistically significant for several of the conservation tools, but these varied somewhat depending on the tool. Indoor behavior changes are negatively influenced by current need, and positively influenced by future need and climate change; low-flow faucets and showerhead use is negatively influenced by current need, and positively influenced by future need; low-flush toilet installation is positively influenced by future need; appliance installation was not statistically significantly influenced by any awareness variables; leaks were positively in

As expected, current need – views that the respondent's community has enough water to meet current needs – negatively influences adoption of conservation tools; future need – beliefs that the community will need to increase water supply – positively influences adoption; and climate change – beliefs that climate change will reduce water supply in the respondent's area – positively influence adoption of conservation tools. However, these variables were not all statistically significant, and their relative influence varied by conservation tool.

We measured beliefs about current water needs on a 5-point Likert-like scale, where 1 indicated that the respondent answered "Definitely No" and 5 indicates that the respondent answered "Definitely Yes" to the question "In your opinion, is there currently enough water in your area to meet the needs of your community?" We found that for every 1-level increase in this scale, the probability of adopting indoor behavior changes falls by 4.5%; installing low-flow toilet falls by 3.2%, adopting outdoor water use behavior changes falls by 3.9%, installation of new lawn/plants falls by 0.8%, and installation of rain barrels falls by 0.6%. This variable was not statistically significant for other conservation tools.

We asked a similar question related to future water needs, where a 1 indicates "Definitely No" and 5 indicates "Definitely Yes" to the question "In your opinion, will your community need to increase its water supply or reduce water use within the next 20 years?" For every 1-level increase in this scale, the probability of adopting indoor behavior changes increases by 4.5%, installing low-flow toilets increases by 4.7%, installing low-flush toilets increases by 4.5%, fixing leaks increases by 6.9%, adopting outdoor water use behavior changes increases by 8.3%, and the likelihood of adopting no water conservation tools falls by 6.1%.

Views on climate change also have the expected impact, but were not highly significant; only indoor behavior changes and outdoor behavior changes have statistically significant influences form climate change views. For every 1-level increase in the belief that climate change will reduce water supply, there is a 2.8% increase in the use of indoor water conservation behaviors, and a 3.2% increase in the use of outdoor water conservation behaviors. This may indicate that education about climate change may be needed to boost changes in water use behaviors.

Association, as captured by views on effectiveness of water conservation tools, was highly influential. For every 1-level increase in the perception of a conservation tool as effective in reducing water use, there was an 18.8% increase in the use of indoor water behavior changes, a 13.6% increase in the installation of low-flow faucets/showerheads, a 10.9% increase in the installation of low-flush toilets, a 14.7% increase in repairing leaks, a 17.5% increase in the use of outdoor conservation behavior, a 1.6% increase in the use of water conserving lawn/plants, and a 2.2% increase in the use of rain barrels. Again, indoor and outdoor behavior changes are most heaving influenced.

Acquisition, as measured by the minimum water price change (as %) needed to adopt water conservation tools, the likelihood of reducing household water use for a 20% increase in water prices, and whether the respondent's household had changed in the last five years, provided weak results. As expected, the less sensitive a respondent is to price change, the less likely they are to adopt conservation. More every 10% increase in minimum change in water prices needed to adopt conservation, the chance of adopting rain barrels decreases by 0.7%. Also, for every 1-level increase in the chance that a respondent's household would use less water if prices rose by 20%, there was a 3.1% increase in the adoption of indoor water conservation behaviors. We also found that reported changes in water use over the past five years has a clear influence on the likelihood of adopting water conservation tools. We asked respondents to respond to the question "Over the last five years, how has your household's water use changed?" where 1 – Large Decrease, and 5 – Large Increase. For every 1-level change (increase in water use), we find a 5.8% decrease in the adoption of indoor water conservation behaviors, a 2.6% fall in the installation of low-flush toilets, a 5.1% drop in the adoption of outdoor conservation behaviors, and a 0.8% drop in the installation of rain barrels.

For comparison, we also tested a conceptual model with only awareness and association variables (Table 22). We still found that association (effectiveness) dominated the model results.

Table 22. Impact of Attitudes on Adoption of Conservation Tools

	Attitude Questions			
	Intercept	**Current Need**	**Future Need**	**Effectiveness**
Indoor	-3.5732	-0.2138***	0.1763**	0.8545***
Low-flow	-3.4757	-0.1674**	0.2283***	0.6395***
Low-flush	-4.8275	-0.00336	0.2700***	0.6733***
Appliances	-5.5613	0.0778	0.0847	0.8349***
Leaks	-3.2899	-0.0101	0.2724***	0.6028***
Outdoor	-3.8369	-0.1907**	0.3268***	0.7404***
Plants	-5.7853	-0.3599**	0.3368	0.6667***
Rain Barrels	-6.9760	-0.3514**	0.1710	1.1538***
None	-0.4833	0.1258	-0.4834***	-

*** = 1% Significance, ** = 5% Significance, * = 10% Significance

We also tested other conceptual models, including one that evaluated perceived barriers and the use of conservation tools (Tables 23 and 24); and the influence of views on community and neighbor efforts on conservation tool use (Table 24).

Stated barriers to adoption are good indicators of self-reported adoption of water conservation tools. For every 1-level increase in the view that water conservation tools provide not enough water savings, we find a 17.3% drop in the use of indoor behaviors, a 11.6% drop in the use of low-flow faucets/showerheads, a 9.8% drop in the installation of low-flush toilets, a 5.1% decline in the installation of water conserving appliances, and a 3.0% drop in leak repairs. For a 1-level increase in the view that cost is too high, we find a 14.6% drop in the use of low-flow faucets/showerheads, a 15.7% drop in low-flush toilet use, a 6.8% reduction in the installation of water conserving appliances, a 1.6% decline in outdoor water behavior changes, a 2.0% fall in the installation of water conserving lawn/plants, and a very negligible 0.006% fall in the use of rain barrels. Difficulty of installation was also a factor, with increased perceptions of difficulty negatively influencing adoption – by 9.7% for indoor behaviors, 17.2% for low-flow faucet/showerheads, 8.6% for low-flush toilets, 16.1% for leak repairs, and 14.2% for outdoor behavior changes. Insufficient information was also a major barrier that influences water conservation tool adoption, and negatively influences indoor water behavior changes by 14.9%, low-flow faucets/showerheads by 14.9%, low-flush toilets by 12.5%, water conserving appliances by 3.0%, outdoor behavior changes by 14.5%, and water conserving lawn/plants by 1.8%.

Table 23. Logit Model Comparing Barriers to Water Conservation Adoption

	Barriers to Adoption (Relative to 'No Barriers')					
	Intercept	Not Enough Water Savings	Cost is too High	Difficult to Install or Adopt	Not Enough Information	Currently No Water Shortage
Indoor	-0.5761	-1.1035***	-0.5225	-0.5408*	-0.9093***	-1.0333***
Low-flow	-0.7438	-0.8876**	-1.1020***	-1.5724***	-1.2139***	-1.3916***
Low-flush	-1.0645	-1.1973**	-1.7275***	-0.9504***	-1.7081***	-0.7479***
Appliances	-1.3909	-1.7002*	-1.4896***	-14.7530	-0.6633*	-1.0070***
Leaks	-0.2733	-1.8043*	-0.4888	-0.7383**	-0.3881	-0.4630**
Outdoor	-0.6415	-0.4000	-0.9680*	-0.8054**	-0.8249**	-0.5767***
Plants	-3.0890	-0.8230	-1.4436*	-1.2548	-1.2418*	-1.3997*
Rain Barrels	-2.7132	-1.5773	-1.3895*	-13.8307	-13.8307	-0.8869*

*** = 1% Significance, ** = 5% Significance, * = 10% Significance

Table 24. Logit Model Comparing Barriers to Water Conservation Adoption, Marginal Effects

	Barriers to Adoption Marginal Effects (Relative to 'No Barriers')

	Not Enough Water Savings	Cost is too High	Difficult to Install or Adopt	Not Enough Information	Currently No Water Shortage
Indoor	-0.1725***	-0.0932	-0.0971*	-0.1489***	-0.1778***
Low-flow	-0.1158**	-0.1461***	-0.1722***	-0.1485***	-0.1661***
Low-flush	-0.0984**	-0.1572***	-0.0863***	-0.1247***	-0.0732***
Appliances	-0.0509*	-0.0678***	-0.1200	-0.0300*	-0.0417***
Leaks	-0.3037*	-0.1105	-0.1607**	-0.0891	-0.1058**
Outdoor	-0.0778	-0.1631*	-0.1422**	-0.1452**	-0.1113***
Plants	-0.0123	-0.0203*	-0.0164	-0.0177*	-0.0197*
Rain Barrels	-0.0006	-0.0006*	-0.0018	-0.0159	-0.0004*

*** = 1% Significance, ** = 5% Significance, * = 10% Significance

Views about water conservation efforts by neighbors and utilities had little influence with a few important exceptions (Table 25). For every one-level increase the belief that neighbors are making efforts to conserve water, there is an expected 13.8% increase in the use of indoor water conservation behaviors, and a 20.1% increase in the installation of water conserving appliances; and for utility's effort, a 1-level change in perceived effort increases leak repair by 12.8%. Also, importantly, increased perceived effort by utilities significantly reduces the likelihood of adopting none of the water conservation tools – by a substantial 14.2%.

Table 25. Influence of Other-Regarding Behavior on Water Conservation Adoption

	Other-Regarding Behavior Questions		
	Intercept	Neighbor Conserve	Utility Conserve
Indoor	-0.9181	0.1384*	0.0408
Low-flow	-0.9133	0.0558	0.00484
Low-flush	-0.9856	-0.00291	-0.0654
Appliances	-2.1828	0.2018**	0.0112
Leaks	0.1179	-0.0754	0.1276**
Outdoor	-0.3747	-0.0330	0.0657
Plants	-3.2096	-0.1176	0.0947
Rain Barrels	-2.7039	0.0508	-0.2029

None	-1.1992	-0.0252	-0.1420*

*** = 1% Significance, ** = 5% Significance, * = 10% Significance

Conclusion

We conducted a survey of Oklahoma water users to identify major barriers to and primary drivers of water conservation tool use. Water conservation tool use varied significantly by tool, with repairing leaks most likely to be used, and replacing lawn/plants least likely. In every case, the adoption rate of these tools approximated the percent indicating no barriers to their use.

The results indicate that approaches to implementing water conservation tools would do best to tailor programs to water users' specific perceptions. For example, programs that ease the economic burden of installing appliances, low-flow faucets/showerheads, and ultra low-flush toilets would address cost concerns, which drive decisions regarding these tools. Replacing lawn and other water consuming plants, and installing rain barrels are both seriously limited by insufficient information. Also, in general, fundamental beliefs about needs for water conservation drive the use of these tools. For example, believing that there is currently no water shortage is a major barrier that could be overcome with an effective public awareness and information campaign. The same is true of climate change, although this issue has perhaps been too politicized to gain traction with many water users.

Using econometric models, we predicted the likelihood that an Oklahoma resident would adopt water conservation tools. We examined receptivity factors including awareness, association, and acquisition, and found that association is a major influential driver of adoption. Awareness and acquisition were also somewhat determinative, but much less so. We also examined stated barriers and perceptions on community and neighbor efforts on conservation. Stated barriers were highly influential, but perceptions were less influential. We note, however, that respondents' perceptions about their water utility's efforts on water conservation have a significant influence over whether the respondent adopts any water conservation tools or not.

The results from the study showed that high costs and lack of information were major barriers to households adopting new conservation alternatives. Association between a conservation mechanism's effectiveness and a future water demand problem increased the likeliness of a household to adopt the mechanism. The findings of this research will be useful for water policy educators and decision makers in developing water programs to meet the demands of their population in the future. This survey and model could be replicated in other areas to further test the validity of the findings and assist other regions that will need to make tough decisions about how to manage the precious resource of water in the future.

Objective 6, is achieved by writing this report and extending our results through the research and extension publication channels.

The report will include a list of feasible alternatives to consider in the Comprehensive Water Plan process. We will present the results to the Oklahoma Water Resources Board and to other interested stakeholders as appropriate. These are likely to include the Oklahoma Rural Water Association, the Oklahoma Municipal League, and Oklahoma Cooperate Extension Service professionals.

Principal Findings and Significance:

This project evaluated water conservation policy tools that have been used or proposed in Oklahoma and other parts of the United States, and looked for conservation tools that are feasible in Oklahoma given water managers' and water users' views. The analysis is ongoing, but initial results show that efforts by many water utilities are asynchronous with water users' preferences. While only 6% of Oklahoma water utilities have adopted programs that promote non-price based conservation tools, this category was the most popular with water users. On average, water users were much more supportive of non-price water conservation tools, with 76.4% likely to support these conservation tools being in their community; only 8.8% registered opposition to their use.

Likewise, 22% of Oklahoma utilities have raised average water rates to promote conservation, but this was viewed as least popular by water users. They were decidedly opposed to water utilities raising average water rates on all users as a means of conserving water, with 54.8% opposing its use, and only 19.6% in support. Although there was less support for price-based tools, water users were generally supportive of conservation pricing, which charges higher per-unit water rates to high volume users. A clear majority (60.0%) were supportive of this approach to conserving water. These results stand in stark contrast to the approach typically taken by most Oklahoma water utilities, and suggest an area where decision-making by utilities may need additional support.

Our literature review provides estimates on average costs of implementing various price-based an non-price based water conservation programs. When coupled with the results of major drivers of both price and non-price conservation programs by utilities, and specific preferences and drivers of water conservation adoption by water users, preferred conservation strategies could be identified. Additional work will identify these, and this information will be shared with appropriate stakeholders in Oklahoma in due time.

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Appendix A. Oklahoma Water Managers Survey

Oklahoma Water Use Efficiency and Conservation Survey

August 2009

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"Conservation" has been defined many different ways. Some studies have defined water conservation to be similar to water efficiency (i.e., reducing wasteful use). For example, a utility provides its customers with low flow shower heads to reduce the amount of water being used per shower, resulting in higher efficiency. Other studies have defined water conservation to mean a decrease in total water use. For example, a utility mandates that its customers are not allowed to water their yards, resulting in a total reduction in water use.

Our desire is to determine which programs are best at increasing efficiency as well as reducing water use. For the purposes of this survey, please consider "conservation" to mean both increased efficiency and reduction in total water use.

In some cases, more than one water system is run by the same person or group. If this describes your situation, please answer the following questions according to the system with the MOST METERED CONNECTIONS.

1. What region of the state is your utility in? *(circle one answer)*
    a. Northwest (NW)
    b. Northeast (NE)
    c. Central (C)
    d. Southwest (SW)
    e. Southeast (SE)

2. How is your utility's ownership structured? *(circle one answer)*
    a. Municipal, county, or state owned
    b. Private investor owned
    c. Customer owned nonprofit or cooperative
    d. Other – public *(please describe)* ___________________
    e. Other – private *(please describe)* ___________________

3. In a typical year, what are primary and secondary sources of water for your utility? *(circle the source that applies)*

	Primary	Secondary	Not Applicable
Surface water, self supply	P	S	n/a
Surface water, purchased from other utility	P	S	n/a
Ground water, self supply	P	S	n/a
Ground water, purchased from other utility	P	S	n/a

4. Roughly what percent of your utility's water is delivered to the following? (*provide estimates that adds to 100%)*

_____ % Residential
_____ % Industrial
_____ % Commercial and institutional
_____ % Oil & Gas
_____ % Agricultural
_____ % Wholesale and sale to other systems
_____ % Unaccounted water loss
_____ % Other *(please specify)*_______

5. During a non-drought period, how many gallons of metered water does your system deliver? *(provide an estimate in the blank)*

6. Over the last five years, how has the amount of water that your system delivers changed*? (circle one answer for (6a) Total Delivery and (6b) Per Capita Delivery)*

6a) Total Delivery	6b) Per Capita Delivery
a. Decreased by more than 10%	a. Decreased by more than 10%

b. Decreased by 5% to 10%	b. Decreased by 5% to 10%
c. Stayed about the same	c. Stayed about the same
d. Increased by 5% to 10%	d. Increased by 5% to 10%
e. Increased by more than 10%	e. Increased by more than 10%

7. In your opinion, what is the primary cause for the change in demand?

8. Who in your system determines RATE changes? *(check all that apply)*

	Recommends changes	Has final approval	Not applicable
Utility/District manager	☐	☐	☐
Utility's board of directors	☐	☐	☐
City/county/state government	☐	☐	☐
Utility's customers (by direct vote)	☐	☐	☐
Corporate decision	☐	☐	☐
Other *(please specify)*___________	☐	☐	☐

9. Who in your system determines CONSERVATION programs? *(check all that apply)*

	Recommends changes	Has final approval	Not applicable

Utility/District manager	☐	☐	☐
Utility's board of directors	☐	☐	☐
City/county/state government	☐	☐	☐
Utility's customers (by direct vote)	☐	☐	☐
Corporate decision	☐	☐	☐
Other *(please specify)*___________	☐	☐	☐

10. How does your utility notify its customers about changes to water rates and conservation programs? *(select all that apply)*

☐ Special mail out

☐ Attachment in water bill

☐ Local TV and radio stations

☐ Posting on utility's web-page

☐ Notice in local newspaper(s)

☐ Public meeting

☐ Other *(please specify)* _______________

11. Where can your customers learn about your utility's current water rates and rate structure? *(select all that apply)*

☐ Contact the utility

☐ Visit the utility's website

☐ Water bill

☐ Utility newsletter

☐ Contact the municipality

☐ Visit the municipal website

☐ Annual report available to public

☐ Utility's website *(please provide website address)* ____________________

12. How does your utility plan on meeting future water demand? *(select all that apply)*

    ☐ Secure new water supply from traditional ground and surface water sources

    ☐ Secure new water supply from alternative sources such as reclaimed water, desalination, etc

    ☐ Replace or improve infrastructure, including water loss control

    ☐ Increase water or sewer rates

    ☐ Demand-side programs to promote water use efficiency and conservation

    ☐ Other *(please specify)* ____________________

13. What factors will significantly impact your utility's ability to meet future water demand? *(select all that apply)*

    ☐ Leakage/loss in old infrastructure

    ☐ Inefficient use or waste by customers

    ☐ Increasing population

    ☐ Increasing cost to treat water

    ☐ Increasing cost to meet testing and other regulatory requirements

    ☐ Inability to maintain access to supply

    ☐ Inability to maintain withdrawal levels

    ☐ Other *(please specify)* ____________________

14. Do you believe that long-run changes in weather patterns (including regional climate change) will seriously and negatively impact your utility's available water supply?
    a. Yes
    b. Not sure
    c. No

    What plan does your utility have to adapt to these long-run changes?

15. Does your utility plan on increasing its delivery capacity in the next five years?
    a. Yes
    b. No (skip to question 17)

16. Please describe the projects to increase capacity over the next five years

    Type of Project

    Total Cost $ ($/gallon if known)

    Total increase in capacity (gallons/day if known)

17. Please include a copy of your rate schedule with the survey or provide a link to a website where the rates are available.

    Website address_______________________________

18. How important are the following components when determining your utility's water rate (1-lowest, 4-highest)? *(please circle one rank per row)*

Issue	**Lowest**			**Highest**	**Not Applicable**
Consumer expectations & attitudes	1	2	3	4	n/a
Cost of delivery (other than regulatory requirements)	1	2	3	4	n/a
Future capital and infrastructure re-investment	1	2	3	4	n/a
Reduce wasteful water use	1	2	3	4	n/a

Regulatory requirements	1	2	3	4	n/a
Repair and maintenance of infrastructure	1	2	3	4	n/a
Revenue or profit requirements	1	2	3	4	n/a
Subsidies for non-water util. operations	1	2	3	4	n/a
Other *(please specify)*_______________	1	2	3	4	n/a

19. Has your utility changed its water rate structure in the last five years? *(for example, declining block to inclining block)*
    a. Yes
    b. No (skip to question 22)

20. How has your water rate structure changed in the last five years? (for example, declining block to inclining block)

21. What were the major reasons for changing the rate structure?

22. Has your utility's AVERAGE rate changed in the last five years?
    a. Yes
    b. No (skip to question 25)

23. How has your utility's AVERAGE water rate changed in the last five years?

24. What were the major reasons for changing the rate?

25. Has your utility estimated how a change in water rates will impact water use?
    a. No
    b. Not sure
    c. Yes (please indicate source of information or process used)

26. If residential water rates increased by 10%, what change in total gallons delivered would you expect? *(select one answer for (26a) Total Delivery and (26b) Per Capita Delivery)*

26a) Total Delivery	26b) Per Capita Delivery
a. Increase	a. No change
b. Decrease	b. Less than 5%
c. Stayed about the same	c. 5-10%
	d. 10-15%
	e. 15-20%
	f. More than 20%

27. Has your utility ever used non-price programs such as rebates, water restrictions, low flow devices, etc to manage water demand or promote conservation?
    a. Yes
    b. No (skip to question 33)

28. Please indicate which water conservation programs your utility has used or is currently using. *(select all that apply)*

	Currently using	Have used in the past
Rebates & Retrofit	☐	☐
Efficient irrigation systems	☐	☐
Voluntary watering restriction	☐	☐
Mandatory watering restrictions	☐	☐
Education/awareness programs	☐	☐
Xeriscaping and/or turf buyback	☐	☐
Leak detection at homes	☐	☐
Water budgets and/or audits	☐	☐
New water meter (e.g., smart meters)	☐	☐
Other *(please specify)* ____________________	☐	☐

29. Please describe the water conservation program (or group of programs) that saved MOST water per dollar spent.

Program name or description

Program cost $ ($/gallons if known)

Reduction in water use (gallons/day if known)

Process used to estimate these (study, internal estimate, etc)

30. Please describe the water conservation program (or group of programs) that saved LEAST water per dollar spent

Program name or description

Program cost $ ($/gallons if known)

Reduction in water use (gallons/day if known)

Process used to estimate these (study, internal estimate, etc)

31. How does conservation PRICING impact your utility's revenue? *(select one answer per column)*

Revenue	Revenue Variability	Budget
a. Increase	a. More variable	a. creates a Deficit
b. Decreases	b. Less variable	b. create a Surplus
c. No effect	c. No effect	c. No effect

32. How do conservation PROGRAMS impact your utility's revenue? *(please select one answer per column)*

Revenue	Revenue Variability	Budget
a. Increase	a. More variable	a. creates a Deficit
b. Decreases	b. Less variable	b. creates a Surplus
c. No effect	c. No effect	c. No effect

33. What are the primary barriers to your utility using conservation pricing or conservation programs? *(select all that apply)*

☐ Currently no water shortage

☐ Conservation rates impact low-income customers

☐ Decision makers have little awareness of the policies effectiveness

☐ Cost-effectiveness of programs

☐ Not enough funding for programs

☐ Limited staff

☐ Revenue requirements

☐ Regulatory requirements

☐ Not enough politically support

☐ Other *(please specify)* ________________________

Thank You

If you would like to receive a report summarizing our results, please provide your contact information below. Your information will be kept confidential, and will not be used to identify your survey responses.

Name ________________________________

Address ________________________________

____

____

Phone ________________________________

Email ________________________________

Thank you very much for completing this survey. Your insight will play an important role in determining which water conservation programs work best in Oklahoma. Our contact information is below; please feel free to contact us if you have any questions or comments about the survey.

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Appendix B. Oklahoma Water Users Survey

zoomerang

Oklahoma Water Use and Conservation Survey_V7

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Oklahoma Water Use and Conservation Survey

Page 1 - Image

The Oklahoma Water Resources Research Institute and Oklahoma Cooperative Extension Service are concerned with water use and conservation and how they might affect our daily lives and businesses.
Your views and the views of other Oklahoma residents about water use and conservation as provided in the following survey are very important to guide research and educational efforts in our state.
Your response to this survey is important - you are one of only 800 Oklahomans being asked their views on water use and conservation. Your responses will represent the residents of our state.
Would you please complete this questionnaire? It should only take about 7-10 minutes to complete. Also, your response will remain completely confidential, and no personally identifying information is requested.

Page 1 - Question 1 - Yes or No [Mandatory]

Are you an Oklahoma resident, or have you lived in Oklahoma within the last 5 years?

- ○ Yes [Skip to 2]
- ○ No [Screen Out]

Page 2 - Heading

Water Use and Conservation in Your Community

Page 2 - Question 2 - Rating Scale - One Answer (Horizontal) [Mandatory]

In your opinion, is there currently enough water in your area to meet the needs of your community?

Definitely No	Somewhat No	Neutral/Not Sure	Somewhat Yes	Definitely Yes
○	○	○	○	○

Page 2 - Question 3 - Rating Scale - One Answer (Horizontal) [Mandatory]

In your opinion, will your community need to increase its water supply or reduce water use within the next 20 years?

Definitely No	Somewhat No	Neutral/Not sure	Somewhat Yes	Definitely Yes
❍	❍	❍	❍	❍

Page 2 - Question 4 - Choice - Multiple Answers (Bullets) [Mandatory]

Which of the following water conservation tools or programs has your community used within the last 5 years? (check all that apply)

- ☐ Mandatory watering restrictions
- ☐ Voluntary watering restrictions
- ☐ Helping homeowners install low-flow fixtures and appliances
- ☐ Helping homeowners install rain barrels
- ☐ Paying homeowners to remove turf-grass or plant drought-tolerant plants
- ☐ Increasing water prices for all water users
- ☐ Using conservation pricing so high-volume users pay more for excess water
- ☐ Education and awareness campaigns on water use and conservation
- ☐ None/Don't know

Page 2 - Question 5 - Rating Scale - Matrix [Mandatory]

In your opinion, how effective are the following water conservation tools or programs?

	Very Ineffective	Somewhat Ineffective	Don't Kn
Mandatory watering restrictions	❍	❍	❍
Voluntary watering restrictions	❍	❍	❍
Helping homeowners install low-flow fixtures and appliances	❍	❍	❍
Helping homeowners install rain barrels	❍	❍	❍
Paying homeowners to remove turf-grass or plant drought-tolerant plants	❍	❍	❍
Increasing water prices for all water users	❍	❍	❍
Using conservation pricing so high-volume users pay more for excess water	❍	❍	❍
Water budgets/audits for high-volume users	❍	❍	❍
Education and awareness campaigns on water use and conservation	❍	❍	❍

Page 2 - Question 6 - Rating Scale - One Answer (Horizontal) [Mandatory]

In your opinion, do your neighbors make an effort to conserve water?

Definitely No	Somewhat No	Unsure	Somewhat Yes	Definitely Yes
❍	❍	❍	❍	❍

Page 2 - Question 7 - Rating Scale - One Answer (Horizontal) [Mandatory]

In your opinion, does your local water utility promote water conservation?

Definitely No	Somewhat No	Unsure	Somewhat Yes	Definitely Yes	Do not get water from a local water utility
❍	❍	❍	❍	❍	❍

Page 2 - Question 8 - Rating Scale - Matrix [Mandatory]

Please rate your support for the following practices to conserve water during a drought?

	Definitely Would NOT Support	Probably Would NOT Suppor
Mandatory water restrictions	❍	❍
Increased water prices for high-volume users (conservation pricing)	❍	❍
Increased water prices for all users	❍	❍

Page 2 - Question 9 - Choice - Multiple Answers (Bullets) [Mandatory]

What information sources have you used to learn about your water prices? (Please check all that apply)

- ☐ Visited the utility's website
- ☐ From a water bill
- ☐ From a utility newsletter
- ☐ Contacted the municipality
- ☐ Visited the municipal website
- ☐ Read an annual report
- ☐ From traditional media (e.g., TV, newspaper, radio)
- ☐ Do not know my water price
- ☐ Do not buy water (e.g., have private well)
- ☐ Other, please specify

....

Page 3 - Heading

Household Water Use and Conservation

Page 3 - Question 10 - Choice - Multiple Answers (Bullets) [Mandatory]

Which of the following has your household adopted?

- ☐ Changed behavior and daily routines for indoor use (e.g., shorter showers)
- ☐ Installed new low-flow faucets and/or showerheads
- ☐ Installed ultra low-flush toilets
- ☐ Installed a water-conserving dishwasher and/or washer
- ☐ Repaired a leaky faucet, showerhead, or toilet
- ☐ Changed behavior and daily routines for outdoor use (e.g., watering lawn less often)
- ☐ Replaced lawn or other water-consuming plants
- ☐ Installed a rain barrel for outdoor water use
- ☐ None of the above
- ☐ Other, please specify

....

Page 3 - Question 11 - Rating Scale - Matrix [Mandatory]

In your opinion, how effective are each of the following for reducing household indoor water use?

	Very Ineffective	Somewhat Ineffective	Unsure	Somew
Changes in behavior and daily routines (e.g., taking shorter showers)	○	○	○	
Installing low-flow faucets and/or showerheads	○	○	○	
Installing ultra low-flush toilets	○	○	○	
Installing water-conserving appliances (e.g., dishwasher)	○	○	○	
Repairing a leaky faucet, showerhead, or toilet	○	○	○	

Page 3 - Question 12 - Rating Scale - Matrix [Mandatory]

In your opinion, how effective are each of the following for reducing household outdoor water use?

	Very Ineffective	Somewhat Ineffective	Unsure
Changes in behavior and daily routines (e.g., watering grass lawn less often)	○	○	○
Replacing lawn or other water-consuming plants	○	○	○
Installing a rain barrel	○	○	○

Page 3 - Question 13 - Rating Scale - Matrix [Mandatory]

What barriers prevent your household from adopting each of the following for indoor water conservation?

	No Barriers (Have already adopted)	Not Enough Water Sav
Changes in behavior and daily routines (e.g., taking shorter showers)	❍	❍
Installing low-flow faucets and/or showerheads	❍	❍
Installing ultra low-flush toilets	❍	❍
Installing water-conserving appliances (e.g., dishwasher)	❍	❍
Repairing a leaky faucet, showerhead, or toilet	❍	❍

Page 3 - Question 14 - Rating Scale - Matrix [Mandatory]

What barriers prevent your household from adopting each of the following for outdoor water conservation?

	No Barriers (Have already adopted)	Not Enough
Changes in behavior and daily routines (e.g., watering grass lawn less often)	❍	(
Replacing lawn or other water-consuming plants	❍	(
Installing a rain barrel (costing about $50 to $100)	❍	(

Page 3 - Question 15 - Rating Scale - One Answer (Horizontal) [Mandatory]

Over the last five years, how has your household's water use changed?

Large Decrease	Small Decrease	Stayed About the Same	Small Increase	Large Increase	Unsure
❍	❍	❍	❍	❍	❍

Page 3 - Question 16 - Choice - One Answer (Bullets) [Mandatory]

About how much does your water cost (per 1,000 gallons)? Note: the typical household uses about 5,000 gallons per month.

- ❍ Less than $1.00
- ❍ $1.00 - $2.00
- ❍ $2.00 - $3.00
- ❍ $3.00 - $4.00
- ❍ More than $4.00
- ❍ Do not know

Page 3 - Question 17 - Choice - One Answer (Bullets) [Mandatory]

What is the smallest rise in water prices needed for your household to adopt new conservation tools or behaviors?

- ❍ 0 - 10%
- ❍ 10 - 20%
- ❍ 20 - 30%
- ❍ 30 - 40%
- ❍ 40 - 50%
- ❍ More than 50%

Page 3 - Question 18 - Rating Scale - One Answer (Horizontal) [Mandatory]

Would your household use less water if the cost increased by 20%?

Definitely No	Probably No	Neutral/Unsure	Probably Yes	Definitely Yes
❍	❍	❍	❍	❍

Page 3 - Question 19 - Rating Scale - One Answer (Horizontal) [Mandatory]

Based on this scale, please indicate your attitude about the use of water and other natural resources:

Total natural resource use	More use than protection	Equal Balance	More proection than use	Total environmental protection
❍	❍	❍	❍	❍

Page 3 - Question 20 - Rating Scale - One Answer (Horizontal) [Mandatory]

Do you believe that climate change will reduce water supply in your area?

Definitely No	Somewhat No	Unsure	Somewhat Yes	Definitely Yes
❍	❍	❍	❍	❍

Page 4 - Heading

Tell Us About Yourself

Page 4 - Question 21 - Choice - One Answer (Bullets) [Mandatory]

What is your household's drinking water source?

- ❍ Private Supply (Private well, etc)
- ❍ Public Supply (City water utility)
- ❍ Public Supply (Rural water district)
- ❍ Bottled Water
- ❍ Unsure

Page 4 - Question 22 - Choice - One Answer (Bullets) [Mandatory]

Approximately how large is your community size?

- ❍ Less than 3,500 people
- ❍ 3,500 to 7,000 people
- ❍ 7,000 to 25,000 people
- ❍ 25,000 to 100,000 people
- ❍ More than 100,000 people
- ❍ Unsure

Page 4 - Question 23 - Open Ended - One Line

What is your zip code?

....

Page 4 - Question 24 - Choice - One Answer (Bullets) [Mandatory]

Do you rent or own your home?

- ❍ Rent
- ❍ Own
- ❍ Other (e.g. live with family)

Page 4 - Question 25 - Choice - Multiple Answers (Bullets) [Mandatory]

Does your home have any of the following? (Check all that apply)

- ☐ Lawn
- ☐ Irrigation system
- ☐ Pool

- ☐ Garden
- ☐ None of the above

Page 4 - Question 26 - Choice - One Answer (Bullets) [Mandatory]

Including yourself, how many people live in your household?

- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ○ More than 5

Page 4 - Question 27 - Choice - One Answer (Bullets) [Mandatory]

How many bathrooms does your home have?

- ○ 1
- ○ 1.5 or 2
- ○ 2.5 or 3
- ○ 3.5 or 4
- ○ More than 4

Page 4 - Question 28 - Open Ended - One Line

What is your age?

Page 4 - Question 29 - Choice - One Answer (Bullets) [Mandatory]

What is your education level?

- ○ Some High School
- ○ High School Graduate
- ○ Some College or Vocational Training
- ○ Bachelors Degree
- ○ Graduate Degree

Page 4 - Question 30 - Choice - One Answer (Drop Down) [Mandatory]

What is your household's annual income?

- ○ Less than $20,000
- ○ $20,000 - $40,000
- ○ $40,000 - $60,000
- ○ $60,000 - $80,000
- ○ $80,000 - $100,000
- ○ More than $100,000
- ○ Prefer not to answer

Page 4 - Question 31 - Choice - One Answer (Bullets)

Approximately how much time did it take you to complete this survey?

- ○ Less than 5 minutes

- ❍ 5 - 10 minutes
- ❍ 10 - 15 minutes
- ❍ More than 15 minutes

Page 4 - Question 32 - Open Ended - Comments Box

Thank you for your time! Please provide any comments about the survey in the space below.

Thank You Page

Screen Out Page

Over Quota Page

Survey Closed Page

Standard