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Technical Memorandum

To: *City of Franklin IWRP Team*

From: *CDM*

Date: *July 27, 2011*

Subject: *Integrated Water Resources Plan – Water Conservation Technical Analysis - Evaluation of Available Water Conservation Strategies*

Realizing desired savings through water conservation measures requires understanding the options available and how they relate to the planning goals and unique characteristics of the utility. This memorandum provides a discussion of components of a an effective water conservation program as well as common water conservation program options available to to Franklin, Tennessee. In addition, costs and savings realized by other agencies and utilities that have implemented these programs will be presented where possible to illustrate economic impacts of particular water conservation program options.

Integrating water conservation goals and programs into utility water planning is emerging as a priority for communities outside of the traditional water-short regions of the western United States (US) Catalysts for implementing water conservation programs include growing competition for limited supplies, increasing costs and difficulties with developing new supplies, increasing demands that stress existing infrastructure, and growing public support for resource protection and environmental stewardship. Many utilities are also beginning to understand the value of water conservation as a way of saving on costs both to the utility and to its customers. Throughout the US, utilities have experienced quantifiable benefits associated with long-term water conservation programs including:

- Reduction in operation and maintenance costs resulting from lower use of energy for pumping and less chemical use in treatment and disposal;
- Reduced purchases from wholesalers;
- Delaying of capital facilities projects.

1.0 Effective Water Conservation

Selecting the appropriate conservation program includes understanding water use habits of customers, service area demographics, and the water efficiency goals of the utility, among other considerations.

Water conservation has been defined as "any beneficial reduction in water use or in water losses" (Baumann, Boland, and Sims 1984). Consequently, one component of an effective water conservation program is that reduction in water use or water losses produces a net benefit (i.e., the value of savings are greater than the costs required to achieve the savings). Another component of an effective program is that the unit cost of water saved is less than the unit cost of additional new supply. Additionally, an effective water conservation program meets the goals set by the implementing entity. There are a variety of metrics that may determine whether goals have been met and approaches to program evaluation fall into three general categories: 1) process evaluation, 2) impact evaluation, and 3) economic evaluation. The following paragraphs will briefly describe each of these categories of conservation effectiveness evaluation.

Process evaluation is a term applied to tracking and measuring the operational efficiency of a water conservation program. This method of evaluation typically uses tools such as customer satisfaction surveys, fixture retention surveys, and market penetration surveys to gather data on participant attitudes related to their satisfaction with both the water saving devices or behaviors they have adopted and a program's administrative process. This process evaluates program implementation methods and determines whether or not a water conservation program has been successfully and efficiently implemented.

Impact evaluation quantifiably examines water savings that are clearly attributed to a specific water conservation program. Undertaking this method of effectiveness evaluation requires the collection and analysis of water use data over a period of time. Sometimes the water use data is combined with participant level information such as household characteristics, types of water using fixtures, and water use behaviors. Results of impact evaluation indicate the volume of water saved by a specific water conservation program.

Economic evaluation often focuses on the unit cost of water saved (e.g., dollars per gallon per day saved). The cost of water conservation programs varies widely. From the utility perspective, program costs are mostly related to the design and implementation of the program. Cost components of program design and implementation to consider include staff time, rebates and incentives given to customers, length the program, etc. There may also be costs to the utility such as lost revenue from decreased sales and benefits such as reduced pumping and treatment costs.

Cost-benefit analysis of water conservation programs provides an evaluation of an array of options related to water conservation and classifies these items as costs or benefits, depending upon the perspective. For example, a toilet rebate is a cost item to the utility, but counts as a benefit item when calculating the cost of a toilet rebate program from the customer's perspective. A cost-benefit analysis typically evaluates the cost of water conservation programs from different perspectives: utility, customer, rate-payer, and society. Thus, program costs may vary by the perspective used to evaluate a conservation program.

Although two separate utilities may spend the same dollar amount on similar water conservation programs, the participation rates and water savings achieved by the two utilities may differ. As a result, the dollar value of a program may vary by provider based on the customer response to a particular program. Furthermore, separate utilities may face different circumstances such as the cost of source water and feasible alternatives such that a conservation program may be cost-effective for one utility but not another. The following section describes many of the common water conservation programs that have been implemented in different parts of the country and provides cost and savings estimates obtained from case studies of water providers where possible.

2.0 Program Descriptions

Hardware and Rebates

Many utilities have realized significant water savings by implementing programs that offer economic incentives such as rebates to customers for converting older and less efficient water fixtures such as toilets, showerheads, faucets, and clothes washers to newer more efficient models. There is usually a high start-up cost to utilities to initiate these programs ($25,000 to $100,000); making the cost-benefit analysis of such a strategy an important consideration (Alliance for Water Efficiency 2011b).

Some water agencies have also invested in device distribution programs where a water efficient device that can be easily installed (e.g., low-flow showerheads, flow restrictors, low-flow aerators for faucets) are provided to customers. Device distribution has been most commonly used in drought or supply crisis situations and is often targeted to customers, sectors, or areas that present the most cost-effective option for implementation such as areas with older housing, low-income communities, and commercial restaurants and kitchens.

Toilets

Following the passage and implementation of the 1992 U.S. Energy Policy Act (Energy Act), all new and remodeled homes in the U.S. are mandated to install toilets with a maximum flush rate of 1.6 gallons per flush. These toilets are commonly referred to as Ultra Low Flush Toilets or ULFTs. Replacement of less efficient toilets with ULFTs has proven to be a beneficial method of water conservation to both the residential and non-residential water use sectors. For example, in Tampa, Florida, the Tampa Water Department (TWD) offered rebates as high as $100 for replacement of toilets in single-family and multi-family homes, as well as for commercial customers. A 38 gallons per capita per day (gpcd) reduction in water use between 1993 and

2008 has been attributed to the toilet rebate program (EPA 2011a). The cost of the rebates awarded by the TWD from 1993 to 2008 is estimated at about $3.3 million with over 37,000 toilets replaced during that period (City of Tampa 2011).

Urinals

The 1992 Energy Act included mandates for urinals installed in new and remodeled buildings to use 1 gallon per flush (gpf) or less. Older urinals installed prior to the implementation of the 1992 Energy Act typically use between 1.5 and 5 gpf (Vickers 2001). More recently introduced High Efficiency Urinals (HEUs) use 0.5 gpf or less. Non-flush urinals, which use a dry drainage system, are also on the market. Savings from urinal replacement would be predominately realized by commercial and industrial customers. The EPA WaterSense® program estimates that the potential water savings of replacing a 1.5 gpf urinal with a 0.5 gpf model could be more than 4,600 gallons per year per urinal at a cost savings of more than $850 over the useful life of the fixture (EPA 2011b).[1]

Showers and Faucets

Showers account for nearly 17 percent of indoor residential water use, or about 30 gallons per household per day (EPA 2011d). The 1992 Energy Act requires that all showerheads installed in new and remodeled buildings have flow rates of 2.5 gallons per minute (gpm) or less. Showerheads manufactured prior to 1980 had an average flow rate of 4.3 gpm while models designed from 1980-1994 had average flow rates of 3.0 gpm. Efficient models on the market today have typical flow rates of 2.0 gpm. Research by Biermayer (2006) estimates that replacing a 4.0 gpm showerhead with a 2.2 gpm showerhead would result in savings of 14.8 gallons per shower.[2]

Kitchen and bath faucets are the next largest source of indoor residential water use behind showers, accounting for approximately 15.7 percent of use (Mayer et al. 1999). The 1992 Energy Act requires 2.5 gpm flow rates for all newly installed faucets. Recently developed high efficiency faucets have reduced flow rates of 1.0 to 2.2 gpm.

Case studies of utilities that have successfully implemented showerhead and faucet replacement programs have been documented. A combination showerhead and toilet replacement program in Ashland, Oregon contributed to a 16 percent reduction in winter water usage. The program is also attributed with saving an estimated 514,000 kilowatt-hours of electricity annually, mostly through reduced water heating energy use (EPA 2011a).

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[1] Savings estimated based on the assumption that the average urinal is flushed 18 times per day and is in use 260 days per year.

[2] Assuming an estimated national average shower time of 8.2 minutes.

Device distribution programs have been implemented in several U.S. cities. In Houston more than 10,000 high efficiency showerheads have been distributed as part of conservation kits. The conservation kits, which also included faucet aerators, were estimated to produce average water savings of 18 percent per household (EPA 2011a). In Goleta, California, a city of just over 50,000 people, 35,000 low-flow showerheads were installed between 1987 and 1991. Goleta's water efficiency program, which emphasized showerhead replacement and toilet rebates, resulted in a 50 percent reduction in per capita residential water use (EPA 2011a).

Dishwashers

According to 2005 statistics from the U.S. Census Bureau, 63% of households nationwide utilize a dishwashing machine. The average household uses a dishwasher 3 days per week, leading to a substantial amount of potential water savings from water efficient models. Dishwashers manufactured during 1980-1990 used approximately 14 gallons per load (gpl), while models manufactured in 1990-1995 reduced this amount by 3 gallons to 11 gpl. While the 1992 Energy Act did not mandate restrictions on dishwashers, more efficient models continue to be developed with recent models using only 7.0 gpl, as much as a 50% reduction in water use from earlier models. While water savings from dishwashers is significant, this end use comprises one of the smallest portions of indoor water use. Simple education programs, aimed at behavioral changes such as operating the dishwasher with full loads only, are also an important part of enhancing water efficiency for dishwashers.

Non-residential dishwashers use significantly more water than residential versions, often using over two-thirds of overall water use in commercial kitchens (Alliance for Water Efficiency, 2011a). Water usage among these units generally ranges from 0.33 gallons per rack (gpr) to over 20 gpr. Additionally, energy usage by these units is exceptionally high given the amount of energy required to heat water to the required temperature. The life of these machines is generally longer than residential models as well, averaging 20-25 years. Advancements in water efficient technologies, combined with this extended life span, leads to a substantial amount of potential water savings.

Pre-Rinse Spray Valves

Pre-rinse spray valves are handheld devices used in many commercial kitchens and restaurants designed to loosen food and debris from dishes prior to placing them into dishwashers. Dishwashing represents about two-thirds of all the water used in a typical restaurant, with nearly one-half of that water used to rinse dishes before the actual washing. In addition, significant energy is required to heat the rinse water. Most pre-rinse spray valves use 3 to 7 gpm depending on the age of the device. By contrast, low-flow pre-rinse spray valves use 1.6 gpm or less. The 2005 Energy Policy Act requires that pre-rinse spray valves installed in new or remodeled commercial kitchens use these more efficient low-flow spray valves.

Potential water and economic savings will vary by facility based upon patterns of use. A California Urban Water Conservation Council (CUWCC) pilot study estimates water savings of 100 to 300 gpd per valve head when converting from a less efficient to a more efficient device, depending on the size of the establishment. The same study estimates average energy savings as 0.92 therms per head per day for heads with gas water heating and 20.9 kilowatt-hours per head per day for heads with electric water heating (SBW Consulting, Inc. 2004).[3]

Clothes Washers

Significant advances in clothes washer water use efficiency have been made in the past few decades. Models manufactured prior to 1980 typically used about 56 gallons per load (gpl) while those produced between 1980 and 1990 used approximately 51 gpl. More modern top-loading models being produced use about 43 gpl (about 16 percent less water per load than older models). Front-loading high efficiency washers (HEWs) use an average of 27 gpl, require less energy than standard top-loading washers, significantly reduce drying time, and require less detergent.

According to 2005 U.S. Census Bureau statistics, 82 percent of households have a clothes washer. Mayer et al. (1999) found that the average household washes about seven loads of laundry per week. Based on these statistics, the typical household could save an average of 5,824 gallons of water per year by switching from a 43 gpl top-loading washer to a front-loading HEW[4].

A pilot program in Toronto, Ontario, Canada installed high efficiency front-loading washers at six different apartment buildings and tracked hot and cold water use for eight weeks. Results showed a 44 percent reduction in total water consumption with the front-load washers and a 61 percent decrease in hot water consumption. A customer satisfaction evaluation conducted after the eight week period showed very strong satisfaction ratings with two-thirds of tenants stating they were very satisfied (CMHC 2002).

3.0 Irrigation Technologies and Ordinances

Rain Sensors & Weather-based Controllers

The EPA estimates that nationwide about 30 percent of residential water use is for outdoor uses (EPA 2011c). This estimate can vary significantly depending on the particular climatic characteristics of an area. Of this 30 percent, it is estimated that 50 percent is wasted due to poor irrigation practices such as overwatering, improper system design, evaporation, and wind (The Saving Water Partnership 2003).

Traditional irrigation systems use a clock timer with a preset schedule. In contrast, weather-based irrigation control technology uses local weather and landscape conditions to modify

[3] Assumes gas efficiency of 70% and electric efficiency of 90%.
[4] Assumes an average savings of 16 gpl, 7 times per week for 52 weeks.

irrigation schedules to actual conditions on the site allowing irrigation to more closely match the water requirements of plants. Rain sensors are one example of this technology. These sensors save water by eliminating unnecessary watering once there has been sufficient rainfall.

The U.S. Bureau of Reclamation compiled a summary of available research on "smart" irrigation control devices. Literature suggests that typical residential savings following installation of such devices range from about 15 to 25 percent, however, it is important to note that the majority of the studies compiled are reporting observations from programs in the western U.S. (USBR 2008). Residential weather-based irrigation controllers cost $100-250 on average depending on the specific features. Commercial weather-based irrigation controllers can cost several thousand dollars. Vickers (2001) estimates that rain sensors can save 5 to 10 percent of the outdoor water used. Rain sensors have proven to be a cost effective method of saving water. Average prices are $15 to $50 per sensor with the benefits of increased water efficiency and lower water bills quickly outweighing the cost of the device.

Rain sensor giveaway programs and installation ordinances have been implemented in several cities including Austin, Texas and St. Petersburg, Florida. Follow-up on these efforts revealed that rain sensor giveaways were more successful and widely adopted when installation was offered in addition to the free devices.

Cary, North Carolina (a mid-sized utility system) instituted an ordinance in 1997 requiring rain sensors on all automatic irrigation systems. The purpose of the ordinance was to decrease water usage during peak demand months. The City reports that 80 percent of residential customers and nearly 100 percent of commercial customers are in compliance with the ordinance. Other irrigation-related ordinances that have been adopted by Cary include a year-round alternate day irrigation schedule and a water waste ordinance. It is estimated that the landscape/irrigation codes in Cary will save between 0.02 and 0.04 million gallons per day (mgd) between 2009 and 2019 at a unit cost of water saved of $276 per mgd.

Education, Information & Awareness

Customer education (such as the City of Franklin's Water Hog program) is a critical component of any water conservation program. However, determining the direct effect on water use from education, information, and awareness efforts can be difficult because they are often bundled with other conservation programs and tend to vary by region. While water savings directly attributable to education are difficult to estimate, providing information that could change behaviors and water use habits can produce considerable savings. Baumann et al. (1998) and the EPA (1998) have found that public awareness campaigns can be expected to reduce demand by 2 to 5 percent.

Actual reported unit cost of water saved varies considerably. In one study of the costs and benefits of various conservation programs to water suppliers in the Portland, Oregon metropolitan area, the unit cost of information, education, and awareness programs to the utilities and society were $122 per acre-foot saved ($374 per million gallons) (RWPC 2004). Platt and Delforge (2001) estimate a unit cost of water saved through public education in Cary, North Carolina to be $401 per mgd and a benefit cost ratio of 1.53. The Cary, North Carolina example has a goal of reducing per capita consumption by 20 percent by 2020.

4.0 Audits & Accountability Measures

Submetering

Submetering is a useful tool that targets new and/or existing multi-family accounts through ordinances or regulations requiring submeters for individual units. In many cases, multi-family water use is billed to the owner of the complex based on the reading of one master meter. Tenants of the complex pay a flat rate for water use, generally factored into their rent. As a result, the renter receives no direct price signal associated with their water use and has no economic incentive to reduce excess use. A nationwide survey conducted as part of the National Multi-family Submetering and Allocation Billing Program Study in 2004 found that over 85 percent of multi-family residents pay for water use as part of their rent (Mayer et al. 2004). This same study found that submetering of multi-family complexes can reduce water use by 15.3 percent compared to properties that bill water use as part of rent. Many submetering service companies claim water savings of 10 to 30 percent, or more (AWWA 2000).

The costs of implementing a submetering program are varied depending on the level of implementation. Because costs of installation are generally lowest during construction, ordinances requiring submetering only on newly constructed multi-family dwellings tend to be the least costly. The average cost of a submeter system installed during construction is $200 while retrofitting existing properties have an average cost of $250 per unit (AWWA 2000). Costs of installing submeters on existing properties can be the responsibility of the property owner; however, incentive programs implemented by utilities will likely accelerate this process.

Residential and Commercial, Industrial, and Institutional Audits

The purpose of a water audit is to assess water use practices and identify methods to improve water efficiency. Residential audits generally include measurements of fixture flow rates, evaluation of irrigation systems and landscape, and leak detection. Commercial, Industrial, and Institutional (CII) audits are often related to engineering modifications of site-specific water uses such as process water use and cooling use. Water efficiency improvements for CII customers can also include replacement of plumbing fixtures and leak reduction.

Residential water audits can be a precursor to larger, more focused water conservation programs. For example, the city of Ashland, Oregon conducted water audits of almost 1,900 residents from 1992 to 2001, and following the audits, nearly 85 percent of homes audited participated in the city's showerhead and/or toilet replacement program (EPA 2011a). Vickers (2001) found that an audit's typical potential demand reduction ranges from 15 to 35 percent.

Costs can be covered either by the provider, or by the customer receiving the audit. Average costs for a CII audit are $1,000 while residential audits cost significantly less at an average of $75 per audit (Davis and Christiansen 2003). The Cary, North Carolina residential water audit program was reported to have a unit cost of water saved of $547 with a benefit cost ratio of 1.13 (Platt and Delforge 2001).

5.0 Conservation Rate Structures

Increasing Block Rates

An increasing block rate structure, similar to the City's current rate structure, is an advanced method used to allocate costs by the quantity of water used. The concept is meant to be a catalyst for customers to implement voluntary water conservation practices to reduce water use and, as a result, reduce their overall cost for water. The most effective rate structure is one in which the cost per unit of water increases as the customer uses more water. This approach to rates helps water providers achieve the goal of reduced daily peak and seasonal peak usage and overall reduced system demand. Usually, 3 to 4 tiers are adequate for an effective residential rate system.

The savings associated with conservation rates are dependent on customers' responses to increased utility bills. City staff has suggested that the current rate structure has a relatively minor impact on excessive use due to the affluent nature of the customer base. Therefore, a more aggressive rate structure may be necessary to initiate a change in use.

The Irvine Ranch Water District (IRWD) in southern California is an example of a successful and aggressive conservation rate structure program. The IRWD calculates rates for each account based on landscape square footage, number of residents, any additional needs of individual customers, and daily evapotranspiration rates. IRWD observed nearly immediate impacts following implementing their new rate structure in 1991. Water use declined 19 percent in 1991/1992 compared to 1990/1991 with high customer satisfaction ratings (EPA 2011a). This case may be the exception, however, as one study by Little and Gallup (2011) of three utility systems only identified one case where the quantified benefits exceeded the quantified costs from both the utility and participant perspective over the 20 year assumed lifespan of the rates.

Utilities considering a pricing structure that reduces demand should also consider the potential for a decrease in revenue. A nationwide survey of 23 utilities that have implemented conservation rates by Wang et al. (2005) found that only 9 percent reported increased revenues, 26 percent reported decreased revenues, 30 percent believed conservation rates were revenue neutral, and 35 percent did not know or did not respond.

Seasonal Rates

Seasonal water rates are a pricing structure whereby the cost of water per unit is higher during peak seasonal use times, typically summer months, to encourage efficient outdoor water use. The rates should be designed to send a price signal to customers to reduce excess water use and become more conscious of lawn and landscaping water use. The structure can be applied to both residential and non-residential water accounts.

Seasonal water use costs very little for a utility to implement. The primary cost is dedicated to staff time and effort to design an appropriate rate structure. Successful seasonal rate structure programs have been implemented in Phoenix, Arizona as well as Seattle, Washington, where the program is credited as having saved 5 mgd since 1990. A case study analysis from Sandy City, Utah found that two years after the implementation of a seasonal rate structure, savings were 9.1 percent of the pre-seasonal rate water use and average annual savings were about 2.5 mgd for a service area with a population of 100,000.

6.0 Summary and Conclusion

This memorandum provides a high-level discussion of various water conservation program options available to utilities and appropriate for consideration in the City of Franklin. Selecting the appropriate suite of water conservation activities requires understanding a utility's goals for conservation and the demographics and water use characteristics of the service area, among many other considerations. Case study findings have provided examples of both successful and unsuccessful programs throughout the country proving that what works in one location may not necessarily work in another.

This memorandum also discusses three post-implementation approaches to evaluating the effectiveness of a conservation program: 1) process evaluation, 2) impact evaluation, and 3) economic evaluation. These methods of evaluation provide a metric for utilities to cross-sectionally determine whether or not a particular conservation program is effective. A program's effectiveness can be measured quantitatively by calculating water saved, customer participation rates, or the costs vs. the benefits of the program. Programs can also be evaluated qualitatively with surveys of customer satisfaction.

While many of the case studies discussed offer examples from the western U.S., successful and progressive water conservation programs have been implemented in the eastern portion of the country as well. Cities such as Cary, North Carolina and Tampa, Florida have experienced positive results through the implementation of conservation programs tailored to their particular goals and objectives. These examples provide evidence of the broader geographical relevance of water conservation as a useful tool in water demand management.

As a supplement to this document, CDM has prepared a case study specific to the City of Franklin that discusses the potential costs and benefits of a toilet replacement/rebate program. The case study calculates the approximate cost of the program per 1,000 gallons of water saved. Information such as this can be used within the STELLA model to compare against the cost/benefit ratios of other alternatives being considered (such as Water Treatment Plan expansion or new water purchases from the Harpeth Valley Utility District). This will help the City and the Project Team make the best decisions among the options available. Additional water conservation case studies will follow, including the benefits of an Irrigation Control Program.

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