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Technical Memorandum

To: City of Franklin IWRP Team

From: CDM

Date: July 27, 2011

Subject: Integrated Water Resources Plan – Case Study - Evaluation of Toilet Replacement Conservation Program

In most communities, toilets account for the greatest amount of indoor residential water use. Implementing a toilet rebate or toilet replacement program has shown to be a worthwhile approach to conserving water in many cities. Offering customers financial incentives to replace older, less efficient toilets with newer and more efficient models saves water with every flush. This hypothetical case study allows examination of the potential benefits (water savings) that could be achieved and costs associated with the implementation of a toilet rebate program in the City of Franklin, Tennessee. The suggested rebate program would provide City water customers with vouchers to be used for the purchase of 1.28 gallon per flush (gpf) High Efficiency Toilets (HETs).

As discussed in Section 2.0 of the Water Conservation Strategies memorandum, the 1992 Energy Act requires that all toilets manufactured after January 1, 1994 are required to be within a maximum flush volume of 1.6 gpf (Ultra Low Flush Toilets or ULFTs). Consequently, it can be assumed that all housing units built after January 1, 1994 have installed ULFTs. The 3.5 gpf toilets were introduced in the early 1980s. Homes built prior to 1980 were furnished with toilets using 5 to 7 gpf. Therefore, the primary target of an HET toilet replacement program would be installation in housing units built before 1994, because they are most likely to have older and less efficient toilets. However, some customers whose homes already have ULFTs may also participate in the rebate program. For the purposes of this analysis it was assumed that all housing units (as identified by the U.S. Census Bureau) in the City of Franklin are potential candidates for toilet rebates and replacement^{1,2}.

¹ Note that the number of housing units in the City of Franklin is defined by U.S. Census data and does not necessarily correspond to the precise geographical boundaries of the City's water service area.

1.0 Data and Assumptions

Determining the age of the housing stock in Franklin is necessary in order to estimate the number of homes likely to have older, less efficient toilets and the number of homes likely to have newer, more water efficient toilets. Estimating the number of housing units by toilet volume per flush type allows for an estimation of the number of toilets that may be replaced and, consequently, the potential water savings of a toilet rebate program. U.S. Census data for Franklin, Tennessee provides the number of housing units by the age of the structure. According to the 2009 U.S. Census Bureau American Community Survey (ACS) for Franklin, in 2009 there were 22,206 total housing units. 2009 is the last year of available data for age of the housing stock in Franklin and was used as the baseline for this analysis.

Approximately 65 percent of the total housing units in the City have been built in the last 20 years (1990-2009). The ACS only estimates the year a structure is built in 10-year increments (e.g., 1980-1989, 1990-1999, etc.)³. The 2000 decennial census provides this data in 5-year increments after 1990 (e.g., 1990-1994, 1995-1999, etc.). To better understand the number of housing units built in Franklin since 1994, year 2000 Census data for Franklin was used to provide the estimate of housing units by year built in the 1990s rather than interpolating a value from 2009 ACS data.

Table 1 shows the number of housing units in Franklin by the age of the structure. The table also shows the assumptions for the gallons per flush of toilets in the housing unit based on the age of the structure. Housing units built before 1980 are assumed to have toilets that use 5 gallons per flush. Housing units built between 1980 and 1994 are assumed to have toilets that use 3.5 gallons per flush and units built after 1994 are assumed to have toilets that use 1.6 gallons per flush.

Table 1 - Franklin, Tennessee Housing Units by Age of Structure and Assumed Gallon/Flush Toilets

Period Built	# of Units	% of Total	Gallons/Flush
1994-2009*	11,965	54%	1.6
1980-1994*	5,414	24%	3.5
Pre-1980	4,827	22%	5

Source: 2009 U.S. Census American Community Survey

*2000 U.S. Census data is used to provide the estimate of number of housing units built during the 1990s

² The U.S. Census Bureau defines housing units as a house, an apartment, a mobile home, a group of rooms, or a single room that is occupied (or if vacant, is intended for occupancy) as separate living quarters. Separate living quarters are those in which the occupants live and eat separately from any other persons in the building and which have direct access from the outside of the building through a common hall.

³ Note that reporting at this level of detail from the 2010 Census has not yet been released.

2.0 Scenarios and Assumptions

An unknown factor in any voluntary water conservation program is the level of participation by customers in the water service area. Thus, for the purposes of this analysis three scenarios related to the level of participation in a toilet rebate program are evaluated, and form low, medium, and high levels of potential conservation savings. The three scenarios are:

Low Conservation Savings – Assumes that 25 percent of housing units in the City of Franklin service area purchase and install HETs as part of a rebate program.

Medium Conservation Savings – Assumes that 50 percent of the housing units in the City of Franklin service area purchase and install HETs as part of a rebate program.

High Conservation Savings – Assumes that 75 percent of the housing units in the City of Franklin service area purchase and install HETs.

Several assumptions were made in order to calculate potential water savings and program costs from a toilet rebate program. Included among the assumptions used to derive potential water savings are the number of flushes per housing unit per day and the percent of housing units that have retrofitted toilets since the implementation of the mandates of the 1992 Energy Act in 1994. Included among the assumptions used to derive the potential costs of the rebate program are the rebate amount and any administrative costs associated with operating the program. **Table 2** presents the assumptions for estimating potential water savings and program costs.

Table 2 - Baseline Toilet Rebate Program Assumptions for Franklin, TN

Factor	Baseline Assumption
Water Savings Assumptions	
# Flushes per Housing Unit per Day*	12.4
Annual rate of retrofit to 1.6 gpf since 1994	0.5%
Program Cost Assumptions	
Toilet Rebate Amount	\$100/toilet
Administrative Costs (Low Conservation Savings Scenario)	\$5 per rebate
Administrative Costs (Medium Conservation Savings Scenario)	\$10 per rebate
Administrative Costs (High Conservation Savings Scenario)	\$15 per rebate

*Residential End Uses of Water, AWWARF 1999, p. 96

A \$100 rebate per 1.28 gpf toilet is a commonly used as a rebate value. For example, rebate programs in Charlottesville, Virginia, Miami, Florida, Madison, Wisconsin, and Douglas County, Georgia have all offered \$100 to customers purchasing and installing an HET. The assumed cost of program administration is different for each of the conservation savings scenarios. Administrative and marketing costs per rebate issued are assumed to increase as the rate of customer participation increases. In particular the higher participation rates will require more marketing effort. For example, a program with a 75 percent participation rate issues three times the number of rebates as a program with a 25 percent participation rate and therefore is assumed to incur administrative and marketing costs that are three times as high. While it is likely that costs associated with developing a rebate program would be similar under each conservation savings scenario, staff time and marketing materials would likely be proportional to the number of rebates issued. Thus program costs are assumed to increase proportionally to the level of participation.

3.0 Water Savings Calculations

The first step in calculating the potential savings for a toilet rebate program in Franklin is to determine how many housing units exist by gpf category. Table 1 shows the number of housing units by the period built and gpf category. Table 2 presents the assumption that since 1994, housing units in Franklin built prior to 1994 have been retrofitting older toilets with 1.6 gpf ULFTs at a rate of 0.5 percent per year (1 in 200 housing units annually). This rate of retrofitting may vary among communities but is a reasonable assumption when assessing potential savings associated with toilet replacements. The water savings from retrofits are sometimes referred to as natural replacement or “passive savings”.

Table 3 shows the number of housing units by period built and gpf category both with and without the assumption of a 0.5 percent annual rate of replacement of toilets in housing units built prior to 1994. The period of annual toilet replacements analyzed is from 1994 to 2009 (i.e., 3.5 and 5.0 gpf toilets were replaced with 1.6 gpf toilets between 1994 and 2009). Assuming that 8 percent of the housing units built before 1994 replaced their 3.5 or 5 gpf toilets with ULFTs between 1994 and 2009 (0.5 percent annually multiplied by 16 years), the current (i.e., 2009) estimated number of housing units with ULFTs shown in Table 3 increases from 11,965 to 12,784, going from 54 percent to 58 percent of the total housing units in Franklin.

The number of housing units built before 1980 and the number of housing units built between 1980 and 1994 assumed to have undergone a toilet retrofit between 1994 and 2009 was calculated based on the percent of housing units in each category as a percent of total housing units in the city built before 1994. For example, if 30 percent of the housing units built before 1994 were built before 1980 it was assumed that 30 percent of the units that were retrofitted between 1994 and 2009 were built before 1980 and 70 percent were built between 1980 and 1994.

Table 3 - Franklin, Tennessee Housing Units by Age of Structure and Assumed Gallon per Flush Toilets: Comparison of with and without Natural Replacement Assumptions

No Assumption of Natural Replacement				0.5% Annual Natural Replacement, 1994-2009		
Period Built	# of Units	% of Total	Gallons /Flush	# of Units	% of Total	% of Total
1994-2009*	11,965	54%	1.6	12,784	58%	1.6
1980-1994*	5,414	24%	3.5	4,981	22%	3.5
Pre-1980	4,827	22%	5	4,441	20%	5
Total	22,206	100%		22,206	100%	

Source: 2009 U.S. Census American Community Survey

*2000 U.S. Census data is used to provide the estimate of number of housing units built during the 1990s

Table 4 shows the estimated number of households by toilet gpf category and the estimated annual water use estimated for the current mix of toilets and for the three conservation savings scenarios discussed above. *Under the estimated current mix, it is assumed that no housing units have converted to HETs.* Estimated total annual toilet water use for the assumed current mix of housing units is 272 million gallons (about 28 percent of total residential water use in Franklin^{4,5}). Using the assumption of a 25 percent rate of participation in a toilet rebate program by all households in Franklin, annual toilet water use decreases by 13 percent (35.9 million gallons). Under the 50 percent market penetration scenario annual toilet water use decreases by 26 percent (71.7 million gallons), and under the 75 percent market penetration scenario annual toilet water use decreases by nearly 40 percent (108 million gallons). The estimated toilet water use by toilet volume type is shown in **Figure 1**. Note, this analysis only applies to changes within the current housing stock and does not evaluate potential savings in new construction.

⁴ Total residential water use is defined as the total billed water use for single-family and multifamily residential accounts inside the City during the last calendar year of available billing data (April 2009 – March 2010).

⁵ For comparison, the American Water Works Association Research Foundation estimates that toilet water use represents 26.7% of the daily residential indoor water use.

Table 4 - Number of Households by Toilet Flush Volume and Annual Water Use for Current and Market Penetration Scenarios

Conservation Savings Scenario	Toilet Type	# Housing Units by Toilet Type	Annual Water Use (MG)**
Current Mix*	1.28 gpf	0	0.0
Current Mix*	1.6 gpf	11,965	92.6
Current Mix*	3.5 gpf	5,414	78.9
Current Mix*	5.0 gpf	4,827	100.5
Current Mix Total		22,206	272.0
Low	1.28 gpf	5,552	32.2
Low	1.6 gpf	9,588	69.4
Low	3.5 gpf	3,736	59.2
Low	5.0 gpf	3,331	75.4
Low Total		22,206	236.1
Medium	1.28 gpf	11,103	64.3
Medium	1.6 gpf	6,392	46.3
Medium	3.5 gpf	2,490	39.5
Medium	5.0 gpf	2,220	50.2
Medium Total		22,206	200.3
High	1.28 gpf	16,655	96.5
High	1.6 gpf	3,196	23.1
High	3.5 gpf	1,245	19.7
High	5.0 gpf	1,110	25.1
High Total		22,206	164.5

*Current mix assumes 0.5% annual rate of replacement with 1.6 gpf toilets since 1994.

**Assumes 12.4 flushes per housing unit per day; MG is million gallons

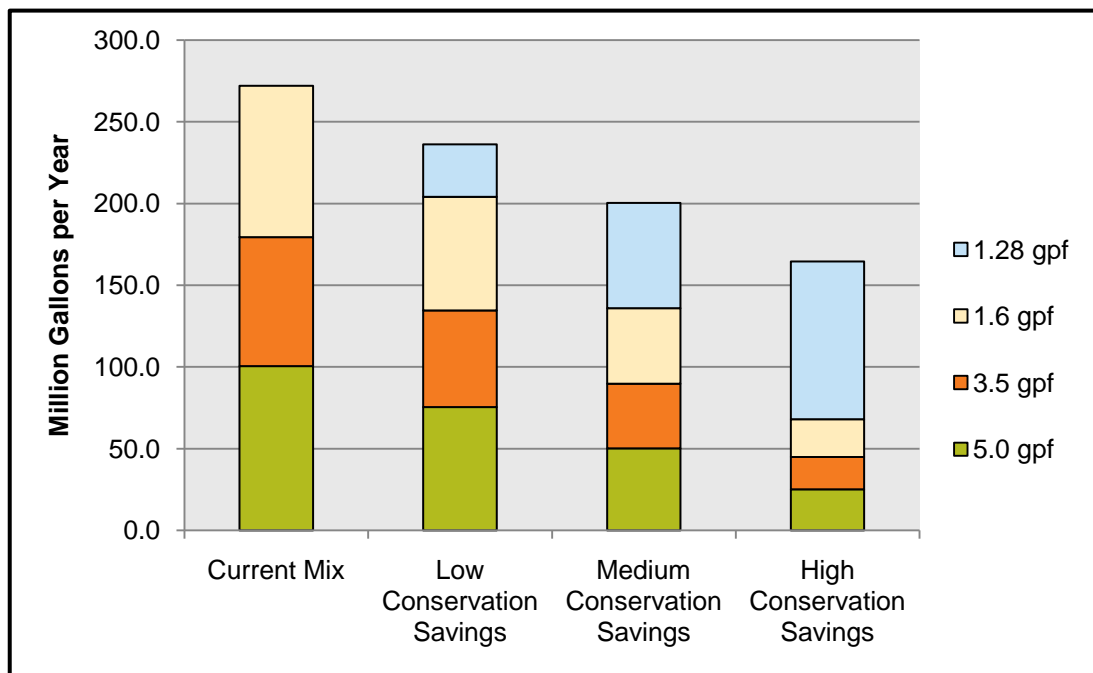


Figure 1 - Franklin, Tennessee Estimated Annual Toilet Water Use by Conservation Scenario

Table 5 provides the water savings calculations by conservation scenario, based on the water use presented in Table 4. The total savings over the current mix of toilets by housing units as well as the savings by account are shown in Table 5. The total estimate of accounts is 12,917 and is the number of residential accounts inside the city during the last month of available water billing data (March 2010). The potential savings estimates are also shown in **Figure 2**.

Table 5 - Estimated Toilet Water Use Savings

Conservation Savings Scenario	Total Annual Toilet Water Use (MG*)	Annual Savings from Current Mix (MG*)	# of Accounts	Toilet Water Use Per Account (GPD**)	% Difference from Current Mix
Current Mix (assuming retrofits)	272.0	0.0	13,026	57.2	0%
Low Conservation Savings	236.1	35.8	13,026	49.7	-13%
Medium Conservation Savings	200.3	71.7	13,026	42.1	-26%
High Conservation Savings	164.5	107.5	13,026	34.6	-40%

*MG is million gallons
 **GPD is gallons per day

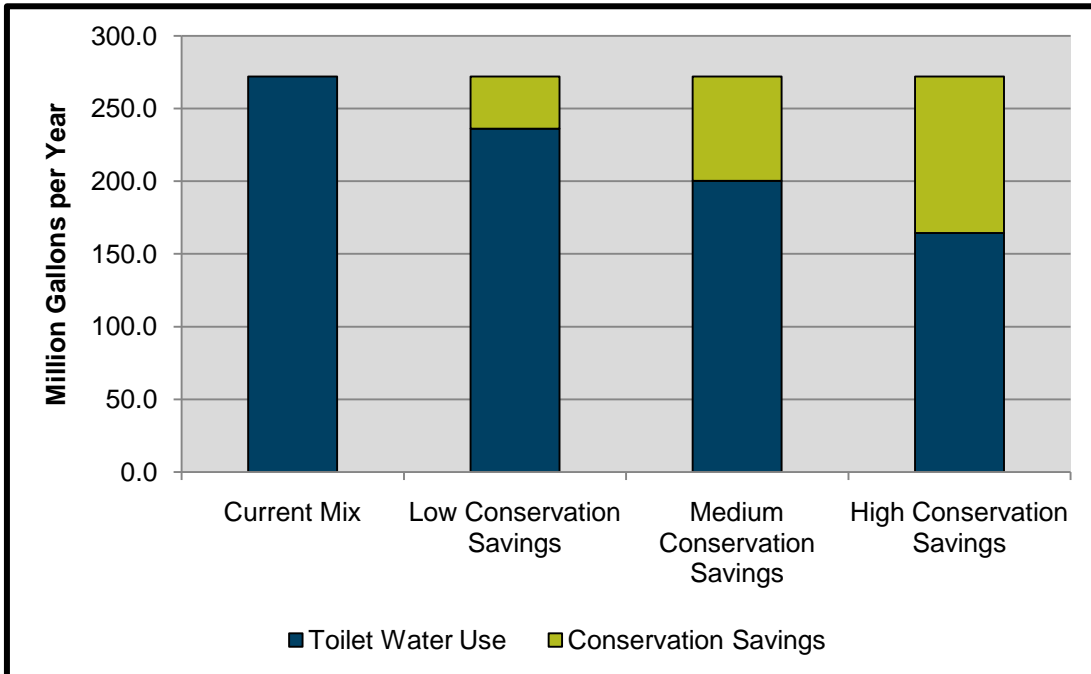


Figure 2 - Estimated Toilet Replacement Conservation Savings Comparison with Current Use

4.0 Cost Calculations

Table 2 shows program cost assumptions for this analysis. In addition to the assumptions shown in Table 2, it is necessary to make an assumption regarding the number of toilets that will be replaced per housing unit participating in the program. National 2010 Census data provides estimates of the number of bathrooms in new single-family homes built from 1973 through 2010 (U.S. Census Bureau 2011). Within the Census dataset, housing units are categorized by units with 1.5 baths or less, 2 baths, 2.5 baths, and 3 or more baths. Assuming that half of the houses categorized as 1.5 baths or less have one bathroom and half have 1.5 bathrooms and assuming that houses categorized as having 3 or more baths have 3 bathrooms, the average U.S. house built between 1973 and 2010 has 2.33 bathrooms. Therefore, for the purposes of this analysis, it is assumed that the average number of bathrooms per housing unit in Franklin is 2.33 and that the average household participating in the rebate program will replace all toilets within their home (i.e., for each participating housing unit, 2.33 rebates are issued).

Using the assumptions discussed above, the cost of a toilet rebate program under three conservation savings scenarios are presented in **Table 6**. The costs presented in the table reflect the costs of the rebates themselves (\$100 per toilet) and administrative costs such as program planning and development, maintaining data records, accounting, public outreach, marketing, and education. Costs associated with installing the new toilets are not factored in to this analysis. As the table shows the most costly scenarios are those that involve providing rebates and replacing the greatest number of toilets. However, these scenarios also result in the greatest amount of potential water savings.

Conservation scenario costs are proportional to potential water savings. For example, total program costs under the High Conservation Savings scenario are 200 percent higher than the estimated costs associated with the Low Conservation Savings scenario and estimated water savings are also 200 percent higher than the Low scenario. The program cost per 1,000 gallons saved varies by about 9.5 percent between the High and Low Conservation Savings scenarios. The program cost per 1,000 gallons saved should also be calculated for the cumulative gallons saved over the life of the new fixture. With proper maintenance, a toilet fixture may last more than 20 years. For illustrative purposes, Table 6 shows the cost per 1,000 gallons saved over 10 years.

Table 6 - Estimated Toilet Rebate/Replacement Program Costs for the City of Franklin

Conservation Savings Scenario	# Housing Units Participating	# Toilets Assumed to be Replaced	Estimated Program Cost	Program Cost per 1,000 Gallons Saved	Program Cost per 1,000 Gallons Saved Over 10 Years*
Low	5,552	12,935	\$1,358,202	\$37.90	\$3.79
Medium	11,103	25,871	\$2,845,757	\$39.71	\$3.97
High	16,655	38,806	\$4,462,665	\$41.51	\$4.15

*Program costs should be spread out over cumulative savings over the lifespan of the fixture.

Figures 3 and 4 show the savings and cost estimates for Low, Medium, and High Conservation Savings scenarios over one year and over 10-years, respectively. Estimated water savings are shown on the left vertical axis while the cost per 1,000 gallons saved are shown on the right vertical axis.

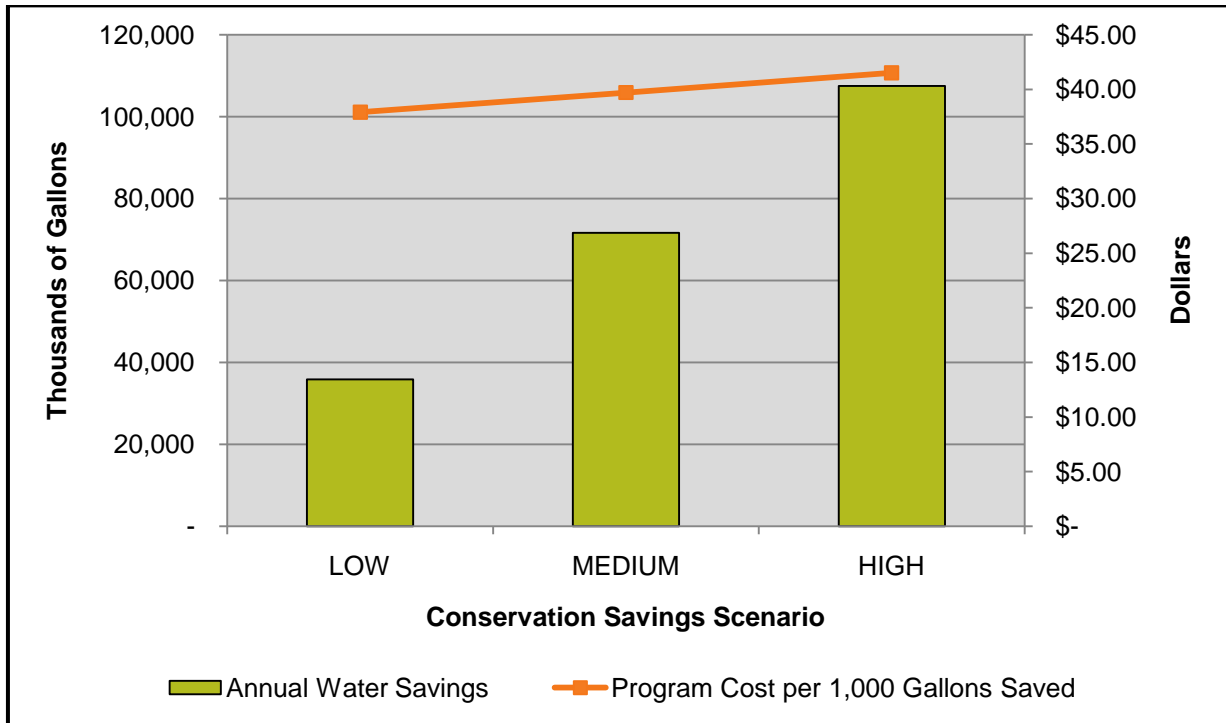


Figure 3 - Estimated Annual Water Savings and Cost per 1,000 Gallons Saved

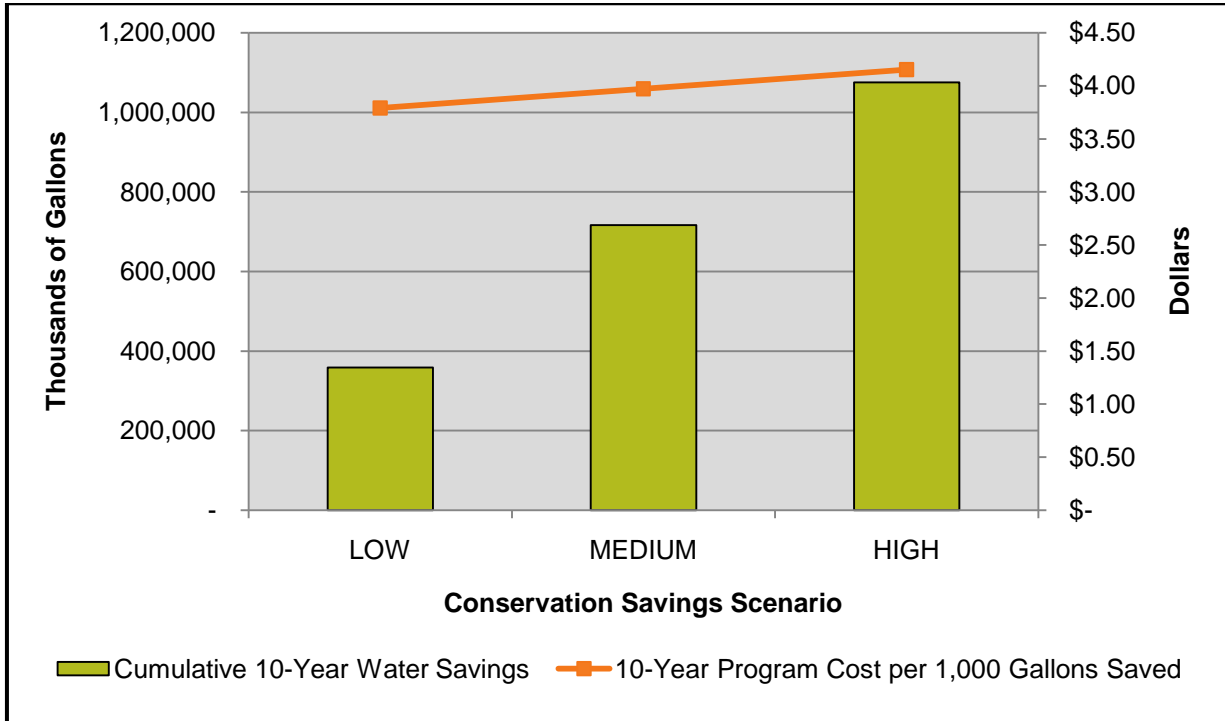


Figure 4 - Estimated 10-Year Cumulative Water Savings and Cost per 1,000 Gallons Saved

5.0 Summary and Conclusions

The case study presented in this document represents one example of a potential water conservation program that could be implemented by the City. Similar programs have been implemented in similar southeastern communities with beneficial results. However, the city-wide benefits and the costs of such a program should be evaluated in comparison with other alternatives being considered to determine the feasibility of the program. According to data provided by City staff, the cost to produce 1,000 gallons of treated water at the City’s WTP is approximately \$1.72. The cost to purchase 1,000 gallons of water from the Harpeth Valley Utilities District is approximately \$2.55. By comparison, the toilet replacement program evaluated for the City of Franklin is estimated to cost approximately \$4.00 for every 1,000 gallons saved. This suggests that the proposed toilet replacement program, while beneficial from an environmental standpoint, may be most costly than the other options being considered as a part of the Integrated Water Resources Plan. Further evaluation of the cost vs benefits of these options will be performed with the STELLA model.

6.0 References

United States Census Bureau. (2011, July 26). Number of Bathrooms in New Single-Family Houses Completed. Retrieved from: <http://www.census.gov/const/C25Ann/sftotalbaths.pdf>.