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Memo

To: Walter Green and Parvathi Gaddipatti, Nashville District Corps of Engineers

From: Stuart Stein and Lars Hanson, GKY & Associates

Date: June 28, 2008 (revised - September 22, 2008)

Re: Water Conservation Plan for the Cumberland County Regional Water Supply Study

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1. Introduction

This memo fulfills the requirements of the draft Water Conservation Plan for the Cumberland County Water Supply Project. The *Phase II Needs Assessment and Water Conservation Plan for Cumberland County Regional Water Supply Project*. (July 11, 2006) states:

> ***Water Conservation Plan**. The Contractor will research existing systems and identify opportunities for conservation. The Contractor will investigate six conservation methods, including system loss reduction, conservation pricing, and other active and passive conservation methods.*
> *The IWR-MAIN proprietary software will also be used to evaluate water conservation. Many of the underlying assumptions will be generated outside of the software, but use of this software is recommended since it is recognized as state-of-the-art in the field.*
> *The Contractor will submit draft and final versions of a report detailing the pros and cons and economic benefits of the six conservation methods and presenting a water conservation plan for Cumberland County. The report will identify the amount of water potentially saved by implementation of the plan.*

As indicated in the Phase II needs assessment instructions, the water conservation plan been completed using the IWR-MAIN Forecast Manager© and IWR-MAIN Conservation Manager© software developed by Planning and Management Consultants, Ltd. (PMCL).

This memo builds upon the *Land-use assumptions for Phase II of the Cumberland County Regional Water Supply Project* (referred to as the "Land Use Memo") and the *Baseline Projections – Water Needs Assessment for Cumberland County, TN* (referred to as the "Needs Assessment"). Additionally, GKY & Associates conducted phone interviews with the utility district managers in Cumberland County prior to modeling the effects of the conservation measures in order to gather information and develop conservation measures as well-suited to Cumberland County as possible.

Among the goals of this study of is to model the potential conservation savings of the various conservation measures proposed over the current conditions. To calculate the potential effects of conservation measures, it is necessary to develop a rough description of the policies or actions needed to enact the conservation measure and to estimate how the policy will affect water usage. The policies presented here are designed to be a rough approximation of actual policies that could be implemented in Cumberland County.

Please review the logic, modeling methods, and results, and conclusions of this Water Conservation Plan. We have endeavored to include the input and opinions of Cumberland County's stakeholders in this study. We welcome your comments and suggestions, and invite your written comments on this memo.

2. Conservation Measure Analysis

Through consultations with the Corps and the utility district managers of Cumberland County, GKY has worked to generate six conservation measures well-suited to Cumberland County. The Conservation Measures memo (February 22, 2008) detailed eight potential measures and six to carry forward into modeling.

In subsequent interviews with utility district managers, one minor change has been made to the proposed conservation measures. There was some concern that meter errors and unmetered connections had little significant impact on the total Unmetered/ Unaccounted for water (UAW) percentage. Several managers expressed the view that line flushing was a significant unbilled water use. Therefore, in combination with metering improvements, system and policy improvements designed to reduce the need for flushing form one conservation measure (See A, below). The other 5 conservation measures remain the same. The conservation measures, therefore, are as follows:

A. Non-Leakage UAW Reduction
B. Leakage Detection and Reduction
C. Water Pricing to encourage conservation
D. Education
E. New Development Water Efficiency Standards
F. Retrofit, Replacement, and Rebate Programs

The following sections will examine each conservation measure by providing a brief description of the conservation measure, the policies and programs needed to enact the conservation measure, the modeling methods used, the results of modeling, the pros and cons and economic benefits of the measure.

In the following sections, the policies describing the conservation measures and the associated results are for the Expected growth scenario. While the conservation measure modeling methods (i.e. the input parameters) for the three growth scenarios are identical, the relative performance of the conservation measures can vary significantly. Additionally, the costs associated with implementation of certain conservation measures may vary according the growth scenarios. For example, water conservation education programs may have to be considerably larger in scope for the Aggressive scenario than the Slow growth scenario to achieve similar effectiveness. Section 9 presents some summary results and discussions and Appendix A presents full results for all three growth scenarios.

3. Metering Improvement and Line Flushing Reduction

A considerable portion of Cumberland County's total produced water is lost to leakage, flushing, firefighting, and other unbilled uses. In the terminology of IWR-MAIN, water that is produced but not billed is referred to as Unmetered/Unaccounted for Water (UAW).

Leakage represents the largest portion of UAW, and is examined more closely in the next section. In Cumberland County, however, a significant portion of UAW can be attributed to unmetered connections, firefighting, meter error and line flushing. In typical systems, these uses and errors represent up to 5% of the total produced water. The Cumberland County utility districts reported a range of two to nearly ten percent. All of the Cumberland County UDs are either in the process of meter replacements or have recently completed meter replacement programs. Additionally, all assert that unmetered connections make up a very small portion of their losses. Thus, meter error, fire fighting use, and line flushing make up the majority of non-leakage UAW in Cumberland County. The rapid pace of construction in Cumberland County and branched distribution networks have led to very high losses due to flushing.

Therefore, a conservation strategy to reduce non-leakage UAW should focus on ensuring metering accuracy and reducing the necessity of flushing. The utilities current meter investments will go a long way toward meter reliability, though ongoing replacement of faulty meters is critical. Meters should also be replaced every 10 – 12 years, not only to remove faulty meters, but also to take advantage of technological advances which may improve accuracy, promote automation (freeing labor for other activities), and allow more flexibility and accountability in billing. Reducing line flushing may provide bigger savings, and may be accomplished by creating a looped network for all new expansions and adding pipe to create loops in currently branched network where feasible.

3.1. Policies: Meter Replacement, Line Looping

While it is difficult to eliminate losses due to meter error, unmetered connections, and flushing, several actions can be performed to reduce these losses to more manageable levels. The most important action is to periodically replace and repair meters. All of the Cumberland Utility districts have recently replaced their meters or are in the process of doing so.

Each utility must decide when to replace its meters. One of the utility managers indicated that meters would be replaced as often as every 10 years. In practice, replacing meters on average every 12 – 15 years should be sufficient to keep metering errors low and take advantage of technological advances. This action will likely be taken by the UDs, even if not part of a conservation strategy, but since it is essential to preserving reductions in the UAW percentage, it is included here.

Flushing usage represents another major contributor to UAW. Line flushing is essential to system maintenance and ensuring high-quality water, so it cannot be eliminated. There are some actions that could be taken to slightly reduce the need for flushing. According to utility district interviews, much of Cumberland County has a primarily branched distribution network. Though more efficient from a capital cost perspective, branched networks often require more flushing due to slower flow velocities and longer residence times in the further branches. In some cases, installing some additional piping could convert part of a system to a looped network, reducing the need for flushing by improving flow velocity and promoting circulation.

Though a large portion of the system must be flushed each year, flushing usage goes up considerably when piping to new developments is brought online. Developing new guidelines for the design of new connection pipe layouts and new policies governing the procedures and costs of bringing new piping online may help reduce the need for flushing. Table 1 presents a summary of these conservation policies and actions intended to reduce non-leakage related UAW.

Table 1 - UAW reduction actions (not related to leakage)

Policy	Duration	Description
Meter Replacement	Every 12-15 years	Full meter replacement every 12-15 on average to ensure accuracy and take advantage of new technology
Line looping	2010 - 2020	Introduce loops into the distribution system to reduce flushing. Develop new piping guidelines for new development to reduce flushing frequency.
New development line flushing rules		Review regulations and fees related to line-filling and flushing for new development to reduce need for multiple flushing events.

3.2. Presumed effects and modeling methods

Non-revenue water use due to meter errors, fire fighting and line flushing make up a portion of the total Unmetered/Unaccounted for Water percentage in IWR-MAIN. Limited data from the UDs in Cumberland County indicates a range of approximately two to eight percent of total produced water. IWR-MAIN only allows setting UAW as whole percentages of total production. Table 2 indicates the total assumed baseline UAW for each study area (column 2) and the presumed non-leakage UAW in each study area and year assuming this conservation measure is implemented. The Base UAW is total unaccounted water as a percentage of total produced water. The Needs Assessment memo provides full documentation of how the base UAW percentage is calculated based on pumping and sales records for each of the study areas. Columns 3 – 8 indicate the total percentage of produced water that is attributed to non-leakage UAW. (The difference between columns 2 and 3 represents the amount of leakage in 2006.)

Table 2 – Non-leakage UAW water as percent of total production

Study Area	Base UAW (incl. leaks)	2006	2016	2026	2036	2046	2056
Cumberland Cove	23%	5%	3%	2%	2%	2%	2%
Crossville	19%	5%	3%	2%	2%	2%	2%
Fairfield Glade	23%	7%	4%	2%	2%	2%	2%
Lake Tansi	23%	5%	3%	2%	2%	2%	2%
Remaining County	23%	5%	3%	2%	2%	2%	2%

The five percent assumption for UAW resulting from flushing, meter error, fire fighting and non-leakage causes is typical for water utilities across the country. Interviews with Cumberland County utility district managers confirmed this estimate was reasonable. Crab Orchard, however, has had somewhat higher non-leakage UAW due to flushing needs associated with bringing new developments and the branched nature of the network in the district's very hilly terrain. Hence, Fairfield Glade, located wholly within Crab Orchard is assumed to have a non-leakage UAW in the base year.

3.3. Results

Table 3 presents the conservation savings for this conservation measure. Columns 2 through 4 present the consumption, UAW and total water needs with conservation. Column 5 includes the baseline total needs. Columns 6 through 8 present several measures of the savings when compared to the baseline water needs. For this conservation measure, it is important to note that the consumption is unchanged from the baseline consumption. Thus, all of the conservation savings are a result of reductions in UAW over the baseline scenario.

Table 3 - Conservation Savings for Non-leakage UAW Reduction

Year	Consumption (MGD)	UAW (MGD)	Total Needs (MGD)	Baseline Total Needs (MGD)	Water Savings (MGD)	% Savings over baseline	Cumulative savings (MGal)
2006	3.87	1.04	4.91	4.91	0.00	0.00%	0
2016	4.81	1.14	5.95	6.11	0.16	2.69%	210
2026	6.00	1.32	7.32	7.64	0.32	4.17%	1091
2036	7.11	1.58	8.69	9.08	0.39	4.30%	2386
2046	8.24	1.84	10.08	10.54	0.46	4.39%	3944
2056	8.81	1.98	10.79	11.28	0.49	4.36%	5687

3.4. Pros, Cons and Economic Benefits

Meter replacement is important for a number of reasons. Most importantly, well-functioning meters improve water accountability, making it easier to identify potential losses due to other causes. Periodic replacement and repair also reduces metering errors, which increase as meters age. A meter replacement program also benefits utilities by taking advantage of technological advances. For instance, Automated Meter Reading (AMR) meters reduce the labor associated with reading meters. More advanced metering also allows more flexibility in creating billing structures. New meters may also benefit customers by providing insights about their water use and alerting customers of usage spikes that might indicate a leak. Furthermore, reducing UAW is an economically beneficial activity. Any reduction in UAW directly reduces costs associated with production and distribution of water without eating into revenue.

The primary drawback of this conservation measure is that the total conservation savings that may be realized are limited since the portion of non-leakage UAW is only a small portion of total usage. Additionally, since flushing and fire-fighting use are inevitable, the reduction is even further limited. Finally, while actions can be taken to reduce non-leakage UAW, such losses are often unpredictable and have a high degree of variability, thus the conservation savings presented here are extremely uncertain as compared to some other conservation measures.

4. Leak Detection

Leak detection is another method of reducing UAW. Cumberland County faces a range of challenges in getting leakage under control. The age of the pipes, rocky soil, and large elevation differences (and resulting high pressure) have been cited by county utility managers as a major cause of the leakage. Leakage detection and repair strategies vary widely by utility district in Cumberland County. All utility districts target replacement of older lines of certain material types and those known to be installed poorly. Besides replacing service lines with known problems, the utilities repair leaks mostly as leaks are found or when there are customer complaints. All the major utilities have begun programs to improve mapping of the service line locations, age and installation activity. Several utilities are looking for further opportunities to install more master meters to give better real time information on rapid changes in water use indicating leakage. Only one utility however, has hired a contractor or used staff to conduct a coordinated leak detection program in the past 10 years.

Technological advances continue to improve leak detection capability and reduce cost. Traditionally, leaks are detected by crews inspecting pipes with various listening devices. Many leaks can be detected this way, though very large pipe breaks often make little noise. More recently, digital correlating devices have become more readily available and affordable. In the past few years, permanent listening devices that attach magnetically to meters and valves to provide continuous leak detection monitoring have become available.

4.1. Policies

Cumberland County faces two challenges in managing loss due to leaks: getting leakage under control, and maintaining low leakage rates over the long term. Both of these challenges will require better information on the distribution network and would benefit from cooperation between the utility districts.

Before starting a leak detection program, Cumberland County should update and modernize its pipe network information systems. Interviews with UD managers indicated that efforts are underway to map the water distribution system including such details as pipe locations, sizes, materials, age, and other pertinent information. The county would be well served in future leak detection and infrastructure management efforts to have a functional and more uniform information system (including GIS layers, data entry forms, and monitoring data). Efforts to improve these systems and standardize information management will greatly aid leak detection efforts.

Since no leak detection programs have been carried out in the county in the past decade or so (with the exception of West Cumberland), it makes sense to hire a leak detection contractor for an initial leak assessment. Based on the size of Cumberland County's water distribution network, it may be most effective for the contractor to survey the entire county's distribution network instead of hiring contractors for each UD. The leak detection services should include (1) listening devices to detect major leaks, and (2) the use of a digital correlator to pinpoint their location. In the process of performing leak detection, Cumberland County utility district staff should observe how the listening surveys are done. Full surveys should be repeated every 4 or 5 years.

In between the five year periods, in-house leak detection of a portion of the system should be performed every year. This will require investment in leak detection equipment. The price of the equipment is low enough that all the UDs may be able to afford it, but equipment may also be shared. The equipment will also be effective in better pinpointing the location of leaks and breaks which surface and require emergency attention.

Leak detection contracting services and in-house leak-detection represent an interim approach to leak detection. The long–term strategy of leak detection should be real time acoustic leak monitoring using permanent leakage loggers. The loggers are attached to valves, hydrant stems, and service lines throughout the system and work by listening for leaks every night during low usage periods. Three well positioned loggers can locate a leak. The loggers currently on the market can be read in much the same way as automated meter reading (AMR) meters. Future loggers will likely be able to relay data to a central location. Permanent leakage loggers will be a key portion of any long-term leak reduction program, and may enable maintaining leakage below current industry averages. Installing permanent loggers for the entire system will be expensive, and is best phased in over several years, concentrating on leaky areas of the distribution system first. Table 4 outlines the leak reduction activities, the intended implementation years, and brief descriptions of actions.

Table 4 - Leak reduction programs and policies

Policies	Years	Description
Information systems upgrades	2009-2011	Upgrade GIS and other information systems related to pipe network. Standardize across county.
Contract leak detection services	2012, 2017, 2022	Hire leak detection services to perform a listening survey on the entire Cumberland Network. Use digital correlator to pinpoint leakage. Assign utility crews to learn from leak detection contractors.
In-house leak detection	2013 - 2030	Purchase 3 sets of leak detection listening equipment, send crews out yearly to detect leaks.
Install permanent leakage loggers	2016 – 2036	Begin installing system of permanent leak detection data loggers, expanding network to all county pipes as funding allows.

4.2. Presumed effects and modeling methods

In the first few years of a leak detection program, significant reductions in water loss can be achieved. Though there are some claims of truly astounding reductions, reducing leakage much below 10% for a long period is difficult. Maintaining leakage losses requires a sustained program. With permanent leakage monitoring and sustained vigilance as described in the previous section, Cumberland County should be able to maintain 7-8 % leakage. Table 5 displays the assumed leakage percentages for the leak reduction programs in the 5 study areas.

Table 5 - Leakage loss after implementation of leak detection and repair programs

Study Area	2006	2016	2026	2036	2046	2056
Cumberland Cove	18%	12%	9%	8%	8%	7%
Crossville	14%	10%	8%	8%	8%	7%
Fairfield Glade	16%	12%	9%	8%	8%	7%
Lake Tansi	18%	12%	9%	8%	8%	7%
Remaining County	18%	12%	9%	8%	8%	7%

These leakage loss targets are generally conservative, as 10 years is a long time over which to implement changes. For instance, the Clayton County Water Authority reduced its UAW percentage from 20% to 11% in just four years.[1] Connellsville, PA reduced its UAW percentage from 25% to 10% in just nine months using a combination of listening survey and AMR correlating loggers.[2]

4.3. Results

Table 6 displays the conservation savings associated with the leakage detection and reduction conservation actions. Interestingly, the total UAW fluctuates as the changes in the rate of leak detection and rate of change of the population vary at different rates.

Table 6 - Conservation Savings resulting from Leakage Reduction

Year	Consumption (MGD)	UAW (MGD)	Total Needs (MGD)	Baseline Total Needs (MGD)	Water Savings (MGD)	% Savings over baseline	Cumulative savings (MGal)
2006	3.87	1.04	4.91	4.91	0.00	0.00%	0
2016	4.81	0.95	5.76	6.11	0.35	5.76%	450
2026	6.00	0.98	6.98	7.64	0.66	8.67%	2303
2036	7.11	1.11	8.22	9.08	0.86	9.48%	5085
2046	8.24	1.30	9.53	10.54	1.01	9.59%	8503
2056	8.81	1.26	10.07	11.28	1.21	10.73%	12560

4.4. Pros, Cons and Economic Benefits

Leak detection and reduction, like all reductions in UAW, is generally an extremely valuable conservation measure as the savings are entirely made up of non-revenue water. Additionally, leak detection audits can lead to better understanding of the distribution system. Finally, leak detection can lead to fewer customer complaints about water quality, and fewer service interruptions resulting from catastrophic main breaks.

The most obvious drawbacks of leak detection are the costs. While leak detection services are becoming more affordably priced, the discovery of a leak must be followed up by repair. Repair costs can be expected to go up considerably in the short term as leaks are found during leak detection audits. Over time, however, the costs of repairs should go down as the frequency of emergency repairs declines due to early detection.

The economic benefits of leak detection and repair are well known. The great majority of water lost to leakage is not revenue producing water. Thus, the treatment and distribution costs of the water are essentially lost. With projected cumulative savings (for the expected growth scenario) of over 12.5 billion gallons over the study period and production costs conservatively estimated at $1.50 (constant 2006$) per 1000 gallons, Cumberland County could save nearly $19 million. In 1999, cost estimates for contracted leak detection services ran $100 - $200 per mile for listen only surveys, and $150 - $300 per mile for listening and digital correlator services.[3] However, costs have come down since then, as West Cumberland utility has contracted leak detection services for about $80 per mile. The cost of doing in house leak detection has also dropped considerably, with listening units priced under $1000, and permanent loggers and digital correlators much lower priced as well. In general, leak detection represents an excellent investment with payback periods as low as two years[4]. Thus, if the initial costs of leak detection programs are affordable, it would almost certainly be a beneficial investment.

5. Education

Education, specifically the education of water consumers related to conservation, can take many forms and can have a wide range of results. Currently, the utility districts of Cumberland County do not have any dedicated conservation education programs, but they do communicate with customers through billing inserts and occasionally at public events. Additionally, during drought periods such as in 2007, billing inserts, radio, the internet, and other means are used to communicate drought restrictions and short-term conservation strategies.

For the purpose of this analysis, education programs are designed to encourage continued conservation. The benefits of education are projected to be two-fold. Firstly, education can provide a direct reduction in water usage due to shifting consumer habits, and secondly, it can make other programs more effective and less costly.

5.1. Policies

Public outreach, communication, and education can have a significant effect on consumption. In general, programs take three forms, (1) general advertisement, (2) targeted messages and public appearances, and (3) structured education programs. Commonly used general advertisement methods include billing inserts, radio advertisement, and website postings, but some programs have had success using alternative means including advertisements on city buses[5] and participating in parades[6]. Targeted messages include public information campaigns designed to encourage specific changes such as encouraging purchasing the most water efficient appliances and shifting irrigation to off peak hours. Structured education programs include in-school education programs and short-courses offered to community organizations, retirement communities and business. Table 7 outlines some general types of programs which could be implemented.

Table 7 - Education programs

Policy	Duration	Intended audience	Description
General advertisement	2009 - 2056	All water users	Water saving tips and information.
Targeted Messages	2012 – 2056	Commercial users, homeowners with irrigation systems, homeowners with older homes, etc.	Communicate well developed messages perhaps once a year to encourage a specific conservation action, e.g: highlight cost savings from replacing toilet, promote xeriscaping, .
Education programs	2014 – 2056	School age children and families	Programs every 2 years for 4th and 5th graders, 9th and 10th graders
		Retirees, community associations	Short (0.5 day) programs in retirement communities, civic centers.

5.2. Presumed effects and modeling methods

Education programs reduce water use by encouraging water consumers to change their water use habits and purchasing decisions. The modeling in IWR-MAIN attempts to include these two modes of change.

The water use effects of changes in consumer habits due to education are inherently uncertain, but in general lead to slight improvements in efficiency. Thus, behavioral changes are modeled using a reduction in intensity factors. The adjustments in the summer intensity factors are accomplished by multiplying the existing factors by an appropriately reduced intensity factor (e.g. 0.95 for a 5% reduction). The winter intensity factor, previously 1, is reduced in the same manner. Education programs are assumed to apply equally in all study areas and subsectors. Table 8 displays the intensity multipliers used in the forecast years to demonstrate the effects of education programs. A solid commitment to education programs should result in gradual shifts to more efficient water use for all end uses. For instance, non-potable water use could decline by encouraging people to only run full loads of laundry and dishes, potable water use could be reduced by encouraging shorter showers, and outdoor use could be reduced by instructing people how to make a watering schedule. For simplicity, it is assumed that the intensity multipliers apply to all end uses equally. The water savings grow over time as a result of school and community education programs reaching a larger portion of the population.

It is difficult to quantify the effects of education programs because they are so difficult to separate from other confounding effects. The assumptions in Table 8 seem reasonable, though. Cary, NC adopted a conservation strategy based primarily on education (with some retrofit kits as well) and was able to hold water usage constant over two years when population grew by five percent per year.[7]

Table 8 - Intensity multipliers for education programs

2006	2016	2026	2036	2046	2056
1	0.98	0.96	0.96	0.96	0.95

The other way education programs can reduce water use is to convince homeowners and businesses to upgrade to more conserving fixtures and appliances. Additionally, an effective education program may encourage someone buying a new dishwasher or washing machine to buy a more water (and energy) efficient model than they otherwise would have. Businesses may be more likely to implement water saving landscape management, and install High Efficiency Toilets. Table 9 includes the rate of change of shifts in efficiency classes over time. These shifts are in addition to the 5% annual shift from Nonconserving to Conserving under the baseline scenario in the Needs Assessment.

Table 9 - Estimated efficiency class shifts spurred by education programs

Efficiency Class Shift	Value (% of units per year)
NonConserving to Ultraconserving	1%
Conserving to Ultraconserving	1%

5.3. Results

The impact of educational programs is hard to predict, mostly because the impact is difficult to measure and isolate from other variables. By appealing to civic responsibility, environmental consciousness, and the pocketbooks of customers, though, there is real potential for water conservation. Table 10 displays the projected conservation savings resulting from the educational programs outlined previously in this section. The percentage savings over the baseline forecast show that the benefits of education programs accrue over time if the programs are continued permanently. The intensity reduction becomes more significant as water use consciousness improves as a result of consumer education. Additionally, the education programs gain considerable benefits from only minor increases in the rate of efficiency class shifts. For instance, in 2056, a five percent reduction is attributable to intensity reduction, but a nearly equal amount of savings is due to efficiency class shifts.

Table 10 - Conservation savings resulting from Education Programs

Year	Consumption (MGD)	UAW (MGD)	Total Needs (MGD)	Baseline Total Needs (MGD)	Water Savings (MGD)	% Savings over baseline	Cumulative savings (MGal)
2006	3.87	1.04	4.91	4.91	0.00	0.00%	0
2016	4.64	1.26	5.90	6.11	0.21	3.42%	267
2026	5.63	1.54	7.17	7.64	0.48	6.22%	1517
2036	6.61	1.84	8.45	9.08	0.63	6.98%	3542
2046	7.60	2.13	9.73	10.54	0.81	7.69%	6179
2056	7.96	2.24	10.20	11.28	1.08	9.59%	9635

5.4. Pros, Cons and Economic Benefits

Education programs have a number of benefits, and only a few drawbacks. The results indicate that the water savings can be surprisingly large and generally increase slightly as long as the programs are continued. Another benefit of education programs is that they establish better communication between ratepayers and the utilities which can lead to better understanding of challenges faced by the utilities and greater acceptance of actions such as rate increases. The effectiveness of other sponsored conservation programs such as retrofit programs may be improved by targeted education programs. Educational programs also benefit the ratepayers by better enabling them to make decisions that can reduce their water bill.

The biggest potential drawback of education programs is simply that they might be ineffective. The management of educational programs may require hiring additional staff, which could be difficult to justify in an economic slowdown, especially if the staff is hired by local government.

Economically, education programs are generally a wise investment. The primary costs are for staff time. The fixed costs are generally small, as they include mostly printing and advertising materials costs. Thus, even small reductions in water use can make education programs worthwhile. Education programs become even more valuable as the utilities approach their safe yield as they can delay large investments in expanded supply and lessen the impact of water use restrictions.

6. Pricing

While water prices are generally set to reflect the costs of production, price changes do affect water demand. The price elasticity of demand indicates the amount of change in demand due to a unit change in price. See Equation 1. An elasticity of one indicates that a 1% increase in price will lead to a 1% increase in demand. Price elasticity of demand for water is nearly always negative (price increases reduce demand), and is generally considered to be inelastic (in between 1 and -1).

$$e = \frac{\Delta q}{\Delta p} \qquad \textbf{Equation 1}$$

Where:

- e is the price elasticity of water demand
- Δq is the percent change in water demand by a water user (or set of users)
- Δp is the percent change in water price

There is a wide range of economics literature examining the price elasticity of demand for various water users. Focusing on residential customers, Arbués et al. (2003)[8] and Worthington and Hoffman (2006)[9] provide good reviews of a large range of economic studies investigating price elasticity of water demand under a wide range of pricing policies. In general, the majority of the estimates of residential long term elasticity fall into the -0.05 to -0.5 range. The IWR-MAIN manual cites residential elasticity as between -0.05 and -0.35.

Several UD managers expressed the view that the water demand of Cumberland County residents is somewhat to considerably more sensitive to price changes than the average U.S. citizen. Supporting this assertion is the fact that many of Cumberland County's residents are on fixed incomes. Residents' response to price signals is also influenced by having a monthly billing cycle in all the Cumberland County UDs. As a result, elasticities in Cumberland County are assumed to be toward the upper end of the ranges presented above.

A wide range of pricing strategies are available for water utilities to meet goals as wide ranging as maintaining adequate revenues to encouraging conservation. Currently, all the Cumberland County utility districts have a fixed fee for consumption up to a certain initial limit (1000 or 2000 gallons), and a fixed block rate for additional consumption above the limit. The following section discusses the potential conservation pricing policies.

6.1. Policies

Interviews with the utility district managers indicated a wide range of view points on the potential for pricing as a conservation measure. All managers expressed a concern that there would be many complaints by residents in response to any price increase. There was a general unwillingness among managers to consider varying prices by season. A few managers expressed willingness to consider increasing block rates, which would mean the marginal price ($/1000 gallons) would increase as monthly consumption exceeded certain targets (e.g. greater than 5000 gallons). Some managers did not like the idea, though. There was also a general unwillingness to introduce more complexity into the billing process. Accordingly, there was little interest in charging different water rates by subsector (i.e. residential vs commercial), or complicated pricing methods such as peak hour rates.

Due to the differences of opinions between the UDs and the limitations of the IWR-MAIN software, the conservation pricing policy is modeled by a significant percentage increase in the marginal price of supplied water. Therefore, the policy for conservation pricing is simply to increase the marginal price of water by a factor of 1.3 over the 2006 price for all study years except the base year. Since constant 2006 dollars are being used, the actual dollar price increases in tandem with inflation (or more precisely, the discount rate).

6.2. Presumed effects and modeling methods

The effect of price changes is modeled by adjusting the intensity of use factor in response to the changes in price. In IWR-MAIN Conservation Manager, this is accomplished by modeling intensity with the multiplicative model with variation by month (Setup→ Intensity). For this study, the multiplicative model generates intensity values according to Equation 2.

$$U_N = B_m \cdot \left(\frac{p_y}{p_b} \right)^e$$ **Equation 2**

Where:

U_N intensity of usage parameter
B_m monthly constant (1 in winter, by subsector in summer)
p_y marginal water price in year y in 2006 constant dollars
p_b base price in 2006
e price elasticity of water demand

As indicated in the previous section, in all years except 2006, the ratio p_y/p_b is always 1.3. Since the elasticity, e, varies by subsector and end use, however, the reduction in intensity varies even with a constant price increase. The B_m parameter preserves the seasonality factors used in the Needs Assessment. Table 11 displays the assumed price elasticity of demand by subsector and end use category. Section 6.1 described some of the ranges of elasticities encountered in the IWR-MAIN manual and in the literature. The Cumberland UD managers indicated that due to income levels and the fact that many residents are on fixed incomes, the customer base of Cumberland County was on average more sensitive to price changes than the national average. As a result, the elasticities were assumed to be at the upper end of the ranges found in the literature and IWR-MAIN manual.

Table 11 - Estimated Price Elasticity of Demand by End Use in Cumberland County

Subsector	End Use	Price Elasticity of Demand, e
Residential	Outdoor	-0.35
Residential	Indoor Potable	-0.2
Residential	Indoor NonPotable	-0.2
NonResidential	Outdoor	-0.12
NonResidential	Indoor	-0.08
CMC	CMC	-0.08

6.3. Results

Table 12 presented the model results for conservation pricing policies. The results indicate that percentage savings remain relatively constant, which makes sense given the pricing policy presented in section 6.1. Note that price ratio, p_y/p_b is expressed in constant 2006 dollars and that base price, p_b, is a constant. Effectively, this means that actual dollar prices must be raised over time to keep pace with the discount rate. These periodic price increases mean that the conservation savings will likely hold steady over time.

Table 12 - Conservation Savings resulting from Pricing Policies

Year	Consumption (MGD)	UAW (MGD)	Total Needs (MGD)	Baseline Total Needs (MGD)	Water Savings (MGD)	% Savings over baseline	Cumulative savings (MGal)
2006	3.87	1.04	4.91	4.91	0.00	0.00%	0
2016	4.60	1.24	5.84	6.11	0.27	4.43%	346
2026	5.73	1.57	7.29	7.64	0.35	4.53%	1473
2036	6.78	1.88	8.66	9.08	0.42	4.65%	2877
2046	7.85	2.20	10.04	10.54	0.50	4.73%	4558
2056	8.39	2.36	10.75	11.28	0.54	4.76%	6449

6.4. Pros, Cons and Economic Benefits

Increasing prices can have a range of effects on the Cumberland County utility districts, ratepayers, local government, and general welfare. The most obvious benefit of large increases in price is that the utilities' revenue increases dramatically. This revenue can then be used to fund capital projects, improved treatment, repairs, pay debt liabilities, or fund other conservation programs. Since water demand is widely considered inelastic, the reduction in consumption will almost never be large enough to negate the revenue increase provided by the higher price. Increased prices also help reflect the environmental costs and other negative externalities associated with water withdrawal and usage, though the magnitude of these externalities is likely lower in Cumberland County than in more arid areas of the country.

A large increase in water price can also have several negative impacts, many of them financial. Increasing water rates can have a significant negative financial impact on residential and commercial water users as they must reduce other spending in addition to reducing water use. The likelihood that customers cannot afford to pay also increases, which would lead to service being disconnected and lower countywide health and welfare. Though not as visible as property tax rates, high water and sewer utility rates could be a potential deterrent to business considering whether to locate in Cumberland County. For established businesses, the increased costs may also be passed to the consumer. Customer complaints to utility managers and local government would almost certainly increase. Finally, the inelastic nature of water limits the amount of conservation savings that can be realized.

7. New Construction standards

One of the most effective ways to generate long term water savings over baseline estimates is to influence the water efficiency of new development. Ensuring that developers are installing efficient fixtures and appliances means that new users will have a lower water use intensity than existing users. Additionally, it is significantly easier to create standards for efficiency before new units are built than to retrofit them later.

As mentioned in the Water Needs Assessment memo, some improvement in water use efficiency can be expected over time due to a combination of government regulation, technological improvement, and market forces. Greater savings and greater certainty of savings, however, can be achieved through the adoption of a plumbing code with adequate efficiency standards and proper code enforcement. Building codes influence water use primarily by mandating fixture efficiency, but the mere existence of codes and monitoring can lead to water savings as well by making builders more aware of efficiency overall. Building codes in general lead to better construction quality which reduces the likelihood of in-home leaks.

7.1. Policies

Cumberland County has several opportunities for generating long term water savings by influencing efficiency in new development. A combination of codes, ordinances, and benefits can effectively promote efficiency.

Currently, Cumberland County lacks building codes in all areas except inside the Crossville city limits. Reportedly, even within Crossville, the efficiency of fixtures is rarely examined by inspectors. To affect significant savings, the county as a whole should implement plumbing codes at least as strict as those in Crossville (which uses the 2003 International Plumbing Code). Cumberland County may also elect to amend codes or pass ordinances to make stricter regulations pertaining to water efficiency such as limiting the percentage of irrigated acreage on certain types of newly developed parcels.

Table 13 - Codes and New Construction Policies

Policy	Duration	Staff Requirements	Description
Enact Plumbing Code in Cumberland County	2009 - 2056	3-4 inspectors (with ~ 0.25 time devoted to plumbing), 1 staff support	Adopt building codes, and specifically plumbing codes for the entire county. Create provision to review codes every 5 -10 years. Hire inspectors for the county.
Update Plumbing Code in Crossville	2009 onward		Update Crossville plumbing code to match the rest of County (2006 codes or later)
Amend codes to encourage conservation	2014 – 2056		Restrictions on faucets, showerheads, all toilets 1.6 gallon or less, irrigation systems have autorain shut off,
Reduce tap fees for developers implementing ultraconserving fixtures and water using devices	2009 onward		Establish defined criteria for benefit, e.g.: - installed high efficiency toilet - low flow fixtures (15% lower than code) - rainwater capture system - high efficiency appliances

7.2. Presumed effects and modeling methods

More stringent codes and ordinances can reduce water usage in two primary ways. First, new construction of all types is held to a higher level of water efficiency with respect to fixtures and appliances. As a result, most new developments will start in the conserving efficiency class. However, the mere presence of codes can spur builders to begin considering water efficiency more explicitly. Presumably, some builders will exceed the efficiency standards as a way to become more competitive. Table 14 presents the starting efficiency classes for new construction. Efficiency classes are the way IWR-MAIN handles improvements in efficiency. The efficiency classes allow groups of users in the same subsector to have different water use rates. In the base year, units start in the non-conserving class, but new units are presumed to be in more conserving classes. The plumbing code year used for the modeling in IWR-MAIN is 2009. Base water use rates vary somewhat by study areas, but the conserving efficiency class represents about a ten percent reduction over the non-conserving class, and the ultraconserving class a twenty to twenty-five percent reduction. The Water Needs Assessment Memo explains the efficiency classes and how they were developed for Cumberland County in much greater detail.

Table 14 - Presumed starting efficiency classes under new codes and ordinances

New units Efficiency Class	Percent of new units in class
Conserving	75%
UltraConserving	25%

The other method by which codes and ordinances can reduce further demand is by influencing the choice of water using devices for existing structures. Effectively, this shifts existing users into higher efficiency classes. Major renovations of existing structures would be subject to inspections, notably in the commercial and institutional sector. The presence of codes in the county also leads to the positive externality of making more efficient devices and fixtures more available in the county, and residents more conscious of them. As a result, some residents will be more likely to purchase more efficient fixtures as they seek to replace faucets, dishwashers, washing machines, toilets, etc. Thus, an additional 3% per year efficiency class shift rate is assumed to move units from conserving to ultraconserving efficiency class. As an example, a residential customer already having ultra low flow toilets who purchased a new high efficiency washing machine would move from the conserving to ultraconserving efficiency class for the non-potable indoor end use. Table 15 displays the shifts for existing users when new codes and ordinances are enacted.

Table 15 – Presumed Efficiency Class Shifts resulting from Codes and Ordinances

Efficiency Class Shift	Value (% of units per year)
NonConserving to Conserving	5%
Conserving to Ultraconserving	3%

7.3. Results

Table 16 displays the modeled conservation savings resulting from codes and ordinances. Notably, the savings start out very small and continue to increase in magnitude as new development continues and existing homes gradually shift to more efficient uses. The growth of the percentage savings over the baseline will eventually level out, but these data do not indicate this will occur within the time period of this study.

Table 16 - Conservation Savings resulting from Codes and Ordinances

Year	Consumption (MGD)	UAW (MGD)	Total Needs (MGD)	Baseline Total Needs (MGD)	Water Savings (MGD)	% Savings over baseline	Cumulative savings (MGal)
2006	3.87	1.04	4.91	4.91	0.00	0.00%	0
2016	4.75	1.29	6.04	6.11	0.07	1.19%	93
2026	5.77	1.58	7.35	7.64	0.30	3.86%	764
2036	6.65	1.84	8.49	9.08	0.59	6.48%	2378
2046	7.52	2.11	9.63	10.54	0.91	8.65%	5118
2056	7.86	2.21	10.07	11.28	1.21	10.73%	8994

7.4. Pros, Cons and Economic Benefits

Well defined and adequately enforced plumbing codes have a range of benefits, especially in the long term. Notably, the water savings are very significant and grow considerably as time progresses. The new standards and inspections also lead to better general construction quality, which is especially important in plumbing since poor workmanship can result in significant water damage when pipes or joints break or leak. The ratepayers in new units benefit by having more efficient fixtures, and as a result, lower utility bills, with little additional effort on their part. The utilities benefit by achieving conservation without much additional cost to them (except in lost revenue from sales). Additionally, the lower marginal use rates of new customers may help prevent wear and tear on pipes.

There are only a few drawbacks to this conservation measure. The county would likely have to hire about 4 or 5 more building inspectors, though perhaps only a quarter of their time would be spent on plumbing related matters. Some unlicensed plumbers would require certification, or else would be forced out of business. Property assessments would like go up with better building codes, which is generally a benefit, but could potentially impose a heavier burden on fixed income residents.

Economically, conservation through codes and ordinances makes a great deal of sense. The costs of hiring inspectors and support staff would be significant for the county, but those costs may be partially recouped over time as property values rise (thus increasing property tax revenue). There are some small administrative costs associated with passing the ordinances and managing inspection programs. Additionally, the utilities may experience a drop in projected future revenue, but their actual revenue would not decline, as adding efficient users still adds to the revenue base of the utilities. Finally, the county may realize significant benefit over time by postponing or eliminating the need for developing new water sources, and expanding water treatment, sewage treatment, and pumping capacity.

8. Retrofit, Replacement and Rebate programs

Retrofit, replacement, and rebate programs can reduce the average water use factors for existing users by replacing (or providing incentives to replace) existing fixtures and appliances with more water efficient ones. The key is that the transition happens at a much faster rate than it would under natural replacement.

The programs can take several forms. One approach is to simply provide inexpensive fixtures and devices such as faucet aerators, shower heads and toilet dams free of charge to users. The drawback is that the consumers do not always install them. As the Massachusetts Water Resources Authority's Steven Estes Smargiassi noted[10], "We discovered if you gave away devices, most of them were 'installed' in kitchen drawers – not on the bathroom or kitchen fixtures." One way to mitigate this problem is to provide free installation as well. Rebate programs provide monetary incentives for the replacement of larger water using devices, notably toilets and clothes washers. While often expensive, rebates for toilets and clothes washers can provide greater water savings than small devices, and some level of certainty in effectiveness as the transition to more efficient water uses can be more easily verified.

8.1. Policies: Retrofit, Replacement and Rebate Programs

One way to reduce water usage is to directly improve the water use efficiency of existing users. Retrofit and replacement programs provide more efficient water using fixtures such as showerheads to customers, often for free. These programs are generally more effective when installation is offered as well. Rebate programs are generally more effective for larger appliances and toilets. The utility provides rebates to customers who replace less conserving water using devices with ones meeting well-defined water efficiency standards. Often, a list of acceptable models for replacement is the most straightforward course of action. Some sort of inspection or verification by receipt is usually necessary to avoid fraud. Payments can be provided as a check or as a utility bill credit. Table 17 outlines some of the general parameters of programs which might be effective in Cumberland County. Note that the programs have limited duration and are designed to have a rapid impact.

Table 17 - Retrofit and Replacement Programs

Policy	Duration	Staff Requirements	Description
Retrofit and installation program	2009 - 2015	4 installers, 2 support staff	Teams of installers respond to requests and go door to door, installing these items: - 1.5 gpm bathroom faucet aerator - 2.0 gpm kitchen faucet aerators - toilet displacement devices - low flow showerheads
Toilet Rebate Program	2009-2015	0.1 inspector, 0.1 support staff	Provide $50 rebate for replacement of 3.5 gpf or greater toilet with 1.6 gpf or less
Clothes Washer Rebate Program	2016 - 2020	0.1 inspector, 0.1 support staff	Provide $50 rebate for replacing washing machine with approved high efficiency laundry machine

8.2. Presumed effects and modeling methods

In IWR-MAIN Conservation Manager, these programs are modeled with the tools → Active Conservation menu. Table 18 describes five programs modeled in IWR-MAIN. The units per year is a sum of the units for the five study areas. For the purposes of modeling this conservation measure, only the residential subsector is targeted.

Table 18 - Retrofit Installation Targets

Policy	Duration	Efficiency Class Shift	End Use	Units per year (countywide)
Retrofit and installation program	2009 - 2015	NC → C	Indoor Potable	1200
		NC → C	Indoor Nonpotable	535
		NC → C	Outdoor	925
Toilet Rebate Program	2009-2015	NC → C	Indoor Nonpotable	920
Clothes Washer Rebate Program	2016 - 2020	C → UC	Indoor Nonpotable	815

These programs have market penetration rates that range from 14% (Indoor Nonpotable C→ UC) to about 38% (Indoor Nonpotable NC→ C) over the life of the programs. This is certainly an achievable goal. The Massachusetts Water Resources Authority once achieved a 55% penetration rate for a retrofit kit program with a customer base of 2.5 million people.[10]

8.3. Results

Table 19 displays the water savings resulting from this conservation measure. In a distinct contrast with many other conservation measures, these programs provide the greatest savings over the baseline in the near term, and the savings erode over the longer term. This is to be expected since the programs are of short duration, and they merely speed the rate of natural replacement. Over time, many of the units would have been upgraded anyway.

Table 19 - Conservation Savings resulting from Retrofit, Replacement Programs

Year	Consumption (MGD)	UAW (MGD)	Total Needs (MGD)	Baseline Total Needs (MGD)	Water Savings (MGD)	% Savings over baseline	Cumulative savings (MGal)
2006	3.87	1.04	4.91	4.91	0.00	0.00%	0
2016	4.46	1.20	5.67	6.11	0.44	7.27%	568
2026	5.68	1.55	7.23	7.64	0.41	5.39%	2131
2036	6.84	1.90	8.73	9.08	0.35	3.85%	3522
2046	7.99	2.24	10.23	10.54	0.31	2.92%	4723
2056	8.59	2.41	11.00	11.28	0.28	2.48%	5797

8.4. Pros, Cons and Economic Benefits

Retrofit, replacement and rebate programs are a very proactive and intrusive conservation action. The primary benefit is that a successful program can effectively reduce water use in a short period of time. Additionally, these programs can help utilities build goodwill with ratepayers since they are helping customers lower their bills. These programs are especially well-received when rates are increased. These programs can also lower energy bills by reducing the amount of hot water used. Finally, these programs are beneficial because they can demonstrate the benefits of conservation in ways that education programs can not.

There are some drawbacks to these conservation actions. One Cumberland Utility Manager said there was an equity issue as some ratepayers would be funding conservation programs that provided direct benefit to other ratepayers. Additionally, there are questions as to the effectiveness of these programs. Not all of the devices given away are actually installed, and some devices are only installed on infrequently used fixtures.

The economic benefits of these programs are mixed. While a great number of the water savings devices are actually quite low in price, reaching the conservation targets can mean buying significantly more units than are necessary, many of which will not be installed. Customers who do take advantage of the programs can benefit financially through rebate programs and over time as their utility bills are reduced. The main benefit to the county and utilities is that the need for expansions of treatment and development of new sources can be delayed.

9. Summary Results

The results of the six conservation measures have been presented, and their beneficial qualities, drawbacks, and economic benefits discussed. This section compares the relative performance of the conservation measures. Table 20 displays the total water needs for the baseline forecast and six conservation measures under all three growth scenarios. (The growth scenarios were developed in the Land Use Memo and Needs Assessment Memo.)

Table 20 - Total Water Needs for Baseline and Six Conservation Measures

Year	Baseline	A) Non-Leakage UAW	B) Leakage Reduction	C) Education	D) Price	E) Codes and Ordinances	F) Retrofits
Aggressive Scenario							
2006	4.91	4.91	4.91	4.91	4.91	4.91	4.91
2016	6.52	6.34	6.14	6.30	6.23	6.43	6.08
2026	8.55	8.19	7.80	8.04	8.16	8.20	8.15
2036	10.60	10.14	9.59	9.90	10.10	9.90	10.27
2046	12.17	11.64	10.97	11.26	11.59	11.10	11.88
2056	13.81	13.22	12.29	12.55	13.14	12.36	13.55
Expected Scenario							
Year	Baseline	A) Non-Leakage UAW	B) Leakage Reduction	C) Education	D) Price	E) Codes and Ordinances	F) Retrofits
2006	4.91	4.91	4.91	4.91	4.91	4.91	4.91
2016	6.11	5.95	5.76	5.90	5.84	6.04	5.67
2026	7.64	7.32	6.98	7.17	7.29	7.35	7.23
2036	9.08	8.69	8.22	8.45	8.66	8.49	8.73
2046	10.54	10.08	9.53	9.73	10.04	9.63	10.23
2056	11.28	10.79	10.07	10.20	10.75	10.07	11.00
Slow Scenario							
Year	Baseline	A) Non-Leakage UAW	B) Leakage Reduction	C) Education	D) Price	E) Codes and Ordinances	F) Retrofits
2006	4.91	4.91	4.91	4.91	4.91	4.91	4.91
2016	5.66	5.50	5.33	5.43	5.41	5.59	5.18
2026	6.52	6.24	5.96	6.05	6.23	6.26	6.06
2036	7.03	6.74	6.39	6.46	6.72	6.55	6.63
2046	7.66	7.33	6.96	6.96	7.31	6.95	7.29
2056	8.41	8.04	7.54	7.50	8.02	7.46	8.05

These results indicate some clear trends in the projected water needs under the baseline and conservation scenarios. Most notably, leakage reduction appears to lead to the most substantial reductions over the entire study period. Education programs and Codes and Ordinances follow a similar pattern of starting off with very modest savings over the baseline and substantially increasing savings over time. The retrofit programs show an opposite trend, with the most substantial savings earlier in the study period. This is potentially significant as the uncertainty in the estimates is substantially lower at shorter time horizons. Interestingly, the results of non-leakage UAW reduction programs and conservation pricing programs are quite similar even though their modes of influence are very different. Figure 1 further highlights these differences by displaying the water savings over the baseline water needs projection. Appendix A.2 includes similar graphs for the Aggressive and Slow growth scenarios.

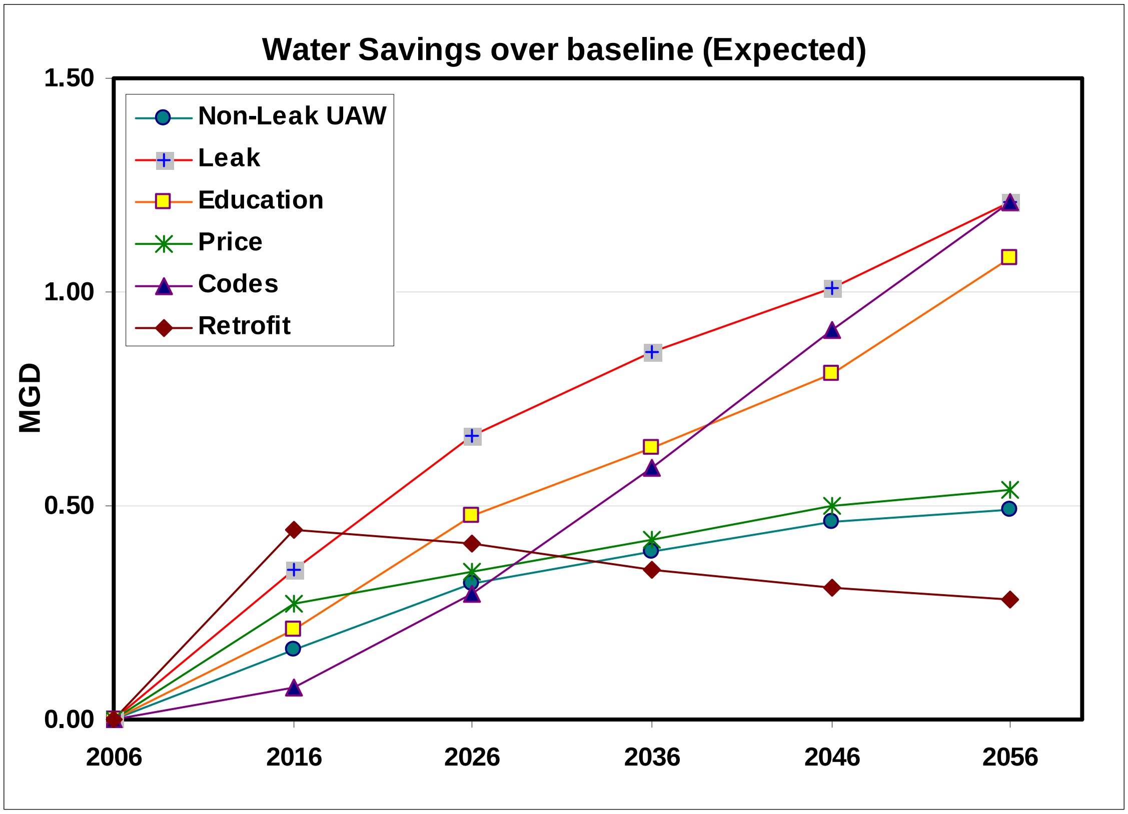

Figure 1 - Water Savings (MGD) over baseline projection

The two most noticeable trends are the rapid rise in savings due to water efficiency codes and ordinances in the second half of the forecast period, and the early peak and relative decline of the savings due to retrofits. The other conservation measures all show relatively steady growth. Another way to measure the effectiveness of the programs is to consider the cumulative savings over the study period.

Figure 2 displays the cumulative water savings over the baseline due to the conservation measures. The cumulative savings are calculated using integration by trapezoids and the water savings data in Figure 1. Cumulatively, the greatest savings occur with leak reduction, education, and codes. The cumulative savings of retrofits, compare favorably with other conservation measures at first, but fall behind in the second half of the forecast period.

Appendix A.3 presents similar graphs for the Aggressive and Slow growth scenarios. The greatest differences occur for the codes and retrofits conservation measures.

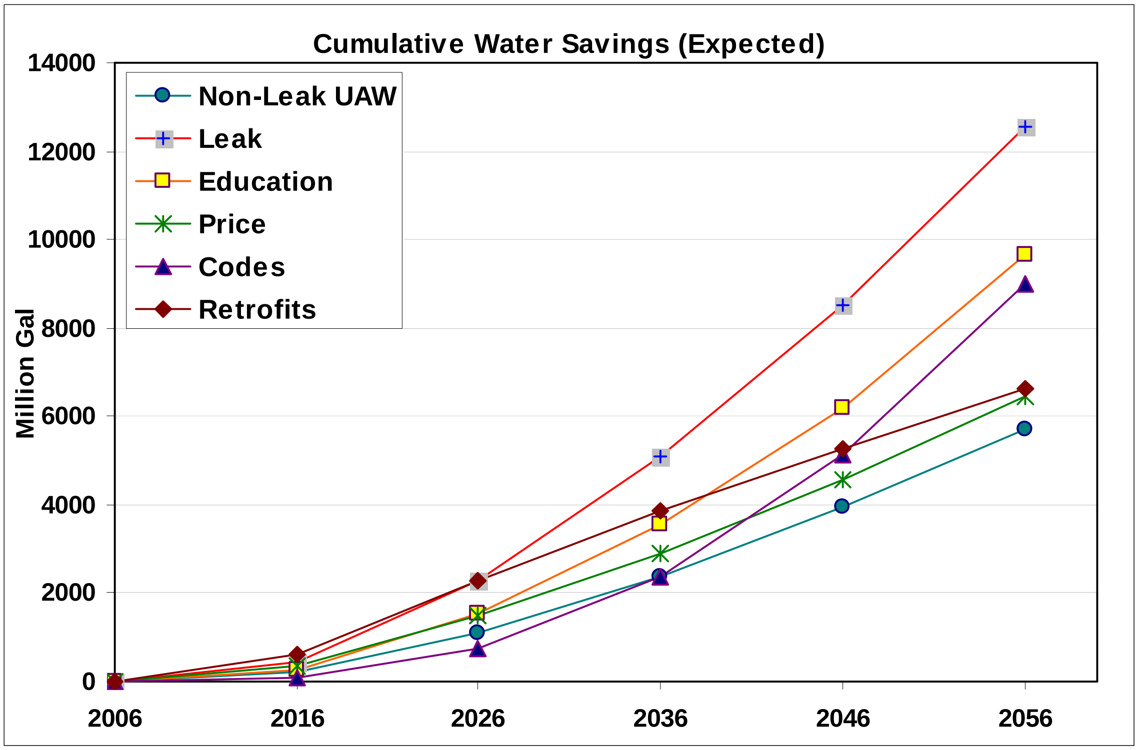

Figure 2 - Cumulative water savings resulting from the six conservation measures

10. Water Conservation Plan Recommendation

We have described six conservation measures, their modeling methods, pros and cons, and water savings impact in this memo. The final Water Conservation Plan recommendation will represent some combination of these measures. Projecting the water savings from a combination of measures is not a simple as summing their individual water savings totals. Due to interactions between conservation measures and the substantial non-linearities in the model, each new combination of conservation measures requires a separate modeling process. Therefore, according to the results presented in this memo, we recommend a Water Conservation Plan (follows). Please comment on the proposed plan so that we may evaluate the proposed plan with the model. Additional combinations of conservation measures and analysis can be addressed in further task orders.

GKY & Associates recommends the following Water Conservation Plan as best suited to meeting Cumberland County's long term water management goals. In combination, institute the following conservation measures as described in this memo:

A. Non-Leakage UAW Reduction
B. Leakage Reduction
C. Education Programs
E. Codes and Ordinances

We at GKY believe these four measures are the most beneficial actions Cumberland County can take for several reasons. First, the combination of measures strikes a balance between short term and long term water savings. Measure B, leakage reduction, provides strong savings throughout. The early savings of measure B can be amplified by including measure A as well. Measures C and E provide very significant long term savings, especially in the 30-50 year time horizon.

These four conservation measures are also very feasible to implement. In fact, most of the measures are in the process of planning or implementation currently, though not quite to the extent described in this memo. All of the utility districts have recently replaced or are replacing meters throughout their service areas. All of the utility districts claim to be reducing system leakage wherever they can, and one has even contracted leak detection services. The city of Crossville already has plumbing codes in place, and Cumberland County appears to be actively considering implementing them. None of the utility districts currently has dedicated education programs, but there are many resources available through the American Waterworks Association, the Environmental Protection Agency, various state environmental departments, private consultants, and other sources.

Especially if the utility districts and county officials cooperate, the conservation measures presented here are very cost effective. Education programs are relatively low in cost. Implementing codes and ordinances has few upfront costs, but some long term enforcement and administrative costs. Measures A and B can be costly, but are generally worthwhile investments as the water savings directly reduce costs without reducing revenues. Furthermore, if leak detection services are contracted for the entire county, and leak detection equipment is shared, costs can be reduced. Finally, leak detection costs are dropping as technology improves.

The other benefit of this plan is that it should be widely accepted by the majority of the stakeholders. Reducing unaccounted for water, and more broadly, establishing water accountability through better system information, better metering, and leak detection is a crucial step toward public acceptance of other conservation actions. Establishing building codes (and water efficiency standards) is generally acceptable as it has many positive impacts on quality of life in the county. Educational programs, as long as they are well managed, are generally accepted. Price increases for the purpose of conservation, however, are usually unpopular. Additionally, certain stakeholders have already expressed a mild opposition to retrofit and rebate programs.

Finally, implementing the proposed conservation measures leaves open the possibility for future conservation measures. In the event that the proposed plan does not meet conservation targets, or growth occurs at a faster than projected rate, other conservation measures can be implemented. Measures A and B will lead to a much better understanding of the water balance throughout the distribution system and identify opportunities for further conservation. Establishing a framework for education programs leads to better communication between utilities, ratepayers, and other stakeholders, which could make future actions more effective. Strict efficiency codes help create a local market for more efficient fixtures and appliances. Additionally, once codes are adopted, a legal framework is established for future amendments and ordinances.

This concludes the Water Conservation Plan memo. Once your comments are received, we will model the results of the final conservation plan and produce a final report.

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Appendix A.1 Summary Results (Aggressive Growth Scenario)

Conservation Program	Year	Consumption (MGD)	UAW (MGD)	Total Needs (MGD)	Savings over Baseline (MGD)	% Savings over Baseline (MGD)	Cumulative Savings over baseline (MGal)
0	2006	3.87	1.04	4.91			
Baseline Forecast	2016	5.13	1.39	6.52			
	2026	6.70	1.85	8.55			
	2036	8.28	2.32	10.60			
	2046	9.49	2.68	12.17			
	2056	10.76	3.05	13.81			
A	2006	3.87	1.04	4.91	0.00	0.00%	0
Non-Leakage UAW reduction	2016	5.13	1.21	6.34	0.18	2.70%	225
	2026	6.70	1.49	8.19	0.36	4.22%	1205
	2036	8.28	1.86	10.14	0.47	4.39%	2716
	2046	9.49	2.15	11.64	0.53	4.32%	4526
	2056	10.76	2.47	13.22	0.59	4.25%	6558
B	2006	3.87	1.04	4.91	0.00	0.00%	0
Leakage Reduction	2016	5.13	1.01	6.14	0.38	5.77%	481
	2026	6.70	1.10	7.80	0.75	8.77%	2539
	2036	8.28	1.30	9.59	1.02	9.61%	5769
	2046	9.49	1.48	10.97	1.20	9.82%	9812
	2056	10.76	1.53	12.29	1.52	11.03%	14776
C	2006	3.87	1.04	4.91	0.00	0.00%	0
Education	2016	4.95	1.34	6.30	0.22	3.36%	280
	2026	6.30	1.74	8.04	0.51	6.01%	1620
	2036	7.73	2.17	9.90	0.71	6.66%	3850
	2046	8.78	2.48	11.26	0.91	7.46%	6798
	2056	9.77	2.78	12.55	1.26	9.12%	10756
D	2006	3.87	1.04	4.91	0.00	0.00%	0
Pricing	2016	4.90	1.33	6.23	0.29	4.45%	371
	2026	6.39	1.76	8.16	0.40	4.62%	1621
	2036	7.89	2.21	10.10	0.50	4.74%	3260
	2046	9.04	2.55	11.59	0.58	4.78%	5239
	2056	10.24	2.91	13.14	0.67	4.82%	7518
E	2006	3.87	1.04	4.91	0.00	0.00%	0
Codes and Ordinances	2016	5.06	1.37	6.43	0.09	1.41%	117
	2026	6.43	1.77	8.20	0.35	4.11%	926
	2036	7.74	2.17	9.90	0.70	6.61%	2848
	2046	8.65	2.44	11.10	1.07	8.81%	6085
	2056	9.63	2.73	12.36	1.45	10.50%	10688
F	2006	3.87	1.04	4.91	0.00	0.00%	0
Retrofit, Replace, Rebate	2016	4.79	1.30	6.08	0.43	6.67%	556
	2026	6.39	1.76	8.15	0.40	4.67%	2079
	2036	8.02	2.25	10.27	0.34	3.17%	3423
	2046	9.26	2.62	11.88	0.29	2.39%	4566
	2056	10.55	3.00	13.55	0.26	1.89%	5572

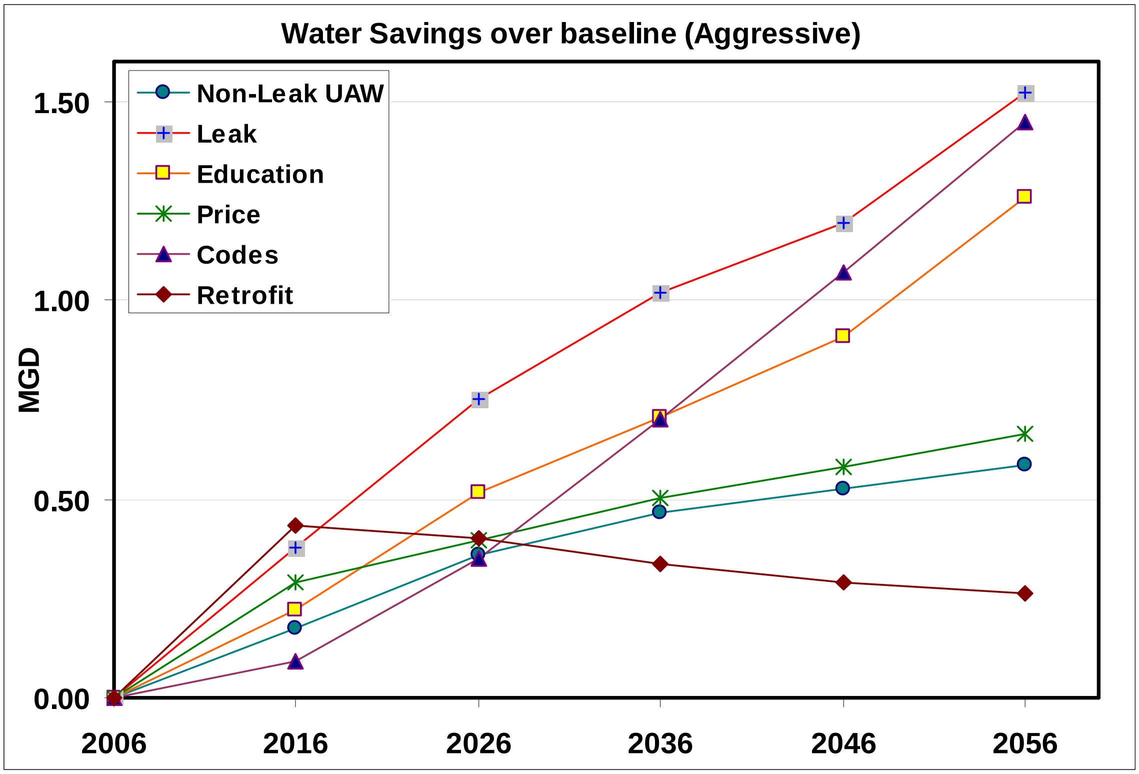
A.1 (continued) Expected Scenario

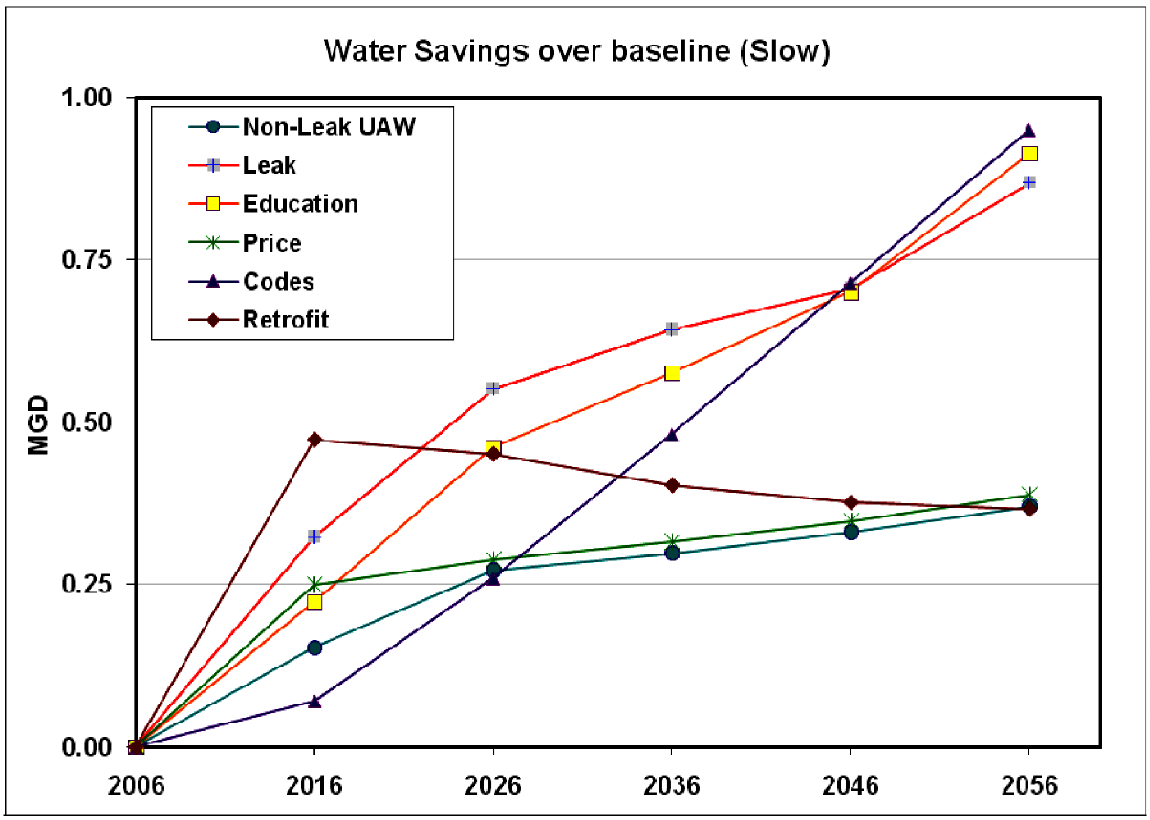
Conservation Program	Year	Consumption (MGD)	UAW (MGD)	Total Needs (MGD)	Savings over Baseline (MGD)	% Savings over Baseline (MGD)	Cumulative Savings over baseline (MGal)
0	2006	3.87	1.04	4.91			
Baseline Forecast	2016	4.81	1.30	6.11			
	2026	6.00	1.64	7.64			
	2036	7.11	1.97	9.08			
	2046	8.24	2.31	10.54			
	2056	8.81	2.48	11.28			
A	2006	3.87	1.04	4.91	0.00	0.00%	0
Non-Leakage UAW reduction	2016	4.81	1.14	5.95	0.16	2.69%	210
	2026	6.00	1.32	7.32	0.32	4.17%	1091
	2036	7.11	1.58	8.69	0.39	4.30%	2386
	2046	8.24	1.84	10.08	0.46	4.39%	3944
	2056	8.81	1.98	10.79	0.49	4.36%	5687
B	2006	3.87	1.04	4.91	0.00	0.00%	0
Leakage Reduction	2016	4.81	0.95	5.76	0.35	5.76%	450
	2026	6.00	0.98	6.98	0.66	8.67%	2303
	2036	7.11	1.11	8.22	0.86	9.48%	5085
	2046	8.24	1.30	9.53	1.01	9.59%	8503
	2056	8.81	1.26	10.07	1.21	10.73%	12560
C	2006	3.87	1.04	4.91	0.00	0.00%	0
Education	2016	4.64	1.26	5.90	0.21	3.42%	267
	2026	5.63	1.54	7.17	0.48	6.22%	1517
	2036	6.61	1.84	8.45	0.63	6.98%	3542
	2046	7.60	2.13	9.73	0.81	7.69%	6179
	2056	7.96	2.24	10.20	1.08	9.59%	9635
D	2006	3.87	1.04	4.91	0.00	0.00%	0
Pricing	2016	4.60	1.24	5.84	0.27	4.43%	346
	2026	5.73	1.57	7.29	0.35	4.53%	1473
	2036	6.78	1.88	8.66	0.42	4.65%	2877
	2046	7.85	2.20	10.04	0.50	4.73%	4558
	2056	8.39	2.36	10.75	0.54	4.76%	6449
E	2006	3.87	1.04	4.91	0.00	0.00%	0
Codes and Ordinances	2016	4.75	1.29	6.04	0.07	1.19%	93
	2026	5.77	1.58	7.35	0.30	3.86%	764
	2036	6.65	1.84	8.49	0.59	6.48%	2378
	2046	7.52	2.11	9.63	0.91	8.65%	5118
	2056	7.86	2.21	10.07	1.21	10.73%	8994
F	2006	3.87	1.04	4.91	0.00	0.00%	0
Retrofit, Replace, Rebate	2016	4.46	1.20	5.67	0.44	7.27%	568
	2026	5.68	1.55	7.23	0.41	5.39%	2131
	2036	6.84	1.90	8.73	0.35	3.85%	3522
	2046	7.99	2.24	10.23	0.31	2.92%	4723
	2056	8.59	2.41	11.00	0.28	2.48%	5797

A.1. (continued) Slow Growth Scenario

Conservation Program	Year	Consumption (MGD)	UAW (MGD)	Total Needs (MGD)	Savings over Baseline (MGD)	% Savings over Baseline (MGD)	Cumulative Savings over baseline (MGal)
0	2006	3.87	1.04	4.91			
Baseline Forecast	2016	4.45	1.20	5.66			
	2026	5.13	1.38	6.52			
	2036	5.53	1.50	7.03			
	2046	6.02	1.65	7.66			
	2056	6.59	1.82	8.41			
A	2006	3.87	1.04	4.91	0.00	0.00%	0
Non-Leakage UAW reduction	2016	4.45	1.05	5.50	0.15	2.70%	195
	2026	5.13	1.11	6.24	0.27	4.17%	970
	2036	5.53	1.21	6.74	0.30	4.24%	2010
	2046	6.02	1.32	7.33	0.33	4.31%	3158
	2056	6.59	1.45	8.04	0.37	4.40%	4438
B	2006	3.87	1.04	4.91	0.00	0.00%	0
Leakage Reduction	2016	4.45	0.88	5.33	0.32	5.71%	413
	2026	5.13	0.83	5.96	0.55	8.46%	2009
	2036	5.53	0.86	6.39	0.64	9.13%	4188
	2046	6.02	0.94	6.96	0.71	9.21%	6648
	2056	6.59	0.95	7.54	0.87	10.32%	9522
C	2006	3.87	1.04	4.91	0.00	0.00%	0
Education	2016	4.28	1.15	5.43	0.22	3.94%	285
	2026	4.77	1.29	6.05	0.46	7.06%	1532
	2036	5.08	1.38	6.46	0.58	8.19%	3424
	2046	5.47	1.50	6.96	0.70	9.13%	5754
	2056	5.88	1.62	7.50	0.91	10.85%	8699
D	2006	3.87	1.04	4.91	0.00	0.00%	0
Pricing	2016	4.26	1.15	5.41	0.25	4.41%	319
	2026	4.90	1.32	6.23	0.29	4.42%	1300
	2036	5.28	1.43	6.72	0.32	4.48%	2402
	2046	5.74	1.57	7.31	0.35	4.55%	3615
	2056	6.29	1.73	8.02	0.39	4.62%	4960
E	2006	3.87	1.04	4.91	0.00	0.00%	0
Codes and Ordinances	2016	4.40	1.19	5.59	0.07	1.24%	90
	2026	4.93	1.33	6.26	0.26	3.98%	691
	2036	5.15	1.40	6.55	0.48	6.84%	2042
	2046	5.46	1.49	6.95	0.71	9.31%	4224
	2056	5.85	1.61	7.46	0.95	11.29%	7262
F	2006	3.87	1.04	4.91	0.00	0.00%	0
Retrofit, Replace, Rebate	2016	4.09	1.10	5.18	0.47	8.35%	604
	2026	4.78	1.29	6.06	0.45	6.91%	2289
	2036	5.22	1.42	6.63	0.40	5.72%	3847
	2046	5.72	1.57	7.29	0.38	4.90%	5268
	2056	6.31	1.74	8.05	0.37	4.35%	6622

Appendix A.2 Conservation savings over baseline projection (Aggressive and Slow)





Appendix A.3 Cumulative savings over baseline