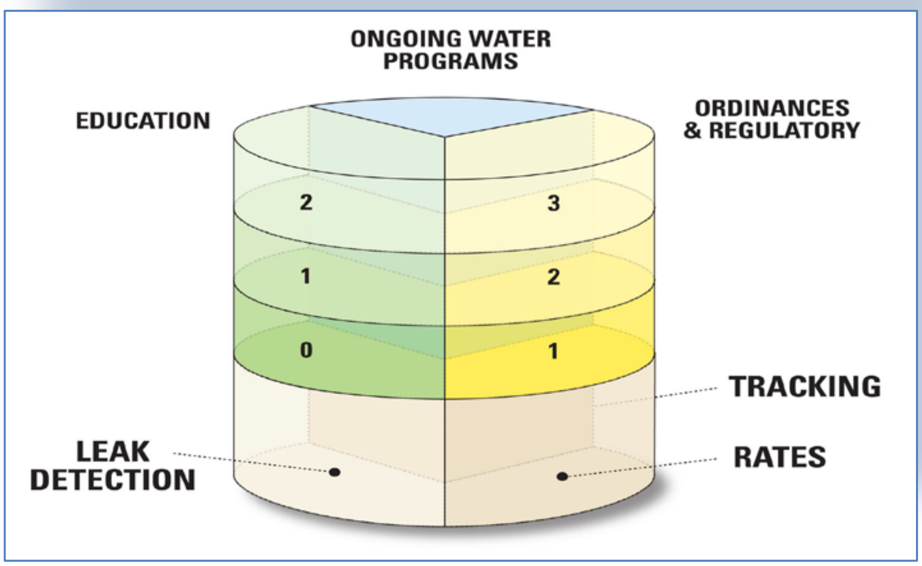
SWSI Conservation Levels Analysis
Final Report



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Colorado Water Conservation Board

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Section 1
Project Background and Goals

Background

In September of 2009, the Colorado Water Conservation Board (CWCB) and the Office of Water Conservation and Drought Planning (OWCDP) agreed to implement a series of projects (AKA – Approach to a Water Conservation Strategy) to "develop a comprehensive water conservation technical platform that would support the CWCB in its continuing efforts to develop strategies to meet Colorado's future water supply needs," (Reidy and Deheza, 2009).

The proposed projects were conceived to achieve four specific goals:

- Identify and analyze the water conservation savings from the year 2000 to present that are permanent versus temporary.
- Identify current penetration rates for the best practice water conservation measures identified in the Best Practices Guide for Water Conservation in Colorado and forecast what they are expected to be through 2050.
- Analyze and reevaluate the conservation levels included in Statewide Water Supply Initiative Phase I (SWSI I).
- Create a Best Practices Guide for Water Conservation in Colorado.

The OWCDP expects that achieving these goals will provide a more scientifically valid foundation to determine future municipal demand levels. Furthermore, by completing the series of projects, the roles of water conservation and demand management in the context of future water resource management will be better defined (Reidy and Deheza, 2009). To this point, the Water Conservation Strategy was conceived by the OWCDP to support efforts being conducted by the CWCB Water Supply Planning Section, the Interbasin Compact Committee (IBCC) and the various Basin Round Tables (BRT) to understand and characterize the role of water conservation in filling the water supply "gap," where the gap is defined as the difference between the combination of current water supplies and identified projects and processes (IPPs), and future statewide water demand.

Project Goals and Approach

This specific project – SWSI Conservation Levels Analysis – focused on achieving the third goal of the proposed Water Conservation Strategy. The overall goal of this project was to re-assess the water conservation classification "levels" developed and used in the SWSI I to estimate future water demand reductions associated with passive and active water conservation savings[1] based on a review and evaluation of the best available data collected by the CWCB over the past eight years.

As part of this project, a quantitative re-assessment was made of potential future water demand reductions associated with the "passive" water conservation predicted in SWSI I. Follow-up projects to be conducted by CWCB will re-assess and perform quantitative assessments to characterize potential "active" water conservation savings predicted and/or discussed in both phases of SWSI (i.e., SWSI I and II).

To achieve the goals of this project, the following tasks were performed:

- Collect and analyze data from past CWCB projects (including the Drought and Water Supply Assessment (DWSA) of 2004, the Colorado Drought and Water Supply Update (CDWSU) of 2007, and SWSI I and II) and from those Water Conservation Plans currently approved and on file with the OWCDP;
- Analyze SWSI I water conservation level evaluations; and
- Develop a new framework for evaluating and characterizing ongoing water conservation conducted by Colorado's water utilities and special districts.

In addition, analyses were performed to estimate the likely range of municipal water demand reductions expected as a result of current and future passive water conservation.

The analyses that result from the data review will address the following key issues from the perspective of the State's water utilities and special districts[2] that provide municipal and industrial (M&I) water supply (including municipal, industrial, commercial and institutional water use):

- Do water utilities have meaningful water conservation programs;
- How do water utilities best support meaningful customer water conservation;
- What are the costs to utilities to support water conservation measures and programs;
- What was the influence of the 2002 drought on water demand, independent of ongoing water conservation efforts; and
- What is the potential for future water conservation savings (based on those Water Conservation Plans submitted to the OWCDP)?

It is important to note that for the purposes of this project and related reports, water conservation is viewed as those measures and programs, and related actions and activities, that permanently reduce M&I water demand.

[1] Water conservation in SWSI I was defined as those future demand reductions associated with "passive" and "active" water savings. These terms are defined in the footnote on page 18 of this report.

[2] For purposes of simplifying the language used in this report, the labels "water utilities" and "water providers" are used interchangeably to represent any entity in Colorado that develops, treats and distributes water on a retail basis for M&I uses.

This remaining portion of the report is organized as follows:

Section 2 – reviews the data sources available from past CWCB projects.

Section 3 – presents the analyses of the CWCB data sources.

Section 4 – reviews the SWSI I water conservation levels and presents the new framework proposed to characterize water provider water conservation efforts.

Section 5 – presents a revised estimate of potential passive water conservation savings expected in Colorado by 2050.

Section 2
Background and Review of Data Sources

This section provides a discussion of the nature of each of the data sources used in the project, including the similarities and differences between the data collected and uses of that data. The specific data sources are as follows:

- Drought and Water Supply Assessment (Bouvette Consulting, 2004)
- Statewide Water Supply Initiative Phase I (CDM, 2004)
- Colorado Drought and Water Supply Update (Aquacraft, Inc., 2007)
- Statewide Water Supply Initiative Phase II (CDM, 2007)
- Water Conservation Plans submitted to the OWCDP after July 2006 (various dates by various authors)

Drought and Water Supply Assessment (DWSA)

The DWSA was the first project of its kind conducted by the CWCB. It was performed to engage Colorado water users and water interests from all the major river basins to:

- Determine how Colorado prepared for drought, and
- Identify limitations, and related measures, to better prepare Colorado for future droughts.

The DWSA involved the collection and evaluation of water use and opinion data from 537 water providers and water interests from across the state in 2003, including municipal, agricultural, industrial, recreational, and environmental users. The opinion data focused on characterizing how prepared Colorado was for drought and identifying drought mitigation measures that may help the state, its citizenry and its businesses better prepared for future droughts. The opinion data characterized those key issues that water managers and planners throughout the state faced with respect to the short- and long-term management of local water resources such as:

- Limitations to current water supply;
- Current status of water supply, drought and water conservation planning and implementation within each water user organization;
- Impacts observed from the most recent drought by the different water user segments.
- Limitations to planning for future water supply;
- Water user needs for structural and non-structural projects to mitigate drought;
- Use of cooperative agreements to manage drought now and into the future; and
- State role in future drought planning and mitigation efforts.

Based on the results of the survey, water user responses were summarized, and issues related to current and future state water policy were identified.

SWSI Phase I

The Executive Director of the Department of Natural Resources Russell George wrote the following regarding the importance and use of SWSI I (George and Catlin, 2004):

> *"The CWCB's overarching goal for SWSI was to help water providers and state policy makers ensure an adequate water supply for Colorado's citizens and the environment. Resolving Colorado's water supply and water needs required the development and implementation of a complex process that took a sustained and long-term effort. During the execution of SWSI it was apparent that developing trust and open communication would take time. To this point, SWSI has been conducted in phases such that information collection and analyses could be honed as new and better data becomes available.*
>
> *The first phase of SWSI (i.e., SWSI I) occurred as the result of the 2003 Colorado General Assembly authorizing the CWCB to implement SWSI, an 18-month basin by basin investigation of our existing and future water needs. This was an unprecedented effort. Never before in the history of the state had we developed such a comprehensive picture of our water future. Never before has the state assembled all water users – farmers, ranchers, municipalities, industrial users, recreationalists, and environmentalists – to look at our future. Never before have we gone to each of Colorado's eight major river basins to explore how much water they use today, how much water they need in the future, and how local water providers are planning to meet that need.*
>
> *Conducting this study was no easy task. Water is controversial and contentious, and the tensions and conflicts at times have spanned generations. Water is an issue that goes to the core of who we are and what we can be as a state. As a result, this study needed to proceed thoughtfully and strategically, always in respect of the role and jurisdiction of local water providers.*
>
> *With the help of hundreds of Coloradans, that is what the SWSI I did. For the first time, we had estimates for:*
>
> - *How much water Colorado will need in 2030, basin by basin;*
> - *What is being done to address our water needs, statewide and by basin;*
> - *How much we are short (i.e., what is the gap), and where we are short; and*
> - *What is being done, and what more can be done, about the shortfall.*
>
> *This information has provided a critical foundation for local water providers and other decision-makers to take the necessary steps to provide Coloradans with a safe and reliable water supply.*
>
> *Critical to the overall outcomes provided by the SWSI I effort was the identification of processes and projects (IPPs) that can potentially meet 80 percent of those municipal and industrial water demands expected to occur in 2030; however, some water suppliers may need help building infrastructure,*

> *mitigating and permitting projects, enhancing and improving the environment, and conserving water."*

SWSI I catalogued the specific projects, plans, and processes that local water suppliers have identified and are performing, or are planning to implement, to meet expected future water demands that they have predicted. As a whole, if all these projects are implemented as planned, 80 percent of the state's 2030 M&I water needs would be met. This is the most optimistic scenario; but there is uncertainty and hurdles to overcome. SWSI II, which was completed about three years after SWSI I, was designed in part to better characterize the nature of the 20 percent "gap" and how the IPPs will (or will not) fill the gap.

Colorado Drought and Water Supply Update (CDWSU)

The authors of the CDWSU wrote (Aquacraft, Inc., 2007):

> *"The CDWSU was conducted in 2007 to obtain new information on the current status of drought planning and preparedness, water conservation planning and programs, and water supply. This study was conducted for the Colorado Water Conservation Board with the assistance of the Southeastern Colorado Water Conservancy District. The research team included Aquacraft, Inc., National Research Center Inc. (NRC) and Aspen Media and Market Research.*
>
> *Focused on municipal and urban water providers in Colorado, the CDWSU implemented a detailed telephone survey to evaluate key components of water supply planning. A similar study, the DWSA conducted in 2004, had a much broader focus that included agriculture and other water use sectors in the state. By necessity, CDWSU had a more limited schedule and budget; hence the opinion data collection was restricted to municipal and urban water providers."*

Data collected during the CDWSU was used to characterize:

- Drought status and preparedness
- Water conservation planning and programs
- Climate change and long-term planning
- Needs assessment from Colorado's water providers (related to the need for state assistance in future water supply planning and project implementation)

SWSI Phase II

Based on the finding of SWSI I, CWCB identified several recommendations that could lead to the better characterization and quantification of Colorado's future water needs, issues, and opportunities. One of the recommendations involved the formation of Technical Roundtables (TRTs) to continue the work of characterizing the nature and issues related to the IPPs and the 20 percent gap identified in SWSI I.

The specific TRTs formed to support the SWSI II effort were associated with four key areas:

- Water Conservation and Efficiency;
- Alternative Agricultural Water Transfer Methods to Traditional Purchase and Transfer;
- Delineating and Prioritizing Colorado's Environmental and Recreational Resources and Needs; and
- Addressing the Water Supply Gap (between Current Supply and Current and Future Water Needs)

According to the authors of SWSI II (CDM, 2007):

> *"SWSI II's overall goal was to develop reconnaissance level concepts to address the 20 percent M&I gap, agricultural shortages, and environmental and recreational enhancements. To the extent possible, multi-objective concepts were considered. Developing a range of potential solutions were expected to assist water providers, policymakers, and stakeholders gain a deeper understanding of the relative role that water efficiency, agricultural transfers, and new water development can play in meeting future needs and the trade-offs associated with these concepts. These concepts can then be considered in the context of meeting human needs for water and providing for the needs of Colorado's natural environment and recreation."*

Water Conservation Plans on File with the OWCDP

Water conservation planning has long been required by state statute. Beginning with the Water Conservation Act of 1991, M&I water providers that had retail sales of greater than 2,000 acre-feet per year were required to have water conservation plan approved by the CWCB by 1996. M&I water providers that met this retail sales requirement were considered to be "covered entities". A covered entity that did not have a CWCB approved plan could not receive loan proceeds from either the CWCB or the Colorado Water Resources and Power Development Authority.

The 1991 Act did not require the reporting of any data by the planning entity – so no information regarding population served, number of connections, water use and/or delivery data, or information regarding the costs and benefits of local water conservation efforts were included in the plans that the CWCB was bound by statute to approve. The plans did not include any information regarding the goals of future water conservation efforts or the manner by which water conservation savings would be measured and verified. The contents of a state required water conservation plan created by a covered entity and approved before July 2006 (which is when new legislation passed during the 2004 legislative session took effect) provided minimal information relevant to characterizing active water conservation efforts.

This seeming oversight was not surprising given the state of the science regarding water conservation planning at that time. It was not until Colorado's drought in 2002, and other regional droughts in various locations in the United States, did water conservation planning become more robust and data intensive.

Given the broad impacts of the 2002 drought, a bill was passed in 2004 requiring water conservation plans to include more detailed analyses and information. Specifically, the 2004 legislation required that water conservation plans submitted after July 2006 contains:

- Goals for future water conservation efforts;

- Defined monitoring and verification efforts; and
- Scheduled updates for the plans, not to exceed seven years.

The CWCB added policies between 2004 and 2006 to further define the reporting requirements for covered entities to include the identification of water use, both as a total and by customer class for the past five years; the population served during each of these years; the benefits of past water conservation efforts, in terms of water saved; and the identification and evaluation of costs and water savings associated with various water conservation measures and programs that a covered entity may select for implementation. The CWCB also requires that an implementation plan be included in the water conservation plan submitted for approval.

Note that SWSI I only had the pre-2006 water conservation plans to draw upon for data and evaluation of ongoing water conservation in the state. SWSI II had less than a half dozen water conservation plans available for review in 2007. To this point, this project was scoped to review all the 30 water conservation plans on file with the CWCB as of January 2010, thereby increasing the amount of relevant data used to support the goals of the Water Conservation Strategy developed by the OWCDP. A listing of those covered entities with CWCB approved water conservation plans as of January 2010 is provided in Table 1.

Table 1 – List of Water Conservation Plans on File with the CWCB

Alamosa, City of	Fort Collins-Loveland Water District
Arapahoe County WWA	Fort Lupton, City of
Aurora, City of	Fort Morgan, City of
Boulder, City of	Fountain, City of
Brighton, City of	Greeley, City of
Castle Pines North	Left Hand Water District
Castle Rock, Town of	Longmont, City of
Centennial Water and Sanitation	Northglenn, City of
Cherokee Metro District	North Table Mountain
Colorado Springs Utilities	North Weld County
Denver Water	Pagosa Area Water and Sanitation
East Larimer County	Parker Water and Sanitation
Erie, Town of	Rifle, City of
Evans, City of	Salida, City of
Firestone	Windsor, Town of

Discussion

Since 2000, the CWCB and the OWCDP have collected and analyzed an unprecedented amount of data characterizing current and future water supply and demand; water supply, drought and water conservation planning in the State; and future water resource management projects and project needs. In conjunction with these efforts, substantial resources have been committed by individual water providers to characterize local and regional M&I water supply needs and limitations as additional data has become available and the state of the science has improved. This project utilized the data made available through both the state and the local planning efforts to support the development of updated analyses that characterize the manner in which covered entities plan for and implement meaningful water conservation programs. This project also used data that has become available since 2007 from studies conducted locally and nationally to estimate passive water conservation savings.

Given the quantitative nature of analyses presented herein, the opinion data collected as part of the DWSA and CDWSU had value in some respects for identifying trends and perceptions held by the water community; however, these projects collected limited quantitative data which prohibited the extent to which the information could be used to inform future demand projections and related water conservation program analyses.

On the other hand, SWSI I and II did not have the benefit of substantial information regarding water provider conservation efforts, since the vast majority of the plans on file with the CWCB were created after SWSI II was completed. This project's review of SWSI I and II therefore focused on determining which data were used to characterize current and future Colorado water conservation efforts and evaluating how those data were used to estimate the impact of water conservation measures and programs on future water demands.

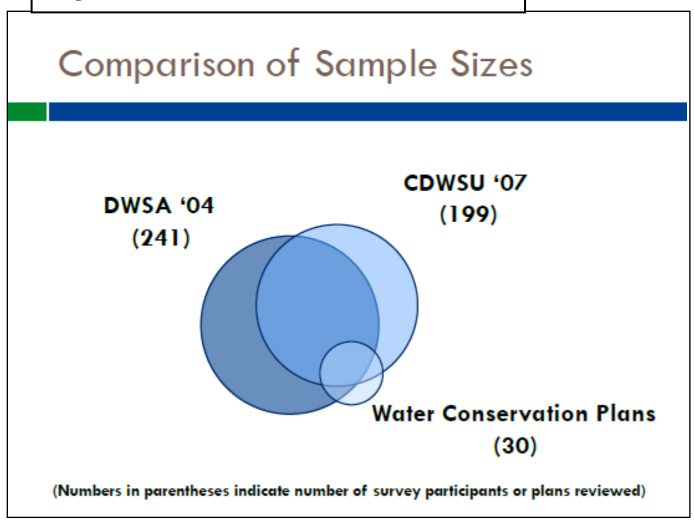
The most robust data available to support this project came from the Water Conservation Plans on file with the OWCDP obtained since July 2006. These plans included data characterizing annual water demands since 2000 by water use customer type, water conservation goals, and cost-benefit analyses. Developing a new framework for characterizing water conservation in Colorado in lieu of the SWSI I conservation levels, and estimating the amount of future water demand reductions related to passive water conservation relied heavily upon those data contained in the Water Conservation Plans on file with the CWCB, supplemented with data available in the relevant literature.

Section 3
Data Analyses

The data analyses presented in this section focus upon a review of the status of water conservation in the state. Specifically, the review characterized the nature and reliability of the available information that may be used to support the overall Water Conservation Strategy being developed by the CWCB. Of particular interest are those issues that would support the quantification of active water conservation in the state, including:

- Do water utilities and special districts have meaningful water conservation plans?
- What are the best water conservation programs that water providers can implement?
- What are the costs for these measures and programs?
- What was the influence of the 2002 drought on customer water demand?
- What is the potential for water demand reductions through utility sponsored water conservation programs?

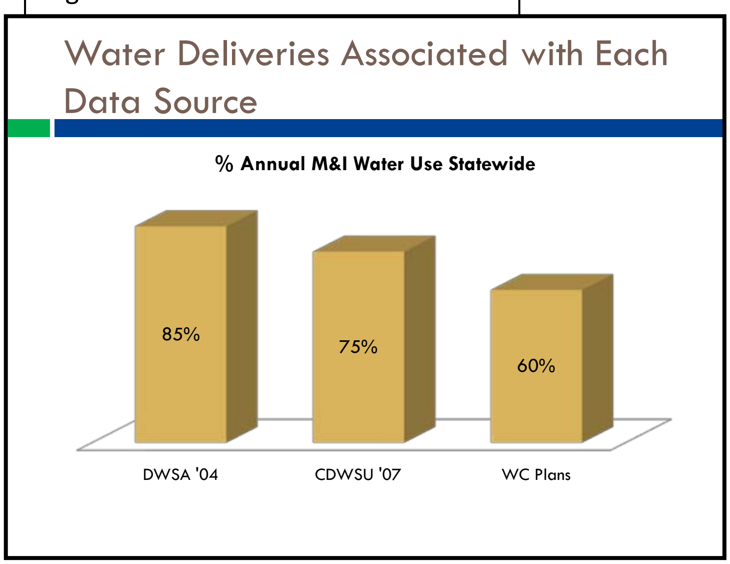
Figure 1



Each of these topics is discussed in light of the data collected in the past by the CWCB, using the data sources presented in Section 2.

Prior to presenting the analyses, it is important to compare and characterize the data in these reports. For example, Figure 1 presents the number of municipal water providers represented in three sets of data – the DWSA, the CDWSU, and the Water Conservation Plans on file with the CWCB. Note that sixteen of those covered entities with approved Water Conservation Plans also participated in both the DWSA and the CDWSU, which is just over 50 percent of those with plans on file with the CWCB. One hundred and thirty two M&I water providers participated in both the DWSA and the CDWSU (or about 2/3 of all the CDWSU participants also participated in the DWSA). Generally, these overlaps suggest that the responses from these three data sources represent a similar population of M&I water users.

Figure 2



To further illustrate this point, Figure 2 presents the portion of total M&I water use represented by the participants from these three projects. As shown in

Figure 2, the three data sources – the DWSA, the CDWSU and the Water Conservation Plans on file with the CWCB – represent 60 percent or more of the all the State's M&I water use[3]. For each case, the percentage of M&I water use is considered representative of trends and conditions statewide.

Do Water Utilities and Special Districts Have Meaningful Water Conservation Programs?

It is clear from the three data sources that water providers across the state have been and continue to conduct water conservation planning. According to the DWSA, about 48 percent of surveyed water providers had water conservation plans. Four years later, about 43 percent of surveyed water providers had water conservation plans. These two numbers are essentially the same, given the error introduced by sample and population size.

However, only a fraction of those claiming to have water conservation plans in 2007 (approximately 40 percent), have approved plans on file with the CWCB. In addition, less than half of the water conservation plans reported to the CDWSU included information on specific measures and programs that would be used by the water provider to reduce customer water demand. To these points, it is unclear if the majority of the water conservation plans that have been created by water providers meet the basic state requirements.

In addition, less than half of the water conservation plans identified by the CDWSU include budgets to implement the plans. Another CDWSU observation was that only 11 percent of the 2007 CDWSU respondents indicated that they collect data to track water savings related to water conservation efforts.

Based on these observations, it is unclear as to the extent of meaningful water conservation[4] that is occurring within the State since most plans that have been created are not on file with the CWCB; do not include specifics regarding water conservation measures and programs; and/or do not indicate that tracking data are collected to characterize the effectiveness of implemented water conservation measures and programs. In addition, the majority of the surveyed water providers do not appear to have budgets specified for implementation of their water conservation programs. Although most of the major water providers in the state have water conservation plans, and many are implementing meaningful water conservation programs; the majority of the providers that are large enough for the CWCB to require water conservation plans from them have yet to implement meaningful water conservation programs.

Some of the lack of clarity related to the extent to which meaningful water conservation is occurring in Colorado as of 2007 may relate to the overall role of water conservation in utility operations. Water utilities and special districts were created to provide safe, reliable potable (and in some cases non-potable) water to their customers. It is no surprise that Colorado's utilities and special districts excel in meeting this need and fulfilling this role. Water conservation can be a distraction for some organizations that lack staff and

[3] Water conservation plans on file with the CWCB include 23 from the South Platte River basin, four from the Arkansas River basin, and one each from the Rio Grande, Colorado and San Juan/Dolores River basins.

[4] The CWCB defines meaningful water conservation as those measures and programs that provide for measurable and verifiable permanent water savings – which may include measures and programs that are being implemented for political reasons and/or to improve customer satisfaction. Although cost-effectiveness is one metric to evaluate and select meaningful water conservation efforts, other selection criteria may be used by planning entities. However, not all water conservation measures and programs can be considered meaningful.

resources to plan and implement meaningful water conservation. Water conservation can also be considered counter-productive for organizations whose revenue is either solely or chiefly produced through water sales.

Water conservation can also be considered by some utilities to have negative impacts on return flows, downstream water rights holders, and overall supply reliability (depending on what the saved water is used to support[5]). Only recently have rigorous cost-benefit analyses been available to help water utilities evaluate the value of water conservation with respect to ongoing operational and budgetary issues. Without reliable, tested cost/benefit data and analyses related to market penetration and permanent water savings, and information on the impacts of changing technology, water utilities can have difficulty performing rigorous water conservation planning.

The state of the science of water conservation in Colorado and the United States has greatly improved in the past three to five years, such that more meaningful planning can now occur at the utility and district level – better than at any time before. This is in part due to the efforts of those covered entities with approved Water Conservation Plans on file with the CWCB, since they are currently implementing local water conservation measures and programs, and are collecting data associated with costs, water savings and penetration rates. To this end, more meaningful water conservation is becoming more accessible than ever before for water utilities in Colorado.

It is becoming increasingly important for water utilities to integrate water conservation planning into water resource and financial planning, such that water conservation programs support system reliability; reduce costs for future water projects; reduce ongoing operational costs; and reduce or postpone costs related to future infrastructure projects. In addition, utilities must collect data as water conservation programs are implemented to measure and verify the program effectiveness and appropriateness.

The new framework described later in this report will discuss some of the advancements that have been made regarding water conservation planning and implementation, specifically from the view point of water utilities and districts.

What are the Best Measures and Programs that Utilities and Special Districts have to Reduce Customer Demand?

The nature of water conservation from the point of view of a water provider has been evolving in Colorado and across the United States since the turn of the century. As indicated earlier, this is due to changes in the state of the science, various federal and state regulations, advancements in technology and improved data collection and management efforts. Noteworthy is that State of California regulations and energy policies must be counted in the mix of new developments that influence water conservation opportunities in Colorado, given the size and influence of California and its regulations on the marketplace. California laws can drive the supply chain to get improved water conservation technology to the market, thus impacting Colorado.

[5] Water conservation can be used to improve overall water supply reliability if planning entities can store and carryover saved water. Some planning entities; however, are planning on using saved water to support future population growth, which may reduce water supply reliability.

Since the marketplace has changed, along with an understanding of what works best and what doesn't, it is not surprising to see that opinions of Colorado's water providers have changed regarding the most effective water conservation measures with each new survey or study. Table 2 presents the top five water conservation measures and programs based on M&I water provider opinion data collected in 2003 and 2007. The table also identifies the most popular measures and programs included in the 30 water conservation plans that are currently on file with the CWCB. Note that the table includes two categories from the DWSA completed in 2004 – one category for those measures and programs in use at the time and one category for the measures and programs considered to be the most effective at saving water.

Table 2 – Summary of the Most Effective Water Conservation Measures and Programs based on M&I Water Provider Opinions and Plans

Study	Most Effective Measures and Programs (top five)				
DWSA	**1**	**2**	**3**	**4**	**5**
In Use	Metering	Public Information and Education	Leak Detection	Water Conservation Pricing	
Most Effective (as indicated by survey participants)	Public Information and Education	Metering	Water Conservation Pricing	Leak Detection	New Development Standards
CDWSU					
In Use	Public Information and Education	Water Conservation Pricing	Water Waste Ordinances	New Development Standards	Leak Detection
WC Plans					
In Use	Public Information and Education	Water Conservation Pricing	Customer Water Audits	Customer Rebates and Incentives	Leak Detection

By comparing opinions over this time span (2003 to 2007 to present), it is interesting to see that some of the "favorite" measures and programs persist (e.g., water conservation pricing), while others come and go (e.g., new development standards). It is also interesting to note that public information and education, which have not been shown to create water savings when conducted by themselves (Artz and Cook, 2007; Chestnut,

2000) are identified as <u>the</u> most valuable measure and program (noting that none of the opinion data is supported by actual water savings data except in very rare instances). This observation meshes with previous observations that the majority of the water conservation plans being created and used in Colorado may not be producing meaningful results.

Based on the current state of the science, the most effective water conservation measures and programs for any utility or district are dependent on a number of factors (Vickers, 2001; Bouvette and Gardener, 2005; Maddaus and Maddaus, 2007; Bouvette, 2010) including:

- The size of the district or utility;
- The types and numbers of customers that are served;
- The age of the infrastructure maintained by the utility and/or district; and
- The nature of the water provider's water rights (e.g., direct surface diversion versus transmountain diversions versus storage).

One size does not fit all; when it comes to water conservation planning and implementation. However, there are important commonalities that can be identified to help focus and manage the costs and benefits of water conservation programs being planned and implemented by Colorado's utilities and water districts. Those water conservation measures and programs that are well suited for all utilities and districts are called "foundational measures and programs." These measures and programs are being documented by the Colorado WaterWise in its upcoming Water Conservation Best Practices manual. More information regarding the foundational measures and programs, as well as discussion of the new framework that has been developed to focus utility water conservation programs, is provided in the next section.

Water conservation currently being implemented by Colorado's covered entities includes a wide range of measures and programs. A table summarizing those measures and programs that have been selected for implementation by Colorado's covered entities is provided in Appendix A. This table which was developed based on a review of the 30 Plans on file with the CWCB provides a list of the measures and programs currently being implemented within the following categories:

- Education
- Rebates and Incentives
- Leak Detection
- Water Rate Structures
- Audits
- Restrictions and Requirements
- Ordinances and Regulations
- Other

Note that water reuse and recycling was not included in this list. Although water reuse and recycling may be a component of a meaningful water conservation program, these activities are not used to reduce overall water demand, but are instead methods to create new, or stretch current, water supplies. An inefficient irrigation system is still inefficient whether it is using reuse water or not. This project is focused on identifying how water providers can improve water use efficiency as a means to create permanent water demand reductions.

What are the Costs to Implement a Water Conservation Program for a Water Provider?

Data associated with the actual costs incurred by water providers to reduce customer water demand are not readily available. Some water providers across the state have committed funds and resources to reduce customer water demands since the mid-1990s[6] based on the pre-2006 Water Conservation Plans on file with the CWCB. However, some of the past expenditures by water providers did not necessarily translate to water savings or reduced customer water demands. Based on a review of Water Conservation Plans provided to the CWCB since 1996, it appears that for many water providers, customer education and information programs consisting of creating and sending out mailers, newsletters and bill stuffers to customers; along with other one-way[7] informational programs, were the sole component of their water conservation programs prior to the drought. As reported in various Water Conservation Plans (e.g., Alamosa, Longmont, Ft. Lupton, Brighton and Pagosa Area Water and Sanitation Water Conservation Plans), and in the literature (Artz and Cook, 2007), one-way educational programs have not been shown to be effective in changing customer behaviors or reducing water demand unless they support other active water conservation measures and programs (e.g., audits, rebates, etc.).

Data included in the 30 plans currently on file with the State submitted since 2006, have greatly improved the statewide understanding of potential costs related to water conservation planning and implementation. For example, most covered entities that submitted Plans, included costs related to the different measures and programs that they selected for implementation. However, data associated with actual water demand reductions measured during Plan implementation have not yet been widely shared with the CWCB. It is anticipated that in the future, when Water Conservation Plans are updated or when grants utilized to implement specific water conserving measures and programs have been completed, cost and water savings data will become more readily available.

Nonetheless, there is a growing amount of data in the literature, and in Colorado, regarding costs and related demand reductions. A few examples include: improved and automated meter reading technology by Castle Pines North and Pagosa Area Water and Sanitation District; commercial water audits by the Town of Castle Rock, Denver Water, Douglas County Government, City of Brighton, and Pagosa Area Water and Sanitation District; industrial process changes by Denver Water and Fort Lupton; faucet and showerhead replacement programs in the City of Brighton and Pagosa Area Water and Sanitation District; high-efficiency toilet replacement programs in the City of Northglenn.

Table 3 summarizes the costs committed to water conservation over the next ten years by the 30 covered entities with Plans on file with the CWCB. Note that the majority of the funding listed in Table 3 relates to

[6] A few Colorado water utilities such as Denver Water began funding water conservation as early as the 1970s, but these efforts which have helped create information valuable to current planning and implementation efforts were not particularly effective in permanently reducing customer demand system wide until after the 2002 drought – at which time data collection related to the effectiveness of specific implemented measures and programs improved.
[7] One-way educational programs include those that do not provide for customer interaction and feedback (e.g., bill stuffers); two-way education includes deliberate and measurable customer feedback mechanisms.

those programs being implemented by Denver Water, Colorado Springs and Aurora Water. These three water utilities, which provide water to about 40 percent of the State's population, are spending just over 75 percent of the total water conservation program funding reported to the CWCB.

Table 3 – Summary of Water Conservation Plan Implementation Costs for the 30 Planning Entities with Plans on File with the CWCB (in millions $)

	Indoor Rebates	Landscape Programs	Audits	Education	Leak Detection	Water Rates	Regulatory	Meter Testing and Replacement	Other[2]	Total
10-Year Total	$ 49.2	71.9	6.4	41.6	2.6	6.4	47.2	6.4	14.3	246.0
% of total[1]	(20%)	(29)	(3)	(17)	(1)	(3)	(19)	(3)	(6)	
Adjusted 10-Year Total[3]	$ 1.4	21.6	1.4	7.1	2.6	5.9	1.2	6.4	3.4	51.0
% of total[1,3]	(3%)	(40)	(3)	(14)	(5)	(11)	(2)	(12)	(7)	

[1] Percentages may not add to 100% due to rounding error
[2] Includes the cost to collect data and track the effectiveness of selected water conservation measures and programs.
[3] 10-year total and percent without the program costs for Denver Water, Colorado Springs and Aurora Water.

The data included in the 30 Plans on file with the CWCB can also be used to estimate the cost of water conservation measures and programs selected by the planning entities on the basis of expected per acre-feet of water demand reduction. Table 4 includes the average, maximum and minimum cost of water conservation per acre-foot as estimated by the water providers with Plans on file at the CWCB.

Noteworthy is that most covered entities continue to fund one-way education and information programs that will not necessarily influence customer water use; however, most water providers have integrated their education and information programs with other water conservation measures and programs, thus improving the overall balance and reach of their water conservation efforts. To this point, the costs provided in the Table 4 include a combination of measures and programs that the water providers have selected to implement including public education and information efforts. Costs for implementing individual measures and programs are not consistently reported by the planning entities, so that data has not been included here.

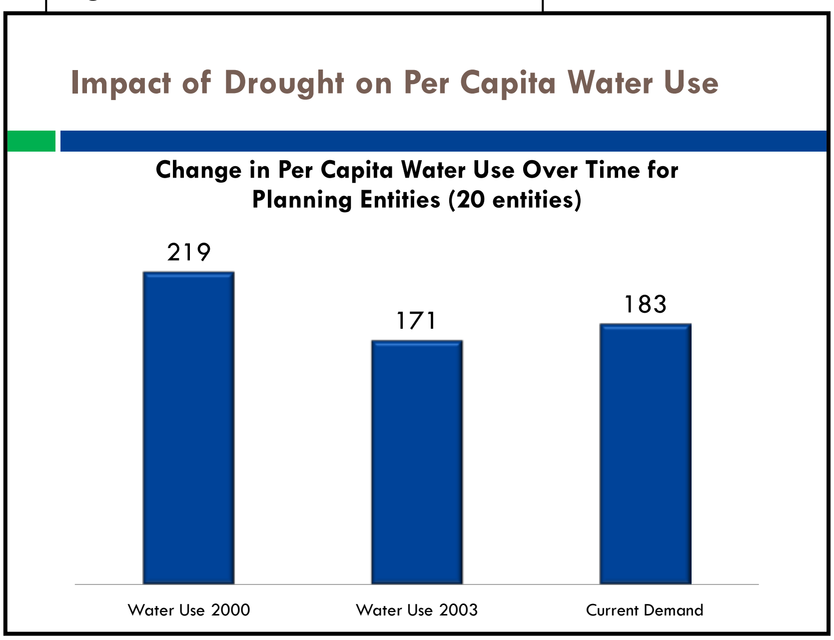
Table 4 – Cost of Water Conservation Programs Per Acre-foot of Expected Demand Reduction[1]	
Minimum	$ 245
Average	$ 6,327
Maximum	$ 37,387

[1] based on Water Conservation Plans on file with the CWCB in 2010

What Was the Influence of the 2002[8] Drought on Water Demand?

One issue of vital interest to many water providers, both with and without water conservation plans, is "what was the impact of the 2002 drought on water demands in Colorado?" Obviously, the impact of the drought on any individual jurisdiction or water provider's service area is influenced by both regional and local conditions. However, the drought of 2002 was of sufficient scale that it can be characterized on a statewide basis using data contained in the Water Conservation Plans on file with the CWCB. This is due, in part, to the State's requirement that covered entities submitting water conservation plans to the CWCB for approval include, at a minimum, 5 years of past water delivery data. Information regarding population served, number of taps, and types of customer classes served is also required.

Figure 3



Of the 30 plans on file, 20 have per capita water use data from 2000, 2003 and the planning year (AKA, some year after the drought (typically 2006, 2007 or 2008)). Twenty six plans contain per capita water use for 2003 and the planning year. Figure 3 presents the average system-wide per capita water use measured by the planning entities prior to, during and after the drought as indicated in their Water Conservation Plans.

This figure indicates that on average a 22% drop in system wide per capita water use was observed in Colorado due to the drought, noting that every one of the planning entities observed a decrease in per capita water use from

[8] The drought of in the first few years of this century was varied in time depending on location within the State. For example, many Front Range utilities define the drought as a 2002 to 2004 event. We have used "the 2002 Drought" as shorthand to describe the drought that was experienced over various durations during this period.

2000 to 2003. This figure also indicates that on average, there has been a 7% increase in per capita water use since 2003. More than half of the planning entities have observed an increase in per capita water use over this time. Those entities that witnessed a decrease in per capita water use since the drought include communities that had diversified water conservation programs dating from either before the drought or shortly thereafter.

Additional information exists to characterize the impact of the drought on customer water demands. Both the Denver Water Department and Colorado Springs Utilities describe the nature of the drought and its lasting impact on their community's future water demand in their Water Conservation Plans. Denver Water indicates that they observed a 20% decrease in customer demand associated with the drought. In addition, they indicate that a permanent per capita reduction of about one quarter of the drought demand reduction (or 5%) will be maintained through implementation of their selected water conservation measures and programs. Colorado Springs on the other hand observed a 17% decrease in water demand, and they are planning to implement water conservation measures and programs to offset any increases in customer demand as the drought impact fades into the future.

Other Colorado communities such as Brighton, Pagosa Springs, Highlands Ranch, Pueblo and Greeley observed similar customer demand reductions associated with the drought. And all of these communities plus others in Douglas County (Great Western Institute, 2007) have seen increases in per capita water use since 2003 despite various levels of water conservation planning and implementation.

It is unclear as to the long-term persistence of the drought demand reduction on customer water use. Some local water experts (water resource managers, water utility financial managers, water utility general managers) have indicated that the impact of the drought will persist at some discernable level for years to decades (Joint Technical Activities Committee, 2010). Consistent messaging and customer education campaigns may also be effective in maintaining behaviors that have in part caused the "drought shadow." Denver Water has opined that their "Use Only What You Need" campaign may have slowed the expected increase in customer demand as the impact of the drought grows fainter (Elliott, 2010). Whatever the future impact of drought on customer demand, it is clear that the 2002 drought impacted customer water demand in locations all across the state and that the overall water demands have not rebounded to pre-drought levels, even in locations without ongoing water conservation programs.

What is the Potential for Water Demand Reductions in Colorado?

Permanent water demand reduction in Colorado will occur in the future due to any number of influences (e.g., passive water conservation savings, drought, active water conservation programs conducted by utilities, etc.). Due to the 2004 legislation, water providers that submit Water Conservation Plans to the CWCB are required to identify the measures and programs that they intend to implement and the overall goal (in percent or in acre-feet of water to be saved) associated with the implementation of their Plan. A review of those Plans that were submitted to the CWCB after July 2006 made it possible to quantify the total reduction of current per capita water demand intended as an outcome of implementing the 30 water conservation plans on file with the CWCB. The results of this data review are discussed below.

Noteworthy is that the CWCB is currently unable to track successes and challenges associated with ongoing implementation efforts since data reporting to the OWCDP from the covered entities with Plans only occurs at five to seven year intervals. To fully and comprehensively determine actual water demand reductions associated with ongoing active water conservation programs will require additional data collection and analysis, which the OWCDP will conduct in the near future.

It is important to note that SWSI I included an estimate for per capita demand reduction through 2030 based on the data available at the time. The analyses presented in SWSI I were based chiefly on a selected group of reports describing passive water savings[9] (i.e., Florida, California, Oregon, Alabama, and North Carolina) and potential savings from water conserving homes described in two reports (Western Resource Advocates, 2003; Gleick, et. al., 2003) using the assumption that 100% market penetration of selected measures and programs would occur. SWSI I also utilized the information contained in the Water Conservation Plans on file with the CWCB prior to 2006; however, these older water conservation plans generally did not contain information regarding water use or the expected future water savings associated with implementation of the selected water conservation programs.

Mindful of the data challenges, SWSI I estimated that water providers and customers statewide would reduce 2000 per capita water demand by about 12% by 2030, which results in a estimated savings of about 231,700 acre-feet of water. SWSI I indicated that the **passive** savings associated with implementation of the 1992 National Energy Policy Act would be 6% statewide, and that **active** water conservation[10] would contribute an additional 6% (or about 115,850 acre-feet) to the overall water demand reduction predicted for 2030. Given the impact of the drought discussed above, it is unclear if this 12% is in addition to the 22% demand reduction observed in the state in 2003, or if the drought shadow would persist through 2030 impacting the estimated acre-feet of savings[11].

The covered entities with approved Water Conservation Plans filed with the CWCB since 2006 have identified their active conservation goals. The goals stated by the covered entities were generally defined based on a specific planning period selected by each utility – noting that the planning periods varied from 5 to 30 years. A metric of water conservation savings was estimated for each utility using information contained within the Plans on file for the ten-year period from 2008 to 2017. Since the Plans do not consistently report expected future water savings in acre-feet, estimates were developed using stated goals, expected water conservation savings and/or forecasted future water use with and without water conservation. A summary of the active water conservation saving estimates for each Plan are presented in Appendix B.

Based on the analyses in Appendix B, an average water demand reduction of 11.3% over 10 years (or 1.13% per year) was expected for the 30 covered entities. The total cumulative active water savings for the 30 covered entities was therefore expected to be about 68,500 acre-feet by the end of 2017. Note that about 70% of the ten-year water savings are associated with the Denver Water and Colorado Springs Utilities programs.

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[9] Passive (or naturally-occurring) water conservation savings are defined as water savings that result from the impacts of plumbing codes, ordinances, and standards that improve the efficiency of water use. These conservation savings are called "passive" savings because water utilities do not actively fund or implement programs that produce these savings. In contrast, water conservation savings from utility-sponsored water conservation programs are referred to as "active" savings (SWSI I, Appendix E, (CDM, 2004)).

[10] See footnote 9.

[11] A further discussion of the conservation savings presented in SWSI I is provided in the next section of this report.

Extrapolating demand reductions from these proposed water savings to other water utilities and districts or past 2017 can be problematic for the following reasons:

- Proposed water savings may not be realized by the implementing entity;
- Water conservation measures and programs that will be cost effective and implementable for large utilities, may or may not be applicable to smaller utilities;
- The value and applicability of water conservation measures and programs is dependent to some extent on the nature of a water providers water rights portfolio, which may change depending on water availability;
- Expected future infrastructure improvements may impact the value of water conservation to a specific water provider;
- Future opportunities for water conservation savings may not be available once a selected measure and/or program has(ve) been implemented and permanent water savings related to these actions are realized (e.g., indoor fixture replacement); and
- Future water conservation savings will likely require the design and implementation of a new suite of measures and programs as market penetration rates change and the market matures.

It is clear that additional active water conservation savings will occur after 2017 in response to the collective efforts of Colorado's water utilities; however, predicting these future active savings is beyond the scope of this project.

To better estimate post-2017 active savings, the CWCB will need to better understand achievements and successes of those measures and programs implemented over the next 5 to 7 years. The data that will be reported to the CWCB through Water Conservation Plan updates and implementation reports (associated with Water Efficiency Grant supported projects) will help to characterize costs and water saved for measures and programs currently being implemented by water utilities across the state. Specific data that the CWCB will need to estimate current, as well as future active savings, will include, but not be limited to, type and timing of implemented measures and programs, water deliveries per customer, customer type and number of connections over time versus the specific timing of implemented measures and programs.

Passive demand reductions may also differ from those estimated in SWSI I. For example, the state or federal government may implement ordinances or regulations designing water efficiency requirements in new and/or existing construction. New ordinances and/or regulations could substantially impact the potential for future water demand reduction independent of the efforts conducted by water utilities. Expected future passive water savings are further discussed in Section 5 of this report.

Section 4
Levels of Active Conservation

One of the key goals of this project was to review and update the "Levels of M&I Active Conservation" described in Appendix E of the SWSI I Report (CDM, 2004). As defined in SWSI I, M&I "active" conservation savings are water savings that result from utility-sponsored water conservation measures and programs. Such measures and programs may include education programs, incentives and rebates, fixture replacement programs, audits and conservation rates and surcharges.

A review of the SWSI I Levels of Conservation[12] was conducted using the following approach.

- Review the specific assumptions and data utilized during the SWSI I study to identify and develop the levels of conservation;
- Identify areas of potential improvement to the SWSI levels;
- Propose a new framework for characterizing meaningful water conservation at the water utility level; and
- Utilize the proposed framework to compare and contrast representative Water Conservation Plan programs proposed since 2006 by local water providers.

Overview of the SWSI I Active Water Conservation Levels

SWSI I was conducted when data collection and reporting of water conservation activities in Colorado had not yet matured since the July 2006 deadline for new water conservation plan submittals to the CWCB had not yet occurred. Additionally, SWSI I developed its analysis of potential water conservation savings at the county level; and admittedly more data was available at the provider-level than at the county-level. Therefore, the assessment performed in SWSI at the county-level was self-proclaimed to be "subjective" (CDM, 2004).

Each county was assigned with one of five levels of water conservation, based on the SWSI I subjective analyses and the limited information contained in those Water Conservation Plans on file with the CWCB at the time (i.e., 2004). The levels were assigned based on assumptions made regarding which measures and programs had been implemented within each county in 2000. For example, Level I conservation related to only passive conservation savings where presumably no active water conservation programs were being conducted by water utilities. Since many counties in Colorado do not contain covered entities, it was reasonable to assume that no active water conservation was occurring in those counties with a population of 8,000 or less.

[12] SWSI I Report included five levels of conservation; however, the first level of conservation, Level I, related solely to passive water conservation savings and not to water provider sponsored measures and programs. As defined in SWSI, passive savings defined for water conservation Level I chiefly relate to the water demand reductions associated with the impact of the 1992 National Energy Policy Act. The other four levels of conservation – II through V – relate to active water conservation.

Level II water conservation was assumed to occur in counties with metering programs for all water customers and leak detection programs in place for all water utilities, in addition to the passive savings expected due to the national plumbing code. Level III water conservation included passive savings, implementation of metering for all customers and leak detection programs plus all nine water conservation measures and programs listed in Colorado Revised Statute (CRS) 37-60-126. Level IV water conservation included all Level III programs plus an aggressive combination of ordinances, water pricing, and additional rebates and incentive programs. Level V water conservation included all of Level IV plus the elimination of all leaks, use of high-water using landscapes, and the replacement of all non-high efficiency water using fixtures and appliances statewide.

Water demand reductions for each of these levels were not readily available from the literature or the water conservation plans on file with the CWCB in 2003. To fill this knowledge gap, SWSI I utilized two 2003 studies to characterize maximum potential water demand reductions (associated with the Level V) as follows:

> Smart Water: A Comparative Study of Urban Water Use Efficiency across the Southwest, 2003, Western Resource Advocates (Western Resource Advocates, 2003) – which estimates hypothetical single-family sector water savings for six cities if they could achieve levels of water use efficiency in a model community.
>
> Waste Not, Want Not: The Potential for Urban Water Conservation in California, 2003, Pacific Institute (Gleick, et. al., 2003) – which estimates a statewide reduction in urban water demand given complete implementation of current technology and a reduction of leakage.

Based on these studies, SWSI I estimated maximum water demand reductions to be 35 percent by 2030[13] (from a baseline date of 2000). To achieve these reductions, SWSI I assumed that that there would be 100 percent participation by residential customers to create permanent water use reductions through improved indoor water use (via more efficiency toilets, showerheads, faucets, dishwashers, clothes washers, and leak reduction). Assumptions for water demand reductions at the other three levels of water conservation (II through IV) were “generalized estimates” based on the potential maximum reduction (CDM, 2004).

Various issues arise out of the SWSI I approach to estimating the potential for future water conservation savings in Colorado. To begin with, SWSI I appears to make assumptions that indoor residential water savings would translate to consistent demand reductions in all customer water use classes. However, SWSI I did not appear to include a quantitative assessment of demand reductions associated with any of the following viable use reductions:

- Outdoor residential
- Indoor commercial, industrial or institutional
- Outdoor commercial, industrial or institutional
- Impacts of the 2002 drought

[13] The Smart Water Report by Western Resource Advocates indicates that a “conserving” household could reduce indoor per capita water use from 69.3 to 45 gpcd (a 35% reduction). It also indicates that western cities could conserve from 28 to 67% of residential water use by reducing water demand to the equivalent of a Smart Development in Arizona, which includes both indoor and outdoor efficiencies.

- Increased population density

In addition, SWSI I appears to base its estimate of Level V water savings on the assumption that 100 % of all residential customers would implement improved leak repair and the complete replacement of clothes washers, faucets, showerheads, dishwashers, and toilets by 2030. Consequently, the maximum water savings quantified in SWSI I includes the implementation of measures and programs that are not under the control of Colorado's water providers.

Another concern with the SWSI I approach is that it assumed water providers had substantially more water conservation efforts in place in 2000 than they actually had. As discussed previously, the majority of water providers lacked meaningful water conservation programs in 2000, due in part to the lack of maturity of water conservation planning and implementation at the time. As Western Resource Advocates stated in their 2003 report:

> *"Water users [providers] are just beginning to learn how to conserve water. How best to motivate them is not yet broadly understood. In many respects, in our region we are at the same stage in water efficiency as we were with energy efficiency two decades ago. Water efficiency is a new frontier for many water providers."*

The assumption that water providers were conducting water conservation programs that included all the nine water conservation measures and programs listed in CRS 37-60-126 in 2000, lead SWSI I to substantially over estimate future water use reductions created by water provider sponsored programs in nearly every county in Colorado that was characterized as having a Level II or III conservation program.

Overall, SWSI I did not have consistent and reliable data upon which it could develop accurate estimates of county-level water conservation savings. It is therefore appropriate and timely for the SWSI Level Analyses and related OWCDP projects to be conducted such that the SWSI I estimates of future water conservation savings can be revised and updated.

Developing an estimate for statewide water conservation savings today continues to be a challenge. However, work has been done by various organizations, including some of those entities with water conservation plans on file with the CWCB, the Colorado WaterWise, and other contributing non-profits and consulting organizations that have substantially improved the collective understanding of:

- What constitutes meaningful water conservation for water providers; and
- What types of measures and programs are most effective for water utilities to implement to create permanent water demand reductions?

The results of some of the research and studies were used to develop a new framework that is presented below.

Proposed New Water Conservation Framework

Key improvements to the SWSI I conservation levels focus on water provider operations and infrastructure efficiencies. For this reason, the new framework begins by defining foundational measures and programs that all water utilities should have in place before embarking on more sophisticated water conservation efforts. These foundational measures and programs involve metering and billing (including water rate structures), leak detection, and water use tracking. Once these measures and programs are in place, then a water utility can begin to support demand reductions based on business decisions that improve their own and their customer's water use efficiency.

The newly proposed framework differentiates education from improving ongoing water use (through audits and rebates, etc.) from ordinances and regulations. Although these three groups of measures and programs are most effective when implemented in combinations, each has a specific role in meaningful water conservation, and each creates a strikingly different result when implemented independently. For example, providing audits, rebates and incentives to improve the efficiency for ongoing water use has been found to create a market penetration rate often in the range of 10 to 25 percent (Water Resources Engineering, Inc., 2002; Gleick and Cain, 2004; Maddaus, 2007; Whitcomb, 2002). On the other hand, ordinances and regulations have market penetration rates of 100 percent if adequate enforcement and oversight efforts are funded and performed. Education also has the potential to penetrate 100 percent of the market; however, education by itself has not been shown to permanently reduce customer water demand.

The new framework therefore includes measures and programs in the following four categories:

- Foundational
- Ongoing Water Use Programs
- Ordinances and Regulation
- Education

The components of each of these four categories are described in the following sub-sections.

Foundational Measures and Programs

The foundational measures and programs are those that all water utilities and districts should have in place to support their operations by maintaining positive cash flow, limiting system wide leaks, and tracking those data that will allow the organization to understand and predict trends in customer water use[14]. Having these foundational measures and programs in-place, and integrated with other foundational processes, water utilities will be in position to implement some of the most basic and cost-effective water conservation programs. Without these foundational measures and programs in place, water utilities may struggle to make business decisions regarding which water conservation measures and programs best suit their specific situation. Water conservation is after all focused on identifying and evaluating those methods that will reduce costs or improve cash flow for water utilities related to:

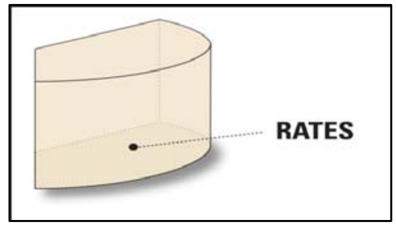
- Reducing utility water use and waste;

[14] One important reason to track customer water use relates to pricing water at a rate or rates that cover utility costs to obtain, transmit, treat, distribute, track and bill for its water uses. It is important for each water utility to be aware of changes to customer water use behaviors given the impact of changing water use on sales revenue. The need to follow and incorporate customer behaviors into water rates and structures points to the value of two-way educational programs and customer water audits described later in this section.

- Postponing and/or reducing capital projects;
- Reducing replacement water needs; and
- Pricing water at rates consistent with the fiscal needs and obligations of the utility, as dictated by customer use, the cost of securing new water supplies, etc.

It is also expected that through the implementation of appropriate water conservation programs, water utilities will improve the reliably of their water supply systems. Achieving these overall goals starts with better operational programs that are under control of the utility.

Rates



Each utility has a water billing system that effects the collection of revenue from its customers. Accurate billing starts with the installation of meters that collect water use data. Water utilities should be moving toward metering that allows for the accurate monthly billing of water deliveries to each customer. Metering should also be conducted to differentiate large indoor and outdoor water use for individual customers. Called sub-metering; large commercial, industrial and institutional users that have both indoor and outdoor water uses should have taps that are specific to each use (to help the utility better understand the water use of these types of customers, which in turn helps utilities identify potential measures and programs that would benefit them and their customers). Utilities should also maintain meter testing and replacement programs such that the impact of under reading meters, which tend to occur more often on large taps, are minimized. Ultimately, water utilities will be reliant on metered water use to track and characterize customer water use and identify the impact(s) of any specific water conservation measure and program that is implemented. New technologies in meter reading using automated meter reading (AMR) and advanced metering infrastructure (AMI) will becoming increasingly valuable to utilities as they and their customers become more water efficient (Lovely, 2010).

Utilities should also develop monthly meter reading programs such that customers can be billed on a monthly basis, which in turn reduces the period of time that utilities need to carry debt related to fixed and variable costs. Beyond improving cash flow, monthly billing helps the water utility and its customers to identify customer side leaks and inappropriate water use, especially during the summer irrigation season. Finally, monthly data helps the water utility better understand customer demands.

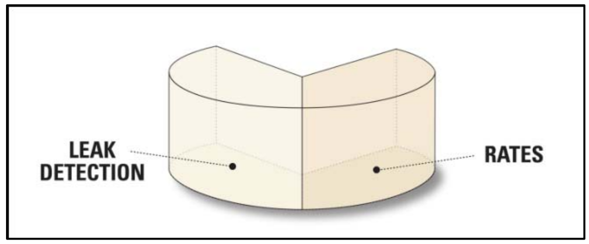
Water conservation pricing has been used effectively by water utilities to improve customer water use efficiency. For this reason, utilities should consider developing inclining block rate structures for water billing to discourage excessive customer water use; however, utilities need to take care to design block rate structures that maintain an average price curve that has a positive slope resulting in customers getting charged more money per gallon as they use more water[15]. Water rate increases can also reduce customer

[15] Some utilities currently have inclining block rate structures that do not encourage water savings due to blocks either being too large or not effectively tied to excessive water use (Western Resource Advocates, 2007). In addition, some water utility bills only include a small percentage for water use (bills can include costs for new infrastructure, debt service and costs for securing new water supplies). For some of these utilities, inclining block rates can be inconsequential in comparison to other water bill costs – such that inclining block rates do not influence customer water use behaviors.

water use (Howe and Goemans, 1998; Howe and Goemans, 2007); however, the utility will need to have customer and customer class data to support any future water rate planning and changes. Water budgets unique for each customer are also effective in promoting customer water demand reductions.

Finally, water customers have begun to demonstrate an interest in real time water use data that can be accessed in a home or business (Lovely, 2010). Real time data can help homeowners and businesses better manage their water use as it occurs. Water utilities that institute AMR and AMI can create a more sophisticated customer base that will support the implementation of more advanced water conservation measures and programs while considering the business needs of the utility.

Leak Detection



Any compromise in a utility's water transmission and delivery system reduces its effectiveness and impacts the utility's overall profitability. An effective leak detection and repair program is therefore integral to a utility's overall water resource management program. Unfortunately, the average water utility nationally loses more than 15% of its transmitted and distributed water (Beecher, 2002), with some utilities and districts losing as much as 30% of their water after treatment. In Colorado, non-revenue utility water loses have been reported to average about 9-10% by Denver Water in their IRP; however some small utilities and water companies have reported losses as high as 50%. These losses are a combination of apparent and real losses (termed non-revenue water). Some of the apparent losses that occur relate to water that is delivered but not billed to customers due to inaccurate meters. Other apparent loses include treated water that is used without tracking or billing (e.g., backwash water, flushing water, etc.). Real system losses occur due to leaking pipes, treatment plants and appurtenances.

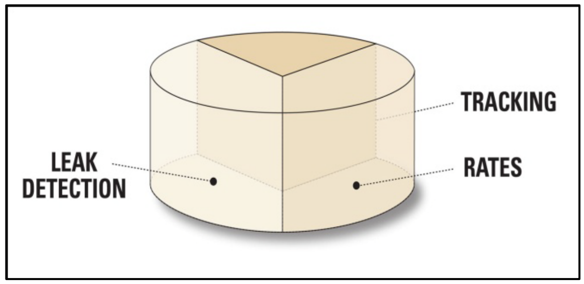
Older systems tend to leak as pipes and junctions age. Newer systems may leak, or may appear to leak due to meters not being accurate enough to balance water discharged from the treatment plant with water delivered to customers. In some cases, utilities do not collect adequate data to track the difference between treated versus delivered water (which requires the tracking of flushing flows from fire hydrants, backwash flows, emergency water use, etc.). Water utilities may also be losing water from their transmission and distribution system that they may otherwise be able to sell. Either way losses due to leaks directly impact the bottom line of any water utility.

The Water Conservation Plans on file with the CWCB inconsistently reported non-revenue water – some reported these losses, others did not. Without an accurate characterization of non-revenue water, utilities may not have an accurate picture of losses within their system. For this reason, utilities must maintain a rigorous leak detection program that proactively identifies system transmission and distribution inefficiencies. Of course, all utilities need to have strong leak repair programs; however, a leak repair program does not replace the need for a strong leak detection program.

The most effective leak detection programs couple accurate and regular metering with rigorous meter testing and replacement programs. System wide leak detection programs based on zonal testing, ultrasonic testing, and/or other methods are also helpful. For example, the City of Durango is conducting a zonal metering program that isolates flows and water deliveries into and out of older sections of town to identify leaks if they occur within selected sections of its water distribution system. The Town of Castle Rock regularly utilizes ultrasonic testing of its water distribution piping to identify and proactively repair leaks before they become significant. These tools are available to all utilities.

Tracking

Water utilities should also develop rigorous tracking of customer water use data since it is these data that will help the water provider best understand its customers and help the utility focus its resources on effective and meaningful water conservation, as well as other business operations. Specific data that water utilities should be tracking, at a minimum (Dziegielewski, 2010), include:



- Total annual and monthly production
- Total annual and monthly retail sales
- Monthly tabulation of number of connections and/or customer accounts
- Annual and monthly water use by customer and customer type (e.g., residential, non-residential)
- Monthly non-revenue water use by utility (e.g., filter backwash water, flushing flows, water deliveries to nonpaying entities, construction water, known meter inaccuracies, etc.)

In addition, water utilities should consider collecting data to differentiate customer types (e.g., multifamily versus single family, industrial versus institutional, etc.) and indoor versus outdoor water use (through sub-metering). Water providers should also compile monthly listings of what and how many customers are paying for water under each of the tiers of the utility's water rate structure. These data will help the water utility develop targeted water conservation measures and programs for high water use customers.

Note that the calculation of both system-wide and sector-specific water use metrics are best developed using available water production and sales records coupled with the number of connections or customer accounts, which are precisely recorded by water providers. Other measures of system size such as population served, number of housing units, or the number of employees are typically not precisely defined and at best are updated annually. For this reason, the commonly used metric of annual production per capita, or GPCD, should not be used as a benchmark for utility decision making (Dziegielewski, 2010).[16]

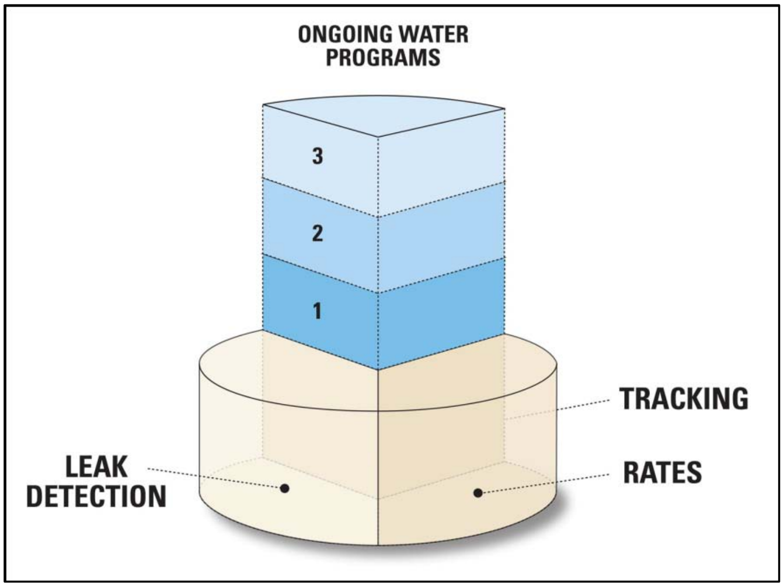
Ongoing Water Use Measures and Programs

Management of ongoing water uses are one of the most important areas that a water utility can influence. Of course, the water utility receives its revenue from this group, so it must determine what its goals are

[16] Author's note- GPCD is used in this project, in part due to the prevalent use of population and water use data in SWSI and other planning efforts. The AWWA report simply has indicated that for individual utilities to best understand their customer's water use, and understand the impact of their water conservation efforts on demand reduction, it should track metrics based on data that is regularly collected and can be precisely measure by each utility.

regarding reducing customer water demand before it commits any resources. Most water providers will find that there are benefits in reducing customer demands as previously discussed in this report (e.g., reduced future water supply needs, improved system reliability, delaying capital projects). However, it is recommended that water providers consider the following hierarchy when developing a water conservation program.

First, the utility should consider finding ways to improve its own water use (this is Level 1). For a municipal utility this includes improving water use efficiency in administration buildings, parks and recreation centers, and other municipal facilities. For special districts, this includes improving water use efficiency in those facilities it controls (e.g., administration building, maintenance shops, golf course, etc.). Implementing these types of water efficiency improvements help to lead the community by example, and create additional treated (and in some cases raw) water supply that can be sold to customers. In addition, most municipalities and special districts are large water users – including both indoor and outdoor uses –where water use efficiencies can be improved through high-efficiency fixtures, appliances and efficient outdoor management strategies



Second, water providers should focus on collecting information to characterize the water use of their largest customers (Level 2). Data collection can best be performed by reviewing water use of individual customers and customer types; and developing audit programs specific to the uses and needs of these customers. Onsite audits can then be used to understand on-the-ground uses and behaviors, spurring analyses that can identify potential water efficiency upgrades that could reduce water and energy related operating costs. Not only can an effort to partner with an utility's large customers create a positive, collaborative business relationship, but improved water use efficiency for the utility's largest water users can reap some of the largest demand reductions – saving the customer operational costs and the utility "real water" in a predictable and cost effective manner.

Third, once data has been collected regarding individual customer and customer type water use, water providers can establish business analyses that support committing resources to customer rebate and incentive programs, as well as different types of technical support for targeted groups and populations (Level 3). It is difficult for utilities to accurately predict the cost and benefit of rebate and incentive programs without customer specific data regarding customer water use, efficiency of existing fixtures and appliances, and customer water use behaviors.

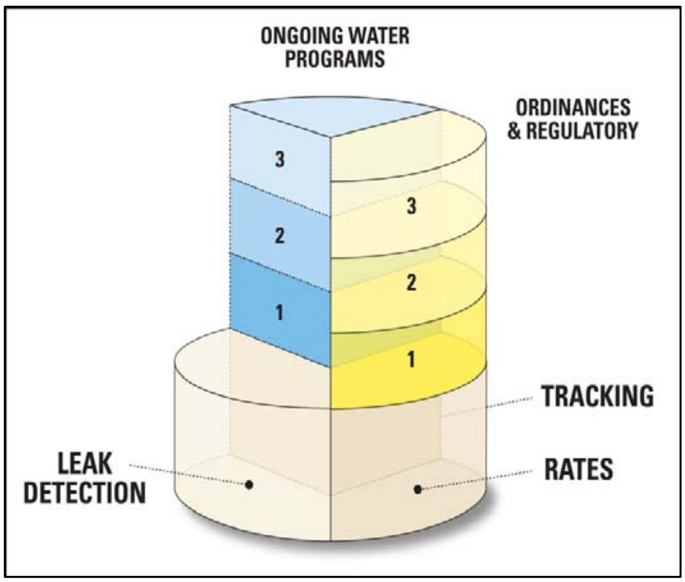
The three hierarchical levels for ongoing water use programs are therefore:

- Level 1 – Water demand reductions by the water utility at its own facilities.
- Level 2 – Collect information characterizing customer water use – focusing on the utility's largest water users.
- Level 3 – Commit resources to assist customers in their water demand management.

Ordinances and Regulations

Ordinances and regulations have the advantage of potentially applying to a large percentage, if not all, of a water provider's customers, depending on the nature and reach of any specific set of rules. For example, new construction building requirements can be created to apply to 100% of all new construction dictating fixture and appliance efficiency, as well as outdoor watering (or landscape material) requirements. There are distinct challenges that some water providers face in creating and establishing ordinances and regulations, due to jurisdictional and other limitations. However, all water providers have the ability to establish and/or influence the development of local ordinances and regulations that would help to improve water use efficiency in their individual service area – albeit that some water companies, special districts and water departments only have a small amount of influence in some circumstances.

For example, most water providers in Colorado have water waste ordinances that vary from location to location. The intent of any effective water waste ordinance (RE: non-volunteer) is to give the water utility the right to fine inappropriate or wasteful watering practices – such as time of day watering, watering pavement, etc. Although water waste ordinances are intended to reduce wasteful water practices by a utility's customers, the effectiveness of this or any other local ordinance or regulation depends on the amount of enforcement that occurs – which in turn is dependent on the amount of resources committed to the effort. For many water providers in Colorado, water waste programs are not adequately funded to consistently identify and engage customers that have wasteful practices; therefore, the effectiveness of these kinds of practices can be spotty. Nonetheless, ordinances and regulations can be very effective if properly crafted and funded.

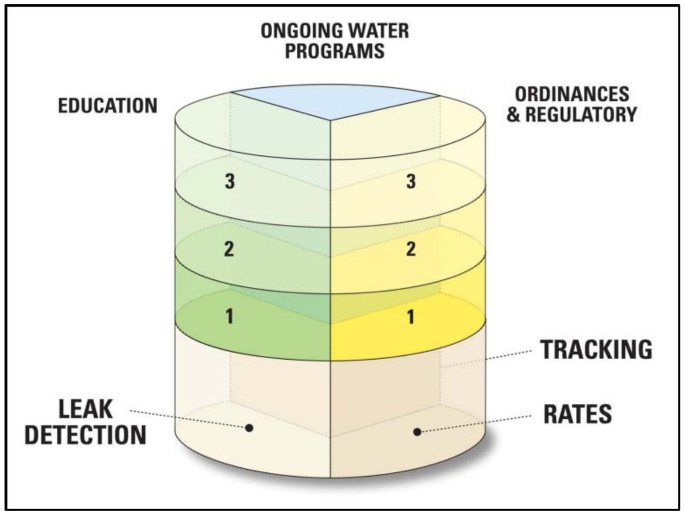


As with ongoing water use programs, there is a logical hierarchy associated with developing ordinances and regulations that pertain to water. To begin with, water providers should focus their efforts on those ordinances and/or regulations that they can actually create and enforce. For some water providers, they can only develop ordinances to control ongoing water waste. For others, they may be able to create ordinances and regulations in all three of the hierarchical levels.

The three hierarchical levels are:

- Level 1 – Water waste ordinances, cooling tower single use prohibitions
- Level 2 – New construction controls related to obtaining water taps (e.g., landscaper certification requirements, soil amendment requirements, irrigated turf restrictions, indoor fixture and appliance requirements, etc.)
- Level 3 – Existing construction controls related to point of sales compliance (through bank loan programs)

Educational Measures and Programs



How educational measures and programs support meaningful water conservation is highly dependent on the suite of measures and programs that a water provider chooses to implement and track. As indicated earlier, meaningful water conservation cannot be accomplished through simple educational efforts alone. For example, most one-way education does not influence customer water use behavior without the implementation of other measures and programs (see page 13). For example bill-stuffers or mass mailings of CDs on water conservation practices will not create measurable water demand reductions. However, if a utility is creating a targeted customer audit and rebate program, one-way educational efforts can help to publicize the effort and create customer engagement and interest. In addition, comprehensive marketing and advertizing campaigns (which are one-way communication efforts) can be highly effective in influencing customer water use behavior when conducted in conjunction with more engaging educational programs (e.g., focus groups), as well as comprehensive water conservation programs. For these reasons, educational programs can be complicated to plan and implement, and can require a substantial investment of resources when correctly conducted.

For purposes of this framework, one-way education is Level 1, one-way education with some feedback mechanisms is Level 2 and educational programs with two-way communications are Level 3. Examples of educational measures and programs for each level are provided below:

- Level 1 – bill stuffers, mass mailings, web pages, Xeriscape demonstration gardens
- Level 2 – water fairs, interactive websites, K-12 teacher and classroom education programs
- Level 3 – focus groups, customer surveys, citizen advisory boards

Consistent messaging is vital to any educational program that a water provider funds. Consistent messaging - one that is authentic and guided by the principles that drive and shape the utility - represents to the community that water conservation and water use efficiency is important and respected. This kind of messaging can be very powerful and create substantial impact. However, if the community observes inefficient watering behaviors in the public space (i.e. municipal or utility properties), most often associated with poor or wasteful irrigation practices, then any messaging from the utility may not be taken seriously.

Therefore, whenever a utility decides to invest in educational measures and programs, it is recommended that it have established foundational programs and rudimentary water conservation practices itself to lead by example; otherwise, the resources expended may not produce the desired outcomes, negating the benefit of the investment.

Discussion

The new framework presented herein helps focus and, more importantly, prioritize water conservation measures and programs that will support the efforts of Colorado's water providers. Of course, each provider will have to craft programs that best suit its individual customer base and financial situation. However, the hierarchy integral to each of the four categories of measures and programs is designed to help individual utilities collect and leverage those data that will support utility operations and decision-making.

Currently, Plans on file with the state typically lack some of the foundational measures and programs, and in some cases have proposed to implement ongoing water use or educational efforts without fully characterizing their customer base or targeting their biggest water users. To illustrative this point, Appendix C presents a comparison of those measures and programs selected for implementation by a group of water utilities with Plans on file with the CWCB with the new framework. The Plans included in Appendix C were chosen to represent different service populations, customer types and geographies in the state.

Although the CWCB will approve water conservation plans that are not constructed in a manner that is consistent with the new framework, the CWCB will be able to use the new framework to make recommendations to planning entities that may help them be more cost effective and successful in their efforts to reduce future water demand and track changes in customer water use.

Section 5
Passive Water Savings

Passive savings, as defined in SWSI I, are those water savings that result from the impacts of plumbing codes, ordinances and standards that improve the efficiency of water use. These conservation savings are called "passive" savings because water utilities do not actively fund and implement programs that produce these savings. (CDM, 2004). In practice, SWSI I estimated passive savings based chiefly upon the expected impact of the 1992 National Energy Policy Act. **For the analyses presented herein, the analysis of passive savings was expanded to include those water savings related to retrofitting homes and businesses with high efficiency fixtures and appliances that are subject to not only the 1992 Act, but to the other relevant regulations and market influences not actively funded or implemented by water utilities as presented later in this section. To this point, passive water savings are calculated to occur as a result of retrofitting housing stock and businesses that exist prior to 2016** (this date is explained further in the following text)**.**

Passive savings could also occur as a result of local, state or federal regulations or requirements not currently "on the books"; however, no attempt was made to predict the effect of potential regulations or requirements on future water use demand given the amount of speculation necessary to conduct such analyses. Additional discussions of what is and is not considered passive savings for purpose of the analyses presented herein are presented below.

Customer Behavioral Changes

Customer behavioral changes are also excluded from the calculation of potential passive savings. There are a number of reasons for this. First and foremost, there is limited data quantifying the nature and permanency of customer behavior change. For example, Colorado witnessed substantial customer water use behavior change in response to the 2002 drought, which was in fact a response to enforced watering restrictions, mass media messaging, and other drought response measures. As a result of the drought and all the lifestyle change implications that accompanied it, water providers in Colorado experienced on average more than a 20% drop in per capita water use. What water providers do not know is when, if ever, this observed drop in customer water use will rebound to pre-drought levels.

Second, although many entities in Colorado believe that a full rebound will never occur, as time passes and new citizens move into the region, our collective memory of the drought and its related challenges will likely fade. In addition, the penalties for excessive water use, which are stiffer now than at any time before the drought, embodied by more aggressive pricing of water and the enforcement of water waste ordinances, do not impact the behavior of all residents and businesses. In fact, previous studies indicate that wealthier individuals have more access to water and therefore consume more water (Corral-Verdugo, et. al., 2003). They may not feel the need to conserve because what they do not have, they can buy. Ilanit, et.al. (2006) suggest that it may also be true that the lower-income individuals know that other groups have virtually unlimited access to water and therefore they do not feel the need to conserve because their water use is already rationed[17]. It is a classic tragedy of the commons dilemma (Hardin, 1968) because there is no immediate or long-term perceived pay off for conserving by either party. Because of these points, assuming that permanent savings will occur as a result of all of the drought-associated water demand reductions is not necessarily reliable.

The estimation of passive water savings is based on permanent savings. Therefore, any current behavioral changes that have been observed as a result of the 2002 drought were not included in the calculation. This is in part due to not having data to suggest the permanency of the change. It is also due to the fact that Colorado's largest water providers are implementing active water conservation efforts to prolong the behavior changes that occurred as a result of the drought (Denver Water, 2007, Colorado Springs Utilities, 2007). Behavioral changes are considered to be either not permanent or a component of active water conservation conducted by water utilities; and therefore, are not included in estimates of future passive savings.

Changes in Population Density

Another factor that will undoubtedly impact future water demand in Colorado will be the increased density of new construction as urban infill development continues. Increased density of housing associated with infill construction will reduce outdoor water use as development go "up" rather than "out." Given that outdoor water use is over 50% of current M&I demand, changes in housing density will decrease per capita water use as outdoor demand decreases.

Water utilities do not control future construction trends such that changes in housing density are not currently considered to be a result of active water conservation programs. Reductions in per capita water use associated with changes in density are not considered passive savings either, under the definitions provided herein. Therefore, per capita water demand reductions associated with increased housing density are considered to fall into a fourth category of future water savings – one which is not drought related, nor passive or active.

Customer Physical Changes

Passive water savings are directly linked to the replacement of older, inefficient water using fixtures and appliances with high efficiency fixtures and appliances. There are a number of key legislative acts that have or will influence the rate and type of fixtures and appliances that will be replaced. These include the following:

> **1992 – National Energy Policy Act** - this Federal act required uniform water efficiency standards on nearly all toilets, urinals, showerheads, and faucets manufactured after January 1994; and included efficiency standards for toilets used in commercial installations by 1997.

[17] Rationing is used in this article by Ilanit, et.al. as a means to indicate that low income water customers can not afford as much water as high income water customers, which is considered to be a form of rationing. This reference to rationing is not related to outdoor watering restrictions or government imposed restrictions.

2002 – California Energy Commission (CEC) Water Efficiency Standards – the California legislature ordered the CEC to establish water efficiency standards for residential clothes washers. Accounting for a reported 22% of an average household's water usage; washing machines are prime candidates for increased water efficiency regulation. The proposed standards required machines to meet a certain "water factor" (WF) ratio calculated by dividing a washer's gallons of water used per load by its water capacity starting in 2007. Although the federal Energy Policy and Conservation Act (ECPA) expressly preempts states from regulating "energy efficiency, energy use, or water use of any product covered by federal energy efficiency standards," the CEC requested a waiver from the DOE that would allow California to regulate water efficiency standards for residential washing machines. CEC won its request for a waiver in 2009 (Proctor, 2010).

2007 – California Assembly Bill 715 – this bill required high-efficiency (HE) standards for all toilets (1.28 gallons per flush (gpf) or less) and urinals (0.5 gpf or less) sold in the state after January 1, 2014[18].

2009 – US Department of Energy State Energy Efficient Appliance Rebate Program – is a program that will provide states with $300 million to design and implement rebate programs that encourage consumers to turn in their old, inefficient appliances for new energy efficient ENERGY STAR models. Water-efficient dishwashers and clothes washers are included under the ENERGY STAR label and will be targeted to receive the biggest rebates. Using these funds, the State of California targeted dishwashers (Griffiths-Sattenpiel, 2009).

The specific impacts of these acts on Colorado's urban water demand have been mixed. For example, no appreciable water demand reductions were seen in association with the 1992 National Energy Policy Act, even though many Colorado water providers pointed to this piece of legislation as a firm part of their water conservation programs, helping reduce urban water demand in customer's homes and businesses. The lack of observed water savings from the 1992 Act is due to technology challenges before 2002, and that water conservation savings associated with the 1992 Act were small enough to not necessarily be measurable versus other water demand impacts. For example, the technology of low flow toilets produced before 2002 did not necessarily reduce flushing flows, since prior to that time toilet performance which was previously thought to be homogeneous showed a wide variation.

> "With utility funding, the National Association of Home Builders (NAHB) Research Center put 49 popular toilets through a battery of tests and reported in 2002 that nearly three-quarters of them performed unsatisfactorily. In October 2002, Consumer Reports published an article on toilet performance that used very different testing methods and produced strikingly different results. Consumers and builders were left frustrated and without a place to turn for toilet performance information they could trust.

[18] The import and relevance of this bill to the production and sales of high efficiency toilets and urinals in California and the western United States was further increased by the passage of California Senate Bill 407 which requires point-of-sale retrofits for all residential and commercial property sold after January 1, 2014.

> In response, more than a dozen municipal water utilities in the United States and Canada—including agencies that were actively promoting water conservation—funded projects to develop a comprehensive testing protocol that would accurately measure toilet flush was the Maximum Performance (MaP) testing. MaP measures how much mass of a standardized testing media (cultured soy encased in latex sleeves) a toilet will flush successfully in two out of three tries" (Wilson, 2006).

The Maximum Performance testing program provided an objective standard by which to compare toilet flush performance thus leveling the toilet industry. Along with the MaP testing, EPA's WaterSense program (launched in June 2006) has substantially improved toilet reliability, and therefore, efficiency of high-efficiency toilets. However, water savings associated with the 1992 Federal act were difficult to ascertain prior to this time.

In addition, new construction has been found to utilize about the same amount of water as older homes (Mayer, 2010). This is presumably due to the fact that while indoor water use in toilets and other appliances has been reduced, outdoor water use has increased in association with the installation of automated irrigation systems (versus older homes without automated systems). Although more data is needed to better clarify residential and commercial "end use", analyses conducted have not verified the savings expected at the time the California 2007 legislation was enacted.

In fact, the legislation in California has arguably had a greater impact on Colorado's urban water use than the 1992 Federal Act. This is primarily due to the size and power of California's economy. Creating and satisfying demand in California dominates the manner in which manufacturers and suppliers operate in the western US. Thus, California's actions have dominated the clothes washer and dishwasher markets in recent years, in combination with actions by the California Energy Commission and the US EPA (through their Energy Star and WaterSense programs). It is becoming increasingly difficult for consumers in Colorado to purchase clothes washers that are not substantially more water efficient than those produced before 2005. Commercially available top loaders are 24% more water efficient and front loader are 40% more water efficient than their predecessors. Similarly, dishwashers have become 25% more water efficient when compared to those available prior to 2005.

No other type of indoor or outdoor water use was included in the passive saving estimates since other domestic and commercial water uses are subject to potential quality of life issues. For example, low flow showerheads could save considerable water, not to mention energy; however, customers have the propensity to not select high efficiency showerheads for reasons that are not entirely clear. Faucet aerators could easily be downsized to 0.5 gallon per minute (gpm) flow rates in bathrooms. However, many newer faucet and lavatory configurations require special hardware configurations for the aerator to attach to the spigot which do not lend themselves to the 0.5 gpm option. Hot water on demand may or may not reduce water use in a home or business depending on the configuration of the system and its use.

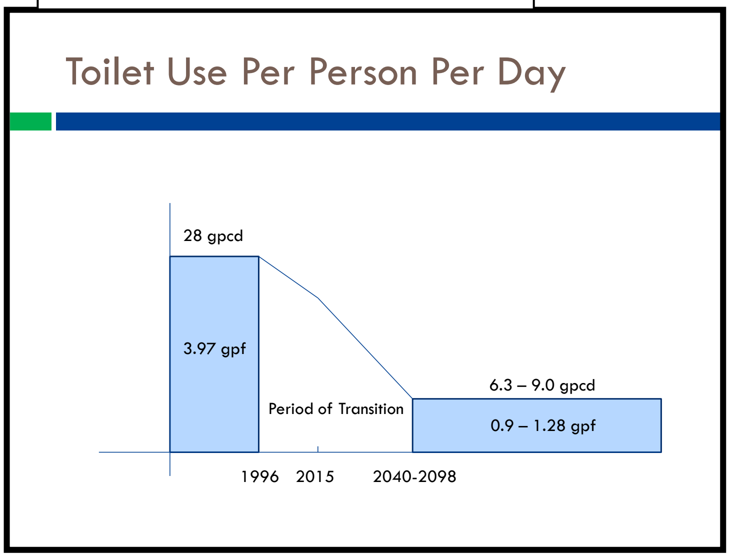
As previously indicated, outdoor water use has increased with new construction. For those entities willing to remove current landscape in favor of native plantings and Xeriscape material, water use reductions can be substantial for existing construction. However, there are a substantial number of home and business owners that are installing automated irrigation systems to maintain turf each year. For this reason, there does not appear to be adequate data to support passive calculations that extend beyond toilets, clothes washing machines and dishwashers.

Passive Savings Calculations

Based on these observations, future water demand reductions associated with passive savings were calculated for each year beginning in 1996, which is when benchmark toilet flushing volume data from Denver was available. The calculations used to estimate future demand reductions were developed for reasonable minimum and maximum scenarios based on the assumptions related to the retrofit of existing housing and commercial construction with high-efficiency toilets, clothes washers and dishwashers as indicated below. The calculations based on these assumptions were used to estimate a range of future passive water savings for each year starting in 2000 and continuing until 2050. Limitations related to the use of these assumptions are discussed at the end of this section.

Toilets – Beginning in 1994, homes and businesses were required to replace older, inefficient toilets with 1.6 gallons per flush (gpf) toilets at the time that toilet replacement was needed (e.g., remodeling, replacement of broken equipment). The first Colorado specific data that was available to characterize average toilet use from this period was from 1996, which indicated that the average flushing volume per toilet in Denver was 3.96 gpf (Aquacraft, Inc., 2006). This average flush volume (which was in the range of other average flush volumes in the literature (SFPUC, 2004)) and the average number of flushes per person per day (which includes both residential (5.05) (Mayer, et. al., 1999) and commercial (2) uses (Vickers, 2001)) of seven was used to calculate the average per capita daily toilet water use in 1996[19]. Future year per capita demand reductions were calculated based on these data and the following assumptions:

Figure 4



- Range for toilet replacement rates - 1.2% (Google, 2010) (minimum) to 4% per year (Alliance for Water Efficiency, 2009) (maximum).
- For pre-1994 construction, toilet retrofits include 1.6 gpf toilets until 2015 at which point all toilets are replaced with 1.28 gpf toilets.
- For pre-2016 construction, all toilets including those replaced since 1996 will be replaced with 1.28 gpf toilets.
- Minimum passive savings are calculated using 1.28 gpf toilets, where as maximum passive savings are calculated using dual flush 1.28 gpf toilets (which average 0.9 gpf) (Caroma, 2009).

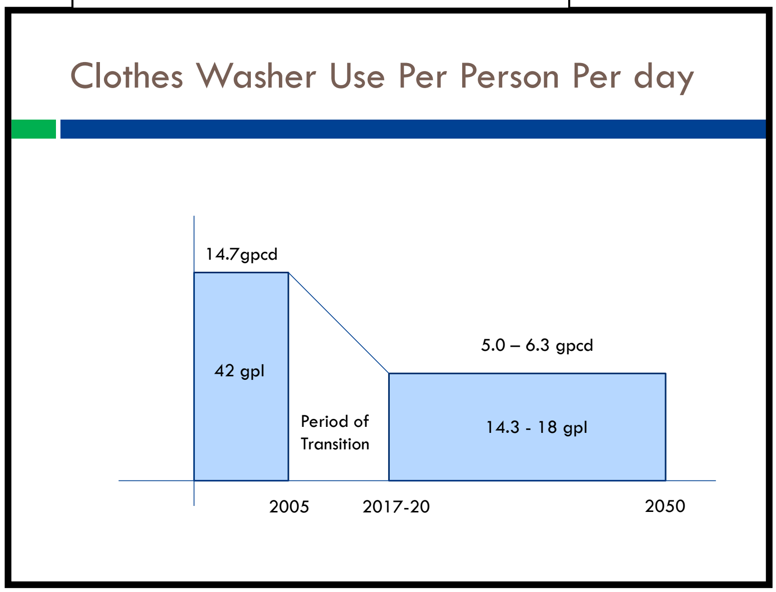
Clothes Washers – The typical top loading washing machine in service in homes and apartments in 2000 used approximately 40 to 45 gallons of water per load (Alliance for Water Efficiency, 2009). Today's high-efficiency

[19] Water savings from the period 1994 to 1996 are assumed to be included in the per capita toilet use data reported for 1996 by Aquacraft, Inc., 2006.

horizontal axis washing machines with a 3 cubic foot capacity can use as little as 12 gallons of water per load, with a typical range of between 15 and 30 gpl (Alliance for Water Efficiency, 2009). Future year per capita demand reductions were calculated based on these data and the following assumptions:

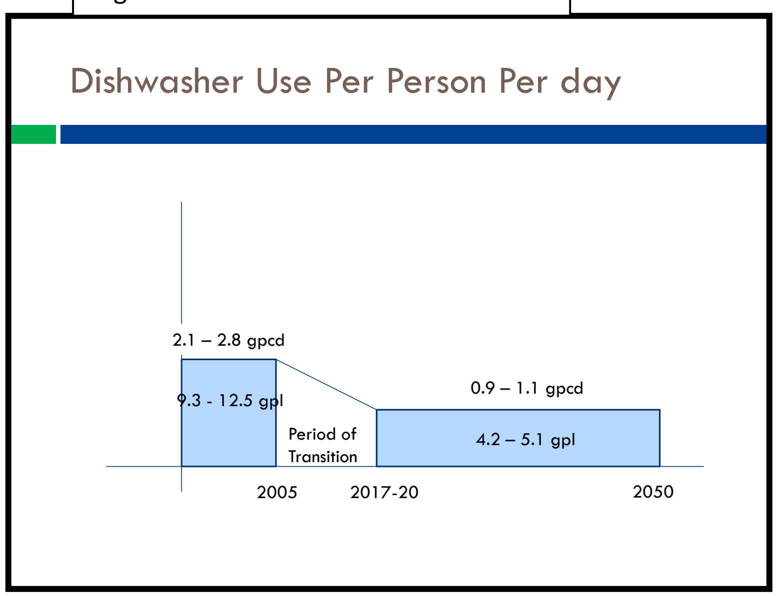
- The replacement rate for clothes washer was estimated to range from every 12 years (8.3% per year) (Alliance for Water Efficiency, 2009) to every 15 years (6.7% per year) (SFPUC, 2004).
- It was further assumed that 42 gallon per load (gpl) clothes washers would be replaced with a combination of HE horizontal axis washing machines and HE vertical axis machines. Project calculations used 14.3 gpl for maximum savings and 18 gpl for minimum savings based on the characteristics of EPA's Energy Star listed clothes washers (see Appendix D).
- Finally, it was assumed that the number of loads of wash per day per person would be 0.35 based on the likely range identified by the Chestnut (2004).

Figure 5



Dishwashers - In 2000, the average gallons of water used per load of dishes was about 6 to 10 (Soap and Detergent Organization, 2000), although the SFPUC estimated its customer's average dishwasher use to be 12.5 gpl in 2000. US EPA indicated that prior to 1994, dishwashers used on average 13 gpl or more, whereas new Energy Star dishwashers use less than 5 gpl (US Environmental Protection Agency and US Department of Energy, 2010). The typical number of loads washed per person per day was estimated to range between 0.1 and 0.3 (Mayer, et. al., 1999). Future year per capita demand reductions were calculated based on these data and the following assumptions:

Figure 6



- The replacement rate for dishwashers was estimated to range every 12 years (8.3% per year) (Alliance for Water Efficiency, 2009) to every 15 years (6.7% per year) (SFPUC, 2004).
- It was also assumed that 9.3 to 12.5 gallon per load (gpl) dishwashers would be replaced with EPA Energy Star dishwashers. Project calculations used 4.2

gpl for maximum savings and 5 gpl for minimum savings based on the characteristics of EPA's Energy Star listed dishwashers (see Appendix D).

- Finally, it was assumed that the number of loads of wash per day per person would be 0.225 based the likely range identified by the Chestnut (2004).

The passive saving calculations were made by calculating the adjustment to per capita water use for each fixture/appliance for each year in the planning period (i.e., 2000 to 2050) in accordance with the reduction that occurs as the market penetration rate shifts from inefficient to high efficiency fixtures and appliances. The market penetration shift occurs over the periods indicated in each of the figures shown previously. This calculation is represented by the equation below.

$$\Delta \text{ GPCD}^{yr}_{fix/app} = \%\text{ Old GPCD}^{yr}_{fix/app} * \text{Old GPCD}_{fix/app} + \%\text{ New GPCD}^{yr}_{fix/app} * \text{New GPCD}_{fix/app}$$

$\text{Old GPCD}_{fix/app}$ = gallons per capita per day for use of inefficient fixture or appliance

$\text{New GPCD}_{fix/app}$ = gallons per capita per day for use of high-efficiency fixture or appliance

$\%\text{ Old GPCD}^{yr}_{fix/app}$ = percent of inefficient fixtures or appliances remaining in use versus total number of fixtures or appliances in use for target population in target year (see Table 5)

$\%\text{ New GPCD}^{yr}_{fix/app}$ = percent of high-efficiency fixtures or appliances in use versus total number of fixtures or appliances in use for target population in target year (see Table 5)

The change in per capita water use by county from the baseline demands of 2000 defined in SWSI I for any given year thereafter is the sum of the individual savings related to the replacement of toilets, clothes washing machines, and dishwashers. This sum is calculated for each year in the planning horizon for both the minimum and maximum savings scenarios.

The total water use for each county was then calculated for each year using the following equation:

$$\text{WU}^{yr}_{County} = (\text{GPCD}_{County} * \text{POP}^{yr}_{County}) - \left(\sum\nolimits_{fix/app}(\Delta \text{ GPCD}^{yr}_{fix/app} * \text{POP}^{fix/app}_{County})\right)$$

WU^{yr}_{County} = Total water use per county for each year[20] (gallons per day)

GPCD_{County} = Gallons per capita per day for each county in the baseline year of 2000 (from SWSI I, see Appendix E)

POP^{yr}_{County} = Population of each county for each year (from SDO, 2010; CDM, 2004, 2010, see Appendix F)

$\text{POP}^{fix/app}_{County}$ = Population relevant to each type of retrofit for each county (see Table 5)

[20] Total Water Use for each county was calculated using this equation for those counties that are predicted to grow. For those counties that are not predicted to grow, or do not grow during any single year, the Total Water Use for that county was calculated as $(\text{GPCD}_{County} - \sum_{fix/app}(\Delta \text{ GPCD}^{yr}_{fix/app})) * \text{Pop}^{yr}_{County})$. Counties with which did not have some growth in every year of the planning period included Baca, Bent, Cheyenne, Clear Creek, Conejos, Costilla, Jackson, Kiowa, Lincoln, Otero, Phillips, Prowers, Rio Blanco, Rio Grande, San Juan, Sedgewick, and Washington. All population in Broomfield County was treated as new growth.

Table 5 – Summary of Years Relevant to Fixture and Appliance Retrofits	
1.6 gpf Toilets	All pre-1994 construction (beginning the transition in 1996)[1]
1.28 gpf Toilets	All pre-2016 construction with 1.6 gpf or greater toilets
Clothes Washers	All pre-2006 construction
Dishwashers	All pre-2006 construction

[1] passive savings prior to 1996 were assumed to be included in the per capita toilet use reported in the literature for 1996 (Aquacraft, Inc., 2006).

Separate calculations were made using the minimum and maximum scenario values presented included in Table 6. **Note that the minimum and maximum passive savings scenarios were developed using only the "middle" population projects developed by CDM for 2050 as reported in Appendix F.**

Table 6 – Summary of Passive Saving Calculation Assumptions

	Per Use[1]		Rate of Use (daily)		Replacement Rate	
	Min	Max	Min	Max	Min	Max
Toilets						
Average Pre-1996 Toilet	3.97 gpf	3.97 gpf	7	7	25 years	83 years
1.6 gpf Toilet	1.6 gpf	1.6 gpf	7	7	25 years	83 years
1.28 gpf Toilet	0.9 gpf	1.28 gpf	7	7	25 years	83 years
Clothes Washers						
Pre-2005	42 gpl	42 gpl	0.35	0.35	12 years	15 years
Post-2005	14.3 gpl	18 gpl	0.35	0.35	12 years	15 years
Dishwashers						
Pre-2005	9.3 gpl	12.5 gpl	0.225	0.225	12 years	15 years
Post-2005	4.2 gpl	5.1 gpl	0.225	0.225	12 years	15 years

[1] gpf – gallons per flush; gpl – gallons per load

Results

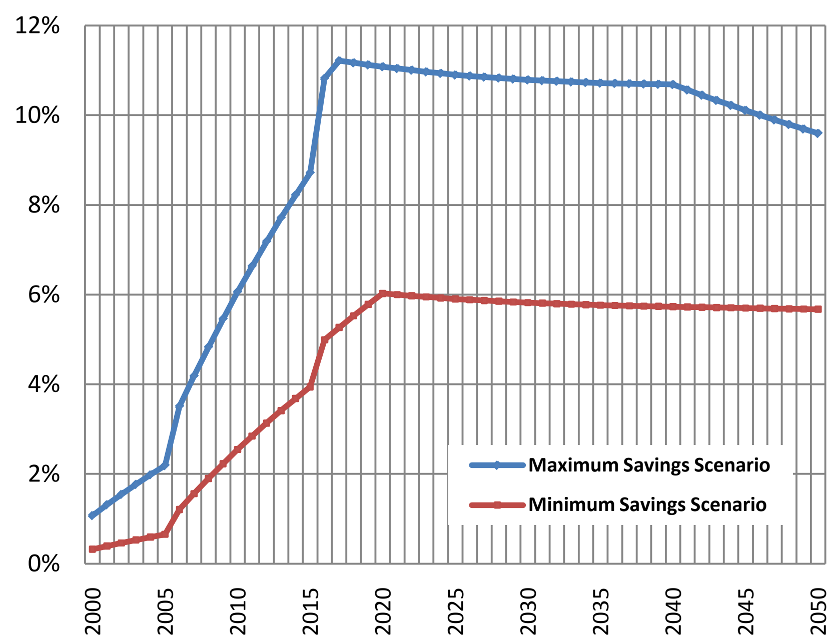
The results of the passive savings analyses indicate that future demand reductions, measured as a percentage of future statewide or basin wide M&I water demand[21], are dependent on both location and time. This is due to the fact that passive savings (measured as a percent of total M&I demand) are dependent on the age of the housing stock, the rate of population growth, current and future per capita water use, and the timing of fixture and appliance replacement. This observation is illustrated by the graph presented in Figure 7. Figure

[21] The method that was used by SWSI I involved developing percent saving estimates to predict passive water savings by basin and statewide. This report presents a similar analysis for comparison purposes.

7 presents the percent of passive savings versus the State's total M&I water demand for each year from 2000 to 2050 using the SWSI I defined baseline (i.e., 2000) gpcd demands by county (see Appendix E) using those assumptions listed in this section of the report.

From this figure, it can be seen that the percent of passive savings relative to statewide M&I demand changes each year. To begin with, a small amount of passive savings is shown to occur as a result of fixture replacements that occur from 1996 to 2000. For the period from 2005 to 2017 (or 2020, depending on the scenario), the percent of passive savings increases rapidly due to the replacement of clothes washers and dishwashers. It can further be seen that once the clothes washers and dishwashers have been replaced by either 2017 or 2020, the percent of passive savings relative to the statewide M&I demand decreases. This observed decrease results from the population increase generating additional demand which out paces the passive savings associated with the installation of high efficiency toilets. After 2017 or 2020, the percent of passive savings are expected to decrease statewide until the end of the planning period.

Figure 7 - Percent Statewide Demand Reduction From Passive Savings



Two key points of interest should be noted by the reader. First, the observed decrease in the percent of passive savings after 2017 (or 2020) may be offset or reversed in the future if technology enhancements or new regulations are developed to improve residential and/or business water use efficiency beyond that represented in the analyses conducted herein. Technologies may be developed to reduce any number of domestic or commercial water uses that would positively impact passive saving estimates after 2020. New ordinances and/or regulations dictating water use efficiency could also be established at the local, regional, state or federal level penetrating 100% of the targeted market, thus allowing for significant increases in passive water savings not included in the current analyses.

Table 7 brings into sharp focus the potential savings that could be realized by statewide legislation, new ordinances or regulations that effect new construction such as those that have been created in California. This table, which summarizes the number of new homes that will exist in Colorado over the coming decades, as compared to those that exist in 2010, provides some insight into the size of the new construction market and therefore the potential impact of new construction ordinances and/or regulations.

Table 7 – Estimated Percent Change in New Housing Stock in Colorado

	2020	2030	2040	2050
% Increase from 2010	20%	40%	57%	75%

Second, the percentages of passive savings as presented in Figure 7 are impacted by the lasting effect of the 2002 drought on current and future water demand in the state[22]. Any lasting drought-related demand reduction that is not considered to be a component of future active water conservation would effectively decrease the State's total M&I demand, and result in an increase in the relative percentage of passive savings. The analyses presented in this report did not discount future M&I demand by any lasting impact of the 2002 drought.

Importantly, the impact of the passive savings on daily per capita water use is not affected by population growth, or the lasting impact of the drought. Figure 8 presents the reduction of daily per capita water use as natural toilet, clothes washer and dishwasher replacement occurs in the State. This figure exhibits the same general trends indicated in Figure 7 – namely the change of savings related to when clothes washers and dishwashers are replaced; however, Figure 8 shows only the change to daily per capita water use, which does not decrease at any point in time, but rather flattens out once maximum passive savings have been realized.

Based on the analyses presented in Figure 8, passive savings are expected to reduce system wide daily per capita water use by between 19 and 33 gpcd by 2050. These savings, which are chiefly associated with residential indoor water use, represent a reduction of between 23% and 39% of the average indoor water use reported by Western Resource Advocates (2003) of 69.3 gpcd[23].

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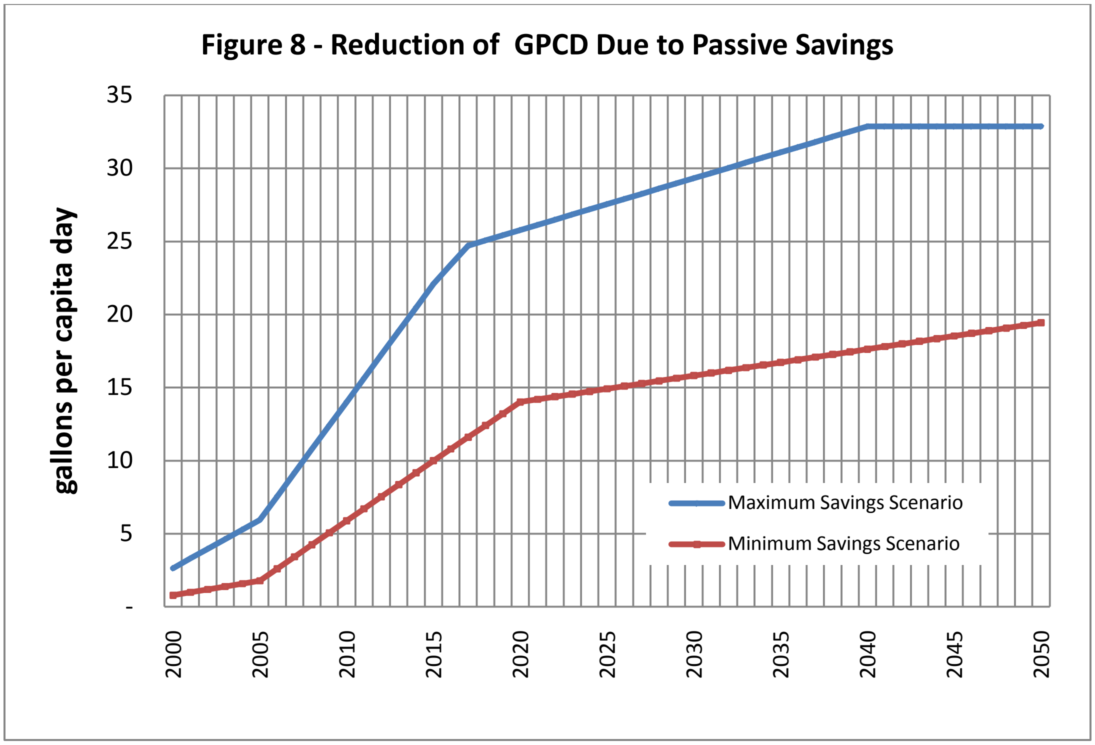
[22] A 22% reduction in M&I demand that was observed in 2003 as a result of the 2002 drought – based on the impact of media messaging, watering restrictions, and other customer behavioral changes. Many water providers in Colorado (Joint Technical Activities Committee, 2010) have indicated that pre-drought water demands may not be observed for many years. If water demand does not fully rebound to pre-drought levels, then passive savings will be greater as a percentage of the reduced M&I demand. Note that in some cases, (e.g., Denver Water and Colorado Springs), local Water Conservation Plans call for the implementation of specific measures and programs that will extend the effects of the drought on customer water use. In these cases, prolonging the drought impact is considered to be active water conservation. In cases where the impacts of the drought extend beyond active water conservation practices, the percentage of passive water savings relative to total &I demand would need to be revised accordingly.

[23] The maximum and minimum savings for residential indoor water use were estimated to be about 17 and 27 gpcd, respectively. The remaining passive water savings relate to water use at businesses associated with increased toilet efficiency.



Another important aspect of passive savings is the predicted water demand reduction by river basin. Passive savings vary by major river basin in Colorado due to differences in housing stock, current system wide per capita water use and expected rates of population growth. Table 8 presents the passive savings estimated for each major river basin in 2030 (to allow for a ready comparison between the 6% passive savings used for passive savings in SWSI I and the results of the analyses performed as a result if this project) and 2050, as a percentage of total M&I demand. Based on the information contained in Table 8, it can be seen that the percent of passive conservation ranges from a low of 4.0% to a high of 11.1% in 2030, with a statewide average of between 5.8% and 10.8% in 2030. These percentages of passive savings decrease over time from 2030 to 2050 as presented in Table 8.

An estimate of the acre-feet of passive savings is a better metric to support planning efforts (e.g., the SWSI update) than the percentage of passive savings, since the acre-feet of savings do not vary by time, per capita water use, changes in future population estimates (after current projections for the years 2010 through 2015), or the lasting impact of drought on future M&I water demand. This is due to the fact that total acre feet of passive savings are only a function of per capita water use caused by the impact of retrofits and /or fixture replacement and the population of each county in 1994, 2005 and 2015 (based on the assumptions provided herein). Population projections changes for the years after 2015 will not change the total acre feet of passive savings estimated using the methodologies presented in this report. Table 9 presents the acre-feet of passive water savings calculated based on the assumptions presented in this section.

Table 8 – Percent of Passive Savings by Major River Basin and Statewide[1]

	2030 (%)		2050 (%)	
	Minimum	Maximum	Minimum	Maximum
Arkansas	5.9	11.0	5.9	9.9
Colorado	4.7	8.7	4.0	6.8
Dolores/San Juan	5.6	10.3	5.2	8.7
Gunnison	5.6	10.4	5.4	9.1
North Platte	5.5	10.2	5.4	9.2
Rio Grande	4.0	7.5	4.1	6.9
South Platte	6.0	11.2	6.0	10.2
Yampa/White	4.8	9.0	3.7	6.2
Statewide	**5.9**	**10.9**	**5.7**	**9.7**

[1] As a percentage of total M&I demand without including self-supplied water supplies.

Table 9 – Acre Feet of Passive Savings by Major River Basin and Statewide

	2030		2050	
	Minimum	Maximum	Minimum	Maximum
Arkansas	18,900	35,100	23,200	39,400
Colorado	6,500	12,000	8,000	13,500
Dolores/San Juan	2,200	4,000	2,700	4,500
Gunnison	2,200	4,100	2,700	4,600
North Platte	30	50	40	60
Rio Grande	1,000	1,800	1,200	2,000
South Platte	70,000	130,000	86,000	146,000
Yampa/White	1,000	1,700	1,200	2,000
Statewide[1]	**102,000**	**189,000**	**125,000**	**212,000**

[1] Statewide totals have been rounded to three significant digits.

Discussion and Recommendations

In practice, it is expected that actual passive savings that will be realized over the coming decades will trend toward the maximum savings estimates presented in Table 9 for a number of reasons. To begin with, water and energy savings will become increasingly important to water customers as water and fuel costs rise. As water customers seek more efficiency in their homes and businesses, high efficiency fixtures and appliances will become increasingly efficient as technology improves and customers strive to reduce their variable costs related to water and energy.

In addition, the potential exists to realize substantial permanent water demand reductions in the future if appropriate regulations and ordinances are developed to address water use in existing and new construction.

Regulation of existing construction can be developed using the California models, to require and inspect for the installation of high-efficiency toilets, shower heads, faucet aerators, dishwashers, and clothes washers as real estate is bought and sold. Regulation of new construction can be even more far-reaching and substantial with respect to future per capita water use demand reductions – since both indoor and outdoor water use can be addressed for all customer types (i.e., residential, commercial, industrial, etc.). Table 7 provides insight into how many new homes will be created in Colorado overtime, as an indication of the potential breadth and relevance of new construction regulations.

Finally, the impact of commercial retrofits (e.g., restaurants, motels, ski area condominiums, centralized laundries, commercial laundries, bars, etc.), is not well captured in the passive savings analyses since information regarding numbers of and ages of individual types of commercial properties were not available. Passive savings estimates will increase as more commercial, industrial and/or institutional water customers install retrofits.

For all these reasons, it is more realistic to expect 200,000 plus acre-feet of passive water savings statewide by the year 2050, than less than 200,000 acre-feet.

There are of course limitations related to the analyses presented in this section. It is vital for any entity or individual that chooses to use the data presented in the passive analyses to understand these limitations. To begin with, total water use adjustments using percentages have limited accuracy. Although information associated with water use by individuals using toilets, clothes washers and dish washer can be estimated on average, substantial differences may exist between counties and river basins due to the age and nature of housing stock and commercial water uses. It is more accurate to utilize estimated reductions in per capita water use for housing stock that is a candidate for retrofits, as opposed to percentages, since percentages change both spatially and temporally.

The impact of passive savings on future M&I water use demand is only one part of the overall puzzle related to predicting future water demands in Colorado. Water use demand reductions in the future may result from any one of the following impacts, in addition to passive water savings:

- Drought related (either related to lasting impacts of the 2002 drought in locations that have not implemented active conservation efforts to prolong drought water use behaviors, or the impacts of future droughts)
- Active savings (related to measures and programs implemented directly by water providers to reduce customer water demand and improve customer water use efficiency)
- Other savings (e.g., increases in density of new construction)

As water demand reductions occur in the future, it will be difficult to discern which of these categories of factors create the observed changes in water use, especially in locations with multi-faceted water conservation programs. Therefore, passive savings may be lumped into other categories of future water savings observed by utilities, such that it may be difficult to measure the exact impact of passive savings within any specific utility's service area without a focused data collection and related customer evaluation program. To this point, verifying passive savings in the future will require coordinated data collection efforts conducted by water utilities and the state taking into consideration the effects of ongoing water conservation programs.

Data collection efforts by water utilities and the State will need to include tracking water use and water savings by individual water customers and customer classes related to specific measures and programs that a utility chooses to implement. The water utilities should also track dollars spent per water conservation measure and program, timing of program implementation, and market penetration rates. More information regarding the data collection efforts that are most valuable will be developed by the Office and the Water Conservation Technical Advisory Group.

Section 6
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