Municipal and Industrial Water Use in the Colorado River Basin: Moving Towards a Paradigm Shift in Water Reclamation

By Matthew McNerney and Shannon Thomas

Key Findings:

-M&I growth will contribute between 64-76% of the total increase in Colorado River demand over the next 60 years.

-The population of the Basin States is expected to approximately double in the year 2060.

-Supply enhancement, namely pipelines, will only continue to exceed the limits on the already diminished Colorado River.

-Conservation is a necessary aspect of meeting future water needs in the Basin.

-Both the Front Range and Las Vegas serve as case studies to show varying conservation strategies that can be used as lessons of effective and ineffective techniques for different water districts.

The 2013 Colorado College State of the Rockies Report Card
Water Friendly Futures for the Colorado River Basin

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Introduction

Today, the Colorado River Basin supplies more than 30 million people with water in the seven basin states.[1] Currently, Municipal and Industrial (M&I) water use comprises between 22-26% of total demand for Colorado River water.[2] According to the Bureau of Reclamation (BOR), M&I growth will contribute between 64-76% of the total increase in Colorado River demand over the next 60 years. This large growth in the M&I sector is mostly attributed to booming populations in the basin. In a recent study, the BOR has produced population projections for several possible scenarios. Maintaining business as usual the Bureau projects we will have 19,840,000 water users in the basin alone by 2060 (not including water users from adjacent areas). When paired with the adjacent areas that also receive Colorado River water to meet their needs, the same projection rises to 62,435,000 water users by 2060.[3]

Meeting increasing water demands while facing a diminishing water supply has been the challenge posed to basin stakeholders in the last decade and has been a fervently debated issue by federal and state governments, water providers, and conservationists. Through this literature we see an increasingly necessary aspect of meeting future water needs in the basin is water conservation, especially in the domestic sector. Reclamation was historically used as a means to control free-flowing rivers with large scale infrastructure projects such as the Hoover Dam and Central Arizona Project, but has now taken the meaning of conserving water in various sectors. Due to drought, population booms, and over-apportionment of the Colorado River, there has recently been a

resounding call across the basin to adopt new measures to minimize water use in order to save water for in-stream flows, recreation, and the possibility of continued posterity in the American Southwest. From ordinances and auditing programs to water reuse and storm water management programs, basin stakeholders are adopting a variety of measures to meet the growing demand for water. This section will take an in-depth look at the varying techniques of water conservation today for municipalities and provide examples of where different techniques are being implemented.

Focusing on the Colorado Front Range, we develop a snapshot of techniques used throughout the basin in the conservation programs of five water providers: Denver Water, Aurora Water, Colorado Springs Utilities, Pueblo Board of Water Works, and The City of Fort Collins Water Department. Based on demographics, location, and seniority of water rights, each water utility has a regionalized approach of how they promote domestic and commercial water conservation. These varying techniques can be used as lessons of effective and ineffective techniques for different water districts. This section will also provide a case-study on Southern Nevada Water Authority in Las Vegas to share another example of effective M&I water conservation measures in one of the basin's largest cities

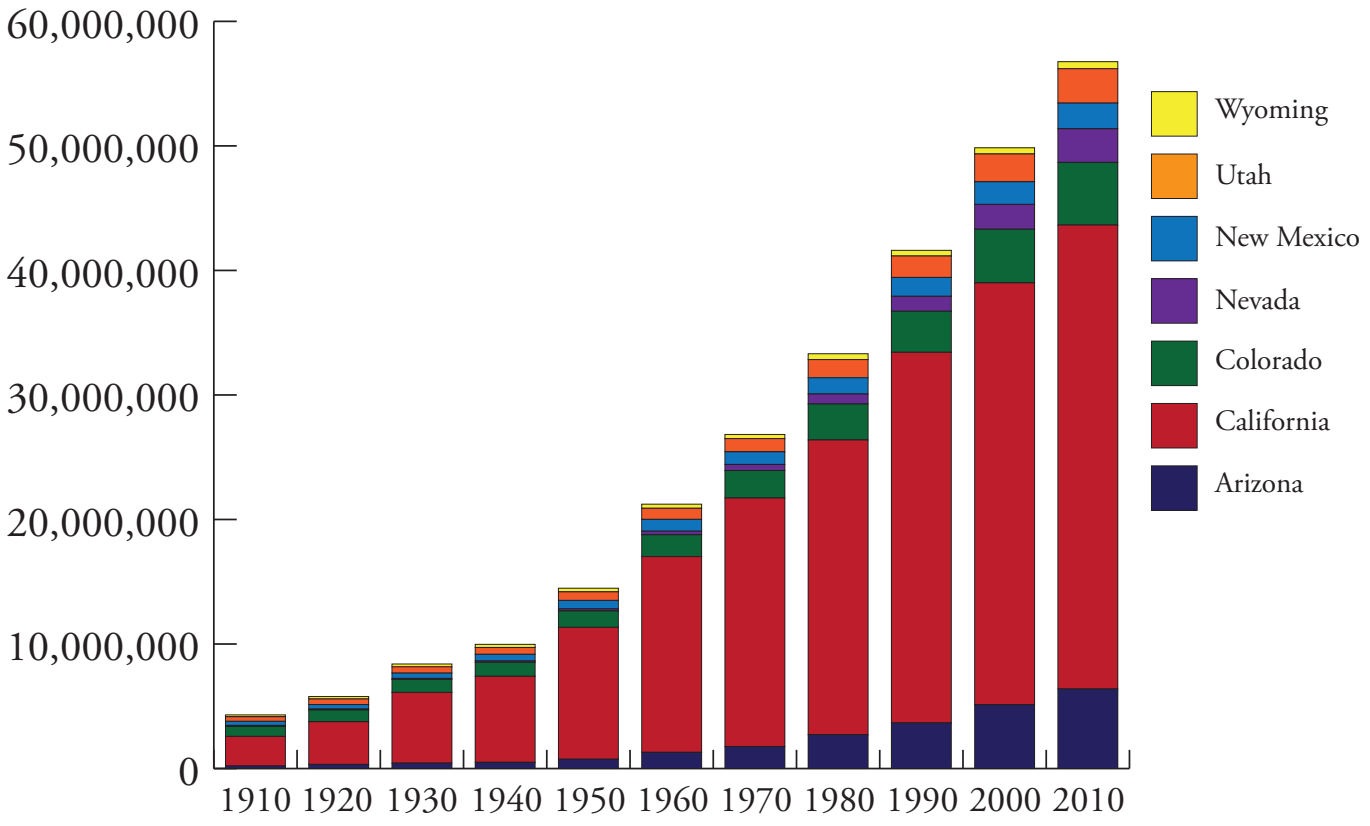
Water conservation can provide substantial results in decreasing M&I water usage, but for many water providers and their communities it is not enough. In order to meet the increasing demand, many are looking towards supply enhancement strategies, such as new large scale infrastructure projects - namely pipelines - to divert new water to major population hubs. One such example discussed below is the proposed Lake Powell Pipeline to St. George, Utah. Conservationists and concerned stakeholders fear that adding additional pipelines will drastically exceed the limits on the already diminished Colorado River.

BOR Supply and Demand

As mentioned in the BOR Overview, the Supply and Demand Study projects future growth of M&I water demand for the Colorado River Basin. M&I water use has increased consistently over the years mainly because of population growth in basin states. These states have contained some of the fastest growing areas in the United Sates and almost all exceed the national average. **Figure 1** shows historical population levels within the basin states while **Figure 2** displays the percent change in population for all seven basin states against the national average.[4]

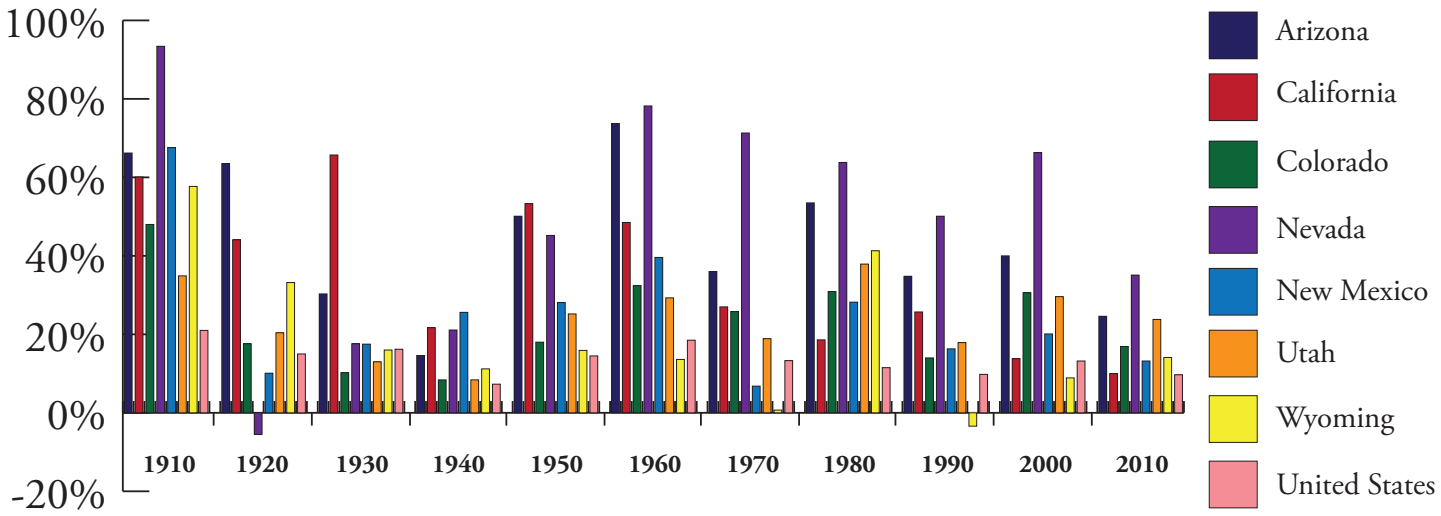
In **Figure 2** we see that all the basin states have exceeded the national average population growth rate from 1980-2010 with the exception of Wyoming in 1990. From 1960-2010, Nevada and Arizona have seen the highest growth in population. In fact, Nevada has maintained the highest percent change from 1960, with an average percent change of 60.80% per decade. In comparison, the U.S. average is shown to be among the lowest population percent changes throughout the 20th century and into the 21st century. From 1910 to 1950, the U.S. average was the lowest compared to all the basin states and continued to be the lowest in 1980 and 2010, with only Wyoming containing the lowest percent change

Figure 1: Historic Population Levels - Basin State Populations from 1910-2010



Source: U.S. Census Bureau, Residential Population Data, accessed July 5, 2012, http://2010.census.gov/2010census/data/apportionment-pop-text.php.

Figure 2: Percent Change in Historic Population Levels - 1910-2010



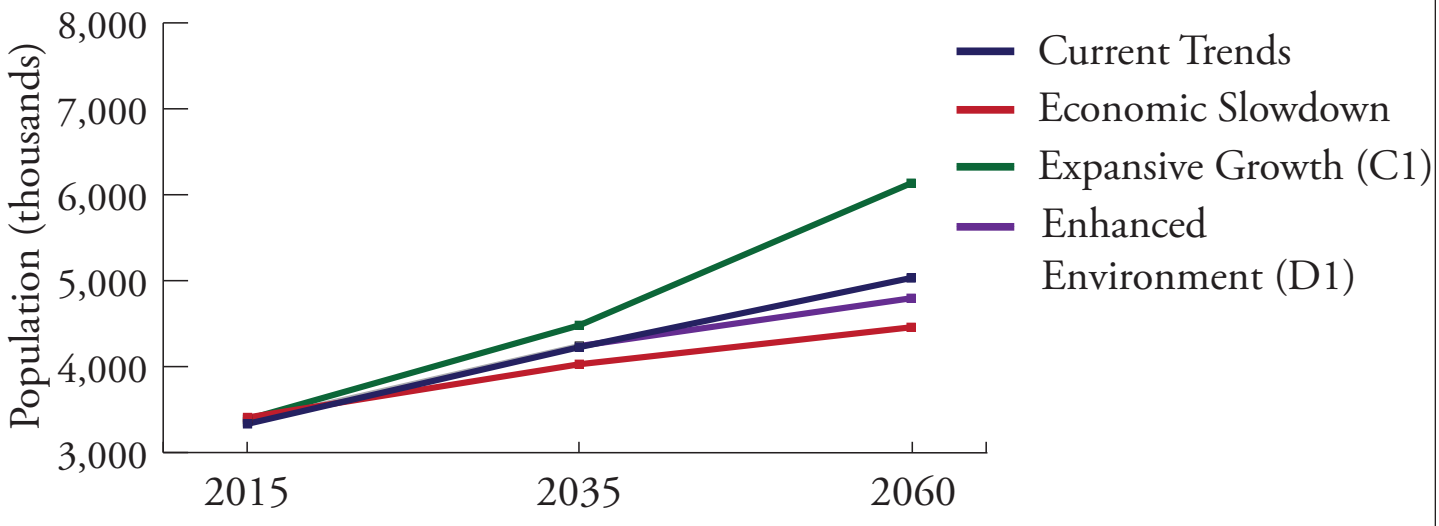
Source: U.S. Census Bureau, Residential Population Data, accessed July 5, 2012, http://2010.census.gov/2010census/data/apportionment-pop-text.php.

in 1960, 1970, 1990, and 2000. From these graphs, though population growth has slowed in recent decades, we can see that growing population has been and continues to be a problem for M&I uses of Colorado River water. With growing demands in M&I uses and an increasing population, future projections will only continue this distressing pattern.

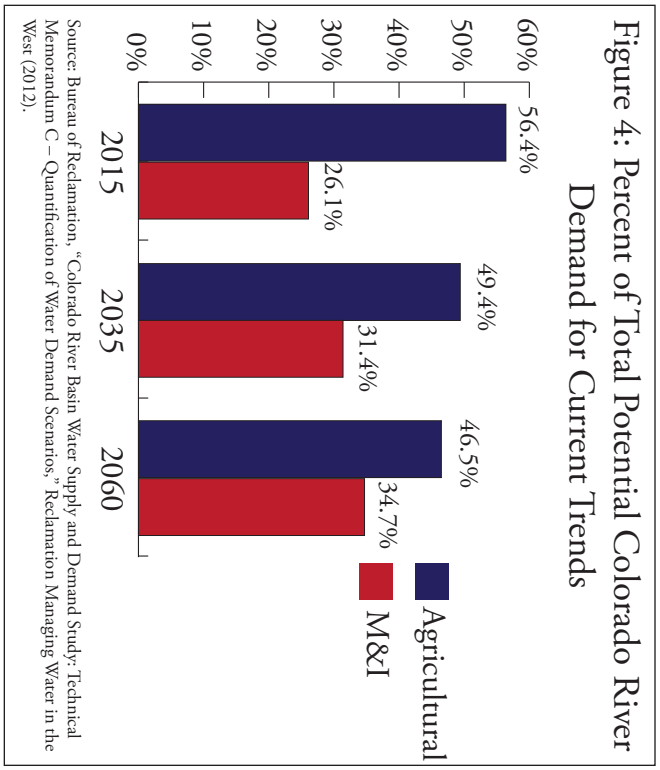
The Bureau of Reclamation study provides population projections depicting four varying scenarios. **Figure 3** displays the population projects for Current Trends, Economic Slowdown, Expansive Growth (C1), and Enhanced Environment (D1). In the graph, we see that through Current Trends, population will increase from approximately 39,953,000 in 2015 to 62,435,000 in 2060. Current trends for population are also used for the Enhanced Environment scenario. While Economic Slowdown predicts a population of 38,856,500 in 2015 to reach 49,262,800 in 2060, The Expansive Growth scenario predicts population levels of 41,141,700 in 2015 to reach an alarming 76,487,000 people in the basin states. From a percent change perspective, this means that for the Current Trends and Enhanced Environment models, population will have a percent change of 56% from 2015 to 2060, an Economic Slowdown model will only produce a 27% increase in 2060, and an Expansive Growth model will produce a disturbing 86% rise from 2015 to 2060.

Figures 4-7 show the percentage increase in M&I demand compared to agricultural demand. As mentioned previously, increases in population have been the primary cause for the increase in M&I demand. As the second largest component of overall demand, M&I demand is expected to increase from approximately 27% in 2015 to 33-38% in 2060 depending on the scenario.[5] Of this percentage, 19-32% of the increase is expected to occur in the Upper Basin, while the remaining 68-81% will occur in the Lower Basin.[6] When examining the Upper Basin, increases in M&I demand are

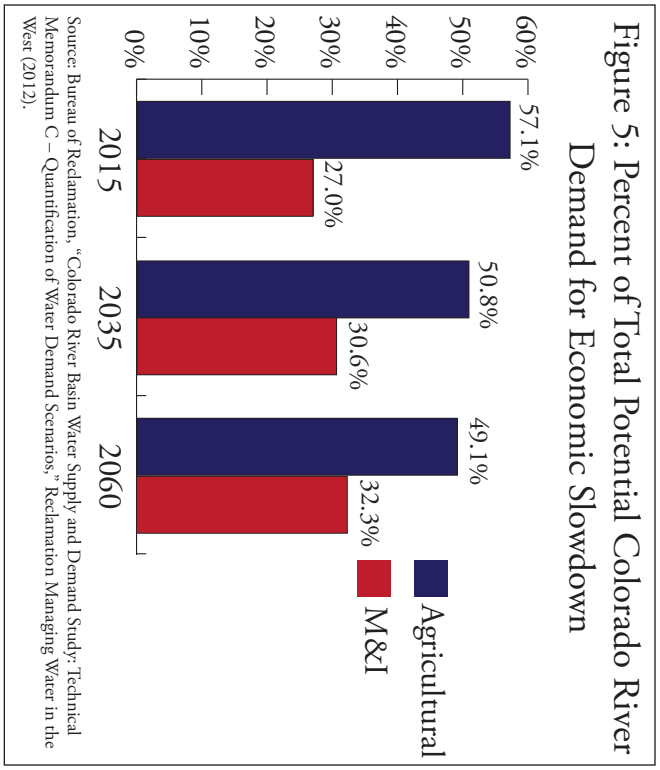
Figure 3: Total BOR Population Projections for the Basin States



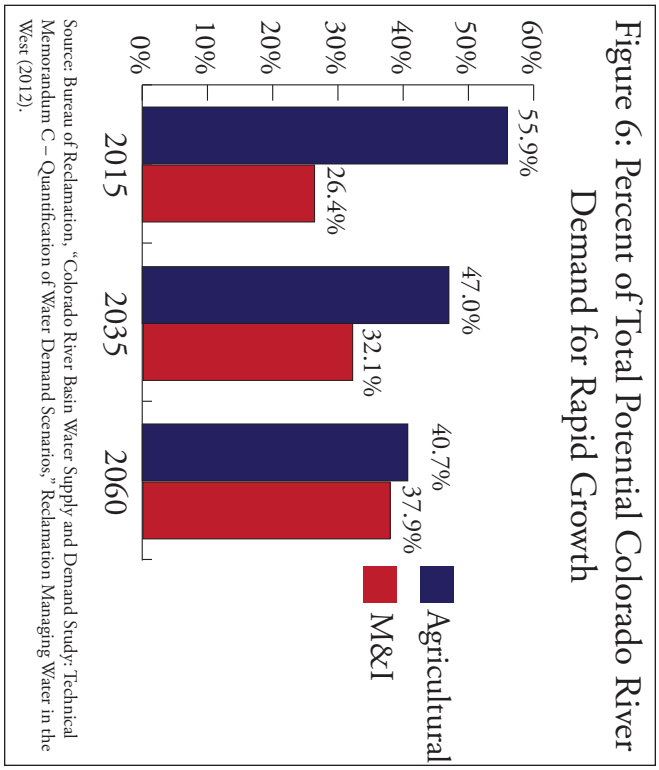
Source: Bureau of Reclamation, "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios," Reclamation Managing Water in the West (2012).



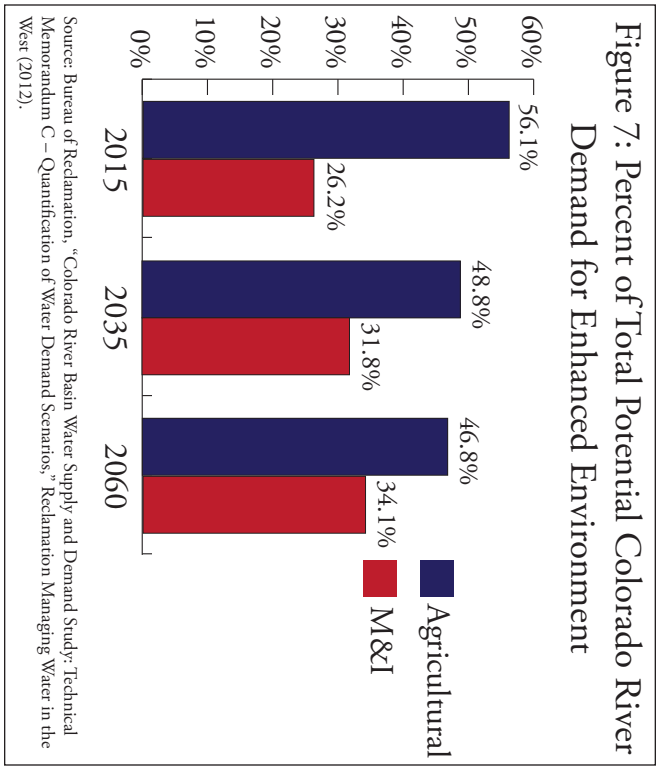
Source: Bureau of Reclamation, "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios," Reclamation Managing Water in the West (2012).



Source: Bureau of Reclamation, "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios," Reclamation Managing Water in the West (2012).



Source: Bureau of Reclamation, "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios," Reclamation Managing Water in the West (2012).

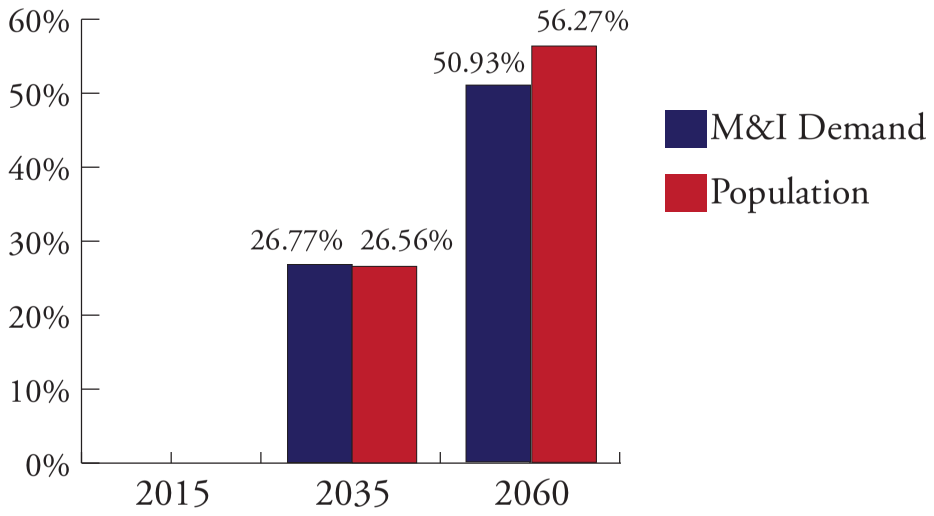


Source: Bureau of Reclamation, "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios," Reclamation Managing Water in the West (2012).

mostly due to projected population growth in Colorado, with the remaining demand predicted in New Mexico and Utah, and a small increase in Wyoming. In the Lower Basin, Arizona is expected to have an increase in M&I demand of 50% while together California and Nevada will make up the other 50% in all scenarios.[7]

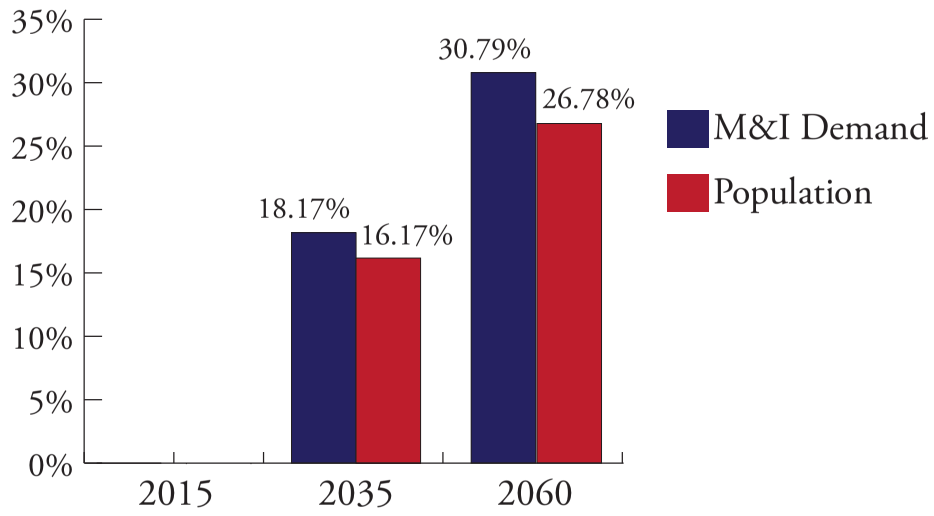
When viewing the percent changes in both population and M&I demand, both changes are similar and follow the same trend. **Figures 8-11** show the percent changes in population compared to M&I water use for each scenario. From these graphs, **Figure 11** shows the most idealistic scenario: Enhanced Environment. Even though population continues to increase for the "best estimate" predictions, M&I demand contains a significantly lower percent change. This is due to growing environmental consciousness and stewardship paired with a growing economy.[8] Increasing social values and awareness for the Colorado River Basin are essential, but also pose the greatest challenge. This change in values involves a paradigm shift in the public perception of future water supplies and necessitates a shift in understanding the need to conserve more water.

Figure 8: Population Percent Change versus M&I Demand Percent Change for Current Trends



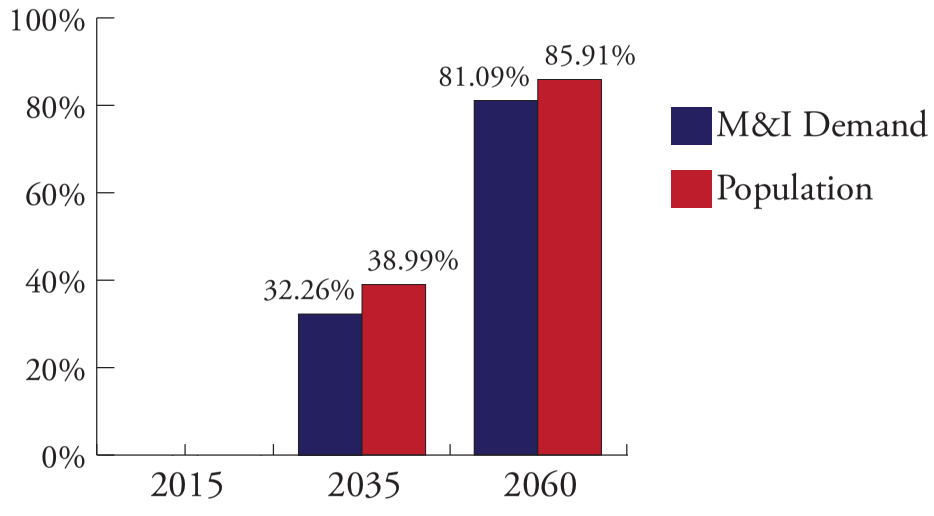
Source: Bureau of Reclamation, "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios," Reclamation Managing Water in the West (2012).

Figure 9: Population Percent Change versus M&I Demand Percent Change for Economic Slowdown



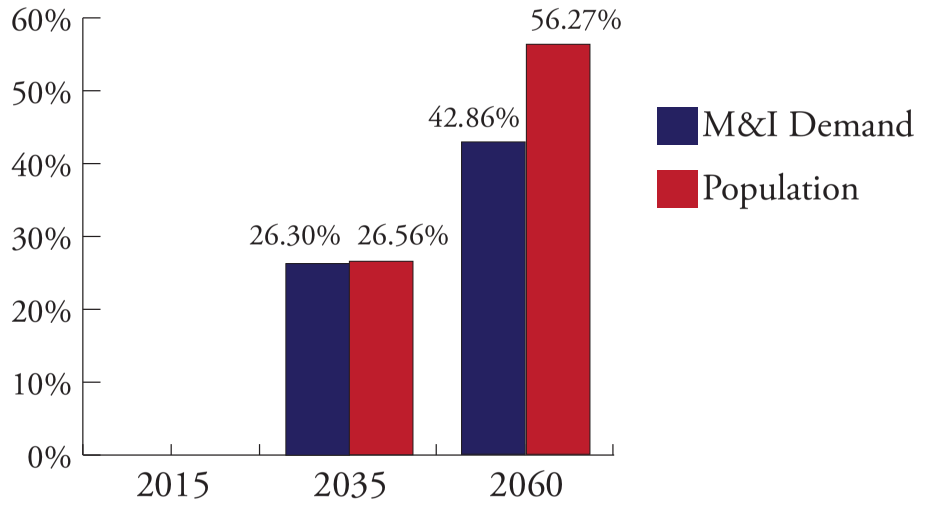
Source: Bureau of Reclamation, "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios," Reclamation Managing Water in the West (2012).

Figure 10: Population Percent Change versus M&I Demand Percent Change for Expansive Growth



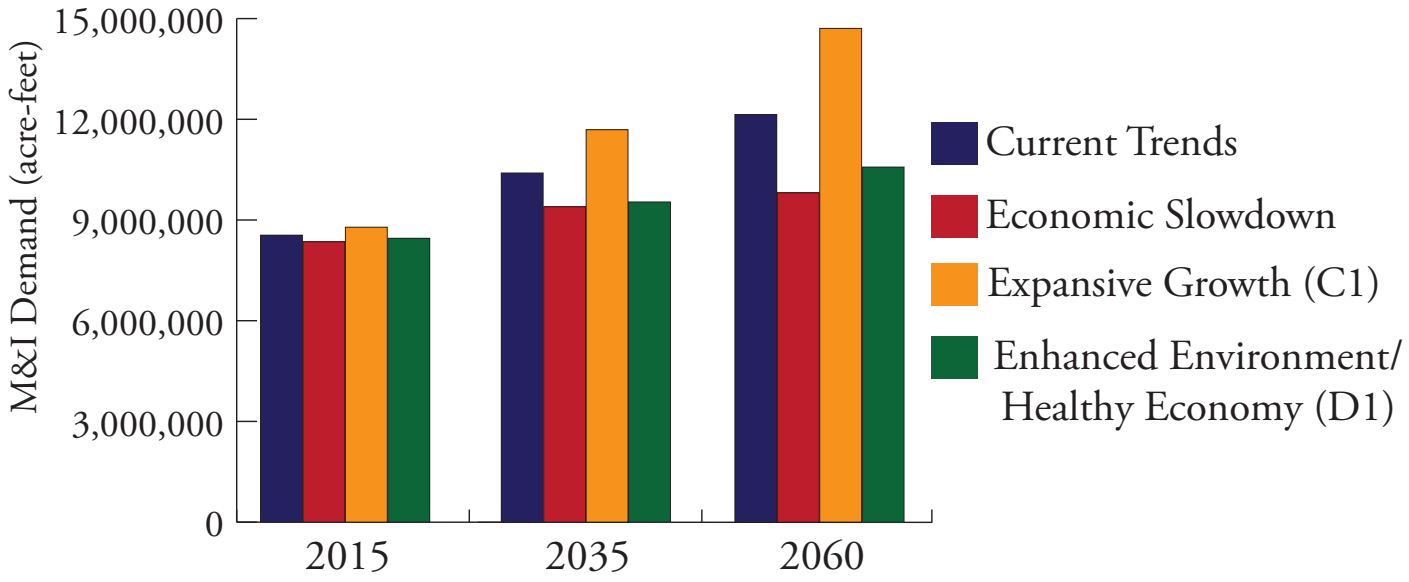
Source: Bureau of Reclamation, "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios," Reclamation Managing Water in the West (2012).

Figure 11: Population Percent Change versus M&I Demand Percent Change for Enhanced Environment



Source: Bureau of Reclamation, "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios," Reclamation Managing Water in the West (2012).

Figure 12: Total M&I Demand (acre-feet)



Source: Bureau of Reclamation, "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios," Reclamation Managing Water in the West (2012).

Figure 12 displays total M&I demand from 2015 to 2060. All scenarios show an increase in demand, but the Expansive Growth model continues to be the most alarming due to the large increase in population. The four models for M&I uses contain the following results:

-Current Trends model shows an increase in demand from 8,547,528 acre-feet in 2015 to 12,140,626 acre-feet, a percent change of 42%.

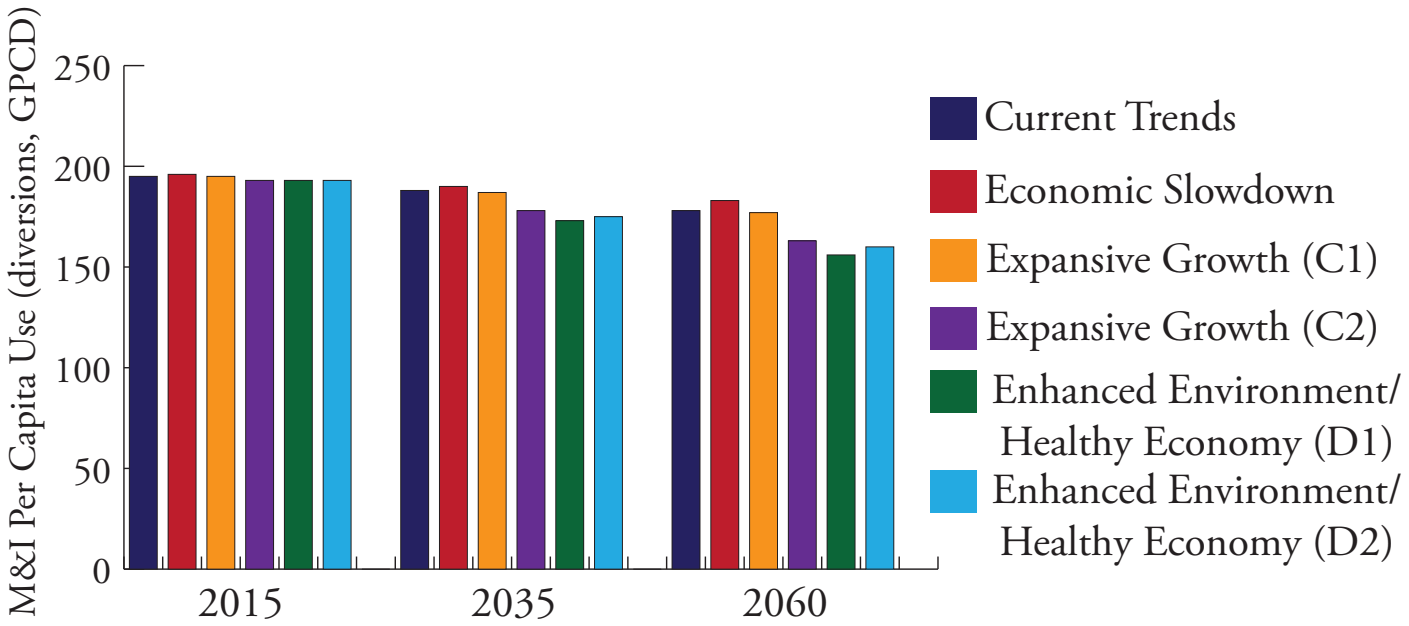
-Economic Slowdown shows that demand increases from 8,351,954 acre-feet to 9,809,819 acre-feet in 2060, a percent change of 17%.

-Expansive Growth demand increases from 8,785,467 acre-feet to 14,707,607 acre-feet in 2060, showing a percent change of 67%.

-Enhanced Environment demand starts out at 8,455,154 acre-feet and increases to 10,567,359 acre-feet by 2060, displaying a percent change of 25%.

Unlike M&I demand, per capita water use is projected to decrease in all four scenarios and in six out of the seven basin states. Wyoming is the only state where per capita rates increase partially due to expected urbanization of rural regions.[9] **Figure 13** displays each scenario with relation to

Figure 13: Total M&I Per Capita Use



Source: Bureau of Reclamation, "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios," Reclamation Managing Water in the West (2012).

M&I per capita use from 2015 to 2060. While total demand for M&I uses continues to increase over the next 50 years, M&I per capita use will actually decrease over the next half century. M&I per capita water use is measured by amount of water produced or diverted per person in a given municipality (industrial, commercial, and residential). From this graph, we see that the Enhanced Environment scenario shows the largest decrease in per capita consumption with a percent change of -19%, while an Economic Slowdown model shows the smallest decrease in usage with only a -7% change. When viewing the data state-by-state (**Figures 14-20**), the majority of states are predicted to decrease their per capita consumption with the exception of Arizona in the Economic Slowdown model and Wyoming in all models except Enhanced Environment. Decreases in per capita water use arise from improvements in indoor fixtures and appliances, which to some extent offset M&I demand from increases in population.[10] Due to current conservation plans, per capita water use in the Colorado River Basin and adjacent areas is expected to decrease by 7-19% from 2015 to 2060.[11]

Figure 14: M&I Per Capita Use for Arizona

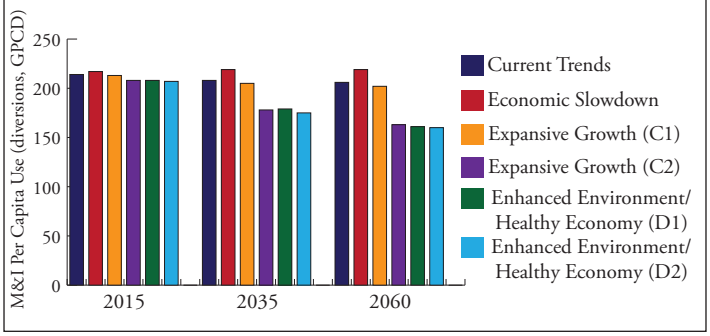


Figure 15: M&I Per Capita Use for California

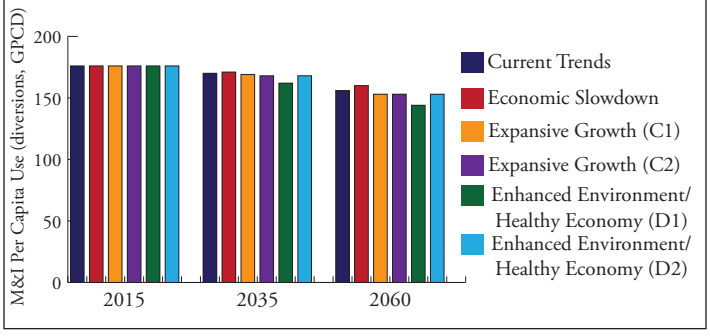


Figure 16: M&I Per Capita Use for Colorado

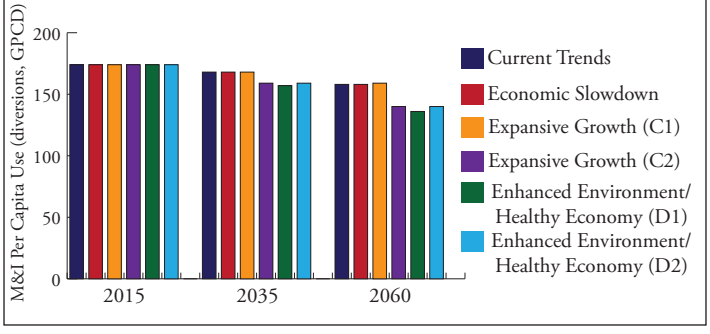


Figure 17: M&I Per Capita Use for Nevada

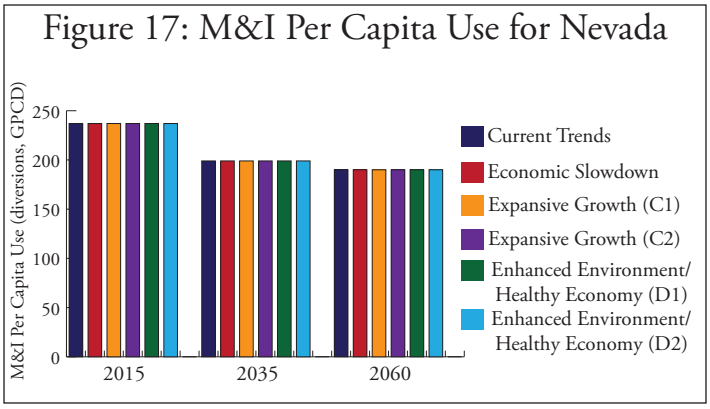


Figure 18: M&I Per Capita Use for New Mexico

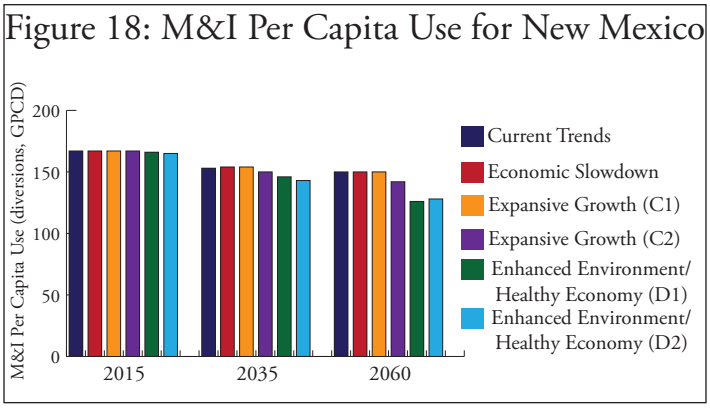


Figure 19: M&I Per Capita Use for Utah

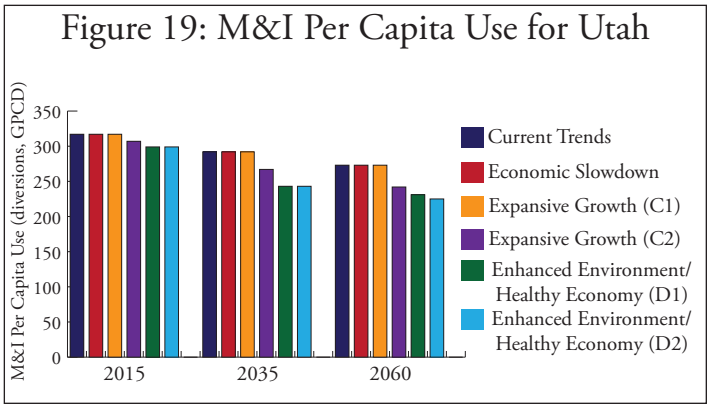
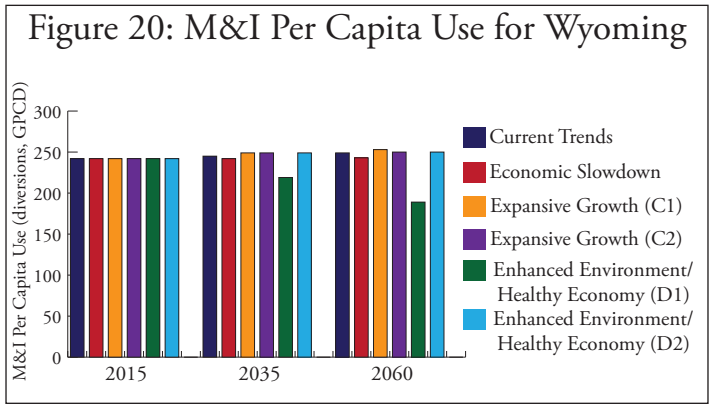


Figure 20: M&I Per Capita Use for Wyoming



Source for Figures 14-20: Bureau of Reclamation, "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios," Reclamation Managing Water in the West (2012).

Figure 21 provides an overview of the seven basin states with respect to change in population, per capita water use, and percent of total Colorado River demand. From this table, we can see the large variability in the expected population, per capita use, and demand for Colorado River water depending upon the scenario analyzed. Out of the scenarios examined above, the greatest water conserving scenario for the future of M&I demand would be Enhanced Environment (D1). Under this situation, population levels would remain consistent with the current "best estimate" projections along with increased federal investments in water conservation, government regulation, and social values.

Figure 21: Overview of Projected Population, Per Capita Water Use, and Colorado River Demand All Scenarios

	Approximate Populations for 2015	Expected Populations for 2060	Expected Change in Per Capita Water Use by 2060	Percent Growth of Colorado River Demand by 2060
Colorado	6 million	9-11 million	9-22% less	2-27% growth
New Mexico	1.5 million	2-3 million	11-24% less	14-63% growth
Utah	2.4 million	3.7-6.2 million	14-25% less	19-26% growth
Wyoming	.31 million	.37-.44 million	4% more-22% less	15-50% growth
California	20.4 million	19.8-34.6 million	9-18% less	4-7% growth
Arizona	7 million	9.8-16 million	1% more -23% less	5-41% growth
Nevada	2.3-2.6 million	4.2-5.1 million	20% less	63-100% growth

Source: Bureau of Reclamation, "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios," Reclamation Managing Water in the West, 2012, Appendix C2 4-6, Appendix C3 4-6, Appendix C4 4-6, Appendix C5 4-6, Appendix C6 4-8, Appendix C7 6, Appendix C8 4.

Municipal and Industrial Water Conservation Techniques and Practices

Faced with current and projected conditions, in order to avoid the high end population and water use projections presented above, it is necessary to find new and innovative ways to satisfy water demand. Yes, agriculture accounts for 70-80% of the water in the Colorado River Basin, and 89% of the water for the state of Colorado, but over time agricultural water uses are decreasing, while M&I uses are increasing.[12, 13] Moving forward, the most substantial savings will not be in the fields and farms, but on the lawns and in the washrooms of our homes and businesses. Simply put, providing water for the projected populations in 2060 will require alternative strategies; continuing business as usual runs the risk of exacerbating basin-wide water scarcity.

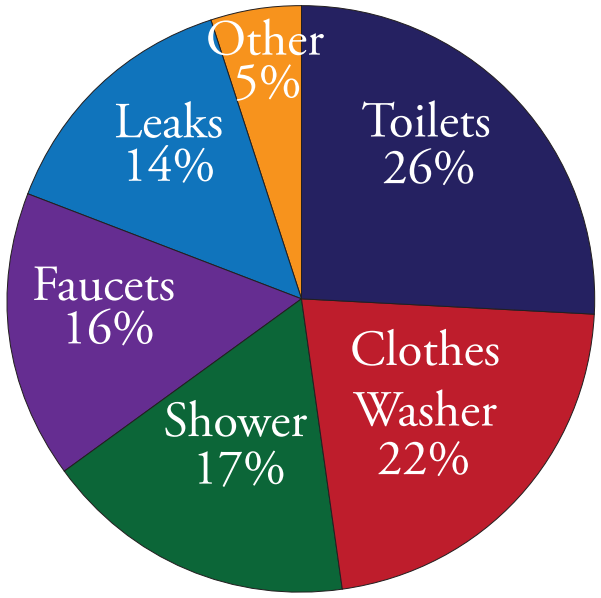
Water utilities in every major municipality have plans for meeting future water demands. Their plans include supply enhancement such as the construction of new infrastructure, and the revitalization of current infrastructure to improve efficiency, as well as demand management, such as conservation techniques. The following section focuses on conservation in the home and community, exploring the many water conservation techniques and practices in use today, and offering examples of where these techniques are being utilized around the basin.

Indoor Conservation

Water use in the home typically accounts for 30% of our monthly water bills, the other 70% being used outdoors.[14] Of this 30% the vast majority is from everyday fixtures and devices. One of the simplest ways to conserve water in the home is by replacing toilets, faucets, and other fixtures with more water efficient ones.

As seen in **Figure 22**, the single greatest use of water in the home is flushed down the toilet about five times a day. Toilets account for roughly 26% of indoor water use, about 18 gallons per day. Washing machines are a close second, compromising 22% of indoor use, followed by showers and faucets.[15] Besides just not flushing and washing, here are several ways to reduce these numbers. The availability of improved water use technology, along with top-down mandates, such as the national Energy Policy Act (EPAct) of 1992, are key forces at play to reduce the number of gallons per flush, gallons per load, and gallons per minute for indoor fixtures. Stricter state legislation is being proposed in Colorado today, and great strides are being made in California to bring these mandated numbers down as well.[16, 17] In the 1950s, a toilet could have used up to seven gallons per flush

Figure 22: Average Residential Water Use In Homes by Type



Source: Western Resource Advocates, "New House New Paradigm: A Model for How to Plan, Build, and Live Water-Smart" (Boulder, Colorado, 2009), accessed August 2012, http://www.westernresourceadvocates.org/water/newparadigm/NewParadigmReport.pdf.

Case Study: Lake Powell Pipeline

Large scale infrastructure projects, or supply enhancements, always have and always will draw controversy. From the construction of Hoover Dam in the early 20th century, to the proposal for the Flaming Gorge pipeline today, each is surrounded by controversy, and each comes with a long list of pros and cons. On the summer 2012 State of the Rockies research trip our team had the opportunity to take a closer look at the issues surrounding one such large project, while still on the drawing board. In St. George, Utah, student researchers met with a water conservancy in favor of, and a conservationist group opposed to the proposed Lake Powell Pipeline. The proposed pipeline would draw nearly 100,000 acre-feet of water from Lake Powell each year to Washington and Kane Counties, Utah. The water would be pumped through a 139-mile, 66-inch underground pipeline. Depending on whom you ask, the estimated cost of the pipeline ranges from $1.6 to $3.2 billion.

From our discussions we found the greatest argument in favor of the pipeline is the impending need for a more stable water source. As St. George and the surrounding counties continue growing, people are starting to realize they need alternatives for water sources, and for some the most practical of these alternatives is to build a pipeline.

The greatest argument against the pipeline is the high price tag: Washington County will bear the brunt of the costs. For those who doubt the necessity of such an expensive project, the question arises of whether funding could be better spent on different supply enhancement or demand management measures. Furthermore, since the pipeline will be financed through state bonds (which must be paid off at a later date), some citizens in the area are realizing the project could mean increases in both their taxes and their water bills.

Washington County has experienced some of the highest growth rates of any county in the basin. Between 2005 and 2006, Washington County experienced the highest growth rate of any county in the country, and the next year it ranked second. One of the biggest questions regarding the construction of the pipeline is whether this growth will continue.

As of now the pipeline is in the planning phase. The Lake Powell Pipeline Development Act was passed in 2006 and currently the Washington County Water Conservancy District (WCWCD) would like to see deliveries from the pipeline begin between 2020 and 2025. Pending legislation from the State of Utah Legislature, the project will get off the ground, but there is an army of dissenters. In the Lake Powell Pipeline Development Act of 2006, the state agreed to finance the pipeline through bonds, which the participating counties will have to repay over a 50- to 60- year period. The big question opponents of the pipeline are asking is: How can Washington and Kane counties repay these bonds? **Figure 23** examines some of the key issues surrounding the pipeline and discusses the pros and cons of each.

Figure 23: Pros and Cons of the Lake Powell Pipeline

Issues	Basics	For	Against
Costs	2006 Lake Powell Pipeline Act outlined financing for the project through the State of Utah, which will be repaid by Washington and Kane counties over a 50- to 60- year period. Estimated costs of the project vary and will not be truly realized until after completion.	Through block-by-block financing the two counties will be able to use a block of water and repay the state of Utah on a block-by-block basis, financed by impact fees, development fees, and property taxes.* Current costs estimates by WCWCD are $1.6 billion.	The burden of repaying the pipeline costs will be great for Washington and Kane counties. If the pipeline were to cost $2 billion, for example, the counties would have to repay an average of $45 million per year. Current costs estimates by Citizens for Dixie's Future (CDF) range from$1.8-$3.2 billion.**
Water Needs	Currently Washington County has a 75,088 AF total water allocation. The county currently uses 62,098 AF, leaving approximately 12,000 AF available. Currently per capita water usage for Washington County is around 270 gpcd.***	High end population projections estimate Washington County will be short of water by 2020, with conservation initiatives. The creation of the Lake Powell Pipeline is the only way to supply the increasing water needs of the county.	Increasing conservation, through such techniques as increasing water rates, and setting ordinances for landscape irrigation, along with Agriculture to Urban water transfers can supply the water needs to meet this impending gap.
Population Projections	2008 population projections from the Governor's Office of Planning and Budget estimated population of 279,864 by 2020 and 860,378 by 2060; recently revised estimates have dropped those numbers to 179,396 by 2020 and 498,239 by 2060.	Ron Thomson, the general manager of the WCWCD, argues that the new projections are a low-ball number and the new pipeline is still a necessity to meet incoming demand in his district.	The population estimates the pipeline was originally based on were set in a time of unprecedented growth, which has since decreased since the economic downturn. Recent estimates released show a decreased need for the pipeline.

Sources: [18, 19, 20, 21, 22]

Notes: * Washington County Water Conservancy District is one of few water providers who is able to collect revenue through property taxes levied on customers.
** High end cost estimates include an estimation of construction costs for Hurricane Cliffs Pump Storage Plant.
***Per capita water usage varies based on sources, 270 gpcd agrees both with literature supplied by WCWCD and numbers supplied by Paul Van Dam of Citizens for Dixie's Future (CDF).

(gpf); today, a high efficiency fixture can use one gpf or less. In the 1980s and 1990s, a washing machine could use up to 50 gallons per load (gpl); today, that number is halved.[23] The challenge is figuring out how to convince customers to replace outdated fixtures for modern, highly efficient ones. There are several ways to do this as previously mentioned; one option is through government mandates. This is known as passive conservation and occurs when producers and consumers are required to construct and purchase more water efficient devices. Another way to achieve this is through rebates, provided by water utilities or local governments, which incentivize consumers to replace their outdated fixtures through offering compensation for all or part of the cost.

An additional way to achieve conservation indoors is through educating and encouraging consumers to take matters into their own hands. Anyone can go to the local hardware store to purchase the most water efficient devices, or even adopt water efficient practices, such as only running full loads in the washing machine and turning faucets on only when needed. This topic of education will be discussed later in the paper, as it is arguably the most important means to achieving water conservation.

Besides replacing our fixtures, there are other ways to conserve. An individual toilet leak alone can waste more than 100 gallons per day (gpd). Although this is the exception rather than the rule, a 1999 AWWA study found that the average water lost for homes with toilet leaks is 21.9 gpd. Leaking toilets, faucets, and pipes are a huge waste and an easy fix. Identifying leaks can be as simple as listening for running water coming from fixtures, or in the case of toilets, by applying a line of dye along the inside of your toilet and looking to see if it runs. These simple measures can lead to great savings.[24]

These changes can take place in industrial and business settings as well. High efficiency urinals today are entirely waterless. Replacing water use fixtures in offices and homes reduces water bills and more importantly reduces the burden to the Colorado River.

An example of a successful toilet rebate program occurred in Los Angeles in the 1990s. Starting in 1990, the LA Department of Water helped to fund, through rebates and community involvement, the installation of more than 900,000 1.6 gpf toilets. The program saved an estimated 28.7 million gallons per day (mgd), and around 31.7 gpd per toilet replacement. From 1990 to 2000 the program spent around $107 million – that's about $3.70 per gallon saved. When the city surveyed their customers, they found that 80% said they would be likely or somewhat likely to participate in the program a second time.[25]

Outdoor Water Use

By far the largest use of residential water is spent outside the home, watering our lawns and landscaping our properties. A 25-by-40 foot area of lawn consumes around 10,000 gallons of water in one summer. Planted turf grass covers 25 million acres of U.S. soil, an area roughly the size of the state of Virginia.[26] To maintain this turf grass, Americans spend around $750 million a year on seeding lawns, and $25 billion for landscaping equipment and maintenance.[27] Here in the West where water sources are scarce and strained, it has reached a point of necessary self-reflection in which homeowners should ask themselves if the grass in their front yard is more important than the Colorado River reaching the Pacific Ocean as it once did. Curtailing our outdoor water use can be done in many ways, and as with indoor conservation, there are big and small steps to be taken, all leading in the right direction.

Simple water efficiency measures can be taken to reduce use. For starters, not watering during the heat of the day saves water by reducing losses to evaporation. It is generally accepted that the rate water lost through evaporation and transpiration is roughly 50-70% of the open pan evaporation rate.[28] Another crucial way to conserve is by discontinuing the practice of watering our sidewalks, driveways, and streets. Monitoring sprinkler systems and paying attention to their placement will greatly reduce water loss. Most importantly, however, is the use of water-efficient technologies: replacing sprinklers with more efficient systems, installing rain sensors, and using hose nozzles/shut-off devices are a few of the many tools that can be used.[29, 30]

These measures are reactive, but there is also a need for proactive measures in the planning and design of new and old landscapes. The use of native and adaptive plants is an important step forward to replace nonnative turf grass with vegetation more inclined to live in an arid or semiarid environment. The term xeriscaping was coined by Denver Water in 1981, combining "landscape" and "xeros," the Greek word for dry. This innovative term introduced a new idea of water efficient landscaping.[31] An all too common misconception is xeriscaping means rocks and cacti. This does not have to be the case. The American West contains a stunning variety of plant life. Water efficient landscaping utilizes plants adapted to flourish in this part of the country. Xeriscaping is not confined to the Colorado River Basin however; below are seven principles of xeriscaping as outline by a University of Georgia study:[32]

1. Proper planning and design

Before retrofitting a turf area or constructing a new landscape it is important to have a plan. Taking into consideration such things as water use zones, shade areas, and site characteristics are important aspects of a successful water efficient landscape.

2. Soil analysis

Soil can make or break a landscape. The higher quality the soil the more water it will retain, and the more efficient it will be. Before planting it is necessary to inspect the soil and see if it will meet the needs of whatever is being planted in it.

3. Appropriate plant selection

When choosing plants for your xeriscaping project there are many considerations involved. How much water is needed? What plants require what amounts of water? Choosing drought resistant plants and planting based on similar watering profiles will increase landscape efficiency.

4. Practical turf areas

Xeriscaping and water efficient landscaping does not mean a zero grass yard. As long as it is well planned and watered there can still be a place for practical turf areas. The important thing to recognize is that this should not be the entirety of a landscape. The going maxim states: if the only time you walk on your lawn is behind a lawn mower, take it out. Homeowners and businesses can also use water efficient grasses such as blue gramma and buffalo grass, which require 80% less water than Kentucky bluegrass.

5. Efficient irrigation

Irrigate different plants and areas differently. By smart planning and grouping plants of similar water needs together, one can save on irrigation. Using alternative techniques is also effective. Switching to drip irrigation systems, especially for plants with lower water needs, and avoiding sprinklers that cause misting or are improperly placed are essential.

6. Use of mulches

Mulch can reduce evaporative losses, cool soil, and control weeds. Mulching is an important part of water efficient landscaping. It keeps water in the soil. One can also top-dress a lawn by applying a thin layer of mulch on top of the grass. This will increase the organic content of the soil, protect grass roots, and decrease evaporation rates.

7. Appropriate maintenance

Too often watering systems operate without human involvement. A crucial aspect of water savings outside is maintenance. Inspecting fixtures, sprinkler heads, hoses, etc. is a simple and easy way to ensure not to incur water loss to leaks and inefficiencies.

Many water utilities promote xeriscaping and water efficient landscapes through demonstration gardens and rebates. These gardens allow customers to see what xeriscaping can look like in their own backyards and can be an important tool in the planning process of personal home gardens by offering examples of appropriate plants.

Rebates: Addressing Indoor and Outdoor Water Conservation

As mentioned in the previous two sections rebates are often offered by water utilities as a way of incentivizing customers to purchase more efficient water technologies, such as replacing indoor fixtures, irrigation and sprinkler systems, or turf grass for more efficient landscaping. Rebates can either cover the entire cost of replacement or a portion of the cost as incentive (often times 50%). A good example of successful rebate programs can be seen with the Southern Nevada Water Authority (SNWA). The SNWA offers a turf replacement program that pays participating customers between $1.00 and $1.50 per square foot of turf removed.[33, 34] The authority's Water Efficient Technologies program provides various rebates for both outdoor and indoor technologies such as a rebate of $200 or 50% of the purchase price for smart irrigation controllers.[35] The SNWA provides customers with a free device replacement and retrofit program where the authority will give faucet aerators, water efficient showerheads, toilet flappers, and leak detection tablets to homes built before 1989.[36]

An interesting criticism of rebate programs is they are not worthwhile because passive conservation (e.g., government legislation) will eventually require the replacement and use of the same efficient technologies. The EPAct of 1992, for example, set the standard for toilets at 1.6 gpf.[37] A similar argument is made based on market demand. As consumers become more informed about water savings, they will choose to purchase water efficient devices and appliances, thus the companies manufacturing such devices will be motivated to produce water efficient products. Although such arguments do have some grounding, rebates programs such as those offered by the SNWA have proven an effective way to reduce water demand in the short run.

Audits

Audits are another successful tool used by water providers to implement indoor and outdoor conservation measures. Water audits consist of trained technicians surveying homes and offices to evaluate water uses and offer suggestions to property owners on how to change watering practices, replace devices, and fix water leaks. These audits are meant to be education oriented as they offer a way for consumers to learn where there are inefficiencies in their water usage. This is often seen as the most successful way to implement many of the indoor and outdoor conservation measures discussed previously.

Water audits can be especially useful for promoting water savings in the commercial sector, as these are often the largest water users in a municipality. Commercial customers are concerned with meeting their bottom line – to produce and/or sell their products for the lowest feasible cost. Conducting water audits for business customers allows both the water provider and customer to recognize where the organization may be using more water than needed. Curtailing this use means lowering water bills and more efficient production.

Denver Water along with other water providers offer free water audits and replacement of inefficient devices to low income households. Lower income families are going to be less likely to pursue these changes on their own, but as with commercial customers, customers participating in such audits will reduce monthly water bills.[38]

Reuse

There are many ways to reuse water to increase water efficiency: from city wide infrastructure; to capture, treat, and return previously used water back into the system for non-potable uses; to collecting shower water to flush toilets and irrigate landscapes. On an individual scale, water reuse can be a cost effective way to increase water efficiency in the home, but there are arguments against it. Using reclaimed water can encourage excessive irrigating. Consumers may have the impression they are saving water and therefore will use more on irrigating than they otherwise would. While there is some validity to this argument, consumers who go out of their way to reuse water are likely to be more conscious of water usage and would not fall into such a conundrum. On a large scale, reclaimed and reused water can be taken through systems installed by municipalities for similar reuse, or to be sent

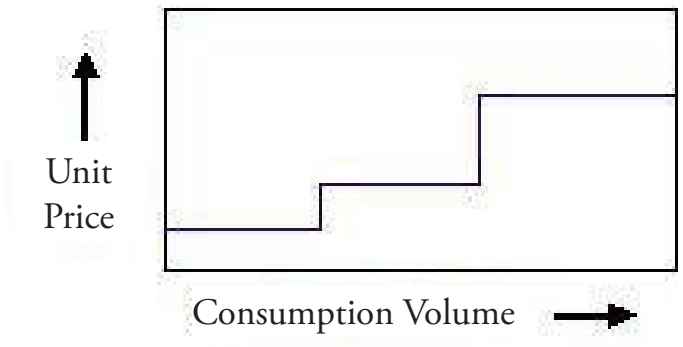
through treatment facilities and reintroduced into the water source, either recharged into aquifers or simply sent back to the river or reservoir it initially came from.

Rate Structures

One of the most effective tools water providers use to incentivize efficient water use is billing structures. Consumers using excessive water can be charged a higher fee to disincentivize overuse. The most common form of this is known as increasing block rate pricing (**Figure 24**). This is a system in which water use is priced in blocks. Low water usage corresponds with low rates for essential uses while higher water usage corresponds with higher rates. Once a customer's water usage surpasses a certain level in a given month, a higher rate will be charged for subsequent use.

Research suggests block structures are most effective when blocks are properly sized and rate increases are large enough to get consumers attention. Ideally the first block of water use will be enough water for the average single family's indoor water use, the second block should allow for efficient irrigation, and the third and possibly fourth blocks should correspond with higher and potentially wasteful usage. It is suggested the most effective block should increase approximately 50% for each tier in order to properly inform customers.[39] Block rate pricing has been found to be more effective with lower and middle income customers than with the upper class customers, as price signals are weaker for the wealthy.[40] The responsiveness to change in prices is known as price elasticity of demand, a measurement of how demand will change when price is affected. A California study found price elasticity of demand for single family residences of -.2, meaning that a 100% increase in the price of water would lead to a 20% decrease in demand.[41]

Figure 24: Average Residential Water Use In Homes by Type



Source: Western Resource Advocates.

Other conservation oriented rate structures include budget based and seasonal rates. Both are more common for commercial customers, but some cities, such as Boulder, Colorado, use budget based rates for residential customers. Budget based rates are first determined by calculating historical averages and necessary/acceptable use. Every customer is assigned a specific, budgeted amount of water. Customers who abide by their budget see very low water bills, while those using more than the allotted amount experience high water bills as a penalty. Seasonal water rates function to disincentivize water usage during peak demand periods in the year. Under these rate structures, customers will pay more for water in the summer than the winter months.

Land Use

The population boom in the southwest since the end of World War II is not over. The Bureau of Reclamation demand projections expect population growth along the lines of 56% in the next 50 years with the current best estimate predictions.[42] This growth means new development and infrastructure, which translates to new opportunities to build water efficiency into homes, developments, and offices. Building with water efficient landscapes, fixtures and appliances, and modifying zoning regulations locks in water savings. Smart growth requires multiple layers of planning. Local governments have the greatest influence on smart growth, but both state and federal governments can influence as well through mandates, regulations, and funding. Water efficient growth necessitates cooperation between water providers and users. Smart growth can be promoted by utilities through offering discounts for efficient developments. This can be in the form of density bonuses (larger lots consume more water) or ordinances, such as the SNWA's banning of turf in front of homes.[43] There are many water efficient developments being lived in today: from Daybreak, Utah, to Sterling Ranch, Colorado, to Civano, Arizona, communities are beginning to learn to build homes suited to their surroundings.[44]

Civano Neighborhoods

The Civano Neighborhoods in Tucson, Arizona, started in the 1990s as the Tucson Solar Village Development with the goal of building an ecologically friendly and efficient community. The community was created as an antithesis to urban sprawl and inefficient resource management. It is one of the first communities to incorporate new-urbanism principles of community and anti-sprawl within an environmental and conservationist framework.[45] In a Memorandum of Understanding drawn up with the city of Tucson, Civano set standards for water use as 53 gallons per capita per day for indoor use, and 28 gallons per capita per day for outdoor use, roughly half the average gpcd for Tucson according to some estimates.[46, 47] The Civano developers put their focus on limiting outdoor water use as it is where the most water is wasted in nearby Tucson. The neighborhoods only use lower water use landscaping with the exception of a few practical turf areas. Outdoor community areas and many homes are irrigated with reclaimed water as well. Total water demands in the community are 20% lower than Tucson's during winter months and 40-50% lower during the high usage summer months.[48]

Ordinances/Mandates

Government legislation and mandates or restrictions by water providers are strong tools for implementing water savings. Legislation, such as the EPAct of 1992, and restrictions, such as the SNWA's no turf grass in front yards, are examples of top-down rules and regulations that prohibit water waste. There is a wide variety of these initiatives all with the guiding principle of telling people how they can and cannot

use their water. A major benefit of such initiatives is their far reaching quality. A restriction on watering times affects an entire community, influencing consumer behavior. As stated previously, there is an array of mandates and restrictions of varying severity. A common example is days of the week watering restrictions (e.g., odd number home and business addresses can only water Tuesday, Thursday, and Saturday). Water providers inform their customers as to what days of the week they can and cannot water, followed up by enforcement, which can either be education or penalty based. Such programs can lead to inefficiency, however. For example, the Pueblo Board of Water Works previously implemented such a regulation, but the water provider noticed that by mandating customers to water on specific days, customers paid less attention to precipitation and irrigated more than previously. Now, as opposed to mandating restrictions, the Board of Water Works requests their customers only water their lawns three days a week. This allows customers to make informed decisions and account for rainfall in their irrigating.[49]

EPAct 1992

The Energy Policy Act of 1992, commonly known as the EPAct, addressed such issues as energy efficiency standards, energy conservation, and the use and acquisition of energy in many fields. In terms of municipal water conservation, the act established maximum use standards for toilets, urinals, faucets, and showerheads. The act stated that future production of such products was required to be under certain levels. Toilets were mandated to 1.6 gpf and urinals to 1.0 gpf. The act set maximum flow requirements for showerheads and faucets at no more than 80 pounds per square inch, which equates to 2.5 gallons per minute (gpm). The act also established labeling standards. This required all such products to bear clearly legible labels indicating flow rates.[50]

Social Norming

Social norming is a new idea in conservation that encourages users to save by sharing comparisons of individual water use to neighbors and the surrounding community. It relies on simple competition and the age old custom of getting ahead of one's neighbors. The practice has seen some success for energy utilities, which have been using the same idea but with electricity bills.

The Sacramento Municipal Utility District began sending out energy use report cards to various customers in 2008. The statements included a bar graph comparing individual energy use, the energy use of 100 additional houses of similar size, and 20 houses with exceptional energy use. The report cards also provided a smiley face rating of either two smiley faces for exceptional usage, one smiley face for good usage, or a frowning face for poor usage (the frowning face was eventually phased out due to too many complaints from customers). The first assessment of the program concluded that customers who received report cards reduced their energy consumption by 2% more than customers who received regular statements.[51]

A 2011 study was conducted in the greater Atlanta region to examine the effects of norm-based messages on water users. Different water users received different conservation messages. Some received water conservation tips with their water bills, while others received those tips along with a comparison of their water use to their neighbors' use. The study found that residents receiving only technical advice reduced their water use by around 1% while residents receiving norm-based messages reduced their usage by around 5%. The study also found high water users who are less influenced by price signals, such as increasing blocks rates, were the most responsive group to social norming.[52]

A potential way to introduce social norming on a large scale for water usage is through metering. Automated/Advanced Metering Infrastructure (AMI) is a new technology that can remotely meter household water use and then report water use to residents by request or on a scheduled basis.[53] With this technology it would be possible to implement social norming into water bills by simply gathering water use data for neighborhoods and supplying averages and efficient use data.

Education

Education is considered by many to be the most important resource for achieving water savings. Although education is the least quantifiable of the listed water conservation techniques and practices, it is how conservationists, utilities, and governments inform consumers about responsible water usage and the value of water itself. Homes and businesses can be told a thousand times over not to waste water, but if consumers do not understand the critical state of the basin and all of the resources going into producing the water supply they will not have the appreciation nor knowledge to pursue water savings and efficiency on their own. Passive conservation and locked-in savings can only go so far. As is the case with rebate programs, there will come a time when the market is fully saturated with high-efficiency devices. Moving forward from there requires informed water users. Helping people to understand the value of shorter showers, turning off faucets, fixing leaks, and minimizing outdoor watering is going to be critical in the coming years as the water supply in the basin becomes more stressed.

Education programs take many forms. From teaching children in schools, to offering adult water use classes, to performing water audits and pursuing informational advertising campaigns, these are all popular and important ways to educate the community at large. Reaching out to children either in school programs or water festivals, where kids can come together to celebrate and learn about water, are great ways to communicate with the youth about how they can save and appreciate their water. Working with the younger generation is a crucial step in long-term conservation as it will influence the next generation of home and business owners. Although adults are a more difficult population to reach, adult education classes are also important. Working with adults on such things as outdoor water use and water saving tips for inside the home can influence consumer behavior and reduce usage. Since the adult population is not already sitting in a class room as our students are, it is necessary to find alternative methods to educate adults. One technique for achieving this is to require

Case Study: Las Vegas: Southern Nevada Water Authority (SNWA)

When speaking of a city using its water resources poorly, more often than not one hears mention of Las Vegas: the opulent sin-city of America, right smack in the middle of the Nevada desert, slurping up the precious waters of Lake Mead and the Colorado River. Surprising as it may be to hear, Las Vegas is just the opposite. The growing desert metropolis has actually become one of the greatest examples for effective water conservation in the Colorado River Basin.

The state of Nevada was apportioned the smallest water allocation from the Colorado River out of the seven U.S. basin states, receiving 300,000 acre-feet annually, only 1.8% of the Colorado's allocated water. When the compact was written in the 1920s, Las Vegas was still a small town, agriculturally based, with little need for much water. Today, Las Vegas has more people per square mile than any city in the West besides Los Angeles. This combination of huge population and a relatively small apportionment of Colorado River water has necessitated the city to come up with creative and innovative solutions to using its water efficiently. The Southern Nevada Water Authority (SNWA) was created in 1991 as an agreement between seven regional water agencies with a goal of changing competition to cooperation and learning. The SNWA regulates the Las Vegas Valley's water resources and spearheads the valley's water conservation initiatives.

Approximately 90% of the valley's water comes from the Colorado River with the other 10% made up of ground water. Up until the 1970s, Las Vegas was a city almost entirely dependent on groundwater, with the majority of the downtown area based off wells. It was due to rapid growth in the 1980s that Las Vegas became reliant on the Colorado River.

Many people's first thought when they hear Las Vegas and water usage is of casinos, resorts, golf courses, and general excessive water usage for the entertainment of millions of tourists. However, the greatest water usage in the valley is not in these entertainment hubs, but rather in everyday residential homes.

As we can see from **Figure 25**, resorts and golf courses account for only 13.9% of metered water usage in the valley while residential single family use accounts for 45% of metered use. Thus, as with many other cities across the basin, the greatest area for water savings is in outdoor residential water use.

The SNWA has four principal demand management tools used in conjunction with each other to reducing water usage. The tools are: educating the public, regulating water use, pricing water to send conservation signals, and incentivizing efficient use. The authority attempts to interlink these four tools with the idea that in order for them to accomplish the greatest savings they will need a little bit of everything.

Education

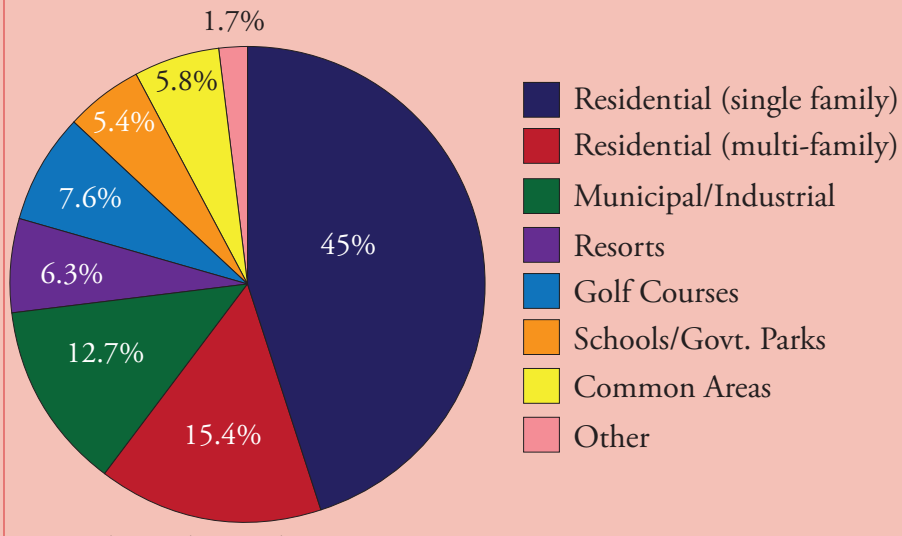
The SNWA education initiative is aimed at increasing consumer buy-in into various programs, as well as teaching the community how to use water responsibly in a desert environment. One of the more interesting programs is H20 University. This is a program designed to work with teachers, and provides lesson plans for teaching water conservation in the classroom. The idea behind the program is not directly sending utility personnel into schools, as many utilities are doing, but rather it can be more effective by educating teachers, thus enabling those who really understand how to reach out to the youth to share conservation ideas with the students. This allows fewer utility resources to be dedicated to the program, while increasing effectiveness.

The SNWA, as well as many other cities, has a public relations campaign, including billboards, television and radio commercials, and direct mail. This campaign is aimed at informing water users how and where they can save with simple messages. The SNWA also sponsors community outreach events, and runs demonstration gardens to further share ways in which the community can save water. But education is not limited to these programs alone. Looking at the authority's other demand management tools, education initiatives are implemented into many other programs, connecting the dots of the conservation nexus.

Partnerships

A crucial aspect of water conservation recognized by the SNWA is the ability to partner with private organizations in order to achieve a dispersal of knowledge and information for consumers. As opposed to consumers constantly being told how to save water and how they must save water, in the case of mandates, the SNWA sees the importance in linking their goals with other organizations around the community. This allows for multiple sources of water savings and water conservation ideas and practices to inundate water consumers with knowledge about smart practices. The SNWA has partnerships through the following programs to achieve this goal:

Figure 25: Average Residential Water Use in Homes by Type



Source: Southern Nevada Water Authority.

Water Conservation Coalition (WCC)

Created in 1995, the WCC is a coalition of local community leaders who work to spread the knowledge of water conservation throughout the community. Members of the WCC speak and work with individuals and businesses in the community to encourage participation in water savings programs offered by the SNWA. For example, in 2008 the WCC worked with Boys Town Nevada, homes for at-risk youth, to install water efficiency upgrades. The program is estimated to have save 2.2 million gallons of water a year.

Water Upon Request

The Nevada Restaurant Association, the WCC, and the SNWA have worked to implement a water savings initiative with local restaurants to only serve glasses of water when customers request them. For every glass of water that is not served, an estimated 1.5 to 3 gallons of water is saved. Currently over 300 restaurants are participating in the program.

Water Smart Home

The Southern Nevada Home Builders Association has partnered with the SNWA to develop a program that certifies new homes with a Water Smart label. These new homes are built with water efficient appliances and devices, as well as with water efficient landscaping. The Association is the nation's largest program for building new water efficient housing. The SNWA also works closely with WaterSense, the EPA program, which provides information on water efficient and environmentally friendly products. SNWA's Water Smart home program is now the model for WaterSense's New Homes Program.

Water Smart Car Wash

This program certifies water efficient car washes and encourages consumers to bring their cars to certified establishments through offering coupons. Certified car washes collect all of their waste water for it to be sent through treatment plants and returned into the system.

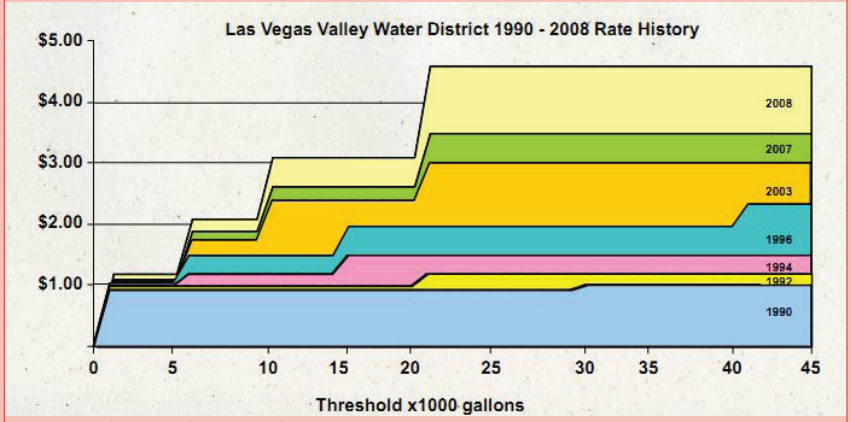
Regulation

One of the biggest differences between the SNWA and other water providers and authorities is the success of their regulation initiatives. The greatest one being turf grass restrictions. For residential homes, lawns are prohibited in front yards and cannot exceed 50% of the land area in new back yards. The idea of practical turf areas is strong here, with the notion if the only time you walk on your lawn is to mow it, it is unnecessary. For nonresidential developments, lawns are prohibited. Although many would at first balk at such stringent restrictions, through education meant to help people understand the reasons for such measures, these regulations have proven to be successful. The SNWA has also been working on regulations with the many golf courses in the valley. After placing a moratorium on the construction of new golf courses in 2003-2004, the authority began a water budgeting system for golf courses based on irrigated acreage. Each course is allotted a certain amount of water, and those exceeding their allotted use will pay high surcharges. This program was implemented in conjunction with water smart landscaping conversions, through which the authority helped golf courses convert unnecessary grass areas into more practical landscapes. Currently, over 35 million square feet of grass has been converted. From 2002-2003 to 2003-2004 alone, golf courses saw a 10% reduction in water use. The other major regulations implemented by the SNWA are their day-of-week and time-of-day watering restrictions. In the winter months, consumers are limited to watering one day a week, three days a week in the spring and fall months, and any day in the summer months. The reason for this delineation is because it was discovered that as opposed to the summer, it was actually the fringe seasons when consumers were over watering. Consumers are also limited to time-of-day restrictions where they can only water between 7 pm and 11 am from May 1st to October 1st. These restrictions are monitored and regulated by the member agencies that send out personnel to inspect water use. Those found not following the regulations are subject to increasing fines, the first being a warning and subsequent offenses carrying fines that double with each successive violation.

Water Pricing

The SNWA's member agencies utilize increasing block rate price structures to encourage efficient water use and penalize those consumers using excessive amounts. The rate structure is set up in a way that the first tier is subsidized by the higher tiers. The tiered rate system allows for growth while incentivizing smart water use. **Figure 26** shows the progression of the Las Vegas Valley Water District's rate history from 1990-2008.

Figure 26: Historical Las Vegas Valley Water Rate Structure



Source: Southern Nevada Water Authority.

Incentives

By far the best known incentive program implemented by the SNWA is their turf rebate program. This program offers consumers a rebate for every square foot of turf grass removed and replaced with water efficient landscaping. The program offers consumers $1.50 for every square foot of grass removed. Thus far the program has converted 160 million square feet and saved 59 billion gallons of water. Other incentives the SNWA offers are smart irrigation controllers and rain sensors, instant rebate coupons for water efficient car washes and pool covers, and indoor rebates for small scale retrofits, such as showerheads and faucet aerators. Along with these

rebates the SNWA started their Water Efficient Technologies (WET) Program in 2001 to offer residential incentives to install approved water efficient devices that save more than 250,000 gallons per year.[54, 55]

In Summary

Las Vegas presents a strong example of a city that has identified a problem and is taking steps to fix it. A combination of a small legal apportionment, and its extreme desert climate, has led to serious and necessary changes in water usage and conservation in the Las Vegas Valley as it has grown. Many are quick to point out the city has a long way to go and that there are many measures yet to be taken, as there is always room for improvement. It is important to focus on the positive moving forward. Innovative conservation measures such as mandates on turf grass and partnerships with other conservationist organizations are strong examples of steps to take to reduce consumer demand.

classes in order to receive rebates; Aurora Water implements this technique.[56] Advertising campaigns are another important part of educating the population. Television commercials and billboards, like the one shown in **Figure 27**, receive constant viewership and can use simple messages to remind and inform consumers about water conservation. Residential and commercial water audits are additional ways water providers can work one-on-one with customers to inform them about water savings. These programs are successful because of their concreteness. As well as offering tips and techniques, technicians performing water audits can share examples with consumers as to where savings can be achieved. The combination of these and other water efficiency education programs will make a difference in the basin as we approach water scarcity in the coming years.

Water Loss and Metering

Ten percent water loss, either through system leaks or unaccounted for water, is the industry standard for acceptable water losses. This is a great quantity of wasted water that can be mitigated through monitoring. Water meters are the main tool used to account for this water loss, and as technology increases, water utilities are becoming more and more capable of recognizing losses. Automated Metering Systems (AMS) are increasingly common for Colorado River Basin water providers. AMS technology consists of individual water meters for homes and businesses, which report each property's water usage to the utility on a consistent basis. Utilities are then able to see when customers are using more water than usual, implying possible leaks or inefficiencies, and inform those customers of their increased usage. These systems can also be complemented by water audits. When a utility sees a customer has a potential leak, they can send a water technician to the property to address the problem.[57]

Agriculture/Urban Water Sharing

As urban areas increase in size and population, they are constantly pushing against land and water rights of long time agriculturalists. As opposed to this being a point of contention as it too often becomes, it presents an opportunity for compromise. Agriculture/urban water sharing refers to a practice whereby farmers are able to lease their water rights to municipalities for profit on long-term schedules, which work with farm planning and practices. There are a number of techniques through which this can be implemented, such as water banking, rotational fallowing, and interruptible supply agreements. The governing idea being a municipality pays a farmer not to use a portion of his or her water for a given season. The price paid by the municipality is assumed to cover the loss the farmer will incur from not growing crops for the season, and the water will be temporarily transferred to municipalities for urban needs. Some important considerations necessary for such agreements to work are: flexibility on the part of all parties involved; recognition that different amounts of water will be leased in different years based on factors such as reservoir levels and rainfall; willingness of both the buyer and seller to participate in the program; security of the water supply insofar as the water sharing does not affect nonparticipating farmers (i.e., beyond available consumptive use amounts); and protection from terms of forfeiture, (i.e., "use it or lose it" laws).[58, 59] A more thorough discussion of water sharing is presented in the Agriculture section of the *Report Card* on page 46.

Figure 27: Denver Water's Use Only What You Need Campaign

Source: Denver Water.

One of the largest scale examples of water sharing is currently taking place in California between the Metropolitan Water District (MWD), the water provider for much of Los Angeles, and the Palo Verde Irrigation District (PVID), an agricultural based water district in Southern California. The mid-1990s saw increasing pressure being placed on the MWD and the state of California to reduce Colorado River water usage. By 2004, the MWD and PVID came to an agreement whereby the MWD would pay farmers in Palo Verde to fallow up to 30% of their land and the MWD would receive up to 115,000 acre-feet (AF) of water each year. The program is based on voluntary participation. Participating

farmers agree to fallow anywhere between 7% and 35% of their land (with the concession that no more than 30% of the district's land can be fallowed). Participating farmers received a one-time payment of $3,170 for each encumbered acre and are paid an additional $604 per nonirrigated acres (adjusted yearly). Ed Smith, the General Manager of the PVID, had this to say about the agreement in a statement for a Colorado State University Study, "I think the community as a whole understands that when times are tough our farmers are going to survive because of this program…. Some years farmers could make more if they weren't in the program, but overall you really can't go broke making money."[60]

One Less

Think about how many times a day you use a faucet. Now think about every second you leave a faucet running when not using it. Washing dishes, washing hands, brushing your teeth, taking a shower, think about every second in a day water is going down the drain when it is not entirely necessary. Does it add up to sixty seconds, to one minute? Everyone has different habits and practices, but we can all use less. What would happen if everyone used one less minute of water each day? The EPA act requirements for faucets is 2.5 gallons of water per minute. If one person used one less minute of water coming from 2.5 gpm faucets for one year they would save 912.5 gallons of water. Denver, Colorado, has a population of around 620,000 people.[61] If every Denver resident used one minute less of water for one year, assuming 2.5 gpm faucets, 565,750,000 gallons of water would be saved, the equivalent of roughly 1,736 AF of water a year, enough water for over 2,500 single family homes for one year. Over 30 million people rely on the Colorado River Basin for water. If all 30 million people used one less minute of water from 2.5 gpm faucets for one year 27,375,000,000 gallons would be saved each year, or roughly 84,010 AF of water a year, nearly 30% of Las Vegas yearly water allotment from the Colorado. Imagine if everyone used two minutes less.

Gallons per Capita per Day (GPCD)

GPCD has become the most common metric for measuring per capita water usage in cities, but interestingly enough, it is not standardized. Utilities, authorities, cities, and states measure this number differently and then attempt to compare numbers to demonstrate they are using more or less water than comparable entities. The term lends itself to what seems to be a clear definition, the number of gallons used per day per person in any given area, but it is not so simple. Some of the main areas of difference are centered on what portions of water use are taken into account: while some measurements account for total water used in a given area, others exclude water used for irrigation and agriculture, or tertiary uses, such as mining or small scale power generation. There is also a differentiation between residential GPCD and total GPCD, where the residential figure will only take into account water used in domestic settings. Furthermore, within these calculations there can arise the question of whether water used by second-home owners or vacationers should be included, as well as whether there should be a differentiation between single and multifamily residences. Another complication with the metric is how population is determined. Ideally total water use would simply be divided by total population, but similar to the aforementioned complication with second-home owners there is a question whether nonpermanent residents should be counted in an area's population. For residential calculations especially, agencies computing GPCD will often look at water usage by household and then divide by an average occupancy rate per household. Any variation in such number will have great effects on the final number. In short, it is important to look critically at such numbers and to realize, although one area may seem to have much higher per capita water usage, it may simply be they are taking more into account when computing their data.

Colorado River water in Las Vegas, Nevada.

Case Study: Australia

"The Big Dry" characterizes a more than decade long period of drought that began in Australia in 1997. Although the drought has been devastating to the Australian people it has also turned Australia into one of the world leaders in water conservation, and the techniques and strategies they have adopted can be lessons to us all. Between 2002 and 2008, per capita water usage in Australia dropped 37% with residential water usage estimated to be around 54-59 GPCD in 2009, nearly half of the per capita usage in the U.S.[62] Many of the changes in Australia's water usage have come from top down initiatives, chiefly originating in the form of legislation from the Council of Australian Governments (COAG). In 1994, the council agreed to the Water Reform Framework, which entailed promotion of market-based management systems for water use and water prices fully reflective of the resource costs. The National Water Initiative (NWI) of 2004 built upon the goals of the Water Reform Framework and sought to move towards "integrated management of water for environmental and public benefit." The National Water Commission (NWC) was instated in that same year to oversee the NWI.

One of the major programs these initiatives have promoted is water recycling. Implementation of systems to reuse once potable water for purposes such as flushing toilets, watering gardens, and washing cars has gained popularity on the Australian continent. In Geelong, Victoria, for example, there is currently a $90 million (U.S.) water recycling plant under construction, part of which is being funded by the COAG. The public is slow to use this reclaimed water for potable uses such as showering, but has adopted reclaimed water for nonpotable uses. The infrastructure in place differentiates the reclaimed water with purple pipes, signifying to all the source of the reclaimed water.

Another large scale initiative the country is pursuing is desalination. Between the country's five largest cities, a combined $13.2 billion (U.S.) is being spent on desalination operations that will eventually meet 30% of the five cities' water demand. This has proved an interesting and effective way to produce a sustainable drinking source, and may be a technique many countries will follow in the years to come; however innovative, it is important to recognize desalination is an energy intensive practice and is accompanied by high costs.

Water use restrictions have become increasingly common in Australia, both temporarily and permanently. Restrictions are typically mandated by local governments and authorities, ranging from such things as time of day watering schedules to the banning of sprinklers (only allowing consumers to water by hand). These restrictions have been met with mixed emotions by the Australian public, but for the short-term people have been pleased to comply. The one concern people seem to have is the time span of these restrictions and whether they will eventually phase out. Some states have even implemented water inspectors of varying authorities, some with the ability to handout fines (although typically not until a second or third offense) while others are tasked with educating consumers using excessive amounts of water. A key focus of the restrictions programs, along with the other initiatives in Australia, is educating the consumers. This is done through mailings, utilities websites, and public advertising. Using these mediums allows the Australian government to inform residents about restrictions affecting them while also spreading knowledge on water saving tips and rebate opportunities.

Water pricing has been another tool used by the Australian government to curtail water use. As opposed to the tiered rate systems we commonly see here in the Colorado River Basin, it is more common to see two-part tariffs in Australia where consumers are charged a connection fee and a volumetric charge for whatever their usage may be. A major aspect of water pricing that the Australian government is working to do away with is subsidies so customers are paying the actual price of water, and not a lower subsidized price. In some rural communities, however, this is impractical and subsidies are necessary, but such subsidies are also made transparent to the public. The main idea with these initiatives is customers are paying rates on a "rational footing" and the higher prices will discourage high water use.

As mentioned above, water education is a central feature of Australia's initiatives to reduce water uses. One of the main aspects of this program is labeling for appliances and fixtures. The labels include water usage for a particular product, as well as a six-star rating system. The more water efficient a product is, the more stars it receives. Included in the education and labeling program are rebates for many water efficient products and even direct installations of some devices such as toilets.[63]

Many of these programs seem similar to programs initiated here in the Colorado River Basin, leaving us with the question: why is Australian water usage nearly half of our water usage? The answer is consumer participation and buy-in to said initiatives. Through the drought, Australians were taught a quick and often times painful lesson about the scarcity of their water resources. In response the government, the people, and countless organizations reacted with an urgent message of conservation. The people have decided to work together and to make sacrifices with their water use, and thus they have seen per capita usage greatly reduced. For the U.S. and the Colorado River Basin to mimic such changes, societies must not only continue with the many programs and initiatives in place and being pursued, but the population must also consciously decide to use less water and work together to accomplish a set of goals.

Case Study: Front Range Comparison

This case study surveys five Colorado Front Range water provider's conservation programs to offer a vignette of conservation techniques adopted over the years in cities that are, while not in the geographic basin, reliant on Colorado River Basin water. Each city has its own unique approaches to conservation based on geographical location, availability of resources, and customer demographics. The five Front Range cities examined serve as a credible case study of conservation plans due to differences in population, seniority of water rights, demographics, and access to the Colorado River Basin and tributaries. **Figure 28** provides an overview of the urban water saving techniques that each provider has adopted in its conservation plan.

Inaugurated in 1937, The Colorado Water Conservation Board (CWCB), under the Colorado Department of Natural Resources, serves to conserve, protect, manage, and develop the waters of Colorado for current and future generations. In 2004, CWCB passed Colorado's Water Conservation Act requiring that all water providers who sell 2,000 acre feet or more of water submit an annual water conservation plan to the state to be approved by CWCB.[64] Each conservation plan must comply to meet the minimum requirements that are included in the act that are listed in **Figure 29**.

Figure 28: Comparison of Urban Water Saving Techniques Adopted by Front Range Water Providers

	Denver	Aurora	Fort Collins	Colorado Springs	Pueblo
1% Per Year Reduction	X	X	X		
Water Loss Tracking/Smart Metering	X	X	X	X	X
Water Audits	X	X	X	X	X
Education/Outreach	X	X	X	X	X
Youth Education	X	X	X	X	
Adult Education	X	X	X	X	X
Commercial Education	X	X	X		
Classes	X	X	X	X	
Land Use Planning/Smart Growth	X	X	X	X	
Residential Indoor Rebates					
Dish Washer			X	X	
Clothes Washer	X		X	X	
Toilet	X	X	X	X	
Residential Irrigation Rebates					
Weather-based irrigation controller	X		X	X	
Rain sensor shut-off device					
Soil Moisture Sensor	X		X	X	
Sprinkler heads with check valves			X		
Weather station for retrofit			X	X	
Pressure-reducing heads				X	
Rotating matched precipitation spray nozzles	X		X	X	
Commercial Indoor Rebates					
Toilets/Urinals	X	X	X	X	
Evaporative Cooling Systems				X	
Commercial Irrigation Rebates					
Weather-based (smart) irrigation controllers	X	X	X	X	
Xeriscape Rebate		X			
Xeriscape Demonstration Gardens	X	X	X	X	
Water Reuse	X	X	X	X	
Water Waste Ordinances	X	X	X	X	X
Revaluing Rate Structure: Increasing Block Rates	X	X	X	X	

Figure 29: Colorado Water Conservation Board's Minimum Requirements for Conservation Plans
As of July 1, 2005, the minimum water conservation plan elements defined in §37-60-126(4) C.R.S. are:
-Water efficient fixtures and appliances, including toilets, urinals, showerheads, and faucets
-Low water use landscapes, drought resistant vegetation, removal of phreatophytes, and efficient irrigation
-Water efficient industrial and commercial water using processes
-Water reuse systems
-Distribution system leak identification and repair
-Dissemination of information regarding water use efficiency measures, including by public education, customer water use audits, and water saving demonstrations
-Water rate structures and billing systems designed to encourage water use efficiency in a fiscally responsible manner
-Regulatory measures designed to encourage water conservation
-Incentives to implement water conservation techniques, including rebates to customers to encourage the installation of water conservation measures
-Statement of the covered entity's best judgment of the role of water conservation plans in the covered entity's water supply planning
-Steps to the covered entity used to develop, and will use to implement, monitor, review, and revise its water conservation plan
-Time period, not to exceed seven years, after which the covered entity will review and update its adopted plan
-Either as a percentage or in acre-foot increments, an estimate of the amount of water that has been saved through a previously implemented conservation plan and an estimate of the amount of water that will be saved through conservation when the plan is implemented
-A public review and comment process must take place. If the covered entity does not have rules, codes, or ordinances to make a draft plan available for a public planning process, then the covered entity shall publish a draft plan, give public notice of the plan, make such plan publicly available, and solicit comments from the public for a period of not less than 60 days after the date on which the draft plan is made publicly available.

Source: Colorado Water Conservation Board. 2004. Water Conservation Act of 2004, Other CWCB Related Bills - Passed, HB04-1365, accessed August 14, 2012. http://cwcb.state.co.us/watermanagement/conservation/Documents/MinReqWaterConservePlanElements.pdf.

Although water providers throughout the region are required to meet these efforts, Front Range agencies often exceed these guidelines and adopt exceptional programs aimed at decreasing demand while concurrently increasing productive use of the current water supply. The Front Range water providers included in this analysis are: Aurora Water, Denver Water, Colorado Springs Utilities, Fort Collins Utilities, and Pueblo Board of Water Works. The following case study shows how these agencies differ in their conservation techniques and practices depending on city demographics, population projections, and availability of water. **Figure 30** provides a basic outline of the demographics of the five Front Range cities.

Aurora Water

Overview

Aurora's conservation plan places a strong emphasis on education, technical and financial assistance, and management. The plan includes education and outreach campaigns, promotion of xeriscaping education and demonstration, innovative pricing structures, water audits, waste water ordinances, consumer rebates, and collaboration with peer agencies. As of 2007, Aurora Water served approximately 306,908 people in a 144-square mile area. The 2007 budget for Aurora's conservation department totaled $2.23 million, making Aurora's budget the second largest conservation program in Colorado, behind Denver Water.[65]

Rebates

Aurora Water offers toilet rebates: $75 for 1.28 gpf or $150 for 1.0 gpf or less. Aurora approximates from 2002 through 2006, 3,778 toilets were rebated, saving a cumulative 418 acre feet of water and making it one of the city's most successful programs in terms of quantifiable water savings.[66] The city previously offered clothes washer rebates, but the program was removed after finding it had little impact on the market. Aurora Water conducted a study, which showed nearly 80% of customers would still have bought a new washer without the rebate.[67] Aurora also offers outdoor rebates to both residential and commercial users for efficient irrigation systems and xeriscaping. For irrigation, Aurora offers a rebate to cover the cost of an irrigation system upgrade; this rebate maxes out at $300 for residential properties and $5,000 for commercial users. Aurora offers $1.00 per square foot of low water use plant material and an additional $.25 per square foot of hardscape material that replaces turf grass, with a maximum rebate of $10,000 for the residential sector and up to $25,000 for the commercial sector. Aurora is the only Front Range water provider of the five cities that gives rebates for turf replacement. The Front Range is notorious for using scarce Colorado River water to sustain water intensive Kentucky bluegrass. Incentivizing bluegrass removal in the arid West is an extremely beneficial conservation technique.

Education

Aurora Water has one of the most extensive and youth driven programs in the Front Range by actively engaging its community in water conservation programs. Their education program includes classroom presentations, field

Figure 30: Demographics of Front Range Cities

	Denver	Colorado Springs	Aurora	Ft Collins	Pueblo
Population, 2010	600,158	416,427	325,078	143,986	106,595
Population, percent change, 2000 to 2010	8.20%	15.40%	17.60%	21.40%	4.40%
Persons Under 18 years, percent	21.50%	25.00%	27.30%	19.90%	24.00%
Persons 65 years and over, percent	10.40%	10.90%	8.90%	8.80%	15.70%
Persons below poverty level, percent, 2006-2010	19.20%	11.80%	16.70%	18.00%	21.20%
Median household income, 2006-2010	$45,501	$53,074	$49,515	$49,589	$34,323
Housing Units	285,797	179,607	131,040	60,503	47,593
Households, 2006-2010	254,181	162,295	120,665	55,889	42,466
Land area in square miles, 2010	153	195	154.73	54.28	53.64
Persons per square mile, 2010	3,922.60	2,140.60	2,100.90	2,652.80	1,987.20

Source: US Census Bureau, State and County Quick Facts, accessed July 5, 2012, http://quickfacts.census.gov/qfd/states/08/0862000.html.

trips, and service learning projects for community schools. Classroom presenters provide water models, games, and activities to engage students and help them learn about the sources of their water, how to prevent water pollution, and the importance of conservation. Aurora Water also provides several fieldtrips and tours for students ranging from preschool to high school. Water treatment and wastewater treatment tours are available for grades 2-12 to learn about treatment facilities and the process of water reuse. Grades 6-12 can sign up for water quality testing fieldtrips in which students are accompanied to a waterway to conduct water quality testing, paired with lessons in the classroom both before and after the trip.

Aurora Water also provides the Aurora Water Quality Understanding and Appreciation (AWQUA) Lounge where water conservation initiatives and awareness are taught in a friendly, underwater environment. Aurora's education program has received and continues to receive high praise for their efforts, including the Silver Award in 2007 from the Denver Regional Council of Governments for their youth education programs, the Local Government Awards Program category of Community Outreach/Public Education, and the Colorado Alliance for Environmental Education Award in Excellence in 2006 for Aurora Water's Youth Water Festival.

The city's education program is not limited to the classroom. Aurora Water also requires customers who wish to participate in rebate programs to attend water efficiency classes. A similar initiative is in place for customers who violate water waste restrictions. This pairing of education with other programs offered by the utility allows for a greater dispersal of knowledge to the adult population.

Programs

Aurora Water provides numerous programs to its customers including free indoor and outdoor water audits, the Water Smart Neighborhood Program for homeowner associations, internship opportunities, and an Industrial, Commercial, and Institutional conservation program. For this program, Aurora Water came together with the Northern Colorado ICI Water Conservation Workgroup in 2005 to create a partnership to address water conservation on the regional level by gathering benchmark data on restaurants, hotels and motels, schools, and nursing homes. This program allows Aurora to further develop educational programs and initiatives aimed at the industrial sector.

Ordinances

Aurora Water maintains ordinances for new construction projects regarding lawn permits, irrigation standards, and car wash reclamation. The city also has water wasting ordinances prohibiting customers from allowing water to run across impervious surfaces, allowing customers to irrigate their landscapes only three days a week, and not allowing watering between the hours of 10 a.m. and 6 p.m.

Research

Aurora Water is one of the nine municipalities to participate in a new home efficiency study that analyzes water use in an average new home versus water use in a high-efficiency new home. Aurora water is also studying the relationship between price sensitivity and conservation measures. The city also actively conducts surveys to assess customer opinions and preferences. These surveys serve as a tool to see what conservation programs work well and what programs need improvements.

Conclusion

Aurora Water shows a strong conservation plan including several approaches to conservation, from rebates and incentives to ordinances and partnerships. Aurora Water is a leader in conservation among water providers and an example to be emulated throughout the Colorado River Basin. Aurora's education program is among the strongest in the Front Range, providing a broad range of opportunities for the residential and commercial sector alike.[68, 69]

Denver Water

Overview

In 2007, Denver launched its 10-year conservation plan with the goal to reduce water use and GPCD by 22% by 2016.[70] By 2011, customers were already using 20% less water, even with a population increase of 10%.[71] Denver Water

services more than a million people in an area of 335 square miles.[72] The most successful aspect of Denver Water's conservation is its public outreach campaign: Use Only What You Need, and the ability of this campaign to create social changes in how we view water.

Education

Denver Water has an expansive education program. This includes a summer program, which hires temporary "Water Savers" who work to educate thousands of customers about water waste and enforce summer watering restrictions. Denver has made a serious effort to reach all of its customers with its Use Only What You Need Campaign. This lively campaign uses creative advertising, pictured in **Figure 31**, to capture the attention of the public, and encourage customers to reduce their water consumption. In the past six years alone, water consumption has decreased by 20%.[73] This campaign recognizes that different types of customers will be reached and affected in different ways; public outreach, media advertising, and a variety of water audit programs have led this program to great success. A recent study conducted by Denver Water found that 90% of its customers recognize the effect this initiative has had on their water consumption.

Figure 31: Denver Water's Use Only What You Need Campaign

Source: Denver Water.

Rebates

Denver's rebate program has seen great success in recent years with an increase of 62% on outdoor commercial rebates since 2009, a 19% increase for residential outdoor rebates, and a 45% increase for indoor residential rebates. Denver Water offers residential customers rebates for clothes washers, toilets, rotary nozzles for sprinklers, and smart irrigation controllers. Industrial rebates are farther reaching and include toilet and urinal replacement, cooling tower equipment, commercial warewashing equipment, and irrigation equipment (smart controllers and rotary nozzles).

Programs

Denver Water runs a large water recycling program, which was first initiated in 2004 and then revised in 2010. The Recycled Water Master Plan outlines and plans for future growth, recommends infrastructure, and analyzes effects of population growth. The water utility has set a goal of delivering 17,500 acre-feet of recycled water each year. Once completed, the system will free up enough drinking water for almost 43,000 homes. In 2011, Denver Water was about one-third of the way toward this goal. Denver Water also provides a variety of water audits. Low income audits allow for water technicians to evaluate lower-class housing where water conservation is less of a priority, and commercial audits are hugely effective in identifying large, hidden water uses in industrial facilities such as cooling towers. Denver implemented a soil amendment program requiring developers to till compost into soil prepped for landscaping, reducing future water needs for irrigation. In 2010 alone, employees performed 1,097 soil amendment inspections on more than five million square feet of land, with the potential to reduce water needs by more than 20 million gallons of water per year.[74]

Conclusion

Denver Water continues to make a great difference in water conservation and deserves every bit of praise it has received. Their public outreach not only affects the Denver population, but also carries over into other Front Range cities like Colorado Springs and Pueblo. With the largest conservation budget, coupled with the biggest service population in the Front Range, their influence is both vast and central for reducing water use in the West.

Pueblo

Overview

Since 2002, Pueblo has reduce per capita water usage by 19%.[75] Pueblo Board of Water Works has focused its conservation plan on education and outreach, and addressing water system water loss.

Education

Pueblo's water information initiative works to spread information to the utilities' customers about water conservation through mailings and public meetings. The city also has Water Wise programs, which are geared towards teaching the youth lessons about water conservation, water sources, and general appreciation of the resource.

Programs

One of Pueblo's most focused conservation initiatives is metering, specifically replacing existing meters with

Sports Authority Field at Mile High

Denver's acclaimed football stadium has undergone a water conservation renovation, saving millions of gallons of water each year. "When you have a big complex like we do, small changes make a very, very big difference," claims Andy Gorchov, general manager of Sports Authority Field at Mile High. "You can't be wasteful."[76] The renowned football stadium has saved millions of gallons of water through two water conservation initiatives. First, the toilet retrofit project replaced 142 toilets with high-efficiency models (1.28 gpf) with a toilet rebate of more than $17,000, saving the stadium thousands of gallons of water each time an event is hosted.[77] The second program is an irrigation contract that has almost halved the amount of water used for irrigating. In 2008, the stadium shifted towards a central control system that allows turf managers to change water schedules based on plant's needs in the 30 acres of land, factoring in weather data, precipitation rates, soil type, sun exposure, and additional factors. Since the installation of the project in 2008, Mile High Stadium has saved 6.8 million gallons of water per year in irrigation use, and received more than $55,000 in incentives from Denver Water. This saved water coupled with the savings of an average of $25,000 a year in water bills has been an extremely successful example of water conservation for commercial projects. "These things make very good business sense," explained Gorchov. "It's very expensive to waste."[78]

new meters that operate under Automated Meter Reading (AMR). AMR allows meter data to be sent to one of the 16 data collection units in the city of Pueblo, rather than the traditional process, which required employees to read meters individually and record the data. The solar powered collection units send the information to a central computer used for billing, customer service, and field services. Upgrading to AMRs began in 2008 and is estimated to be completed in a ten-year period in which all 40,191 meters in the system will be replaced. During the first three years, 18,078 meters were replaced and by the end of 2011, half of the meters had been replaced.[79]

The process is free for customers and promises to increase efficiency for operations. Instead of having employees travel across the city to read meters individually, employees can instantly access the information through a database. Additionally, if customers wish to inquire about a sudden change in their bill, Pueblo Board of Water Works can poll their specific meter and search for any changes which could result in a problem. Pueblo's effort to upgrade metering to prevent water loss and inform customers is a superb effort in water management and water conservation.

Conclusion

Although Pueblo does not include many of the water saving techniques listed in **Figure 32**, it is worth mentioning Pueblo is unique in its demographics compared to the other four Front Range cities. Pueblo has the largest percentage of senior citizens out of the cities, the highest percentage of population below the poverty line, and the lowest median income. Because Pueblo has an adequate supply of water with senior water rights over the Arkansas River, it is not necessary to take such an aggressive conservation stance like that of Denver and Aurora. Despite this, Pueblo has still adopted a conservation plan aimed at preserving their adequate supply for years to come.

Fort Collins

Overview

Serving 8.8 billion gallons of water to 128,000 people in 2007, Fort Collins views water conservation as an important, proactive response to supply variability and increased demand. The Fort Collins Water Utility has a stated goal of reaching 140 GPCD by 2020. Their conservation plan focuses on reducing both indoor and outdoor demand through leak reduction, behavioral change through education, improved technology, and efficient irrigation and landscaping.[80]

Education

Fort Collins Utilities operates a public information campaign in which all water conservation, water use, and billing are provided to customers upon request. The campaign also sponsors various community events, such as Sustainable Living Fair, a family-based event aimed at spreading information on water and energy efficiency. The utility also provides adult, school, and business education programs. Their school education program is comprised of a water conservation curriculum, which educates kids on the importance of using the resource wisely. Adults can participate in a variety of xeriscape programs to learn water conserving techniques and practices for landscaping. Each year the utility runs a Children's Water Festival, where approximately 1,700 third-grade students and teachers come to learn about issues such as wetlands and rivers, water conservation, the impacts of droughts, and the importance of water.[81]

Rebates

Fort Collins offers the most rebate opportunities to its customers of the five cities we examined. For indoor residential use, customers can claim $35 for a 1.28 gpf toilet and an additional $15 for recycling the old toilet, a $50 rebate for an approved clothes washer, and $25 for qualifying dishwashers. Approximately 900 rebates have been given each year for the clothes washer program, making this program one of the most successful.

Fort Collins Utilities offers rebates for weather-based irrigation controllers ($150), both wired and wireless rain sensor shut-off devices ($15 and $30 respectively), soil moisture sensors ($45), and weather stations for retrofit ($50). Fort Collins Utilities is the only water provider surveyed that includes a rebate for pressure reading heads with a $20 rebate for purchases between $40-$79, and a $40 rebate for purchase of $80+. Rebates are also offered for high efficiency nozzles with a $25 rebate for purchases between $50-$99, and $50 for purchases of $100+.[82]

Ordinances

Like many of the other water providers, Fort Collins

maintains waste water ordinances. The utility prohibits homeowner associations from banning xeriscaping or requiring minimum turf areas. The city has a soil amendment ordinance for new properties requiring specific soils to promote landscape efficiency and landscape and irrigation standards for new developments. Under this ordinance, all new development landscape and irrigation plans must be in compliance with the Land Use Code's water conservation standards, which includes requiring a rain shut-off device for commercial sprinkler systems.

Conclusion

Fort Collins Utilities rebate program is one to be highlighted and emulated throughout the region. Because the market has not fully created a demand for water efficient appliances, especially for new efficient irrigation equipment, it is important for utility companies to incentivize such technologies, like Fort Collins has done, and educate their consumers. Similar to Aurora, Fort Collins also offers an impressive education program, aimed at not only adults and businesses, but also the youth.

Colorado Springs Utilities

Overview

Colorado Springs Utilities (CSU) is a community-owned utility with a service area of 184 square miles. In 2006, 26 billion gallons of water was delivered to 417,000 people. CSU emphasizes collaboration and cooperative relationships throughout the region to encourage water conservation and efficiency. In 1999, the city began pursuing a goal of reducing water usage by 30 billion gallons by 2017.[83]

Rebates

CSU offers rebates for toilets ($75), clothes washers ($75), and dishwashers ($50). CSU contains a wide array of outdoor irrigation rebates covering half the price of a weather-based irrigation controller up to $200, a $25 rebate for a wired rain sensor shut-off device, a $50 rebate for a wireless rain sensor shut-off device, and up to $4 for rotating matched precipitation spray nozzles. Colorado Springs is also the only water provider we interviewed to rebate sprinkler heads with check valves with a $50 rebate for purchases between $100-$199, $100 rebate for purchases between $200-$399, and a $200 rebate for purchases of $400+.

Education

CSU asserts that the historical emphasis on education has contributed to low residential per capita use. Their education programs include classes for adults on conservation and water efficiency in the home, public demonstrations such as their xeriscape demonstration garden, school partnerships and education in the classroom, public speakers, water tours, and public information initiatives.

Programs

Similar to the Pueblo Board of Water Works, CSU took a strong initiative to deploy AMRs to all customers by 2010. As mentioned previously, this allows water users to access daily and weekly consumption reports and information, making it a great educational tool. In addition to their AMR program to help customers with their water use, CSU's Peak Day Program will develop education programs aimed at reducing peak day use, specifically in areas with high residential per capita use and high peaking factors. CSU has commercial and residential audit programs to identify large, unnecessary water uses. CSU also launched a campaign specifically targeted at new residential construction. Colorado Springs Utilities developed landscape guidelines for distribution to home buyers, home builders, and realtors.

Ordinances

Colorado Springs Utilities conservation plan contains waste water ordinances, landscape establishment permits, and a Landscape Code and Policy. The Landscape Code and Policy requires water efficient landscaping for new commercial, industrial, and multifamily properties. For years, the landscape code in Colorado Springs has been cited as a model for other communities to follow. The utility recognizes, given recent advancements in irrigation technology and changing customer expectations, the existing code needs review. Elements under consideration include more stringent enforcement procedures and smart (ET) controller requirements. CSU will engage key stakeholders in the code review process. The water waste ordinance sets limitations on pooling or flowing of water across impervious surfaces, as well as time-of-day watering restrictions. The Utilities' landscape establishment permits require customers to install at least three cubic yards of organic material for every 1,000 square feet of planting area.[84, 85]

Conclusion

CSU's single family per capita use is a notable achievement compared to other Front Range water users. Similarly, their emphasis on education and metering programs has led to a strong conservation plan that will help curb the growing water demand of the city.

Comparison

Looking at the Colorado Front Range Case Study is an examination of five water providers meeting the needs of five distinctly different populations, and all possessing very different water rights. Looking at the prices customers pay for water in each of these cities alone speaks to the varying degrees of water rights. In Pueblo, for example, a recent study conducted by the Board of Water Works found that increase block rate pricing would be ineffective at decreasing demand for the city and other conservation initiatives would be better suited. Thus, in Pueblo there are starkly lower water prices than in any of the other Front Range cities studied. This difference in water price is closely associated with difference in water rights. Unlike any of the other four cities, Pueblo possesses highly senior water rights on the Arkansas River (taking much less from the Colorado), and therefore water supply is, for now, seemingly a non-issue. The city is able to charge lower rates. Conversely, the city of Aurora is one in possession of very inferior water rights on the South Platte River. Because of this, the city has a greater need to charge customers more in order to further discourage wasteful use. It is like looking at a puzzle slowly being pieced together, when

Figure 32: Indoor Rebate Programs					
Rebates	**Colorado Springs**	**Denver Water**	**Fort Collins Utilities**	**Aurora**	**Pueblo**
Toilets/Urinals	$75 (1.28 gpf or less)	$75 (1.28 gpf or less)	$35 ($70 purchases made April through July 2012) 1.28 gpf or less, additional $15 for recycling old toilet	$75 (1.28 gpf), $150 (1.0 gpf or less)	
Clothes Washers	$75	$100	$50		
Dishwashers	$50		$25		

one corner is found the rest can start to work around it. The cities of Pueblo and Aurora have found different corners to work with, and not surprisingly they are fitting together their puzzles in different ways.

It is not all a story of differences, however. Among the five cities the popularity of rebates is nearly across the board. **Figure 32** displays various indoor rebate programs for the Front Range cities. While some rebates have been phased out in recent years, e.g., dishwasher rebates in Denver and Aurora, others are still going strong. Until the market is saturated and it no longer makes sense for water providers to facilitate such retrofits, these rebates, e.g., toilet replacements, will continue. Especially in more urban settings the prevalence of such initiatives is continuing, and likely will for years to come.

Outdoor rebates continue to be popular as well, although these tend to vary more based on city demographics and land use trends. Outdoor rebates, such as pressure reducing sprinkler heads and weather station retrofits, are granted by Fort Collins Utilities, but not Denver Water or Aurora Water. This is a case where higher density areas are putting less focus on initiatives utilized by lower density areas. Again the difference is based on the specifics of each city. The outdoor rebate program (shown in **Figure 33**) seems to be determined by the demographics and density of the city.

Different cities are responding to the different needs of their customer bases. Everyone understands conservation is necessary, but the tools utilized in order to pursue this goal will vary. In the city of Pueblo, where the very senior population places a high value on green lawns, xeriscaping programs are poorly received. Realizing this, the Pueblo Board of Water Works has focused its energies on installing smart metering systems to address water loss, something they know needs to be reduced. In Aurora, where water is scarcer, Aurora water has focused their efforts on education, both through teaching the youth the value of water, and educating adults about wasting water. Denver is a city with a huge population, and an even bigger audience. Knowing millions of people drive past or through their city all the time, Denver Water has initiated the Use Only What You Need campaign in an effort to inform the masses of water crisis and the simple notion of using less.

Each city goes about it in a different way, but the lesson to share from this case study is there are many right answers. Yes, the Colorado River Basin is approaching a crisis, water demand will exceed water supply for the basin in the not too distant future, but through education, through addressing waste on all levels, through incentives and mandates, the picture can be turned around. The different approaches of each city are meant to highlight the necessity of finding the conservation strategy that works best for the conditions presented. There is no one right answer; moving forward, the more viable possibilities the better.

Figure 33: Outdoor Rebate Programs					
Outdoor Rebates	**Colorado Springs**	**Denver Water**	**Fort Collins Utilities**	**Aurora**	**Pueblo**
Xeriscaping				$1.00/sq. ft. low water use plant material + $.25/sq. ft. hardscape materials. Up to $10,000 residential, $25,000 commercial	
Weather-based irrigation controller	half of purchase price up to $200	$100 with rain sensor	$150		
WIRED rain sensor shut-off device	up to $25		$15		
WIRELESS rain sensor shut-off device	up to $50	$50	$30		
Rotating matched precipitation spray nozzles (qualifying equipment)	up to $4 each, minimum 5, limit 40	$2 per nozzle, minimum purchase 10, maximum 100	$25 (purchases of $50-$99) or $50 (purchases of $100+) (high efficiency nozzles)		
Pressure-reducing heads			$20 (purchases of $40-$79) or $40 (purchases of $80+)		
Weather station for retrofit			$50		

M&I Conclusion

From the Bureau of Reclamation supply and demand study we can see M&I water demand is expected to increase from approximately 27% in 2015 to 33-38% in 2060 depending on the scenario. From the scenarios analyzed, we determined the Enhanced Environment projection as the most beneficial outcome for the Colorado River Basin. For this scenario to come to fruition, it will take basin-wide social change, governmental regulation, and a greater understanding of what it means to use our water efficiently and responsibly.

In this section we discussed a multitude of conservation techniques and practices that can be pursued by both consumers and water providers. Programs that should be pursued throughout the basin include Las Vegas' mandated ordinances on turf grass, Denver Water's Use What You Need public outreach campaign, CSU and Pueblo's smart metering programs, and Aurora Water and Fort Collins Utilities' comprehensive education programs. These programs work to implement social change, but ultimately it comes down to the consumer's choices and preferences. Pursuing these measures will not only help meet the growing demand of Colorado River water, but also support a sustainable Colorado River Basin water future. We owe future generations nothing less!

Citations:

[1] Bureau of Reclamation. "Colorado River Basin Water Supply and Demand Study: Interim Report No. 1," *Reclamation Managing Water in the West* (2012): 2.
[2] National Geographic, *The Colorado River*, National Geographic Society, accessed July 3, 2012, http://environment.nationalgeographic.com/environment/freshwater/colorado-river-map/.
[3] Bureau of Reclamation, "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios," *Reclamation Managing Water in the West* (2012).
[4] U.S. Census Bureau, *Residential Population Data*, accessed July 5, 2012, http://2010.census.gov/2010census/data/apportionment-pop-text.php.
[5] Bureau of Reclamation, "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios," *Reclamation Managing Water in the West* (2012): 26.
[6] Ibid.
[7] Ibid.
[8] Bureau of Reclamation, "Colorado River Basin Water Supply and Demand Study: Interim Report No. 1," *Reclamation Managing Water in the West* (2012): 6.
[9] Bureau of Reclamation, "Colorado River Basin Water Supply and Demand Study: Technical Memorandum C – Quantification of Water Demand Scenarios," *Reclamation Managing Water in the West* (2012): 26.
[10] Ibid., 4.
[11] Ibid., 15-16.
[12] Bureau of Reclamation. "Colorado River Basin Water Supply and Demand Study: Executive Summary." *Reclamation Managing Water in the West* (2012).
[13] Michael J. Cohen, *Municipal Deliveries of Colorado River Basin Water*, Pacific Institute (Oakland, California, 2011).
[14] Vickers, Amy, *Handbook of: Water Use and Conservation*, (Amherst: Water Plow Press, 2001). p.12.
[15] Western Resource Advocates, *"New House New Paradigm: A Model for How to Plan, Build, and Live Water-Smart"* (Boulder, Colorado, 2009), accessed August 2012, http://www.westernresourceadvocates.org/water/newparadigm/NewParadigmReport.pdf.
[16] Alliance for Sustainable Colorado. *Past Successes*, accessed July 2012, http://sustainablecolorado.org/programs/policy/past-successes.
[17] United States Environmental Protection Agency, "State Appliance Efficiency Standards," in *Clean Energy-Environment Guide to Action: Policies, Best Practices, and Action Steps for States*, April 2006. pp. 4-63.
[18] Amy Joi O'Donoghue, "Lake Powell Pipeline: Albatross or Golden Goose?" *Deseret News*, May 13, 2012. http://www.deseretnews.com/article/865555736/Lake-Powell-Pipeline--Albatross-or-golden-goose.html.
[19] David DeMille, "Drop in Population Projections Raise Questions About Lake Powell Pipeline," *St. George Spectrum*, July 31, 2012. http://www.thespectrum.com/article/20120731/NEWS01/307310021/Drop-in-population-projections-raise-questions-about-Lake-Powell-Pipeline?odyssey=tab|mostpopular|text|FRONTPAGE.
[20] Paul Van Dam and Lisa Rutherford, Interview by author, St. George, Utah. July 18, 2012.
[21] Barbara Hjelle, Interview by author, St. George, Utah. July 18, 2012.
[22] Washington County Water Conservancy District *Facts: Lake Powell Pipeline Project*, accessed July 31, 2012. http://www.wcwcd.org/wp-content/uploads/2012/05/2012-FACTS-LPP-Costs.reliability.pdf.
[23] Amy Vickers, *Water Use and Conservation*, pp. 24, 116.
[24] American Water Works Association Research Foundation, *Residential End Uses of Water*, prepared by Peter W. Mayer, Eva M. Opitz, John Olaf Nelson, Denver, Colorado: AWWA Research Foundation, 1999.
[25] Ibid.
[26] Evan Ratliff, "Turf Wars: The Battle Over the American Lawn, accessed July 11, 2012, http://www.atavistic.org/evan/images/ReadyMade/Lawn%20Wars.pdf.
[27] Amy Vickers, *Water Use and Conservation*, p. 145.
[28] Washington State University, *How to Water Your Lawn*, accessed July 11, 2012, http://county.wsu.edu/benton-franklin/gardening/general/Fact%20Sheets/How%20to%20Water%20Your%20Lawn.pdf.
[29] United States Environmental Protection Agency, *Using Water Efficiently: Ideas for Residences*, accessed July 11, 2012, http://epa.gov/watersense/docs/residence_508.pdf.
[30] MetaEfficient, *Efficient Outdoor Water Use*, accessed July 11, 2012, http://www.metaefficient.com/gardening/efficient-outdoor-water-use.html.
[31] Denver Water, "Water Wise Landscape Handbook," accessed July 11, 2012, http://denverwater.org/docs/assets/6E5CC278-0B7C-1088-758683A48CE8624D/Water_Wise_Landscape_Handbook.pdf.
[32] The University of Georgia College of Agriculture and Environmental Sciences, "Xeriscape: A Guide to Developing a Water-Wise Landscape," accessed July 11, 2012, http://www.marex.uga.edu/advisory/Library/CSCPpdfs/Xeriscape.pdf.
[33] Doug Bennet. Interview by author, Las Vegas, Nevada. July 19, 2012.
[34] Peter H. Gleick, et al. *The World's Water: The Biennial Report on Freshwater Resources*, (Washington D.C.: Island Press, 2009) volume 6, p. 107.
[35] Southern Nevada Water Authority, "Conservation Plan 2009-2013. May 2009, accessed July 11, 2012, http://www.snwa.com/assets/pdf/about_reports_conservation_plan.pdf.
[36] Gleick, Peter H. *The World's Water.* vol. 6, p.107.
[37] U.S. Congress. House. *Energy Policy Act of 1992*. H.R.776.ENR. 102nd Congress. Thomas (The Library of Congress) http://thomas.loc.gov/cgi-bin/query/z?c102:H.R.776.ENR.
[38] Jeff Tejral, Interview by author, Denver, Colorado. August 2, 2012.
[39] Alliance for Water Efficiency, *Conservation Oriented Rate Structures*, accessed July 6, 2012, http://www.allianceforwaterefficiency.org/1Column.aspx?id=712.
[40] Sheila M. Olmstead, Robert N. Stavins, "Managing Water Demand: Price vs. Non-Price Conservation Programs," accessed July 6, 2012, http://www.hks.harvard.edu/fs/rstavins/Monographs_&_Reports/Pioneer_Olmstead_Stavins_Water.pdf.
[41] Bureau of Reclamation, *Effectiveness of Conservation Pricing in Reducing Water Demand, Evidence from Increasing Block Rate Structures*, accessed June 29, 2012, http://www.usbr.gov/research/science-and-tech/research/detail.cfm?id=414.
[42] Bureau of Reclamation. "Colorado River Basin Water Supply and Demand Study: Executive Summary." *Reclamation Managing Water in the West* (2012).
[43] Doug Bennet, Interview by author, Las Vegas, Nevada. July 18, 2012.
[44] Western Resource Advocates, *"New House New Paradigm: A Model for How to Plan, Build, and Live Water-Smart"* (Boulder, Colorado, 2009), accessed August 2012, http://www.westernresourceadvocates.org/water/newparadigm/NewParadigmReport.pdf.
[45] Simmons B. Buntin, "UnSprawl Case Study: Community of Civano, Arizona," *Terrain.org: A Journal of the Built & Natural Environments*, http://www.terrain.org/unsprawl/5/.
[46] C. Alan Nichols, Jason A. Laros, *Inside the Civano Project: A Case Study of Large-Scale Sustainable Neighborhood Development* (New York: McGraw Hill, 2010) pp. 89, 219.
[47] Paul Van Dam and Lisa Rutherford, Interview by author, St. George, Utah. July 18, 2012.
[48] Western Resource Advocates, *"New House New Paradigm: A Model for How to Plan, Build, and Live Water-Smart"* (Boulder, Colorado, 2009), accessed August 2012, http://www.westernresourceadvocates.org/water/newparadigm/NewParadigmReport.pdf.
[49] Paul Fanning. Interview by author, Pueblo, Colorado. June 21, 2012.
[50] U.S. Congress. House. *Energy Policy Act of 1992*. H.R.776.ENR. 102nd Congress. Thomas (The Library of Congress) http://thomas.loc.gov/cgi-bin/query/z?c102:H.R.776.ENR:.
[51] Leslie Kaufman, "Utilities Turn Their Customers Green, With Envy," *New York Times*, January 30, 2009, http://www.nytimes.com/2009/01/31/science/earth/31compete.html?_r=2.
[52] Paul J. Ferraro, Michael K. Price, "Using Non-Pecuniary Strategies to Influence Behavior: Evidence From a Large Scale Field Experiment," *NBER Working Paper Series*. National Bureau of Economic Research, July 2011. http://www.nber.org/papers/w17189.pdf?new_window=1.
[53] Drew Beckwith. Phone interview by author, June 20, 2012.
[54] Doug Bennet, Interview by author, Las Vegas, Nevada. July 19, 2012.
[55] Southern Nevada Water Authority, *Conservation Plan 2009-2013*, May 2009. http://www.snwa.com/assets/pdf/about_reports_conservation_plan.pdf.
[56] Lyle Whitney, Interview by author, Aurora, Colorado. June 27, 2012.
[57] Andy Kercher, "Case Study: Las Vegas Valley Water District, accessed July 13, 2012, http://www.datamatic.com/lvvwd_casestudy.pdf.
[58] Western Resource Advocates. "Colorado River Water Uses: 21st Solutions for the Colorado River Basin's Unbalanced Uses," accessed July, 2012, http://www.westernresourceadvocates.org/water/WaterReportDrewBeckwith1111.pdf.
[59] Drew Beckwith. Phone interview by author, June 20, 2012.
[60] Ed Smith, interview, *Palo Verde and MWD's Land Management, Crop Rotation and Water Supply Program*, in "Agriculture/Urban/Environmental Water Sharing: Innovative Strategies for the Colorado River Basin and the West," by MaryLou Smith, http://cwi.colostate.edu/publications/sr/22.pdf.
[61] Google Public Data, Denver, CO Population, accessed Jan 2013, http://www.google.com/publicdata/explore?ds=kf7tgg1uo9ude_&met_y=population&idim=place:0820000&dl=en&hl=en&q=population%20of%20denver.
[62] Ryan Cahill and Jay Lund, "Residential Water Conservation in Australia and California," November, 2011, accessed July 10, 2012.
[63] Peter H. Gleick, et al. *The World's Water: The Biennial Report on Freshwater Resources*, (Washington D.C.: Island Press, 2012), pp. 97-121.
[64] Colorado Water Conservation Board, 2004, *Water Conservation Act of 2004*, Other CWCB Related Bills - Passed, HB04-1365, accessed August 14, 2012. http://cwcb.state.co.us/water-management/conservation/Documents/MinReqWaterConservePlanElements.pdf.

[65] Mayer, Peter, and Kevin Reidy. *City of Aurora Water Conservation Plan: Aurora Water*. Aquacraft, Inc., Aurora Water, 2007.
[66] Ibid., 13.
[67] Lyle Whitney, Interview by author, Aurora, Colorado. June 27, 2012.
[68] "Water Conservation Rebates" in City of Aurora [database online]. [cited 2012]. Available from https://www.auroragov.org/LivingHere/Water/Conservation/WaterConservationRebates/index.htm.
[69] Laurie D. Audney, Interview by author, Ft. Collins, Colorado. July 12, 2012.
[70] "Water Conservation Rebates." in City of Aurora [database online]. [cited 2012]. Available from https://www.auroragov.org/LivingHere/Water/Conservation/WaterConservationRebates/index.htm.
[71] Baker, Ann. Saving Water for the Future. Edited by Sabrina Hall. 2011th ed. Denver Water, 2011, p. 3.
[72] "Use Only What You Need: Freebies." in Denver Water [database online]. [cited 2012]. Available from http://www.denverwater.org/Conservation/UseOnlyWhatYouNeed/Freebies/.
[73] Baker, Ann. *Saving Water for the Future*. Edited by Sabrina Hall. 2011 ed. Denver Water, 2011. p. 3.
[74] Jeff Tejral, Interview by author, Denver, Colorado. August 2, 2012.
[75] Pueblo Board of Water Works. "Latest News." in Pueblo Board of Water Works [database online]. [cited 2012]. Available from http://www.pueblowater.org/index.php/latest-news.html.
[76] Baker, Ann. *Saving Water for the Future*. Edited by Sabrina Hall. 2011 ed. Denver Water, 2011. p. 3.
[77] Ibid.
[78] Ibid.
[79] Ibid.
[80] The City of Fort Collins, "Resolution 2012-099 of the Council of the City of Fort Collins: Adopting a Water Supply and Demand Management Policy," accessed July, 2012, http://www.fcgov.com/utilities/img/site_specific/uploads/wsdm-policy.pdf.
[81] The City of Ft. Collins, "Water Festival." accessed August, 2012, http://www.fcgov.com/utilities/community-education/youth/water-festival.
[82] The City of Ft. Collins, "Rebates and Programs." accessed August, 2012, http://www.fcgov.com/utilities/residential/conserve/rebates-programs.
[83] Colorado Springs Utilities. *2008-2012 Water Conservation Plan*. Colorado Springs Utilities, 2008. p. 7.
[84] Ibid., pp.7, 8.
[85] Ann Seymour, Scott Winter, Interview by author, Colorado Springs, Colorado. June 21, 2012.

The Down the Colorado Expedition crossing Lake Powell on their solar raft.